

Calpine Enhanced Geothermal Systems Project

Final Environmental Assessment

June 2010

Prepared for:

U.S. Department of Energy 1617 Cole Boulevard Golden, CO 80401

Prepared by:

RMT Inc. 4 West Fourth Avenue, Suite 303 San Mateo, CA 94402

Calpine-Geysers 10350 Socrates Mine Road Middletown, CA 95461

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List of Acronyms

3D 3-dimensional

amsl Above mean sea level

As Arsenic

ATC Authority to Construct

B Boron

BEPA Bald Eagle Protection Act

BMPs Best management practices

BOPE Blowout prevention equipment

CALNET Central California Seismic Network

CARB California Air Resources Board

CCPA Central California Power Agency

CDF California Department of Forestry

CDFG California Department of Fish and Game

CDOGGR California Department of Oil, Gas, and Geothermal Resources

CEQA California Environmental Quality Act

CFR Code of Federal Regulations

CH₄ Methane

CNDDB California Natural Diversity Database

CNPS California Native Plant Society

CO₂ Carbon dioxide

CWA Clean Water Act

dB Decibel

dBA A-weighted decibel

DOE Department of Energy

DWR Department of Water Resources

LIST OF ACRONYMS

EA Environmental Assessment

EGS Enhanced Geothermal System

EIR Environmental Impact Report

EPA Environmental Protection Agency

ESA Endangered Species Act

ESU Evolutionary significant unit

FEMA Federal Emergency Management Agency

FOA Funding Opportunity Announcement

GDMACDA Geothermal drilling mud and cuttings disposal area

GHG Green house gas

gpm Gallons per minute

H₂S Hydrogen sulfide

HFCs Hydrofluorocarbons

Hg Mercury

HMBP Hazardous Material Business Plan

HTZ High temperature zone

IRWP Incremental Recycled Water Program

IS/MND Initial Study/Mitigated Negative Declaration

LBNL Lawrence Berkeley National Laboratory

MBTA Migratory Bird Treaty Act

MEQs Micro-earthquake activity

mg/L Milligrams per liter

ML Richter local magnitude

MPa Megapascals

MW Megawatt

N₂O Nitrous oxide

NaOH Sodium hydroxide

NCG Noncondensible gases

NCSN Northern California Seismic Network

NEPA National Environmental Policy Act

NH₃ Ammonia

NHPA National Historic Preservation Act

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resource Conservation Service

NSCAPCD North Sonoma County Air Pollution Control District

OSHA Occupational Health and Safety Organization

P-32 Prati-32

PFCs Perfluorocarbons

PM_{2.5} Particulate matter 2.5 microns and smaller in diameter

PM₁₀ Particulate matter 10 microns and smaller in diameter

PPE Personal protection equipment

ppm Parts per million

PRMD Permit and Resource Management Department

PS-31 Prati State-31

PTO Permit to Operate

PTS Pressure temperature spinner

RCRA Resource Conservation and Recovery Act

RWQCB Regional Water Quality Control Board

SF₆ Sulfur hexafluoride

SHPO State Historic Preservation Office

SPCC Spill Prevention Control and Countermeasure

SRGRP Santa Rosa Geysers Recharge Project

LIST OF ACRONYMS

SWPPP Stormwater Pollution Prevention Plan

TDS Total dissolved solids

UCB University of California at Berkeley

USFWS US Fish and Wildlife Service

USGS US Geological Survey

VOCs Volatile organic compounds

WDP Waste Discharge Permit

WSA William Self Associates

1.1 Introduction

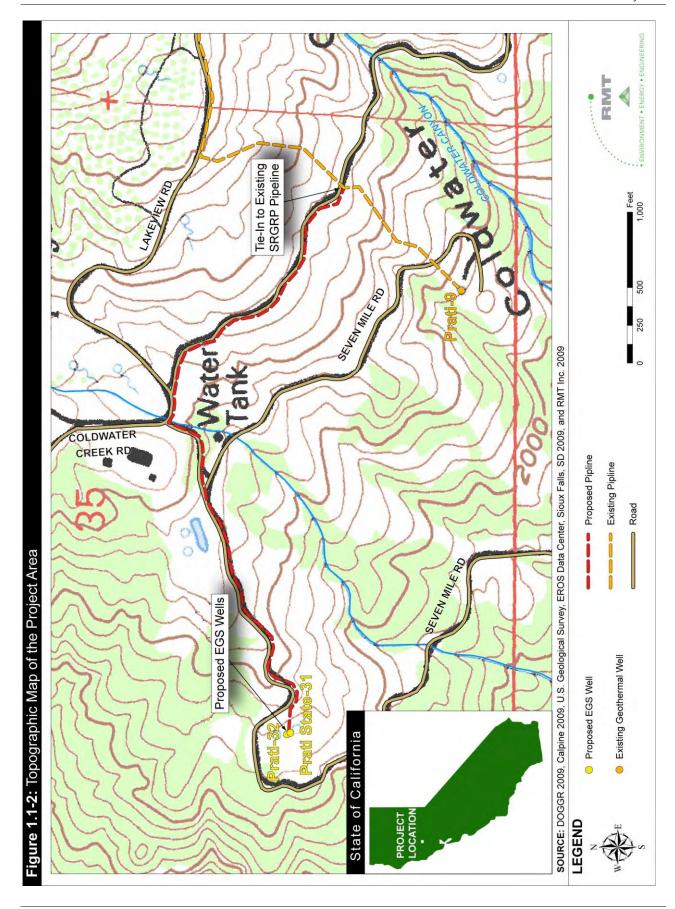
The US Department of Energy (DOE) is preparing an Environmental Assessment (EA) to address the potential environmental effects of the Calpine-Geysers Power Company (Calpine)'s proposed Enhanced Geothermal System (EGS) demonstration project. The proposed project would be located within the Northwest Geysers, Sonoma County, California (Figure 1.1-1, 1.1-2, and 1.1-3) within the Geysers-Clearlake Known Geothermal Resource Area (KGRA).

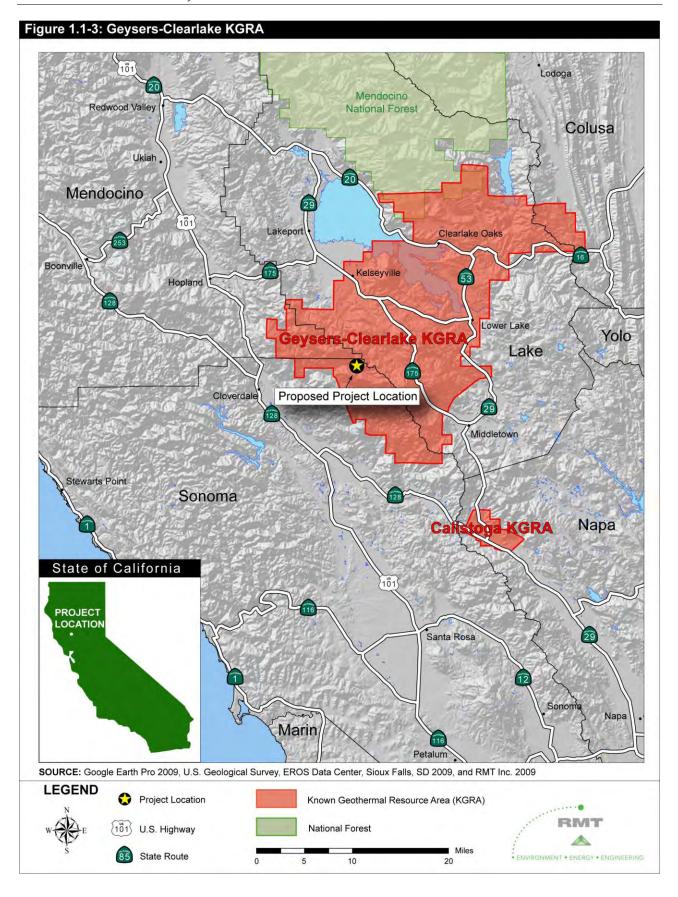
The proposed EGS project includes the injection of water, ranging from 50 to 80 degrees Fahrenheit, into wells to enhance the permeability of an existing high temperature hydrothermal reservoir that would be harnessed to produce electrical energy. The purpose of the project is to demonstrate the ability to stimulate high temperature rocks by monitoring their early response to carefully designed injection tests. The project would be a collaborative effort between scientists and engineers of Calpine Corporation, Lawrence Berkeley National Laboratory (LBNL), and the DOE. The proposed project includes the following phases:

- Phase I: Pre-stimulation
 - Development of the stimulation plan for the proposed EGS concept
 - Construction of a pipeline spur to deliver water from the Santa Rosa Geysers Recharge Project (SRGRP) for injection to the PS-31 well pad
 - Re-opening of two wells (known as Prati State-31 (PS-31) and Prati-32 (P-32)) and performing the necessary well bore modifications (i.e., open and complete the selected wells and potentially deepen the wells)
- Phase II: Stimulation
 - Implementation of the stimulation
 - Monitoring and validation of the stimulated EGS system
- Phase III: Long Term Injection, Data Collection, and Monitoring
 - Continued injection, monitoring and validation of the sustainability of the EGS project

In response to a 2008 Funding Opportunity Announcement (FOA), DOE would provide financial assistance for the proposed project. Granting of DOE financial assistance for this project would constitute a major federal action as defined by the National Environmental Policy Act of 1969 (NEPA). DOE must consider the possible environmental impacts from the project before committing to provide funding. In accordance with the provisions of NEPA and the Council on Environmental Quality (CEQ) and DOE implementing regulations, DOE has determined that an EA must be completed for the proposed project to evaluate the potential environmental impacts that could result from the award of the funding.







This EA has been prepared in accordance with the requirements of NEPA. The DOE Golden Field Office Manager would make the decision concerning this proposed project.

1.2 Purpose and Need

The DOE's proposed action is to provide financial assistance to Calpine in support of the development of the proposed EGS project. Recent growth in electricity has created the need for alternative sources of power. Renewable energy sources, such as geothermal energy, already supply a reasonable amount of energy in western states, especially California. The Geothermal Steam Act of 1970 encouraged geothermal development as a means of diversifying energy supplies in the United States. In April 2008, former President Bush announced a national goal to stop the increase in greenhouse gas (GHG) emissions by 2025. By providing financial assistance to support this project, DOE would support California and the United States in reaching their goals by offsetting some of the need for non-renewable energy sources that produce GHG emissions.

Calpine's proposed project would demonstrate the technology required to extract energy from high temperature, low permeability zones within the earth. The purpose would be to establish and document the feasibility of stimulating the productivity of high temperature rocks by monitoring their early response to carefully designed injection tests. The project would include initially studying highly productive areas within The Geysers (once known locally as the "Big Geysers") to determine the historic evolution of the EGS. Data collected from the initial studies would contribute to the creation of a similar EGS at the proposed site, which is an area of relatively low natural (unstimulated) permeability compared to other portions of The Geysers. Successful demonstration of the technology and methodology has the potential to increase the production of geothermal energy at The Geysers by as much as 300 megawatts (MW).

The Geysers is a suitable location for the creation and monitoring of an EGS project because of its existing infrastructure of wells, pads, access roads, available injection water, and a functioning microseismic array to monitor the early response to injection tests within the proposed EGS demonstration area.

1.3 Public Involvement

Comments on the scope of this EA were sought from the public, regulatory agencies, and other interested parties as part of the NEPA process. A letter describing the scope of the project was sent out to all parties on the project's distribution list on December 11, 2009 (Appendix A). Copies of the letters, distribution list, and responses are included in Appendix A to this EA. All comments were considered in the Pre-Decisional Draft EA.

A letter was sent by DOE to the several tribes within California to initiate a nation-to-nation consultation. The list of tribes that received the letter is also included in Appendix A.

The US Fish and Wildlife Service (USFWS) and the California State Historic Preservation Office (SHPO) have been contacted per requirements of Section 7 of the Endangered Species Act (ESA) and Section 106 of the National Historic Preservation Act (NHPA).

The Draft EA was also duly noticed to adjacent contiguous property owners and interested parties as identified by DOE and the notice was posted on the DOE Golden Field Office reading room web site. DOE received one letter of comment on the Draft EA from the Friends of Cobb Mountain organization. The comments and responses to the concerns noted are included in Appendix L of this Final EA.

1.4 Organization of this EA

This EA has been prepared pursuant to NEPA and DOE guidelines and:

- Describes the existing environment,
- Presents an analysis of the environmental consequences of the proposed project,
- Describes the effects of the no action alternative, and
- Addresses any concerns expressed by interested parties.

The information presented in this environmental analysis was obtained from personal communications with interested parties, background data and information on the project and similar projects, and environmental reports for similar projects in and around The Geysers. References used in preparation of this document are included in Appendix B. A list of persons and agencies contacted is presented in Appendix C.

Proposed Action and Alternatives

2.1 Overview

This chapter describes the Proposed Action and the No Action Alternative. The Proposed Action consists of the DOE's decision to provide funding through its Geothermal Technologies Program for the proposed EGS to be created by Calpine in the Northwest Geysers, California.

The No Action Alternative is described in Section 2.5. No other alternatives were considered since all potential impacts from the project can be minimized.

2.2 Project Location

The proposed project area is located in the northeastern portion of Sonoma County near the Lake County and Mendocino County borders.

The project components would be located in the northwest corner of Section 35, Township 12 North, Range 9 West, Mount Diablo Meridian. The project site is located within an undeveloped 10 square-mile area of the Northwest Geysers between the Aidlin and Ridgeline Power Plants (Units 7 and 8). The proposed project would reopen and convert two existing wells: PS-31 and P-32, as shown in Figure 2.2-1. The project also includes the extension of the SRGRP pipeline from the existing tie-in near the Prati 9 well, for a length of 1 mile, to the EGS wells.

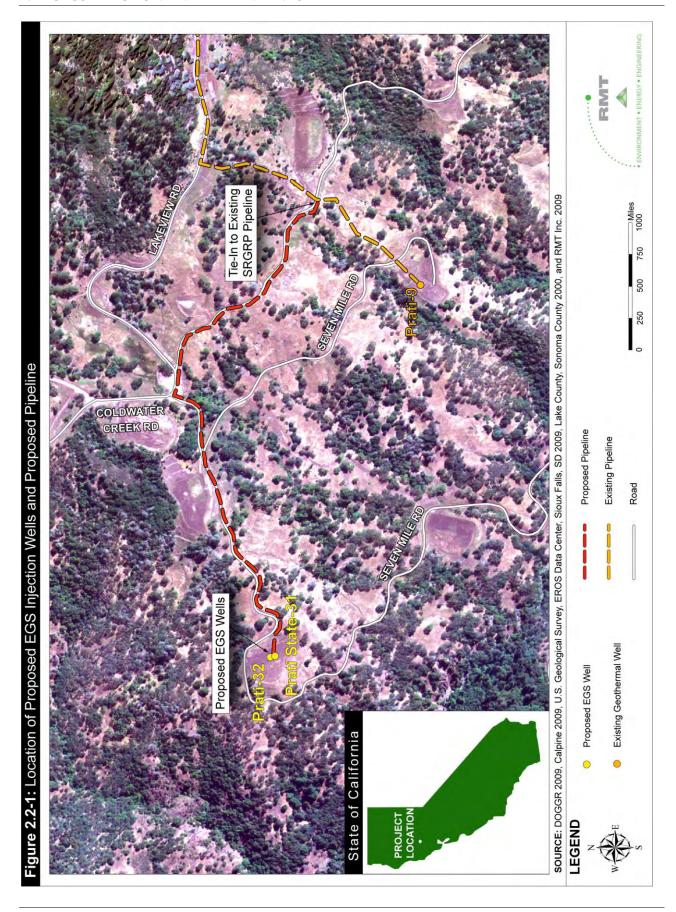
The EGS project would be located entirely on privately-owned surface lands within a mineral estate owned by the State of California, and private Fee Lands. Activities would only occur in previously disturbed areas (surface areas).

2.3 Project Background

2.3.1 DEVELOPMENT OF THE GEYSERS

The first commercial geothermal wells were drilled at The Geysers in 1955 by Magma Power Company. Construction of the first commercial power plant began in 1960 for an 11 MW plant. An average annual generation of 2,000 MW was being produced by 1987. Calpine acquired most of the plants at The Geysers by 1999; however, the production at The Geysers was on a slow decline since the daily power output at The Geysers peaked at 2,000 megawatts in 1987. Supplemental injection programs using recycled wastewater countered the decline.

Supplemental water was brought to The Geysers in 1997 with the implementation of the Lake County-Southeast Geysers Effluent Pipeline Project. The project was the first recycled-water-to-electricity project in the world. The 29-mile underground pipeline delivers 8 million gallons of treated reclaimed water per day to The Geysers to be injected into the geothermal reservoir. The SRGRP was selected in 1998 to bring an additional 11 million gallons of treated recycled water per



day to The Geysers through an underground pipeline. The SRGRP was selected for implementation after extensive environmental review. The City of Santa Rosa completed both the California Environmental Quality Act (CEQA) process and the NEPA process prior to selecting the SRGRP. The SRGRP project was built and began delivering water to injection wells in The Geysers in 2003. An Addendum to the CEQA Environmental Impact Report (EIR) that evaluated the impacts of increasing recycled water deliveries to The Geysers steam field up to an annual average of 19.8 million gallons per day was approved by the City of Santa Rosa on August 14, 2007. Coverage area of the Addendum included the proposed EGS steam field project area.

2.3.2 PROPOSED EGS DEVELOPMENT AREA

The proposed EGS project would be developed and demonstrated in an area of the Northwest Geysers, which was originally explored in the 1980s. The exploratory drilling in the early 1980's revealed a relatively shallow (~8,500 feet) high temperature (>500°F) zone (HTZ) in low permeability rock below the known Geysers steam reservoir. Figure 2.3-1 is a schematic of the EGS reservoir and the normal temperature reservoir. Although the enthalpy (total heat) of the steam produced from the HTZ is very high, the chemical quality of the steam is poor because of very high concentrations (4.0 to 7.5 weight percent) of noncondensable gasses (NCG), and highly corrosive hydrogen chloride gas. This poor quality steam remains unusable for electrical generation because of functional, economic, and environmental restraints.

Calpine proposes to re-open two of the original exploratory wells that penetrate the HTZ and convert them to deep injection wells to stimulate the production of usable quality steam for electrical generation.

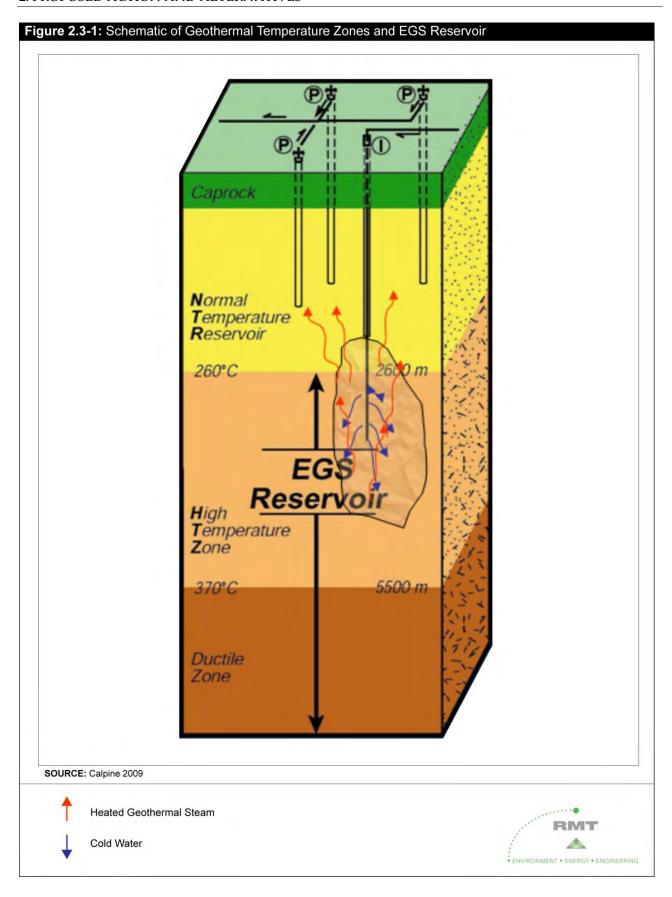
The two proposed abandoned exploration wells (PS-31 and P-32) would require a small amount of deepening to penetrate the HTZ. PS-31 is currently 9,000 feet deep and may need to be deepened by approximately 500 feet. P-32 is currently 9,600 feet deep and is not expected to need further deepening. An extension [1.0 miles in length (5,320 feet)] of the SRGRP pipeline whose present terminus is at the Prati -9 well would provide an ample supply of injection water. Based on historical experience at The Geysers, the injection is expected to lower the NCG concentrations in the steam produced, stimulate fracturing in the HTZ, and provide a sustainable flow of usable quality steam to nearby steam wells.

Calpine has successfully re-opened three other abandoned wells in the area, Prati-9 (November 2007), Prati State-10 (September 2009), and Prati State-54 (August 2007).

2.3.3 PROJECT OBJECTIVES

The objectives of the project are to:

- Develop and demonstrate the stimulation methodologies to create an EGS in a deep, very hot fractured rock system by means of injection of treated wastewater at temperatures substantially lower than the formation.
- Investigate how the water injection affects the fractured rock system, both mechanically (e.g., cooling shrinkage and fracture shear reactivation) and chemically (e.g., dissolution) and how such processes contribute to EGS.



- Demonstrate the technology to monitor and validate the stimulation and sustainability of such an EGS.
- Develop an EGS research field laboratory site that can be used for testing EGS stimulation and monitoring technologies including new high temperature logging tools.

2.4 Proposed Action

2.4.1 OVERVIEW OF THE PROPOSED ACTION

As discussed in Chapter 1, the DOE proposes to fund Calpine's EGS project. The proposed project includes three phases:

- Phase I: Pre-stimulation
- Phase II: Stimulation
- Phase III: Long Term Data Collection and Monitoring

The project would use water supplied by the SRGRP via a pipeline extension of 1.0 miles that would be installed along Seven Mile and Squaw Creek Roads, which are existing roads, already graded with road base and in adequate condition to service the proposed project. The project would include re-opening abandoned exploration wells on an existing pad, with access via existing roads. No new ground surface disturbance in previously undisturbed areas is proposed.

Monitoring of the EGS project would occur using Calpine's extensive existing seismic monitoring network, which are currently used to monitor the SRGRP. Four monitoring stations that are currently being developed as part of another project would also be available by the time the proposed project would be implemented.

2.4.2 PHASE I: PRE-STIMULATION

Overview

The focus of the pre-stimulation phase would be to develop a stimulation plan for the EGS area. This would include:

- Creation of a complete 3-dimentional (3D) geologic model of the EGS area.
- Analysis of the historic induced seismicity within the most productive area in The Geysers.
- Pre-stimulation modeling of the selected EGS wells.
- Construction of the water supply pipeline (SRGRP pipeline spur).
- Preparation of the well pad and access roads.
- Performing the necessary well bore modifications such as opening and completing the selected wells and potentially deepening the selected wells.
- Install injection system equipment.

Creation of 3D Geologic Model

The stimulation plan would be developed by creating a complete geological model of the EGS area. The EGS area has already been well characterized. There are numerous data logs and field

Calpine EGS Project
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data for the project wells (PS-31 and P-32), as well as other nearby wells, that would be synthesized during the pre-stimulation phase to create a 3D geologic model of the EGS area. Data to be evaluated includes:

- Drilling rate (a measure of variation in mechanical properties)
- Drilling mud logs (well bore lithology and identification of steam bearing fractures)
- Caliper logs (borehole break-out can be used to constrain stress field and mechanical properties)
- Pressure temperature spinner (PTS) and spinner log data (to identify hydraulic conducting fractures)
- PTS data in flowing steam (to identify steam producing fractures)
- Bottom hole thermometer measurements made during drilling (the best available measure of formation temperature)
- Temperature of drilling air return
- Logs of H2O and CO2 while drilling (a distinct indicator of the HTZ boundary)

Analysis of Historic Induced Seismicity

The next step would include performing an analysis of the existing injection-induced EGS in The Geysers steamfield. LBNL and Calpine would study the historic evolution of injection and induced seismicity in this area. The area of interest within The Geysers is located within an extent of the HTZ and to the southeast of the proposed EGS area. The injection and evolution of induced seismicity (an indicator of fracture shear reactivation) would be analyzed using tools for stimulation planning, design, and validation (i.e., coupled reservoir-geomechanical modeling techniques), and would be supported and corroborated by analysis of field data, including 3-D tomography (imaging by sections or sectioning through the use of wave energy) and high precision location of earthquakes, satellite based measurements of surface deformations, and chemical isotope analysis of production fluids.

Pre-Stimulation Modeling of PS-31 and P-32

This step would include modeling of stimulation at two scales: (1) stimulation of the well bore (e.g., cooling fracturing of the well connecting with nearby pre-existing fractures) and (2) simulation of the fracture network by shear reactivation to create a substantial EGS volume around the injection well.

Construction of Injection Water Supply Pipeline

System Construction

Pipeline Construction

The project would include construction of a 1.007 mile long water supply pipeline that would be connected into PS-31 and P-32 for injection. The pipeline would be constructed prior to re-opening of the wells in order to supply drilling water to the wells. The pipeline would be built as an extension from the existing SRGRP pipeline, as shown in Figure 2.2-1. The pipeline would be 10 inches in diameter from its existing tie in point, to a future tie-in located approximatley 600 feet

east of the well pad. A metering station would be installed at this tie-in location. The remaining 600-foot length of pipeline to PS-31 and P-32 would be constructed of 6-8 inch diameter pipe. A general decrease in elevation from approximately 2,510 feet to 2,128 feet occurs from the tie-in point to PS-31 and P-32.

The pipeline would be constructed on stanchions within the shoulder of existing roads. The pipeline would be non-reflective and would be colored to match the terrain. Plan drawings for the pipeline are included in Appendix E. The pipeline would include tap points, control valves, and a drain assembly on sleeper supports. One approximately 20 foot tall road crossing vertical loop would be required.

The pipeline would be constructed with trucks and side booms. Supports would be constructed using drilled and poured pier foundations. If the soils within which the stanchions are constructed are determined to be expansive, then the Standard Engineering Methods for Expansive Soils would be employed. These methods include:

- 1. Removal of native soil and replacement with an engineered fill material not prone to shrinking and swelling.
- 2. Soil stabilization, such as lime treatment to alter soil properties to reduce shrink-swell potential to an acceptable level.
- 3. Deepening footings or other support structures in the expansive soil to a depth where soil moisture fluctuation is minimized.

Construction corridors would be confined to the roadway and no new ground disturbance would occur. Travel outside the construction corridors would be strictly limited to designated turnout areas (to be identified) and access roads.

All work would occur in the existing roadway and would not require disturbance of previously undisturbed areas. The pipeline would connect beyond the road into another well pad (Prati-25), but would remain on previously disturbed areas (i.e., the well pad or the road). The pipeline would be tested in accordance with engineering standards; however, no discharge of water to the surface would occur during or after the hydrostatic testing of the pipeline.

Staging, Personnel, and Schedule

Staging would occur along the road and at the well pad. Pipe would be stored only in approved, previously disturbed, staging areas.

Construction of the pipeline would require about 5-8 construction workers and would take approximately 6-8 weeks to complete.

Water Supply

Potable water would be delivered to the site for consumption purposes during pipeline construction. Sanitary facilities would be provided and maintained by a licensed local contractor. Water for dust suppression, if required, would be from water wells or tertiary treated recycled water from the SRGRP.

Waste Disposal

Wastes generated during pipeline construction could include soils and vegetation, as well as construction waste (i.e., packaging). This material would be disposed at an appropriate facility. No hazardous wastes are expected.

Preparation of Well Pad and Access Roads

Pad and Road Preparation

The two wells proposed for modification are located on an existing well pad. The last time this pad was used for operating wells was in 1996, before the two subject wells were abandoned in 2000. Approximately one day of re-grading work would be performed on the pad to prepare it for drilling equipment. The pad is approximately 2 acres in size. Re-grading would entail preparing a perimeter earthen berm, closing off drainage culverts and installing sub-grade water collection points for the retention of storm water and as a contingency for spills from the drilling operation. A layer of gravel is also provided in the work area.

Set up of the pad would primarily be required for mobilizing the equipment and drill rig. The pad would be accessed via Seven Mile and Squaw Creek Road, which is an existing road already graded with road base.

Staging, Personnel, and Schedule

Minimal staging would be required for preparation of the well pad and access road. Any staging required would occur on the well pad.

An estimated four crew members would be involved in well pad activities, which would take approximately four days to complete.

Water Supply

Potable water would be delivered to the site for consumption purposes during pad re-grading. Sanitary facilities would be provided and maintained by a licensed local contractor. Water for dust suppression, if required, would be from well water (under current Calpine entitlements) or tertiary treated recycled water from the SRGRP.

Waste Disposal

Wastes generated during well pad grading and road preparation could include soils and vegetation. This material would be disposed of at an appropriate facility. No hazardous wastes are expected.

Well Bore Modifications

Process to Modify Well Bore

PS-31 and P-32 were drilled between 1983 and 1985. They were operated by the Central California Power Agency (CCPA) until the CCPA Power Plant was closed and abandoned in 1999 - 2000.

PS-31 and P-32 have typical completions as summarized in Table 2.4-1. Schematics and well histories for PS-31 and P-32 are shown in Figures 2.4-1 through 2.4-4. The re-opening of an abandoned well requires the steps described below.

Unplugging the Well

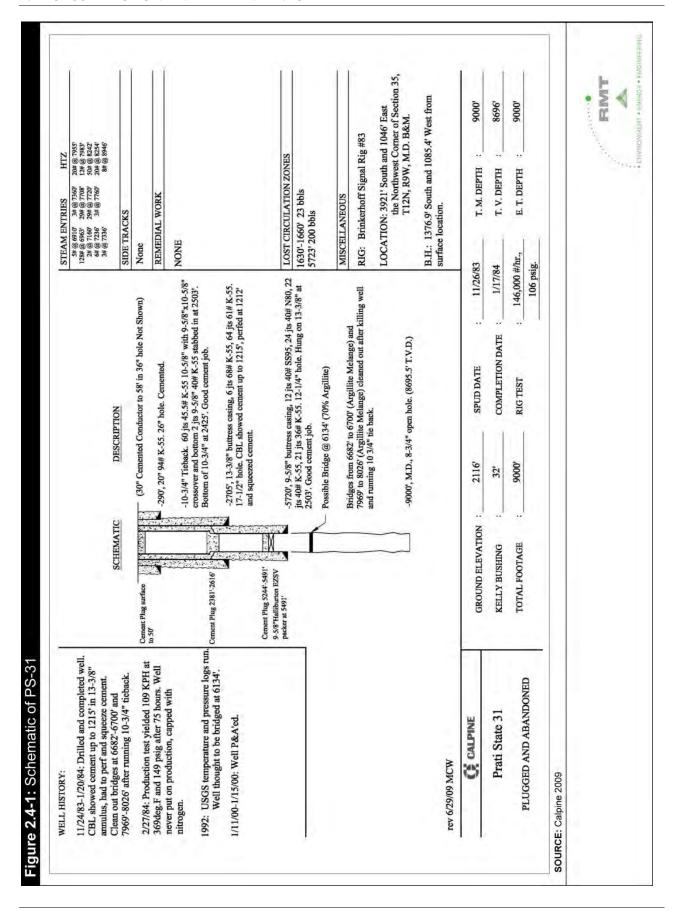
The abandoned casing cut-off below the ground surface would be found and the casing strings would be rebuilt to the surface. A new well head would then be installed on the 13 inch casing. The wells were previously abandoned with cement plugs. The three cement abandoned plugs would be cleaned-out in the 13 inch tieback and 11¾ inch cemented liner, and pressure tests would be conducted after the removal of each plug. A casing caliper log to determine casing condition would be run. A 7 inch packer/cement retainer located above the production liner shoe would be removed.

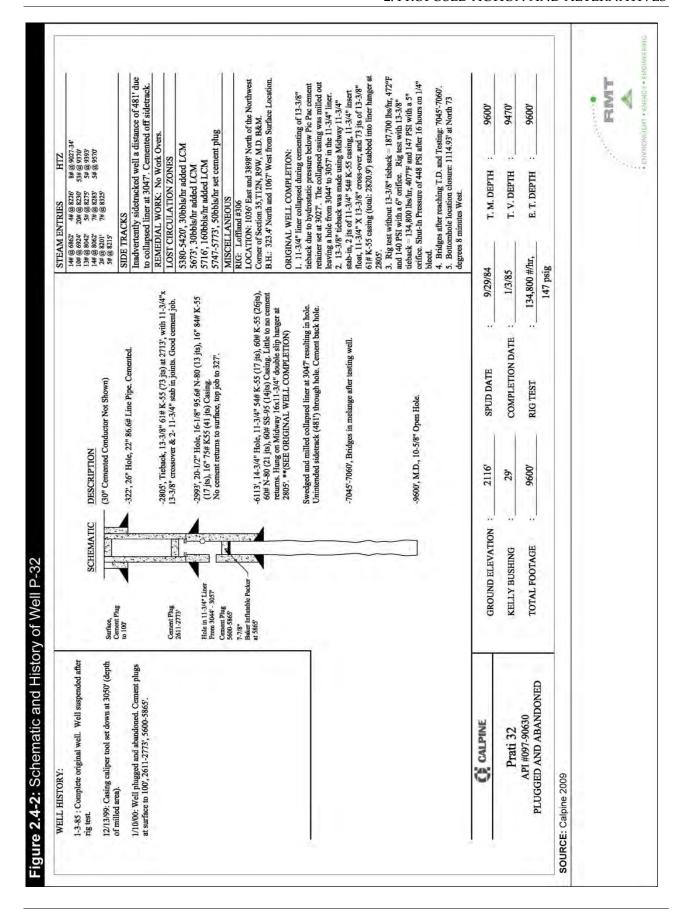
Re-Opening and Well Completion

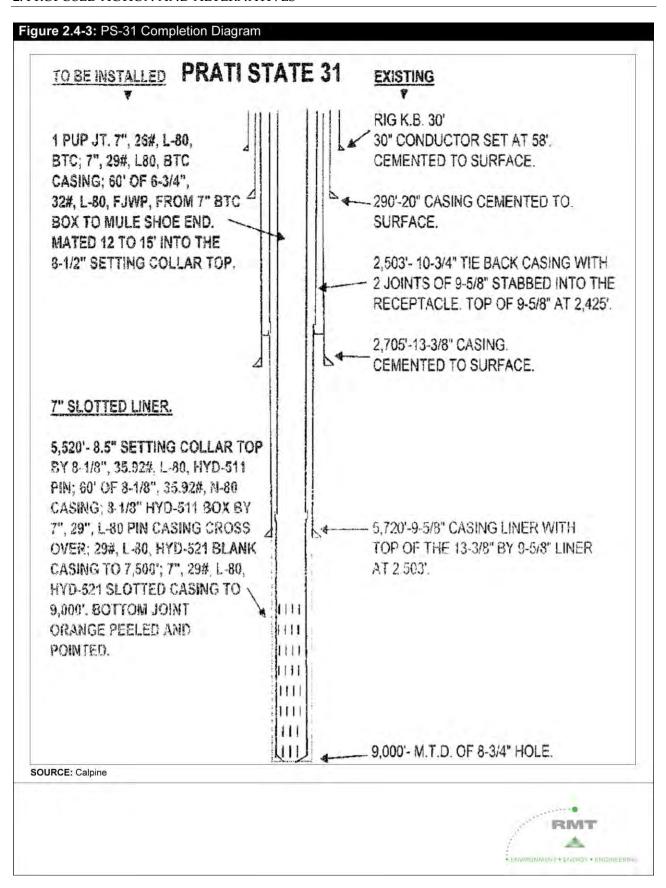
Re-Opening - Re-opening is the process of physically re-opening the hole. The well would be re-opened, deepened, and completed for injection using a large rotary drill rig. During drilling, the top of the drill rig mask may be as tall as 135 feet above the ground surface. A photograph of a typical drill rig is shown in Figure 2.4-5. The rig would be equipped with diesel engines, fuel, and drilling mud storage tanks, mud pumps, and other ancillary equipment. Metal mixing tanks would be used to mix water and drilling mud. Tankage for an estimated 40,000 gallons of mud would be needed. The well would be re-drilled using air and/or mud to circulate the drill cuttings to the surface.

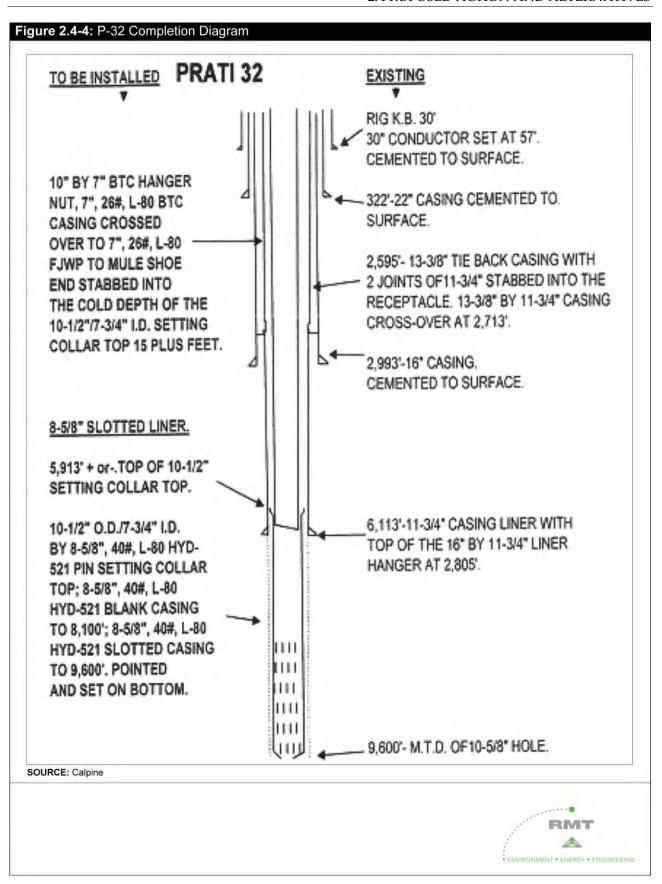
Table 2.4-1: Well Completion Features and Depths for PS-31 and P-32			
Casing size	Depth		
PS-31			
13-3/8 inch production casing	2705 feet		
9 5/8 inch production casing liner	5720 feet		
8-3/4 inch open hole	9,000 feet		
P-32			
16 inch production casing	2993 feet		
11-3/4 inch production liner tied back with a 12-3/8 inch casing	6113 feet		
10-5/8 inch open hole	9600 feet		

SOURCE: Calpine 2009











Sumpless Drilling - A sumpless drilling mud system is proposed for the project. During the drilling process, a liquid holding tank would be used for fresh water and a solids holding tank would be used for solids brought to the surface by the circulation of drilling mud. Using the primary tanks, solids separation system/centrifuge process and transfer pumps, drilling mud, and water would be continuously circulated and returned down the well hole in a closed loop system.

The entire tank and solids removal system would be enclosed within a berm, as would the rig substructure and auxiliary equipment. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit. Mud or aerated mud is proposed for initial drilling operations.

H₂S Abatement - The well is expected to produce 4.0 percent to 7.5 percent NCG by weight, and about 1000 to 1800 parts per million (ppm) of hydrogen sulfide (H₂S) while drilling. H₂S abatement would be required to meet Air Pollution Control District and the US Environmental Protection Agency's (EPA) regulations. Calpine has obtained an Authority to Construct

(ATC)/temporary Permit to Operate (PTO) for the reopening of PS-31 (Appendix D). A similar permit would be obtained for P-32. All permit requirements would be met for H₂S emissions rates.

Emissions of H₂S gas would occur during the air drilling phase of well construction and during well testing. Hydrogen sulfide is a natural component of the produced geothermal steam, and effective techniques for abating H₂S emissions during geothermal well drilling and testing activities have evolved in the Geysers. A Northern Sonoma County Air Pollution Control District (NSCAPCD) approved chemical abatement system would be used to control H₂S emissions during well construction and testing.

The abatement method that would be used during air drilling would be either a scrub and inject or scrub and oxidize method, depending on whether an injection well is available to directly return the steam condensed solution of hydrogen sulfide and sulfide ions back into the geothermal reservoir. Scrubbing is the process of removing a chemical from a vapor. The abatement process would consist of injecting a metered stoichiometric amount of aqueous sodium hydroxide (caustic, NaOH) into the blooie line to scrub the H_2S from the steam into a solution as hydrosulfide and sulfide ions. The resulting solution would either be directly injected into the reservoir or a metered injection of stoichiometric amounts of hydrogen peroxide (H_2O_2) would be added into the blooie line as needed to oxidize the hydrosulfide and sulfide ions to sodium sulfate (Na_2SO_4), which would not revert back to hydrogen sulfide.

The air drilling abatement equipment consists of a 12 to 14-foot diameter cyclone separator/muffler connected at the end of the blooie line, 2 to 4 chemical metering pumps, treatment chemicals storage totes, a water storage tank, emergency shower and eyewash facilities, and miscellaneous hoses and fittings. The cyclone separator serves to separate condensate, rock cutting solids, and any sulfur solids that form in the abatement of steam. Abated steam is exhausted to the atmosphere. Condensate, rock cutting solids, and any sulfur solids are collected in a tank. Solids and particulate matter settle and are transported off-site to Calpine's permitted waste management unit in The Geysers. Condensate is recycled/recirculated in the blooie line for reuse in scrubbing H₂S and particulate in the blooie line.

For well testing, H₂S entrained in the steam produced during tests would be chemically treated and abated in the same manner as during the air drilling phase of well construction.

Blowout Prevention Equipment (BOPE) - BOPE would be used on each well drilled. All necessary precautions would be taken to maintain control of the wells at all times to prevent the uncontrolled release of geothermal fluid into the environment. The BOPE would conform to California Department of Oil, Gas, and Geothermal Resources (CDOGGR) specifications and requirements and would be described in the Notice of Intent to drill the respective wells submitted to CDOGGR.

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¹Stoichiometry is the calculation of quantitative (measurable) relationships of the reactants and products in a balanced chemical reaction.

² A blooie line is a large diameter pipe that routes returning air and drill cuttings to a separator and muffler. The line may be equipped with high-pressure nozzles that spray water to settle dust and sodium hydroxide and hydrogen peroxide to eliminate hydrogen sulfide odors.

The existing Calpine Geysers Emergency Preparedness and Response Plan also includes a Well Blowout section that provides emergency contingency procedures to be taken by employees in the unlikely event of the loss of control of a well, or a well blowout. The Plan sets forth steps to be taken to safely secure the site, assure the safety of on-site personnel and the public, implement emergency notifications, minimize environmental damage, and regain control of the well.

Well Completion

An unstable mélange zone near 7,000 feet measured depth is known to have caused well bore bridging in several of the wells in the proposed EGS area. A "bridge" is an obstruction in the uncased well bore caused by a section of collapsed rock. Bridges occur in the uncased or unlined portions of wells when unstable formation (e.g., mélange) sloughs into the well bore and blocks the flow of fluid. A drill bit would be run through the open hole wellbores to clean-out bridges to their total depth.

The Prati State-31 well would then be deepened, if necessary, 500 feet into the HTZ to ensure a sufficient depth of the well for the demonstration.

An 8-5/8 inch combination blank/perforated liner would be installed to total depth, topped with stab-in receptacle inside 11³/₄ inches. Blank liner would be installed through the normal temperature reservoir and perforated liners would be installed through the HTZ. Blank liners do not let fluid pass into or out of the well, while perforated liners allow for exchange.

A blank 7 inch hang down casing would be installed from the surface into the stab-in receptacle. The well head would be prepared for injection tie-in and shut-in, and then the rig would be released. Well completion diagrams are shown in Figures 2.4-4 and 2.4-5.

Some issues could arise during drilling into the mélange zones and argillite zones below 7,000 feet mean depth; these zones would need to be cleaned out. While drilling through these weak formations below steam entries, three or more air compressors, delivering about 3,600 cubic feet per minute, would be required. This volume of air was found necessary while drilling the original wells to prevent fill on connections and getting stuck.

"Killing" the steam flow from the well prior to running the 8-5/8 inch liner may cause bridging below a 7,000 foot depth in mélange and argillite units. It would be necessary to run a "hot" injection liner into the well while steam is flowing from the well. The liner would be capped on the bottom with a cement plug in order to prevent flow through the liner while running it. Subsequently, the liner would be perforated in the HTZ section.

Well Logging and Testing

Logging and injection testing would occur after the drill rig is moved off-site. Prior to injection, the well would be extensively tested and logged to determine the characteristics of both the overlying normal temperature (450 °F) reservoir and the underlying HTZ (>500 °F). The logging and testing would include steam temperature, pressure, and flow rates; location of steam entries and downhole geochemical sampling; and sampling of the condensate from the steam delivered to the surface.

Numerous temperature and pressure logs would be run during the stimulation phase of the demonstration at the different injection rates to determine the height of the water column in the well bore. No nuclear data logging devices would be used. Logging would enable monitoring of down-hole pressure changes in the well on a regular basis and computation of any long-term changes in well injectivity. Downhole pressure data would also be used to adjust the injection rate so that water levels in the injection well remains below the top of the HTZ. Pressure falloff data recorded during any planned or unplanned interruptions in injection may be interpreted to obtain any temporal changes in formation properties such as transmissivity in the vicinity of the injection wells.

The fluid produced from the well is passed through various-sized orifice plates, which cause differential pressures that are used to determine the mass flow rate and corresponding flowing pressure. Another reservoir test measures static pressure when fluid flow has ceased. Geochemical samples of the vapor and condensed liquid components are measured during the flow tests.

No liquid waste would be generated. It is anticipated that all flow tested medium would be superheated steam and would evaporate from the well head.

Staging, Personnel, and Schedule

All vehicle traffic associated with the project would be restricted to existing access roads that would be maintained. All personnel, subcontractors, and service personnel would attend a training meeting that would include education on the environmental rules and regulations pursuant to all relevant operating permits. Speed limits of 15 miles per hour (mph) would be observed on all dirt roads in the project area in order to meet Calpine safety requirements and minimize dust, avoid collisions, and avoid incidental death of native fauna. Water trucks would be used during access road construction, well pad construction, and drilling operations to minimize dust emissions.

Staging would occur on the well pad. An estimated 12 to 15 crew members would be involved in the drilling activities. Re-opening and completion would take approximately one month, assuming the re-opening and re-completion go as planned. Flow testing would take several days until flow rates have stabilized. Only one well would be drilled and tested at a time.

Water Supply

Approximately 20,000 gallons of water per day (~14 gallons per minute (gpm)) would be needed for re-drilling. Water would be sourced from well water (under current Calpine entitlements) or tertiary treated recycled water from the SRGRP.

Water wells may be drilled for well pad dewatering to prevent steam quenching and well bore corrosion.

Potable water would be delivered to the site for consumption purposes during construction and well drilling operations.

Waste Disposal

A tank system would be used on each production well pad for the containment and temporary storage of drill cuttings and waste drilling mud. All machinery, drilling platforms, and oil and fuel storage areas on the drill pads would use containment in order to prevent the off-site release of spills from these source areas. When mud drilling is finished, all liquid mud and solids would be collected and hauled by tanker trucks to Calpine's geothermal drilling mud and cuttings disposal area (GDMACDA) Waste Management Unit and the Super Sump Solid Waste Management Facility in The Geysers. The system would allow for sumpless drilling of the geothermal resource, as previously described.

Storm water from areas off of the well pad would be directed to ditches around the well pad to settlement basins and through energy dissipaters into local drainage channels, consistent with storm water best management practices required by the County of Sonoma and California Regional Water Quality Control Board.

Sanitary facilities would be provided and maintained by a licensed local contractor.

Construction of Injection System Equipment

The injection system at the well would be constructed and would consist of a well head valve, double check valves for back flow prevention, a metering control valve, diffuser, flow meter, pressure indication, and other ancillary piping. The control valve would be operated from Calpine's central control room. Any electrical needed for the control system would be supplied via a drop from the existing power lines and would run parallel to the pipeline.

2.4.3 PHASE II: STIMULATION

Overview

Phase II is the phase with potential for environmental effects. This phase includes:

- Performing the stimulation
- Monitoring, evaluating, and assessing the results

Performing Stimulation

Injectivity tests would occur prior to stimulation. The initial flow rate needed to collapse the steam bubble in the well bore so that injected water could flow into the wells under vacuum would involve injecting 1,200 gpm of water from the SRGRP pipeline into each well for 8 hours.

Once the steam bubble in the well bore is collapsed and the well is injecting under vacuum, the injection would likely be carried out initially at a low rate (e.g., 100 gpm). Injection would involve supplying gravity fed water from the SRGRP pipeline into the injection well.

Depending on the ability of the fractures to accept the fluid, the injection rate would then be increased (for example, to 200 gpm and 400 gpm). Geothermal wells often exhibit a nonlinear relationship between injection rate (M) and feed zone pressure (p). The suggested injection program (e.g., injection at 100, 200, 400, and 800 gpm) would be designed to ascertain if the pressure increase would result in the opening up of pre-existing fractures in the HTZ, and whether

the change would be reversible. As PS-31 is being stimulated, P-32 would be monitored continuously.

Stimulation would occur for 6 months per well, with a duration for each injection rate of about 1 month. Tracers would be injected into the stimulated well (ammonia in PS-31 and tritium in P-32) and PTS tests for each injection rate would be performed. Geochemical sampling would also be performed. The stimulated well would be shut after the stimulation phase and pressures would be monitored for the next 6 months, while the other well is being stimulated. One well would be stimulated, monitored and shut-in, and then the second well would be stimulated and monitored. This six month process would repeat for two years. Each well would therefore be stimulated for 2 six month periods and monitored without injection for 2 six month periods.

Data Collection, Assessment, and Evaluation of the Well Bore Properties

Accurately monitoring micro-earthquake (MEQ) activity would be conducted from the start of water injection into the HTZ, in order to learn how the injection response moves through the reservoir over time.

Continuous monitoring would occur during the first two years of the project implementation. The effectiveness of the well bore stimulation would be assessed by:

- Evaluation of changes in injectivity over time
- Running PTS logs during steam production before and after stimulation (to register new flowing fractures along the well bore and increased overall production)

Other well bore logging equipment available to the project may also be tested.

The effectiveness of stimulation to create an EGS would be evaluated by:

- Performing high-precision location of micro-earthquakes (MEQ's) during stimulation (to estimate the volume of the rock mass simulated by shear reactivation of critically stressed fractures)
- Conducing 3-D seismic wave tomography using MEQs during the stimulation to study changes in rock-mass mechanical properties
- Conducting chemical and isotope analysis of production fluids (to investigate chemical signature of the creation of new fracture surfaces)

The project would utilize the expanded seismic network that is being installed under the "Monitoring the Injection of Fluids From the Santa Rosa Pipeline on Seismicity at The Geysers, California Geothermal Field" project, which would be available by the time the proposed project commences. The expanded seismic network would provide the needed coverage to perform high-precision MEQ location and 3-D seismic wave tomography and source mechanism analysis.

The actual injection would be coupled with the reservoir-geomechanical model at two scales: (1) at the well bore scale to simulate changes in injectivity and (2) at the scale of the EGS area to compare with observed patterns and the evolution of induced seismicity. This would confirm whether the stimulation worked as planned. The numerical modeling would then be used to analyze and understand the cause of any unexpected behavior.

2.4.4 PHASE III: LONG TERM INJECTION, DATA COLLECTION, AND MONITORING

Phase 3 would include monitoring of the sustainability of the proposed EGS. Continued injection and monitoring could occur during this phase although the amount of injection is unknown at this time and would depend upon the results of the stimulation. While some of the traditional Hot Dry Rock EGS concept involves one, or a few, repeated hydraulically pressurized stimulations to create an EGS, the proposed project would involve continuous injection, which may result in a continuous expansion of the EGS reservoir over tens of years. An important measure of success would be a sustained steam production rate and decreasing NCG concentrations within the operating area.

The monitoring and modeling techniques and data analysis employed for the first two years would also be applied for the continuous long-term monitoring. The exact extent and frequency would be determined in consultation with the DOE.

2.5 No Action Alternative

Under the No Action Alternative, the DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The existing geothermal extraction in The Geysers would continue as it currently operates. The use of the geothermal resource would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts could occur anyway.

2.6 Safety and Risk Assessment

Appendix F provides a detailed description of Calpine's emergency plans for:

- Injuries
- Well blowouts
- Fire
- Spill or discharge contingencies (for drilling mud, geothermal fluid, lubricants, fuels, etc.)
- Hazardous gas control
- Drilling safety and action plans
- Earthquakes

The purpose of these plans is to provide guidance to field personnel and management in the event of an uncontrolled well flow (e.g., "blowout") or other field related emergency. The plans are intended to be comprehensive in that they describe the nature of various hazards or problems that might be encountered and specify appropriate preventive or anticipatory actions and equipment, as well as specific responses, notifications, and follow up procedures that are required in the event

of such a field emergency. In addition to blowouts, emergencies (e.g., accidents and injuries), fire hazards management, and risk assessment are covered.

2.7 Permitting

Table 2.7-1 lists the permits, reviews, consultation, and approvals required for the proposed project, as well as the status of the permits and/or timing of acquisition.

Table 2.7-1: Permitting Requirements and Status					
Agency	Permit/Approval	Status or Timing			
DOGGR	Notice of Intent	60 days prior to the re-opening and conversion of exploratory well to injection, a Notice of Intent will be filled with the Santa Rosa office.			
Sonoma County	Use Permit 08-0062 Permit	Issued June 12, 2009			
Northern Sonoma County Air Pollution Control District (NSCAPCD)	Authority to Construct Permit to Operate	An application must be submitted to re-open and test a well approximately 60 days in advance of drilling. The permit has already been obtained for PS-31, although it may need to be renewed. A permit is needed for P-32.			
North Coast Regional Water Quality Control Board (RWQCB)	Waste Discharge Requirement	Issued, Board Order No. R1-2009-0103			
State Water Resources Control Board	Notice of Intent (NOI)	An NOI will be submitted prior to grading and construction work for enrollment under the General Construction National Pollutant Discharge Elimination System (NPDES) permit. A Stormwater Pollution Prevention Plan will be prepared and maintained onsite during construction.			

2.8 Environmental Protection & Applicant Committed Measures

The specific environmental protection measures listed by activity or environmental resource area below are incorporated into the Calpine's proposed action as integral components of the proposed project. Refer to Appendix G for written confirmation of these environmental commitments.

Air Quality

1. Devegetated areas would be watered or other methods would be employed to entrain dust, in order to minimize any adverse impacts from particulate matter emissions during ground disturbance, including asbestiform minerals.

- 2. All trucks hauling soils or other dusty materials would be covered and two feet of freeboard would be maintained in the trucks
- 3. Inactive construction areas would be hydroseeded or covered with non-toxic soil stabilizers. "Inactive" areas are previously graded areas that are inactive for 10 days or more.
- 4. Traffic would be limited to 15 miles per hour on unpaved roads.
- 5. Painting of the steam pipelines and supports would conform to NSCAPCD Rule 485 for use of compliant architectural coatings.
- 6. The Asbestos Air Toxic Control Measure for construction, grading, quarrying and surface mining as approved by the California Air Resources Board (CARB) would be implemented to avoid adverse effects associated with the emissions of serpentine/asbestiform minerals.
- 7. All conditions of the ATC and temporary PTO from the NSCAPCD would be implemented.
- 8. Dust emissions from venting steam would be reduced by injecting water into the blooie line
- H₂S control would be accomplished through the installation of a NSCAPCD approved chemical abatement system
- 10. Calpine will implement all measures required in the Authority to Construct and Permit to Operate permits issued by the NSCAPCD (included in Appendix D of this EA).
- 11. Calpine will notify the NSCAPCD 24 hours prior to initiating any planned venting operations until such time that an emissions release protocol governing emissions and notifications for such operations is prepared and provided to the NSCDAPCD

Geology

- 1. The SRGRP pipeline spur would be constructed using Standard Engineering Methods for Expansive Soils, as necessary.
- 2. Calpine will comply with the DOE's "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems" (Majer et al. 2008).
- 3. The stanchions for the SRGRP pipeline will be constructed using Standard Engineering Methods for Expansive soils, as necessary.

Biological Resources

1. In order to protect yellow warblers and Common Yellowthroats, any work proposed within riparian woodland habitat between April 1 and August 31 would be surveyed by a qualified biologist. If a nest of either species is discovered within 200 feet of proposed construction activities, construction

- would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.
- 2. In order to protect sharp-shinned hawks, any work proposed within riparian woodland series such as white alder or cattails series, between April 1 and August 31 would be surveyed by a qualified biologist. If an active nest is found within 500 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.
- 3. If construction or re-drilling is to occur between April 1 and August 31 preconstruction surveys would be performed in all construction areas and the drilling area within 500 feet of suitable habitat for raptors. If active nests are found, work within these areas would be halted until after August 31 or a qualified biologist has determined the nest is no longer active and the young have fledged.
- 4. No trees would be removed during construction of the SRGRP pipeline.

Water Resources

- 1. Erosion control methods and Best Management Practices (BMPs) in accordance with a Stormwater Pollution Prevention Plan (SWPPP) would be utilized (such as certified weed-free straw waddle) to reduce erosion or siltation on or off-site during grading of the well pad and construction of the SRGRP pipeline spur.
- 2. No water would be released to the surface from the pipeline during testing or operation of the pipeline.
- 3. A SWPPP would be developed and a Notice of Intent submitted to the California State Water Resources Control Board, prior to grading or construction activities.
- 4. A Spill Prevention, Control, and Countermeasure Plan (SPCC) would be maintained on-site and implemented to contain incidental drips and/or spills. The plan will identify equipment and procedures used for containment and recovery of accidental spills
- Contamination during construction along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater.
- 6. Containment berms will be constructed around all hazardous material or potentially hazardous material storage for both construction and operation.
- 7. A drainage system will be installed around the well pad to contain stormwater.
- 8. BOPE will be installed to minimize blowouts or contamination of the localized shallow aquifer as required by CDOGGR regulations.
- 9. Calpine will obtain an updated Waste Discharge Order that will address injection of effluent and condensate into the EGS wells. Calpine will submit

injection reports to CDOGGR. Injection of water and disposal of waste discharge due to drilling will comply with all requirements outlined in the permit

Cultural Resources

- 1. A condition from the Wildhorse Development Project has been incorporated into the proposed action to further protect cultural resources. The condition requires placing the following note on all construction plans and providing the language to all contractors and superintendents on the job site:
 - "Should any previously unknown historic or prehistoric resources, including but not limited to charcoal, obsidian or chert flakes, grinding bowls, shell fragments, bone, pockets of dark, friable soils, glass, metal, ceramics, wood or similar debris, be discovered during grading, trenching or other on-site excavation, earthwork in the vicinity of the find shall cease, and the County of Sonoma Permit and Resource Management Department (PRMD) staff shall be notified so that the find can be evaluated by a qualified archaeologist (i.e., an archaeologist registered with the Society of Professional Archaeologists). When contacted, a member of PRMD Project Review staff and the archaeologist shall visit the site to determine the extent of the resources and to develop proper mitigation measures required for the discovery. No earthwork in the vicinity of the find shall commence until a mitigation plan is approved and completed subject to the review and approval of the archaeologist and Project Review staff"
- 2. A qualified archaeological monitor will be present during pipeline construction along all of West Squaw Creek Road to the tie-in location to ensure that no construction activities occur outside of the existing disturbed road shoulder and to monitor for cultural materials during construction. If a resource is found during construction, the monitor shall have the authority to stop construction until it can be further evaluated. The pipeline would be installed above-ground on stanchions, such that ground disturbance is already minimized to only the stanchion foundations. Any resource found would be avoided by spanning over the resource and/or moving the pipeline to avoid any resource.

Noise

- 1. Calpine would adopt the following measures to minimize noise from the drill rig during re-drilling and testing operations:
 - Shielding of drill rig motor and air compressors: When practicable, set up the drill rig so that it acts as a barrier to shield noise from the motor and compressors from receptors.
 - Buffer metallic surfaces: If needed, cover V-door and drill rig floor with rubber or wood to reduce impact noise from pipes against these metal surfaces.

- Enclose Rig Floor: If needed, enclose rig floor with metal panels including the V-door opening.
- Muffle connection equipment: Install mufflers around pipe connection equipment such as air tuggers and winches.
- Install check valve: Install a check valve in the drill string to slowly bleed off air pressure and reduce high pressure release noise.
- Bleed air pressure through cyclone muffler: Reduce pressure release noise by bleeding air pressure through the blooie line rather than the rig floor.
- Pipe Handling: Implement procedures for handling drill pipe that minimize contact with metal surfaces (i.e., on the V-door and catwalk).
- During air drilling, the rig will be outfitted with a blooie line and cyclonic separator/muffler designed to reduce noise from the release of steam. Similarly, during well testing a portable blooie line and muffler will be utilized to reduce steam release noise.
- Rig Crew training: Train all rig crews in noise awareness.
- 2. Noise would be controlled in accordance with the standards set in the Noise Element of the Sonoma County General Plan.
- 3. If noise complaint investigations indicate the appropriate noise standard levels have been or may be exceeded, Calpine would be required to install, at their expense, additional professionally designed noise control measure(s).
- 4. Well pad, road, and pipeline construction/grading activities would not occur during the nighttime.

Visual Resources

- 1. Pipelines would be painted in earth-tone colors.
- Rig lights and any other temporary lighting would be shaded and focused downwards to reduce nighttime glare from the well pads during drilling operations. Temporary lighting would only be on for short periods of time, as necessary.

Hazardous Materials, Waste Handling, Human Health and Safety, and Risk Management

- 3. Fire hazards would be minimized through the maintenance of an on-site water supply that can be used to put out any potential fires. Other measures to reduce fire hazards would be implemented and include:
 - a. Fire extinguishers and shovels would be available on-site.

- b. All brush build-up around mufflers, radiators, and other engine parts must be avoided; periodic checks must be conducted to prevent this build-up.
- c. Smoking would only be allowed in designated smoking areas; all cigarette butts would be placed in appropriate containers and not thrown on the ground or out windows of vehicles.
- d. Cooking, campfires, or fires of any kind would not be allowed.
- Portable generators used in the Project Area would be required to have spark arresters.
- 4. Existing Calpine health and safety procedures provide plans that address prevention of fires in The Geysers. These plans would be implemented, including:
 - Fire Prevention Plan (HSP-60)
 - Hot Work Permit Procedure (No. 145)
 - The Calpine Geysers Emergency Preparedness and Response Plan
- 5. Calpine would remove and clear away dry, combustible vegetation from construction sites in the project area that contains substantial forest fire risks and hazards, or are very high fire hazard severity zones as defined by California Division of Forestry and Fire Protection. Grass and other vegetation less than 18 inches in height above the ground may be maintained where necessary to stabilize the soil and prevent erosion. Vehicles would not park in areas where exhaust systems contact combustible materials. Fire extinguishers would be available on the construction site when working in high fire hazard areas to assist in quickly extinguishing any small fires. The Construction Manager would have on site the phone number for the local fire department(s) and would have a phone available when working in high fire hazard areas should additional fire fighting capabilities be required.
- Calpine would implement the Asbestos Air Toxic Control Measure for construction, grading, quarrying and surface mining as approved by CARB.
- 7. Workers would wear hearing protection and other personal protection equipment (PPE) as required by the Occupational Health and Safety Organization (OSHA) to prevent injuries.
- 8. Construction workers would comply with OSHA and CalOSHA asbestos removal worker requirements whenever serpentine rock containing over one percent asbestos is being excavated.
- 9. Calpine would implement its blowout prevention plan.
- 10. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit.

Affected Environment and Environmental Consequences

3.1 Environmental Categories Evaluated and Dismissed from Further Analysis

3.1.1 OVERVIEW

The DOE NEPA guidance documents and a public scoping period were used to identify environmental categories within the affected environment and to evaluate the potential for impacts from the proposed action. Elements of the affected environment are discussed in detail. Some environmental impact categories are not present at the project site or are not likely to have impacts associated with the proposed action. Table 3.1-1 provides an overview of which environmental categories are evaluated or dismissed.

Several environmental analyses have been performed for geothermal development in the project area and are incorporated into this EA by reference. Two key projects include the Subsequent Initial Study and Mitigated Negative Declaration (IS/MND) for the Wildhorse Development Project and the Incremental Recycled Water Program (IRWP) EIR for the City of Santa Rosa.

This project falls within a larger program known as the Wildhorse Development Project. Under the Wildhorse Development Project, Calpine is proposing to drill up to 58 geothermal wells, up to 14 existing drill pads and construct up to 29,000 feet of access corridors for steam pipelines, roads, associated electrical distribution (21kilovolt lines), and other appurtenant facilities to connect the production and injection wells to existing geothermal infrastructure and power plant units. The Wildhorse Development Project was subject to review under the CEQA, as several local and state permits were required for the project.

The IRWP addressed the environmental effects of construction of the pipeline to the project area and the transport and injection of tertiary treated recycled water into the Geysers geothermal reservoir. The analysis and mitigation is incorporated herein by reference.

3.1.2 RESOURCES DISMISSED FROM FURTHER ANALYSIS

Geology and Soils

Mineral Resources

The Sonoma County General Plan does not designate the project area as within a known mineral resource deposit recovery site (Sonoma County 1989). There are no known mineral resources or geologic resources of commercial value in the project area, other than the geothermal resource, which is addressed in Section 3.3 Geology. Mineral Resources is dismissed from further evaluation.

EA Resource	Impact Categories	Determination
Air Resources	Air Quality	Addressed in EA.
	Soils	Addressed in EA
Caalagy	Mineral Resources	No adverse impacts expected. Dismissed from further analysis.
Geology	Seismicity	Addressed in EA.
	Geothermal Resource, Natural Resources and Energy Supply	Addressed in EA.
D. 1 . 1	Vegetation and Wildlife	Addressed in EA.
Biological Resources	Wetlands	Addressed in EA
Resources	Rare and Endangered Species	Addressed in EA.
	Floodplains	No adverse impacts expected. Dismissed from further analysis.
Water Resources	Water Quality	Addressed in EA.
	Groundwater Resources	Addressed in EA.
Cultural Resources	Historical, Architectural, Archaeological, and Cultural Resources	Addressed in EA.
	Land Usage	No adverse impacts expected. Dismissed from further analysis.
Land Use	Farmlands	No adverse impacts expected. Dismissed from further analysis.
	Transportation	No adverse impacts expected. Dismissed from further analysis.
Noise	Noise	Addressed in EA.
Infrastructure	Infrastructure	No adverse impacts expected. Dismissed from further analysis.
	Light Emissions	Addressed in EA.
Visual	Visual Impacts	Addressed in EA.
Resources	Wild and Scenic Rivers	None present. Dismissed from further analysis.
Socioeconomics	Socioeconomics	No adverse impacts expected. Dismissed from further analysis.
Environmental Justice	Environmental Justice	No adverse impacts expected. Dismissed from further analysis.
Hazardous Materials and	Hazardous Materials, Pollution Prevention, and Solid Waste	Addressed in EA.
Human Health and Safety	Health and Safety	Addressed in EA.

SOURCE: US DOE NEPA Guidance Document and Consultant Evaluation

Water Resources

Floodplains

The project would involve the installation of a pipeline on stanchions; however, the pipeline would be installed entirely along the shoulder of an existing road. The project area is over 4.5 miles away from the nearest 100-year floodplain as defined by the Federal Emergency Management Agency (FEMA) (FEMA 1996). Adverse impacts are not expected and Floodplains is dismissed as an impact category for analysis.

Land Use

Land Usage

The project would not conflict with any of the permitted land uses or require a change in land use within the project area. Land in the project area is zoned for resources and rural development (Sonoma County 2008a). Impacts are not expected and Land Usage is dismissed as an impact category for further analysis.

Farmlands

The project would not affect agricultural lands or prime or unique farmland soils as defined by the Natural Resource Conservation Service (NRCS). The project would not occur on or near any farmlands. Impacts are not expected and Farmland is dismissed as an impact category for analysis.

Transportation

The project would not result in an increase in vehicular traffic or require a change in traffic circulation. Small increases in traffic on public roads could occur from Phase II activities (regrading the well pad and re-drilling), but impacts would not be adverse because the area is remote and these types of operations are common in the area. No new roads would be required. Transportation is dismissed as an impact category for analysis.

Infrastructure

The project would not require infrastructure other than access to the well pad via existing access roads and construction and use of the SRGRP pipeline for injection water. The well pads are accessible via Seven Mile Road and Squaw Creek Road, which are currently graded and maintained with road base. Permanent power for the well pad would be needed for equipment operation on the well pad and would be supplied by generators. Water use, wastewater use, and landfill use are addressed in the EA in Sections 3.5 Water Resources and 3.9 Hazardous Materials and Human Health and Safety. Infrastructure is otherwise dismissed as an impact category for analysis.

Visual Resources

Wild and Scenic Rivers

There are no national or state Wild and Scenic Rivers within the project area; therefore, impacts are not expected and Wild and Scenic Rivers is dismissed as an impact category for analysis.

Socioeconomics

There are no residents near the project area. The closest residents are located 2 miles from the well pad site. The proposed site is an existing well pad within the larger geothermal well field operated by Calpine. Construction and operation of the proposed project would not result in any major adverse socioeconomic changes. Socioeconomics is dismissed as an impact category for analysis.

Environmental Justice

There is no population in the vicinity of the proposed project. The project requires limited construction and drilling activities that are commonplace in the project region. The project could result in some air emissions; however, these effects would be mitigated. The project would not have an adverse effect on any minority or low income populations pursuant to Executive Order 12898; therefore it is dismissed as an impact category for analysis.

Intentional Destructive Acts

In December 2006, the DOE Office of General Counsel issued interim guidance stipulating that NEPA documents completed for DOE actions and projects should explicitly consider intentional destructive acts (i.e., acts of sabotage or terrorism). Construction and operation of the proposed project would not involve the transportation, storage, or use of radioactive, explosive, or toxic materials. Consequently, it is highly unlikely that construction or operation of the project would be viewed as a potential target by saboteurs or terrorists. The project location is not near any national defense infrastructure or in the immediate vicinity of a major inland port, container terminal, freight trains, or nuclear power plants. The proposed project would not offer any targets of opportunity for terrorists or saboteurs to inflict adverse impacts to human life, health, or safety; therefore it is dismissed as an impact category for analysis.

3.1.3 RESOURCES EVALUATED IN THIS EA

This EA evaluates the impacts of the Proposed Action and the No Action alternative under the following categories:

- Air Resources
- Geology
 - Soils
 - Seismicity
 - Geothermal Resource, Natural Resources and Energy Supply
- Biological Resources
 - Vegetation and Wildlife
 - Wetlands
 - Rare and Endangered Species
- Water Resources
 - Water Quality
 - Groundwater Resources
- Noise

- Visual Resources
- Visual Impacts
- Light Emissions
- Hazardous Materials, Human Health and Safety, and Risk Assessment
 - Hazardous Materials
 - Health and Safety

3.2 Air Resources

3.2.1 AFFECTED ENVIRONMENT

Climate

The climate within Sonoma County (County) is complex due to the presence of mountain ranges and valleys with various climate regimes. The predominant wind direction is from the south and southeast.

The average seasonal precipitation in Sonoma County ranges from less than 20 inches in the extreme southeast corner of the County through 30 and 40 inches over much of the central part of the County. In the mountains of the northwest portion of the County, rain totals increase to more than 70 inches at some points, and in the northeast they increase to more than 80 inches (Sonoma County 2008a).

The Coast Range east of the Russian River, provides a barrier that protects Sonoma County from the very hot weather of the central valley of California during summer month. Low elevations within the County receive enough sunshine during the summer without any import of hot air from the interior. The nearby Pacific Ocean provides a source of cool, moist air during the summer, and the steady inflow of marine air holds temperatures at low levels over that part of the County through which it moves (Sonoma County 2008a).

Air Quality Regulatory Setting

Air quality in California is regulated by CARB, which implements local programs as well as operates the federal environmental program within the state for implementation of the Federal Clean Air Act, as delegated by the US EPA. The air pollutants of greatest concern in California are:

- Ground-level ozone, commonly known as smog
- Fine particulate matter (mostly from wood smoke or other combustion sources, cars and dust) known as
 - Particulate matter 10 microns and smaller in diameter (PM₁₀) and
 - Particulate matter 2.5 microns and smaller in diameter (PM_{2.5})
- Hazardous air pollutants (also called Air Toxics)
- Carbon monoxide (mostly from motor vehicles)

Two California air basins¹ are located within Sonoma County: North Coast and San Francisco Bay. The project area is located entirely within the North Coast Air Basin. The project area lies within the NSCAPCD. The NSCAPCD is the local permitting agency responsible for the implementation of federal and state air quality plans in addition to preparing regional air quality plans.

The NSCAPCD is classified as having attained all federal air standards; however, the entire North Coast Air Basin is currently designated as in non-attainment for the state 24-hour and annual average PM₁₀ standards. The air basin is designated as unclassified for the state annual PM_{2.5} standard because available data is insufficient to support a designation of attainment or non-attainment (EPA 2009a).

Federal and state standards for ambient pollutant concentration levels are included in Table. 3.2-1. Table 3.2-2 lists the emission standards that apply to direct sources of pollutants. Projects with emission sources may be required to obtain an ATC and PTO from the NSCAPCD.

Pollutant	Average Time	California Standards	Federal Standards	
Ozone	1-Hr.	0.09 ppm		
	8-Hr.	0.070 ppm	0.075 ppm	
Carbon Monoxide	1-Hr.	20.0 ppm	35.0 ppm	
	8-Hr.	9.0 ppm	9.0 ppm	
Nitrogen Dioxide	Annual	0.030 ppm	0.053 ppm	
	1-Hr.	0.18 ppm	–	
Sulfur Dioxide	Annual	–	0.03 ppm	
	24-Hr.	0.04 ppm	0.14 ppm	
	1-Hr	0.25 ppm	–	
PM 10	Annual 24-Hr.	20.0 μg/m³ 50.0 μg/m³	150.0 μg /m³	
PM 2.5	Annual	12 μg/m³	15.0 μg/m³	
	24-Hr.	–	35 μg/m³	
Lead	30-day	1.5 μg/m³	–	
	Calendar Quarter	–	1.5 μg/m³	

ppm = parts per million

μg/m³ = micrograms per cubic meter

N/A = Not available

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¹ An air basin is a geographical structure or climatic condition that results in relatively little movement of air in or out of the area.

Table 3.2-2: Significant Emission Rates for Pollutants Regulated Under the Clean Air Act			
Significant Pollutant	Emission Rate (tons/year)		
Carbon Monoxide	100 tons/year		
Nitrogen Oxides	40 tons/year		
Particulate Matter	25 tons/year		
PM ₁₀	15 tons/year		
Sulfur Dioxide	40 tons/year		
Volatile Organic Compounds	40 tons/year		
Lead	0.6 ton/year		
Fluorides	3 tons/year		
Sulfuric Acid Mist	7 tons/year		
Hydrogen Sulfide	10 tons/year		
Total Reduced Sulfide	10 tons/year		

SOURCE: EPA 2009b

Air Quality in Sonoma County

Inland areas with higher elevations in the western portions of Sonoma County receive less fog and less influence from warm, moist coastal summers. The northern portion of Sonoma County is mostly rural and hilly and includes two urban areas: Healdsburg and Cloverdale. Natural sources such as wind-blown dust, pollen, and intermittent forest fires can occasionally contribute to local levels of pollutants in the atmosphere. Forest fires emit air pollutants such as nitrogen oxides, particulates, and unburned organic compounds. Together with natural sources, human activities can contribute to occasional locally elevated air pollution levels in northern Sonoma County.

The NSCAPCD has adopted regulations to improve air quality with the implementation of regulations requiring all wood burning devices to meet prescribed standards and by prohibiting the installation of conventional fireplaces in new construction or remodeled houses. Construction projects within the district are regulated by public nuisance provisions set forth by the NSCAPCD. Rules 410 and 430 are two applicable provisions which regulate the visible emissions and fugitive dust emissions, respectively (Sonoma County 2008a). Rule 410 sets standards on the length of time and opacity of visible air contaminant emissions. Rule 430 requires reasonable precautions be taken to prevent particulate matter from becoming airborne.

Calpine obtained an ATC and temporary PTO from the NSCAPCD for well PS-31on September 21, 2009. The permit regulates emissions from re-drilling and flow testing. The permit is included in Appendix D. A similar permit would be obtained for well P-32. All permit conditions would be implemented.

Greenhouse Gases and Global Warming

GHGs are global pollutants, unlike criteria air pollutants and toxic air contaminants, which are pollutants of regional and local concern, respectively. The most prominent GHGs that have been identified as contributing to global warming are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆). Emissions of GHGs contributing to global climate change are attributable largely to human activities associated with the industrial/ manufacturing, utility, residential, and agricultural sectors. Transportation is also a large contributor of GHGs, particularly CO₂.

3.2.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Fugitive Dust Emissions

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. The primary pollutant of concern during construction activities for the proposed action would be emissions of particulates in the form of fugitive dust. Fugitive dust emissions would be generated by ground-disturbing activities related to transport of workers and equipment to the site, well pad preparation, and construction of the SRGRP pipeline spur for injection water.

Air quality impacts from construction activities for the well pad and SRGRP pipeline spur would be localized and temporary. The existing 2-acre well pad would require approximately one day of re-grading. Well pad preparation would require the clearing of any vegetation that has established; the installation of drainage improvements; and the laying down of gravel. Construction of the 1-mile long SRGRP pipeline spur would require the removal of soils and vegetation that has established itself in the road shoulder. Fill material may be required for stanchions and would include sand and gravel in addition to the removed soils.

Particulate concentrations in the vicinity of the project would increase on a short-term basis (construction and drilling is estimated to last up to 2 months). Fugitive dust emissions from the well pad and construction of the pipeline would be controlled to meet the requirements of Rule 430 and 410(a). Protective measures included in the project description include:

- Watering and/or otherwise entraining dust on devegetated areas to minimize any adverse impacts from particulate matter emissions during ground disturbance
- Covering all trucks hauling soils or other dusty materials and maintain at least two feet of freeboard on the trucks
- Hydroseeding or applying non-toxic soil stabilizers to inactive construction areas (previously graded areas that are inactive for 10 days or more)
- Limiting traffic to 15 miles per hour on unpaved roads

Emissions of particulate matter would not be adverse with implementation of these measures.

Combustion Emissions

Diesel combustion emissions would be emitted from construction equipment and vehicles used to access the project site. Combustion emissions of criteria pollutants and air toxics (small quantities of diesel PM, acetaldehyde, benzene, and formaldehyde) would be released by diesel-powered equipment during road grading, well pad preparation, and the SRGRP pipeline construction. Given the small size of the construction areas, and the small fleet of vehicles needed for construction (less than 5 for 5-8 workers), emissions would be minimal and would not significantly contribute to or exceed air quality standards.

Other Air Emissions

Field application of paint to pipelines and supports may be a source of volatile organic compounds (VOCs). Painting of the steam pipelines and supports would conform to NSCAPCD Rule 485 for use of compliant architectural coatings such that no adverse effects would occur.

Well Bore Modifications

Fugitive Dust Emissions

The proposed project includes modification and re-drilling of two existing wells. The re-opening and modification of both wells would take approximately 30 days; however, only one well would be drilled at a time. The drill rig would be powered by a large bore diesel engine.

The air drilling phase of well bore modifications would be a source of particulate matter. This particulate matter originates from well bore cuttings removed with the compressed air and steam. Well testing would also be a source of particulate matter originating from the well with the steam. Well drilling would produce condensate, rock and sulfur solids, and particulate matter that would collect in a tank. Dust emissions from venting steam would be reduced by injecting water into the blooie line.

Serpentine rock containing asbestos may be encountered during well drilling. The Asbestos Air Toxic Control Measure for construction, grading, quarrying, and surface mining as approved by CARB would be implemented to avoid adverse effects associated with the emissions of serpentine/asbestiform minerals.

Combustion Emissions

Table 3.2-3 shows a worst-case emissions scenario for a large bore stationary diesel engine based on estimated maximum daily fuel consumption at the well pad. Because of the variables in operating parameters of the engines, emissions are expected to be significantly lower than the worst-case scenario. Additional generators and pumps may be required for the project, but these small sources would have a negligible impact on emissions. The emissions from diesel generation would be considerably less than standards (as shown in Table 3.2-2), especially since most impacts would only occur for 1 month per well during drilling modifications. Combustion emissions would not be adverse.

Other Air Emissions

Production of geothermal fluid during well testing would result in release of water vapor (steam) and NCG to the atmosphere. The amount and ratio of the non-condensable gas constituents within

Table 3.2-3: Estimated Emissions from Large Bore Diesel Engines ¹					
	Emission Factor (lbs/mmBTU)	Maximum Estimated Emissions			
Air Pollutant		Hourly (lbs/hr)	24-hour (lbs/day)	1-month of Drilling Total Emissions (tons) ²	
Carbon Monoxide (CO)	0.085	4.83	115.92	1.74	
Carbon Dioxide (CO ₂)	165.00	942.08	22,609.92	339.15	
Total Organic Compounds (as Methane (CH ₄))	0.09	0.51	12.24	0.02	
Oxides of Nitrogen (NO _x)	3.20	18.27	438.48	6.58	
Particulate Matter ≤10 microns (PM ₁₀)	0.0573	0.33	7.92	0.12	
Oxides of Sulfur (as Sulfur Dioxide (SO ₂))	0.0202	0.12	28.80	0.43	

Notes:

SOURCE: EPA 1996

the geothermal fluid are variable among geothermal resource areas and can be substantially different among individual wells within the same geothermal project area. NCG content is typically comprised of primarily CO_2 (usually accounting for about 95 to 98 percent of the total NCG content), with smaller amounts of CH_4 , H_2S , and trace amounts of ammonia (NH₃). Trace amounts of elements such as arsenic (As), mercury (Hg) and boron (B) may be present.

The majority of geothermal steam emissions would occur during well drilling, testing, and logging.

Boron, Arsenic, and Mercury Emissions

Steam dispersed into the air may contain boron or arsenic. Table 3.2-4 lists chemical data for boron, mercury, and arsenic gathered from flow tests when the wells were constructed in 1984 and 1985. The wells were never produced before being abandoned in 2000; therefore, no other data was collected on these wells.

Boron, mercury, and arsenic in steam emissions would disperse by wind away from the well pad and would eventually settle onto the ground. The estimated emissions for boron, arsenic, and mercury during a 30 day drilling period are shown in Table 3.2-5. Calculations are shown in Appendix I. Boron is highly soluble in water. As water is injected into the blooie line, a substantial amount of boron is expected to be scrubbed from the steam before it is emitted. The boron

¹Values based on the assumption that a maximum of 1,000 gallons of low sulfur (0.02%) diesel oil fuel will be used, and that the average heating value of the fuel is 19,300 BTU per pound of fuel with a density of 7.1 pounds per gallon.

²Assumes 24 hours per day, 7 days per week per well. Drilling would be performed for 1 month per well. Only one well would be drilled at a time. Double the emissions in the last column for 2 month drilling.

Table 3.2-4: Chemical Data from Flow Tests (1984- 1985) for PS-31 and P-32						
	Chloride parts per million by weight (ppmw)	Boron (B) ppmw	Mercury (Hg) parts per billion by weight (ppbw)	Arsenic (As) ppmw		
Prati State-31						
N Samples	20	20	20	20		
Median	18	70	2	<0.01		
Average	25	65	4	<0.01		
Prati- 32						
N Samples	22	22	22	22		
Median	85	80	3	<0.01		
Average	88	73	4	<0.01		

SOURCE: Calpine 2010

Table 3.2-5: Estimated Emissions of Boron, Arsenic, and Mercury during Drilling and Testing						
PS-31 P-32 Total						
Boron	2,520 lb	3,514 lb	6,034 lb			
Arsenic	<0.36 lb	<0.44 lb	<1.0 lb			
Mercury	0.07 lb	0.13 lb	0.20 lb			

SOURCE: Calpine 2010

scrubbing efficiency of the blooie line injection system and cyclone has not been determined, but emissions would likely be less than that presented in Table 3.2-5. Arsenic present in the steam mostly likely becomes soluble in the oxidizing environment of the blooie line and is likely scrubbed from the steam before it is emitted. The amounts of arsenic and mercury that could be emitted in steam over the entire 30 day drilling period is very small (fractions of a pound) and would not have adverse effects. Up to 5,000 pounds of boron could be released; however, boron (as well as mercury and arsenic) is naturally occurring in the area. Adverse effects would not occur.

Hydrogen Sulfide Emissions

Of the non-condensable gas emissions anticipated from the geothermal fluid, the principal constituent of concern is H_2S . H_2S can be released from a well during drilling and would be emitted with the steam and NCGs during flow-testing. H_2S is a colorless, non-condensable gas with a characteristic "rotten egg" odor. H_2S is toxic at certain levels and can cause negative human and animal health effects. Exposure to H_2S can cause dizziness, headache, and nausea at 50 ppm and death from respiratory paralysis at 1,000 ppm. The OSHA indoor workplace standard for H_2S is 10 ppm for an 8-hour day (Klingberg 2005). Nuisance odor is of primary public concern since the

distinctive odor can be easily detected at concentrations far below levels of health concern. Odor is detectable from about 0.008 ppm.

 H_2S is typically encountered during the production zone drilling phase. Well PS-31 is expected to produce 4.0 percent to 7.5 percent of non-condensable gases by weight, and approximately 1,000 to 1,800 ppm H_2S while drilling. The amount of H_2S expected to be encountered from drilling well P-32 would be similar to concentrations emitted from well PS-31.

Federal standards for H₂S emissions are 10 tons per year. Total emissions from well bore modifications and flow testing would be far less than 10 tons per year; however, given the odor and potential threat to human health from H₂S emissions, protection measures have been built into the project to reduce H₂S emissions as much as possible. H₂S control would be accomplished through the installation of a NSCAPCD approved chemical abatement system (as described in *Chapter 2: Proposed Action and Alternatives*).

H₂S emissions would also be minimized through implementation of measures required in the ATC and PTO (Appendix D).

No sensitive receptors are found within 500 feet of the project site, the distance over which odors would dissipate. With monitoring and abatement in accordance with permits, H₂S emissions would not cause adverse effects.

Stimulation

The stimulation phase of the project would involve the continuous flow of water from the newly constructed SRGRP pipeline spur to the re-opened wells at varying rates. An injection program would be designed to study the response of pre-existing fractures in the HTZ by varying pumping rates.

Stimulation would result in the emission of a small amount of steam from the wells if/when venting is required. During venting, the well is "bled" by allowing it to vent a small amount of steam through the well head silencer. Bleeding is usually short term (a few hours) and emissions would include constituents in the geothermal fluid including very small amounts of boron, arsenic, and H₂S. Calpine would notify the NSCAPCD 24 hours prior to initiating any planned venting operations until such time that an emissions release protocol governing emissions and notifications for such operations is prepared and provided to the NSCDAPCD. Operations resulting in an excess of 15 pounds per hour of H₂S would be subject to meteorological forecast per PTO conditions. Emissions would otherwise not occur.

Air emissions of constituents such as boron, arsenic, mercury, and H2S during the testing phase would be similar or less than those emitted during re-drilling. Impacts would not be adverse with implementation of the PTO conditions.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, injection may occur in either or both wells, depending upon the results from the stimulation phase. Impacts would be similar as described for the stimulation phase. Data collection and information assessment includes the long term monitoring and assessment of the closed wells and would not have adverse effects on air quality.

Greenhouse Gas (GHG) Emissions and Global Warming

Construction of the SRGRP pipeline and modifications and re-drilling of the existing wells would result in the emission of some GHGs (mostly from running equipment engines). Emissions would primarily come from the diesel generator on the drill rigs. Approximately 340 tonnes² (a metric ton is 1,000 kg, or 2,204.6 lbs, and is commonly referred to as a tonne) of GHG emissions from large bore diesel engines are estimated. Well drilling and testing would also emit CO_2 and methane in the geothermal steam.

Greenhouse gases are typically reported as equivalents of CO₂, or as CO₂e. Methane is a more potent greenhouse gas than CO₂ by a factor of 21, so methane emissions are converted to CO₂e by multiplying by a factor of 21. Greenhouse gas emissions from this project, based on a 30-day expected drilling duration per well would total 1,755 tonnes (calculations are show in Appendix I). The California Air Resource Board has a proposed emissions standard of 7,000 tonnes per year CO₂ equivalent. The project would emit less CO₂ than the standard for construction and drilling activities. Venting during the stimulation phase would also result in some emissions of GHGs; however, with venting lasting only a few hours, the amounts of emissions would be on the order of 1 metric ton per venting, which is a small amount.

The project would help mitigate GHG emissions since it would provide information that may lead to the long term sustainability of the geothermal resource and mitigation of GHG emissions, which could replace fossil fuel energy sources that emit much more GHGs. Fossil fuel combustion-related CO_2 accounts for 82 percent of the total US human-made GHG emissions (NEIC 2007). A comparison of geothermal and fossil fuel CO_2 emissions from electrical generation is shown in Table 3.2-6. Emissions reported in the table are weighted average values for all geothermal capacity, including binary power plants that do not emit CO_2 (Bloomfield et al. 2003).

Table 3.2-6: Geothermal vs. Fossil Fuel CO ₂ Emissions for Electrical Generation					
	Geothermal	Coal	Petroleum	Natural Gas	
Emissions (pounds CO ₂ per kilowatt hour)	0.20	2.095	1.969	1.321	

SOURCE: Bloomfield et al. 2003

Air Conformity Analysis

The project is not located within any current federal non-attainment areas and would not exceed any conformity requirements as dictated in the EPA's rule "Determining Conformity of General Federal Actions to State or Federal Implementation Plans" (40 CFR 93, Subpart B). The project would not contribute to any violation of federal ambient air quality standards.

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 $^{^2}$ The amount of GHG emissions was calculated by adding the calculated, worst-case scenario emissions of CO₂ and CH₄ from Table 3.2-3 and converting to tons.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts to air resources could occur anyway.

3.3 Geology

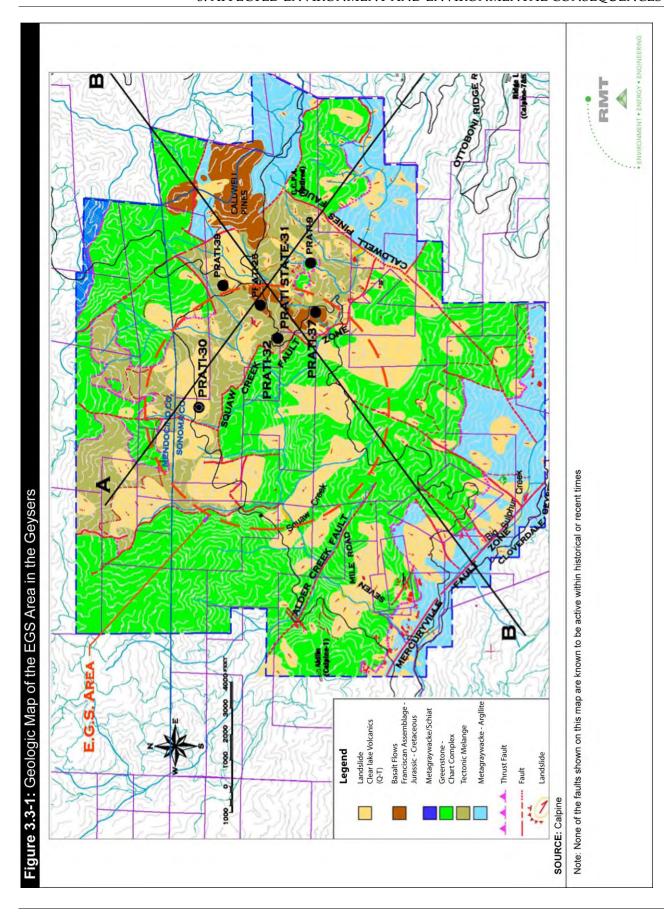
3.3.1 AFFECTED ENVIRONMENT

Geology

The Geysers geothermal area is located within the Coast Ranges geomorphic and tectonic province of northern California. The region is underlain primarily by highly deformed and metamorphosed volcanic and sedimentary rocks of the Jurassic-Cretaceous Franciscan assemblage, which are juxtaposed against similarly aged Great Valley Sequence rocks along the Coast Range thrust fault. These older rocks were intruded and overlain by Pleistocene igneous rocks during a phase of late-stage volcanism attributed to the northward migration of the Mendocino triple junction. The Pleistocene rocks crop out to the northeast of The Geysers near Clear Lake and to the east on Cobb Mountain as the Clear Lake Volcanics. Within The Geysers area itself, the igneous rocks are largely confined below the surface. The heat source driving the Geysers geothermal system is postulated to magma body (bodies) located at mid-crustal depths. Overlying the bedrock are a variety of Quaternary deposits, including recent alluvium along river valleys and landslide deposits, which are ubiquitous in areas of steep topography underlain by sheared Franciscan assemblage rocks. A geologic map of the EGS area in the Northwest Geysers is shown in Figure 3.3-1. PS-31 and P-32 are located within an area of tectonic mélange.

Tectonics

The Coast Ranges are characterized by steep and rugged topography with a pronounced northwest fabric. This fabric of northwest-trending ranges separated by subparallel river valleys is controlled by the northwest-striking structures of the San Andreas fault system. The San Andreas fault system is a 100-km-wide swath of subparallel, primarily right-lateral strike-slip faults along the western edge of California. It comprises the boundary between the North American and Pacific tectonic plates and accommodates most of the transform motion between the two plates. The San Andreas fault is the dominant fault in the system, but numerous smaller faults within this 100 km wide swath of strike slip faults accommodate some portion of the plate motion. Faults within The Geysers area include numerous inactive bedrock faults associated with earlier tectonic regimes, as well as a number of faults active in the Quaternary (approximately 2.5 million years ago, through present times). Faults are described in greater detail in the Induced Seismicity Report (URS 2009) attached in Appendix J.



The Geysers lies within a zone of right-lateral shear and localized extension between two Holocene-aged (less than 11,700 years) active faults of the San Andreas fault system: the Maacama fault to the southwest and the Bartlett Springs fault to the northeast. The localized smaller faults in the project area are shown in Figure 3.3-2 and Figure 3.3-3. Both these faults have documented Holocene activity, and the Maacama fault is actively creeping along much of its length.

Significant seismicity and crustal deformation has been documented in The Geysers area (Lofgren 1978, Ludwin et al. 1982, Oppenheimer 1986, Mossop 1997). Studies attribute most of the activity to the withdrawal and injection of fluids associated with development of the geothermal resource (e.g., Lofgren 1978, Marks et al. 1978, Oppenheimer 1986). Between the Maacama fault and Clear Lake, however, geodetic studies suggest that there is naturally-occurring active right-lateral shear, east-southeast-directed extension, and regional tectonic subsidence. Extension also is reflected in normal faulting mechanisms and the presence of depositional, pull-apart basins within the region. Regional tectonic deformation rates are about an order of magnitude slower than induced rates (Lofgren 1978).

Seismicity

Historic Seismicity

The historical earthquake record of north-central California dates back to the early 1800's when the region was settled. Until the early 1900's, when the first seismographic stations were installed by the University of California at Berkeley (UCB), the historical record was based on observed intensities. The Geysers and surrounding region exhibited a low level of known seismicity prior to 1960 (see Figure 7 in Appendix J); however, seismographic coverage north of San Francisco Bay was only sufficient to record and locate events ML 4 and larger.³

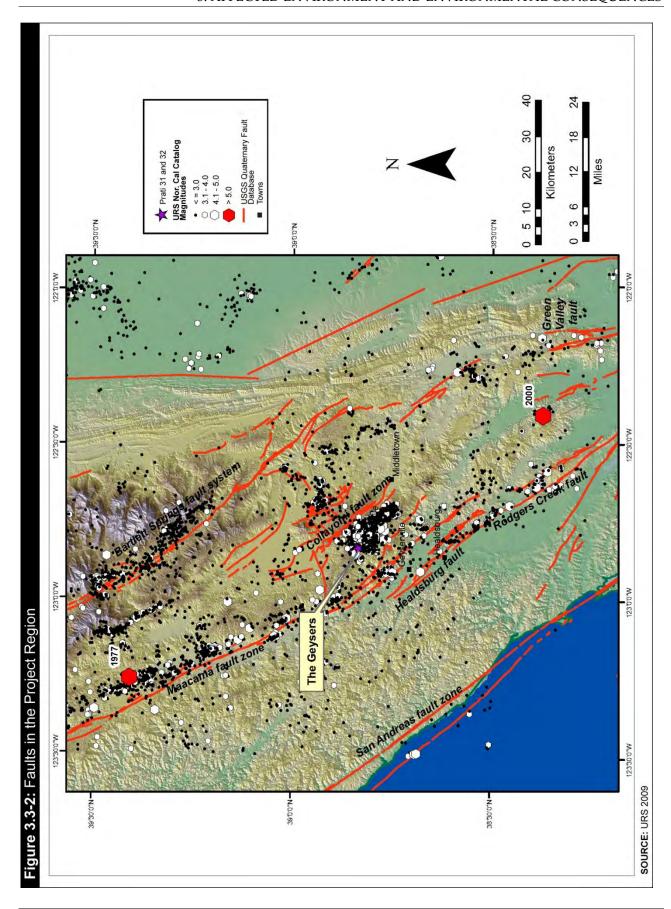
A number of large earthquakes occurred in California prior to 1960 that have probably impacted The Geysers and surrounding region. The two most significant events are the 1906 Great San Francisco earthquake, because of its size and location along the northern San Andreas Fault to the west, and an earthquake in 1955 near The Geysers.

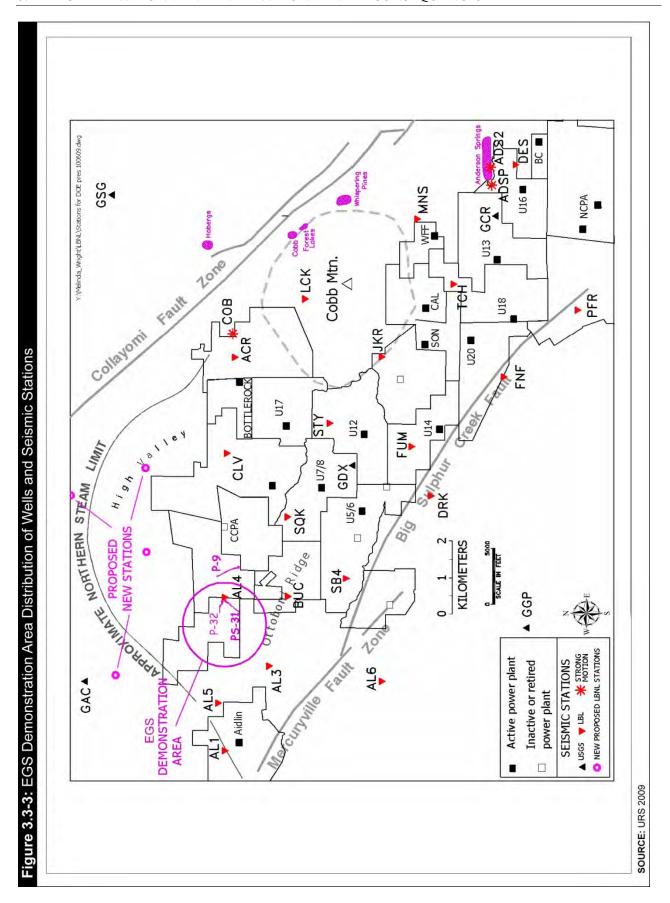
Seismic Monitoring in The Geysers

Seismographic coverage of The Geysers to detect earthquakes smaller than ML 3 began in mid-1975 when the US Geological Survey (USGS) Central California Seismic Network (CALNET) reached The Geysers area (Oppenheimer 1986). The USGS operates an array in The Geysers, which is part of the much larger regional network also operated by the USGS. Since 1976, station density in The Geysers area has been sufficient to determine the location of virtually all seismic events likely to be felt by humans, including thresholds as low as ML 1.2 to 1.5. The system records and locates about 3,000 events per year in The Geysers area. Data from a new LBNL network has recently been integrated into the Northern California Seismic Network (NCSN) system, significantly lowering the magnitude threshold and thereby increasing the number of events captured in the dataset. Local seismic/motion monitoring stations are shown in Figure 3.3-3.

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³ Richter local magnitude [ML] is approximately equivalent to M, or moment magnitude.





Induced Seismicity

Induced seismicity refers to earthquakes and tremors that are caused by human activity that alter the stresses and strains in the Earth's crust. The Geysers geothermal area is the site of a vapor-dominated steam field from which electric power has been generated since the early 1960's. It is also among the most seismically active areas in California (Figure 3.3-2).

Earthquakes are concentrated at the steam production field and extend to a depth of 6 km (about 20,000 feet) (Eberhart-Phillips and Oppenheimer 1984). The Geysers experienced a very low level of seismic activity prior to the onset of power production. However, few stations for recording seismicity had been in place prior to development of the geothermal resource; therefore, data on background seismicity was limited.

The USGS NCSN catalog lists a total of 25 probable Geysers induced earthquakes of ML or M 4.0 and greater (Table 3.3-1). This translates to a rate of one $M \ge 4.0$ event per 1.5 years since 1972. The rate, however, has significantly increased since 2002 to about one $M \ge 4.0$ event every 7 to 8 months after a significant increase in injection volume.

The largest earthquake observed in The Geysers has been an estimated ML 4.6 on May 9, 1973 that occurred near the present-day Aidlin project area which was not developed until the late 1980's. This event occurred on the northwestern edge of the present-day concentrated induced seismicity associated with operation of the Aidlin steamfield. Its depth was estimated at about 12 km (about 39,000 feet), but due to poor seismographic coverage of The Geysers at the time, it is unknown if the earthquake was induced or tectonic. Its magnitude is also uncertain (David Oppenheimer pers. comm. 2009). A M 4.5 event occurred on October 20, 2006 on the northern margin of The Geysers area. It is thought to be induced due to its shallow focal depth (3.5 km or approximately 11,000 feet).

DOE Requirements for Evaluation of Induced Seismicity for EGS Projects

Since 2008, the DOE started requiring adherence to the "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems" (Majer et al. 2008).). DOE had instituted this requirement in order to follow international protocols to address and mitigate potential impacts resulting from induced siesmicity. Calpine's response demonstrating compliance with the protocol is presented in Appendix K. – Statement of Compliance with DOE Seismic Protocol. The protocol requires several considerations to be made by any proponent proposing to conduct an EGS project with DOE funding.

Geothermal Resource, Natural Resources, and Energy Supply

The Geysers, comprising 30 square miles along the Sonoma and Lake County border, is the largest complex of geothermal power plants in the world and world's largest dry-steam geothermal steam field. Calpine owns and operates 15 of the 18 active power plants at The Geysers with a net generating capacity of about 725 megawatts (MW) of electricity, which is enough to power 725,000 homes, or a city the size of San Francisco. Other power plants in The Geysers include the Bottle Rock Power Plant and two plants owned by the Northern California Power Agency.

RMS (sec) 0.07 90.0 91.0 0.05 0.07 90.0 0.04 90.0 0.05 0.07 60.0 90.0 0.00 0.12 0.09 0.04 80.0 60.0 80.0 90.0 0.57 80.0 0.09 0.37 80.0 RIMIT D_{MIN} (km) 33 13 15 9 00 5 (degrees) 119 34 34 37 61 25 25 30 39 25 42 32 23 41 Stations 20 43 36 45 50 46 47 36 55 46 53 46 63 21 62 55 98 38 60 in 61 Ĭ M ZZZZZ Σ ZZ Z 4.0 4.4 4.0 4.2 4.1 4.4 4.3 4.4 4.4 4.5 4.4 4.0 4.1 4.2 4.1 4.1 **Table 3.3-1:** Induced Earthquakes at The Geysers (M≥4.0) 1970 to Present 2.8 5.0 0.0 0.0 2.4 3.9 2.0 2.9 2.2 4.3 9.0 6.0 1.9 3.7 0.3 2.9 2.6 3.5 2.5 3.0 2.1 4.7 -122.770-122.769 -122.854-122.810-122.768 -122.752 -122.773 -122.688-122.822-122.823-122.778 -122.772 -122.792 -122.792 -122.797-122.757 -122.767 -122.803-122.768 -122.726 -122.755 -122.817-122.787-122.797 Longitude -122.971 (degrees) 38.792 38.848 38.825 38.785 38.789 38.816 38.867 38.795 38.819 38.739 38.798 38.860 38.823 38.792 38.782 38.799 38.834 38.749 38.843 38.779 38.932 38.801 38.7823 38.847 38.801 4:48:37 AM 17:27:10 PM 4:06:57 PM 11:04:47 PM 7:41:11 AM 4:50:42 PM 12:00:53 PM 10:37:39 PM 10:38:36 AM 9:08:29 PM 5:32:10 AM 1:19:46 AM L:02:25 PM 6:52:03 PM 10:24:01 AM 7:03:11 PM 7:05:13 PM 1:34:38 AM 9:21:15 PM 8:58:36 AM 8:37:46 PM 10:36:23 AM 10:37:29 AM 5:00:08 PM 4:48:30 AM 19 29 12 14 19 16 18 18 12 12 20 24 30 30 22 20 27 24 4 00 4 00 3 6 Month 12 12 12 10 11 00 6 a œ 0 00 6 00 0 4 SOURCE: URS 2009 Year 2000 2003 2005 2006 2006 2008 1982 1984 1985 1990 1992 2003 2004 2006 2008 2008 2009 1972 1985 1985 1995 1996 1999 2004 2007 10 4 15 91 19 20 13 00 24 12 21 23 9

The Geysers meets the typical power needs of Sonoma, Lake, and Mendocino counties, as well as a portion of the power needs of Marin and Napa counties. The Geysers satisfies nearly 60 percent of the average electricity demand in the North Coast region from the Golden Gate Bridge to the Oregon border. The Geysers is one of the most reliable energy sources in California delivering extremely high availability and on-line performance and accounts for one-fourth of the green power produced in California.

Steam used at The Geysers is produced from a greywacke sandstone reservoir that is capped by a heterogeneous mix of low permeability rocks and underlain by an intrusive felsite body with an age date of about 1 million years (Enedy et al. 1991). At the Prati 31 and 32 locations, the high temperature zone is found within the greywacke reservoir. The heat source that drives the high temperature zone is presumed to be from a small intrusion with an age estimated by the US Geological Survey to be less than 10,000 years before present. The composition of the presumed intrusion is not known because it has not been reached by any well including PS-31 or P-32. G

The Geysers electrical plants reached peak production in 1987, serving 1.8 million people. The steam field has since been in gradual decline as its underground water source decreases.

Techniques developed from EGS research are increasing the production of the region in the future. The two recycled water projects have increased electrical output by 85 MW, enough for about 85,000 homes.

Soils

The National Resources Conservation Service (NRCS) classifies the soils in the vicinity of the project as listed below and included in Appendix L. Soil types include loams, clay loams, and weathered volcanic (NRCS 1972).

PS-31 and P-32

Suther-Laughlin loams, 15-50% slopes (SuF): These moderately well-drained soils are on mountainous uplands. They are underlain by sandstone. The Suther soils have concave slopes, and the Laughlin soils are usually on or near ridgetops. The Suther soils are subject to gullying and landslips. Runoff is medium to rapid, and erosion hazard is moderate to high. Vegetation is chiefly mixed annual and perennial grasses, legumes, oaks, and small shrubs.

Pipeline

- Laughlin loam, 50-75% slopes (LgG): These soil series occur on mountainous uplands and ridgetops. The soils formed in materials weathered from sandstone and shale. Vegetation on these soils are either annual and perennial grasses, forbs and small shrubs, or a combination of oaks, grasses and manzanita. Permeability is moderate, runoff is rapid to very rapid, and erosion hazard is high to very high.
- Cohasset gravelly loam, 30-50% slopes (CmF): This steep soil on wooded uplands formed in volcanic materials. Permeability is moderate, runoff is rapid, and erosion hazard is high. Vegetation includes manzanita, and some burned stumps of Douglas fir and tanoak.

- Guenoc gravelly silt loam, 30-75% slopes (GrG): This is a well-drained soil on mountainous uplands. It is underlain by andesitic basalt. Runoff is rapid to very rapid, and erosion hazard is high to very high. Vegetation is mainly grass, oak, and brush.
- Yorkville-Laughlin complex, 30-50% slopes (YvF): This series consists of moderately well drained clay loams on ridgetops, side slopes and mountainous uplands. The soils formed in material weathered from glaucophane-schist, serpentinized igneous rocks, and metamorphosed greywacke. Vegetation is mainly annual and perennial grasses, forbs, with a few oak and madrone trees. Runoff is rapid and the hazard of erosion is high on the Yorkville-Laughlin complex. Less steep slopes have a cover of grass on the Yorkville soil. The Yorkville soil is subject to landslips.

3.3.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Geology, Tectonics, and Seismicity

Construction would not have effects on tectonics or geology in the project region. Re-grading of the well pad and construction of the pipeline would require some ground disturbance but only in previously disturbed areas and construction activities are not expected to encounter bedrock. Some of the grades to the sides of the road by which the pipeline would be installed are steep; however, the pipeline would be installed within the road shoulder on stanchions and would not result in any hazards related to slope stability.

The pipeline could be impacted by seismic events, particularly of tectonic (versus induced) origins. The pipeline would be designed to accommodate the maximum credible earthquake in the project area so as to reduce potential for adverse effects such as pipeline failure in the event of an earthquake.

Geothermal Resource

Construction would have no effect on the geothermal resource. Construction would only occur on the ground surface and would not impact the geothermal reservoir, which is deep below the surface.

Soils

Expansive soils are common throughout The Geysers; however, the proposed project does not involve work in any previously undisturbed areas or previously undisturbed soils. The well pad would be re-graded and drainage containment would be installed to prevent water run-off and erosion of soils. The only structures to be constructed are the stanchions for the SRGRP pipeline spur, which would be constructed using Standard Engineering Methods for Expansive Soils, as necessary. Adverse effects to or from expansive soils would not occur with implementation of these methods for expansive soils.

Erosion would be controlled with implementation of a SWPPP and BMPs. Adverse effects from erosion would not occur.

Well Bore Modifications

Re-drilling and well bore modifications would not impact the tectonics or geology of the area and would not induce seismicity. The project would be conducted on existing wells and would not affect geologic units or faults in the area or the geothermal resource. The wells would require some redrilling and possibly deepening by 500 feet (for PS-31). Re-drilling and slight deepening would not impact tectonics or geology. Drilling is localized and would not cause movement on faults. The same geologic units are expected to be encountered during deepening and drilling into these units would not be considered a negative impact on the units.

Flow testing would occur after well completion; however, the volumes of steam released during flow testing would be small in comparison to what is currently drawn from the KGRA and would not impact the resource. Well bore modifications would only occur on the well pad site and would not impact soils. The well pad site is graded and covered in gravel.

Stimulation

Geology, Tectonics, and Seismicity

The Induced Seismicity Report in Appendix J provides additional background research and analysis of the maximum potential earthquake predicted for the EGS project. This section summarizes the results and findings of the report.

Induced seismicity is the major concern with EGS projects. A causative relationship between steam production and fluid injection was suggested in the late 1970's by USGS scientists. That relationship has now been accepted based on numerous studies (e.g., Denlinger and Bufe 1982, Eberhart-Phillips and Oppenheimer 1984, Oppenheimer 1986, Stark 1990, Greensfelder 1993). Although it is clear that steam production and injection causes some seismicity at The Geysers, the exact causative mechanism is still not well defined. Eberhart-Phillips and Oppenheimer (1984) found no direct correlation between the volume of cold water injected or the volume of steam withdrawn and the number of earthquakes per month. Eberhart-Phillips and Oppenheimer (1984) suggested that there are two plausible mechanisms that could explain the induced seismicity at The Geysers:

- Volumetric contraction due to mass (geothermal steam) withdrawal, which could alter
 the stress field (the existing conditions and balance of forces in the rock) and cause
 faulting in the reservoir rock that is already near failure due to the regional stress field,
 and
- 2. Aseismic deformation due to regional tectonism may be converted to strike-slip deformation due to an increase in the coefficient of friction along fault surfaces (Eberhart-Phillips and Oppenheimer 1984).

For both mechanisms, Eberhart-Phillips and Oppenheimer (1984) expected seismicity to continue to increase in spite of declining reservoir production and for seismicity to occur in areas where new production is initiated.

The goal of the proposed EGS stimulation is to reopen existing fractures in the HTZ, which would generate MEQs. MEQs may occur from increased shear stress caused by cooling shrinkage (the

rocks "crack" due to shrinkage from the cooling effects of the relatively cool injected water). The environmental repercussions and concerns with re-opening fractures are the magnitude and number of the earthquakes induced, and whether they would negatively impact nearby communities and structures.

Stimulation would include staged injection over 6 months for each well. This is envisioned as a "gentle" progressive stimulation in which cold water is "poured" (under vacuum) into the HTZ. The low pressure injection promotes gradual shear reactivation of existing fractures in the deep reservoir, which would then provide steam into the normal geothermal reservoir.

Other types of more aggressive forms of EGS involve injection under high pressure to cause hydraulic fracturing (i.e., create *new* fractures in the deep reservoir). New fractures could equate to a larger and more dramatic earthquake. This type of EGS was performed in Basel Switzerland and was thought to have caused a 3.4-magnitude earthquake and 3,500 subsequent earthquakes in an urban area of the city occupied by centuries-old buildings. The project in Basel included drilling into a large, historically active fault, in order to use the energy of the fault to create fractures. Calpine's proposed EGS project is different in that the wells are not in or near existing large faults. The goal is to gradually re-open existing fractures rather than to rapidly create new fractures. This is accomplished by applying much less pressure through injection. The amount of pressure that is applied by the hydrostatic column of injected water dictates how dramatic a response occurs in the EGS reservoir. The maximum downhole pressure of the proposed injection is 8 megapascals (MPa), which is substantially below the minimum principal stresses in the rock, which is about 24 MPa in PS-31 and P-32. Injection at a much lower pressure than the minimum principal stresses in the rocks prevents potentially damaging hydraulic fracturing and allows for gradual shear reactivation of existing fractures rather than creating new fractures as proposed in Engineered Geothermal Systems such as the Basel project.

Even though this is an EGS project, the injection response should be similar to injection in other areas of The Geysers in terms of induced seismicity. Recently re-opened well Prati-9 provides data for injection induced seismicity. The largest earthquake recorded at Prati-9 in the nearly two years of injection was a M 2.8, and the induced earthquakes at Prati-9 have not generated any significant shaking at the nearest communities of Anderson Springs and Cobb (URS 2009).

Ground shaking from induced events at PS-31 and P-32 is expected to be even less than at previously re-opened wells such as Prati-9 because PS-31 and P-32 are further from Anderson Springs and Cobb. The maximum predicted event from the proposed project is a M 4.5. If this sized event were generated, the ground shaking would be felt in the nearby communities at a moderate Modified Mercalli Intensity level that is not associated with structural damage. This size earthquake could also occur from tectonics or from the existing geothermal activity in The Geysers. Such an event is unlikely to occur given that only one M 4.5 event has occurred over the past 40 years over the entire area of The Geysers (Wong et al. 2010).

The resulting induced seismicity would be very closely and extensively evaluated for patterns that might indicate an increased rate of larger events that might be felt in Cobb and Anderson Springs. The project includes a detailed modeling and monitoring program and therefore, if such patterns emerge, the injection strategy would be modified to mitigate for such effects.

While non-damaging microseismic activity may increase, the chances of inducing a much larger event are negligible. In general, seismicity induced by geothermal injection increases as the rate of fluid injection increases. Seismicity is also dependent on the amount of fluid injected into the ground, the increase in pore pressure in relation to the orientation of the stress field, the extensiveness of local faults, and the preexisting excess stress on the local faults (Majer 2008). Local faults are not known to be extensive, the project would not include drilling or injecting into any major faults, and the injection wells are not deep (approximately 9,500 feet deep). Majer believes that injection needs to be greater than 15,000 feet deep to induce significant faulting (Majer 2008). The proposed action is therefore not likely to result in any considerable and damaging seismic activity.

Geothermal Resource

It is anticipated that the proposed project would have a positive impact on the geothermal resource. The goal of the injection is to reduce the NCG concentration in the steam in the EGS area by 30-50 percent, to provide a more efficient use of water to generate injection-derived steam, and to support mass replacement in the reservoir, thereby sustaining the energy production potential of the reservoir.

Soils

Stimulation is not expected to impact soils. Some venting of steam may occur during stimulation and low level constituents, such as arsenic and boron, may settle out of the steam onto the ground, but concentrations would be especially low and would wash away with rain.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, injection may occur in either or both wells, depending upon the results from the stimulation phase. Impacts would be similar as described for the stimulation phase and the injection rate would be modified to minimize induced seismic effects to the communities. Monitoring would not have effects on geology, tectonics, or the geothermal reservoir as it would only involve monitoring the response using existing equipment and chemical testing.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts to geology could occur anyway.

3.4 Biological Resources

3.4.1 AFFECTED ENVIRONMENT

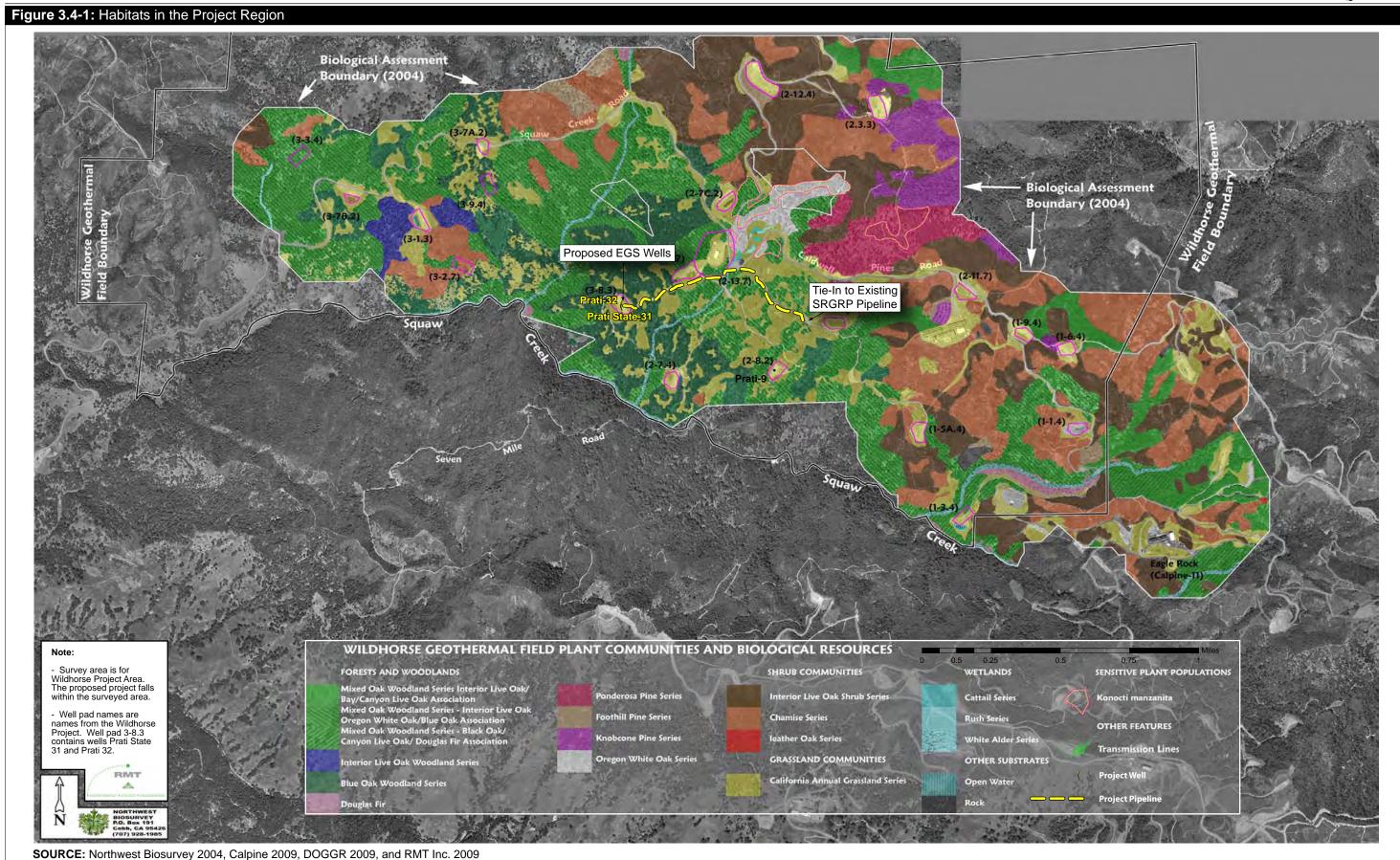
Vegetation

The region supports a variety of brushlands, grasslands, marshland, riparian, woodland, and forest communities. Grassland and herbaceous communities are more limited in distribution, but elements of both native and non-native grasslands can be found scatted throughout the region as understory components of other communities. Where they occur on their own, grasslands are typically dominated by introduced European annuals with California Prairie perennial bunchgrasses and other native vegetation mixed in or found as dominant stands in less disturbed areas.

The well pad and pipeline route is entirely disturbed and comprised of the California Annual Grassland series. California Annual Grassland is a ubiquitous groundcover community and surrounds the existing well pad and SRGRP pipeline location. This community is made up of a wide range of introduced annual grasses.

Adjacent habitats (within 100 feet of the pipeline route) are shown on Figure 3.4-1 and include:

- Blue Oak Woodland Series. The Blue Oak Woodland series occurs on relatively dry exposed slopes north of Squaw Creek and is found interspersed throughout the surrounding grasslands. The structure of the community can range from woodland to open savannah with little to no shrub layer and a continuous groundcover of California Annual Grassland series.
- Mixed Oak Woodland Series-Interior Live Oak. This highly variable community includes a contribution from canyon live oak and foothill pine. Wherever it occurs, it consists of large mature trees either in a woodland or more open savanna form. On dryer, more exposed, south-facing slopes, blue oak or foothill pine become significant members of the community; in areas where these species dominate, the community is mapped with the appropriate series name. Where a shrub layer occurs, it consists of widely scattered manzanita. The groundcover consists of introduced California Annual Grassland.
- Blue Oak Woodland Series. This series occurs as a homogenous blue oak woodland series on the relatively dry, exposed slopes above Squaw Creek. The structure of this community ranges from woodland to open savanna with little or no shrub layer and a continuous groundcover of introduced California Annual Grassland.
- **Knobcone Pine Series.** Dense, homogenous stands of knobcone pine occur as natural communities and as created revegetation sites associated with the closure of CCPA well pads. These dense forests provide 100-percent canopy closure with no shrub or herb layer development (Northwest Biosurvey 2007).





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Wetland and Riparian Areas

Numerous streams have their headwaters in the Mayacamas Mountains. These streams, especially in their downstream, more perennial reaches, support the primary aquatic habitats in the region. Anadromous fish spawning habitat (e.g., steelhead central California coast Evolutionary Significant Unit (ESU)) can be found in nearby Squaw Creek.

Riparian and wetland habitat communities in the region include Cattail series, Rush series, and White Alder series (Figure 3.4-1). The pipeline route and well pad do not overlap any wetland areas; however, White Alder and Cattail series are both found within 0.25 miles of the pipeline route in one location. Cattail habitat communities are usually found near perennial pools of abandoned well pad sumps, roadside ditches, and in slower reaches of principal drainages. White Alder series is a riparian community most often found throughout principal and perennial secondary drainages of the project region and is most often overtopped by Douglas fir and mixed oak woodland trees from the upland community of adjacent steep slopes.

Invasive Species

Invasive plant species are a fairly common occurrence within the rangelands and drainages of southern Sonoma County. The introduction and expansion of invasive non-native plants in the region can threaten biological diversity and may negatively impact sensitive habitats and species. Most invasive species found in the area are widespread and primarily found in disturbed areas, woodlands and grasslands, or riparian habitats. Non-native invasive species in the project region may include:

- Silver hairgrass (*Aira caryophyllea*)
- Black mustard (*Brassica* nigra)
- Field mustard(Briza maxima)
- Yellow starthistle (*Centaurea solstitialis*)
- Bull thistle (Cirsium vulgare)
- Poison-hemlock (*Conium maculatum*)

- Quackingrass (Briza maxima)
- Soft brome (Bromus hordeaceus)
- Red brome (Bromus madritensis ssp. Rubens)
- Tall fescue (*Festuca arundinacea*)
- Italian ryegrass (Lolium multiflorum)
- Pennyroyal (Mentha pulegium)

Most of the invasive species found in the area are widespread and primarily found in previously disturbed areas and roadside ditches, woodlands and grasslands, or riparian habitats (Cal-IPC 2006).

Wildlife

Several wildlife species are known to occur in the general project vicinity and include black-tailed deer (*Odocoileus hemionus columbianus*), California quail (*Callipepla californica*), mountain quail (*Oreortyx pictus*), mourning dove (*Zenaida macroura*), band-tailed pigeon (*Columba fasciata*), wild

turkey (*Meleagris gallopavo*), black-tailed jack rabbit (*Lepus californicus*), brush rabbit (*Sylvilagus bachmani*), and western gray squirrel (*Sciurus griseus*).

The rural setting of the project area supports many raptor and migratory bird species in the surrounding woodlands.

Protected and Special Status Species

Special status species are species that have a designation of endangered, threatened, or a species of concern under either the federal Endangered Species Act (ESA) or the state ESA (as defined by the California Department of Fish and Game (CDFG)). Other protected species include migratory birds under the Migratory Bird Treaty Act (MBTA) and bald and golden eagles under the Bald Eagle Protection Act (BEPA). Plant species identified as threatened or otherwise rare by the California Native Plant Society (CNPS) are also given consideration.

Several protected and sensitive species were identified for the project region. These species were compiled from the following sources:

- A query of the US Fish and Wildlife Service (USFWS) list of endangered, threatened, and candidate species under Section 7 of the ESA
- Plants occurring on the CNPS Electronic Inventory of Rare and Endangered Vascular Plants of California
- A database search of the California Natural Diversity Database (CNDDB) (CDFG 2009)
- The Biological Assessment with Botanical Survey for the Wildhorse Development Project (Northwest Biosurvey 2007)

The biological report for the Wildhorse Development Project (Northwest Biosurvey 2007) included a survey encompassing 2,050 acres and a full, in-season floristic survey. The Wildhorse Development Project area is much larger than the proposed project area; however, the proposed project falls entirely within the Wildhorse Development Project area that was surveyed (as shown in Figure 3.4-1).

The list of potential special status species, their status, habitat affinities, and potential to occur in the project area are included in Appendix H. Key species that could occur in the area are described below.

Plant Species

Konocti Manazanita

Konocti manzanita (*Arctostaphylos manzanita ssp. elegans*) does not have any federal or state status; however, the species is listed by CNPS as sensitive. It is a subspecies of the common manzanita. It is found in chaparral, lower montane conifer forest and volcanic sediments. It blooms from March to May. Known populations are shown in Figure 3.4-1. The nearest population is located about 150 feet north of the proposed SRGRP spur alignment within Oregon White Oak series habitat and Mixed Oak Woodland series (Northwest BioSurvey 2007).

Avian Species

Sharp-Shinned Hawk

The sharp-shinned hawk (*Accipiter striatus*) is a small raptor that prefers cool, moist, well-shaded forest with access to water. It is a California Species of Concern and prefers White Alder series or ponderosa pine and black oak woodland. Nests are usually found in dense stands of conifers near water (Northwest BioSurvey 2007).

Ferruginous Hawk

Typical habitat for the Ferruginous hawk (*Buteo regalis*) consists of isolated perches overlooking open grassland and scrubland for hunting. This species is a California Species of Concern. Suitable wintering habitat for this species occurs in mixed oak woodlands in the project region (Northwest BioSurvey 2007).

Common Yellowthroat

The common yellowthroat (*Geothlypis trichas*), a California Species of Concern, is a passerine transient species that finds food and cover primarily in wetland habitats. It may also nest in riparian areas and grasslands over water or within dense shrubs. Potential habitat exists in the region along perennial drainages (Northwest BioSurvey 2007).

Yellow Warbler

The yellow warbler (*Dendroica petechia*) inhabits riparian woodland such as the White Alder series with dense shrubby understory for nesting and cover. Potential habitat exists in the region along perennial drainages (Northwest BioSurvey 2007).

3.4.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Vegetation, Wetlands, Riparian Habitat, and Invasive Species

Construction activities include construction of the SRGRP pipeline and re-grading the existing well pad. Construction activities would take place on previously disturbed areas, including some paved areas. Minor removal of vegetation may be required on the well pad and the SRGRP pipeline route (located within the shoulder of the access road (Seven Mile Road)) where vegetation has re-established. Re-established vegetation is limited on access roads because of regular travel, regular maintenance, and the existence of the road substrate covering native soils (i.e., gravel or pavement).

Removal of a small amount of vegetation for construction of the pipeline and re-grading of the well pad would not be considered an adverse effect to the general vegetative communities in the area. Ample habitat surrounds the proposed project site that is of higher quality and is undisturbed. No trees would be removed.

Common invasive species are widespread in the region and would most likely be found in previously disturbed areas such as on the well pad and alongside the access road in the project

area. The removal of invasive species during construction would be beneficial to the area. No work would occur within wetland or riparian habitat. Adverse effects to vegetation, wetlands and riparian habitat would not occur.

Wildlife

Removal of vegetation for well pad preparation and construction of the SRGRP pipeline may displace a few common small mammals and reptiles; however, the surrounding habitat is plentiful and adequate to support these animals such that they would not be adversely impacted.

Several large pieces of equipment, as well as trucks and worker vehicles, would access the project site. Vehicles could crush or injure terrestrial wildlife. Keeping vehicles at low speeds would reduce the potential for wildlife mortality. Some mortality of common species, such as lizards and voles, would not be considered a significant adverse impact due to the abundance of these species.

Noise from construction may cause minor impacts to wildlife. Increased noise levels could deter common small mammalian species from occupying the site; however, there is abundant land and habitat nearby for these animals. This impact would not be considered adverse.

Protected and Sensitive Species

No rare or sensitive plant species are expected to occur at the project site. The project pipeline would be constructed on stanchions in the shoulder of the existing graded road. No new areas of ground disturbance would be required to construct the pipeline. The only special status plant identified in the project region is the Konocti manzanita. This species is known to occur about 150 feet away from one section of the pipeline alignment as shown in Figure 3.4-1. The pipeline completely avoids Konocti manzanita. The existing well pad would be re-graded. The currently disturbed nature of the pad as a graded and gravel-covered surface precludes the occurrence of special status plant species. No work would occur beyond the boundaries of the existing pad. No impacts to special status plant species would occur.

Special status avian species known to occur in the project area include:

- Sharp-shinned hawk
- Common yellowthroat and yellow warbler

The sharp-shinned hawk, common yellowthroat, and yellow warbler could breed in oak or riparian woodlands adjacent to the proposed construction areas. Construction noise could cause a significant impact on the nesting of any of these species or other migratory birds. The project includes several measure that require pre-construction avian surveys for each species that could breed in the project area and avoidance until fledging is completed for any active nests identified in proximity of the construction area. The details of the measures by species are identified below:

Yellow warbler and Common Yellowthroat: Any work proposed within riparian woodland habitat between April 1 and August 31 would be surveyed by a qualified biologist. If a nest of either species is discovered within 200 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.

Sharp-shinned hawk: Any work proposed within 500 feet of riparian woodland series such as white alder or cattails series, between April 1 and August 31 would be surveyed by a qualified biologist. If an active nest is found within 500 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.

Avian species protected under the MBTA, such as the ferruginous hawk, could also forage near the project area. These species would likely stay away from the construction area due to the noise. The loss of foraging habitat during construction would be temporary and there is an abundance of surrounding areas for foraging.

Raptors could be significantly impacted by noise if construction were to occur between April 1 and August 31. If construction is to occur during this timeframe, pre-construction surveys would be performed in all construction areas within 500 feet of suitable habitat for raptors. If active nests are found, work within these areas would be halted until after August 31 or until a qualified biologist has determined the nest is no longer active and the young have fledged. Adverse effects to avian species would not occur.

Well Bore Modifications

Vegetation and Invasive Species

The EGS wells are existing wells located on an existing pad. Well testing would include the discharge of steam condensate. Elevated levels of constituents such as boron and arsenic may disperse and settle in the vicinity of the pad during testing; however, the concentration of constituents that reaches the ground would be minor, the area affected would be relatively small compared with the vegetation in the region, and the constituents would likely further dilute and wash away during rain events. Effects to general vegetation would not be adverse. Activities necessary to modify the wells would only occur on the existing gravel pad, and therefore, would not spread invasive species.

Wildlife

Noise from operating drill rigs would be above ambient levels in the immediate vicinity of the drilling, but ample habitats for birds, mammals, and herptiles exist in the surrounding areas; wildlife would be able to avoid these disturbances and would not be adversely affected by drilling noise.

Protected and Sensitive Species

Well bore modifications would only occur on the existing pad and would not directly impact any special status plant species. Breeding habitat for yellow warbler, common yellowthroat, and sharpshinned hawks does not occur within 500 feet of the well pad. Drilling noise would not adversely affect these species. Blue Oak Woodland surrounds the pad. Other protected raptors could breed in this habitat and could be disturbed by drilling noise and activities required for well bore modifications. If well bore modifications (including drilling) were to occur between April 1 and August 31, pre-construction surveys for breeding raptors would be performed within 500 feet of the well pad. If active nests are found, well bore modifications would be halted until after August 31 or a qualified biologist has determined the nest is no longer active and the young have fledged.

Stimulation and Long Term Injection, Data Collection, and Monitoring

The stimulation phase of the project would involve the continuous flow of water at varying rates from the newly constructed SRGRP pipeline to the re-opened wells. The wells would be closed and monitored during the data collection and monitoring phase, with periodic short-term flow testing during that monitoring period. Stimulation and long-term injection, data collection, and monitoring of the geothermal wells would not have an adverse effect on general vegetative communities. Stimulation and monitoring activities would not require removal of vegetation; access to and from the wells and project components would be on gravel or paved access roads and pathways. Data collection and assessment would be done remotely and would have no impact on vegetation, wildlife, or special status species. Stimulation, data collection, and monitoring would not cause the spread of invasive species. Short-term flow tests (steam venting) would occur during stimulation; however, venting would only occur occasionally for short periods of time (about 8 hours). Noise impacts during this phase would be negligible and would cause minor, but not adverse, effects to wildlife.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impact to biological resources could occur anyway.

3.5 Water Resources

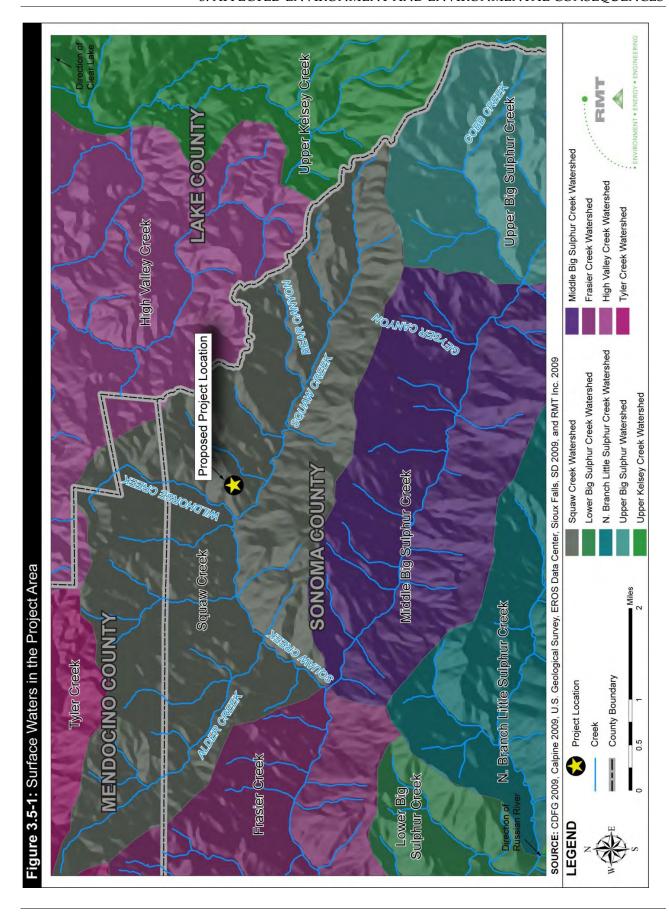
3.5.1 AFFECTED ENVIRONMENT

Surface Water Hydrology

The project site is located in the Mayacmas Mountains at an elevation of approximately 2,100 feet above mean sea level (amsl). The Geysers is located within the Big Sulphur Creek and Squaw Creek Watersheds, which are tributaries of the Russian River.

The average seasonal precipitation in the mountains of the project region can be in the range of 70 to 80 inches (Sonoma County 2008). Storm events typically occur between November and April. There is no snow pack during winter and intermittent snows melt off after a few days.

The topography is rugged and runoff is quickly directed into stream channels. Runoff at the project site typically flows downgradient to either Wildhorse Creek or Squaw Creek, which are located to the west of the project area (Figure 3.5-1). During summer months or periods with infrequent rainfall, these tributaries may dry up.



The largest nearby surface water body is Clear Lake, located 10.3 miles to the northeast of the project area.

Groundwater Hydrology and Use

According to the California Department of Water Resources (DWR), the project is located within the North Coast Hydrologic Region; however, the groundwater-yielding basin within Sonoma County is located to the south of the project area (DWR 2009). No regional groundwater aquifers of significant yield have been reported in the Mayacmas Mountains near The Geysers (Sonoma County 2005).

Water Quality

Surface and Ground Water Quality

Groundwater is limited in the project region; however, the nearest groundwater basin is the Alexander Valley Groundwater Basin, Cloverdale Area Subbasin. Water quality where groundwater occurs in this basin is characterized as moderately-hard to hard (water that is high in minerals such as calcium and magnesium) and is generally suitable for all uses (DWR 2009). Groundwater within the Cloverdale Area Subbasin has detectable total dissolved solids (TDS) levels between 130 and 304 milligrams per liter (mg/L) and three wells have had boron levels exceeding 0.5 mg/L. Boron values are not expected to restrict uses of the water.

Water Quality Regulations

Water quality is regulated by the federal Clean Water Act (CWA). Important applicable sections of the CWA include the following:

- Sections 303 and 304 provide water quality standards, criteria, and guidelines.
- Section 401 requires an applicant for any federal permit that proposes an activity that
 may result in a discharge to waters of the US to obtain certification from the state that
 the discharge will comply with other provisions of the CWA. Certification is provided
 by the Regional Water Quality Control Board (RWQCB).
- Section 402 establishes the National Pollutant Discharge Elimination System (NPDES), a
 permitting system for the discharge of any pollutant (except for dredged or fill material)
 into waters of the United States.
- Section 404 establishes permit programs for the discharge of dredged or fill material into waters of the United States. This permit program is administered by the United States Army Corps of Engineers.

Calpine has a Waste Discharge Order (WDO) [Order No. R1-2009-0103], last revised and approved December 10th 2009 for their activities at The Geysers.

3.5.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Surface Water Hydrology

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. The well pad would be re-graded and a perimeter earthen berm would be constructed. Drainage culverts would be constructed and sub-grade water collection points, for the retention of storm water and as a contingency for spills from the drilling operation, would be installed. The installation of the drainage system would minimize potential adverse impacts to surface water hydrology in the project area.

The construction of the 1.0 mile long SRGRP pipeline spur would occur along the shoulder of existing access roads, creating no new ground disturbance in previously undisturbed areas. The pipeline would be installed on stanchions in the road shoulder. The limited footprint of the stanchions would not have an adverse impact on surface water flow and run-off. Erosion control methods and BMPs would be utilized (such as certified weed-free straw waddle) to reduce erosion or siltation on- or off-site. No water would be released to the surface from the pipeline during testing or operation of the pipeline.

Construction activities may require water for dust control. This water is expected to saturate the ground in the vicinity of the road and would not create the potential for water runoff that could alter the local hydrology.

Groundwater Hydrology and Use

All non-potable water necessary for well pad grading and construction of the SRGRP pipeline would be supplied by the existing Calpine entitlements or the SRGRP pipeline. Adverse effects to groundwater would not occur.

Water Quality

The project would not violate any water quality standards or WDRs. The North Coast RWQCB Board Order No. R1-2009-0103 covers the project area. A SWPPP would be developed and a Notice of Intent would be submitted prior to grading or construction activities.

Stormwater run-off could become contaminated with petroleum fuel, oil, or grease from construction vehicles and equipment and from drilling mud and fluids. Contamination of stormwater run-off at the drilling pad would be minimized through installation of the drainage system and collection of run-off in the reserve tank. Contamination during construction along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater. Calpine would implement an SPCC on-site to contain incidental drips and/or spills. Containment berms would be constructed around all hazardous material or potentially hazardous material storage for both construction and operation. The plans would identify equipment and procedures used for containment and recovery of accidental spills.

Well water (under current Calpine entitlements) or tertiary treated recycled water from the existing SRGRP pipeline would be used for dust suppression. This water has undergone tertiary treatment and complies with all applicable water quality standards for ground application for dust suppression. Adverse effects to water quality would not occur.

Well Bore Modifications

Surface Water Hydrology

Well bore modifications would not have effects on surface water hydrology. All re-drilling would occur from within the well pad, which would have a drainage system installed to contain stormwater. Adverse effects to surface water hydrology would not occur from well bore modification activities.

Groundwater Hydrology and Use

Well re-drilling would require approximately 20,000 gallons of water per day (approximately 14 gpm), for 30 days, for each well, which would come from well water (under current Calpine entitlements) or tertiary treated recycled water from the SRGRP pipeline. No other groundwater users (besides Calpine) are located in the area. No adverse effects would occur from temporary use of groundwater for drilling water supply.

Water Quality

Well bore re-drilling and testing would not impact water quality. The wells would be cased and BOPE would be installed to minimize blowouts or contamination of the localized shallow aquifer as required by CDOGGR regulations. A blank liner would be installed through the normal temperature geothermal reservoir and perforated liners would be installed through the HTZ reservoir. Blank liners do not let fluid pass into or out of the well, while perforated liners allow for fluid exchange. The surface casing and cemented blank liners would minimize cross contamination of constituents from the reservoir into usable groundwater. Adverse effects to water quality would not occur.

Stimulation

Surface Water Hydrology

Stimulation would include the injection of water from the SRGRP pipeline into the injection wells. Stimulation would have no impacts on surface waters or hydrology as it would not involve any water discharge to the surface. Injection would occur through an automated injection system installed at the well head.

Groundwater Hydrology and Use

No groundwater would be used for stimulation. Injection water would be provided by the SRGRP. The injection rate would range between 100 and 800 gpm, depending on the ability of the fracture to accept the fluid. The SRGRP provides 11 million gallons of water per day (7,638 gpm) to The Geysers and would have ample supply necessary to provide the proposed project with injection water.

Water Quality

Surface water would be unaffected by injection. Injection would occur through an automated injection system installed at the well head. Groundwater is limited in the project area and would be protected from injection through casing and liners.

Injection would occur under an updated WDO that would address injection of effluent and condensate into the EGS wells. The injection reports would also be submitted to the CDOGGR. Injection of water and disposal of waste discharge due to drilling would comply with all requirements outlined in the permit.

Injected water would be from the SRGRP tertiary treated recycled water. This water would be injected into the HTZ. This water would have fewer constituents than that found in steam in the HTZ (e.g., constituents found in noncondensable gases). Therefore, stimulation is expected to have a positive impact on the quality of the steam from the HTZ.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Effects to surface water hydrology, groundwater hydrology and water quality would be similar to those described for the stimulation phase.

Surface hydrology and groundwater hydrology and use would not be impacted as no activities would occur on the surface and no groundwater resources would be used. Effects to water resources would not be adverse. Effects to the geothermal reservoir are addressed in *Section 3.3 Geology*.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts to water resources could occur anyway.

3.6 Cultural Resources

3.6.1 Affected Environment

Prehistory

Prehistoric sites in the general project region show affinities to prehistoric cultures that lived to the north in Mendocino County, the east in Lake County, and to the south in the San Francisco Bay area. Numerous prehistoric sites have been recorded in the general geographic area in which the project is located. Hundreds of sites were recorded in the Geysers area during an intensive survey of more than 64,000 acres (Fredrickson 1976a, b).

Historic Settlement

The historic settlement of Sonoma County began with the Russian settlement of Fort Ross, which was founded in 1812 on the Sonoma Coast. Sonoma Mission (Mission San Francisco de Solano), which was designed to prevent further Russian settlement inland, was founded in 1823. Operational aspects of the California mission system resulted in disastrous consequences for the indigenous peoples throughout Northem California, including the Southem Pomo, who occupied the patt of Sonoma County in which the project is located (Ashcroft 2004, Cook 1976).

With Mexican independence from Spain in 1821, large ranchos were established throughout northern California, including 27 on land grants in Sonoma County (Sonoma County Historical Society 2004). Cattle ranching and timber became the economic mainstay in Sonoma County until the Gold Rush, when the large population influx created a demand for other consumer products, most notably dairy products.

In 1859, a mining district was organized in the project area based on the abundant indications of mercury ore (cinnabar or mercury sulfate) in the area. The Cloverdale quicksilver mines near Big Sulphur Creek were operating a furnace by 1877. Eventually, interest in mercury mining faded due to financial losses. Interest was revived in 1972 when the price of mercury (quicksilver) increased to attractive levels. Geothelmal energy was first tapped commercially at the Geysers in the 1920s, when steam from shallow wells was used to generate electricity for a resort on Big Sulphur Creek.

By 1955, full-scale commercial development had begun (Atkinson 1988). The Wildhorse steamfield was originally developed by Geothermal Resources International in the 1980s. Well site pads with associated drilling waste sumps were constructed, along with roads, pipelines, transmission lines, and other appertenant facilities, to supply steam to the Central California Power Agency (CCPA) No.1 Power Plant, which began commercial operation in 1988. CCPA No. I Power Plant and steamfield were placed on long-term lay-up condition in 1996 and were later decommissioned. The plant decommissioning, plugging, and abandonment of the wells and the subsequent restoration activities occurred from 1999 through the early 2000s (WSA 2005).

Ethnography

Archaeological data in the region indicates that the part of Sonoma County in which the project is located was occupied, at least intermittently, for the past six millenia. The projects location borders on three different Native American cultural groups: the Pomo, Wappo, and Lake Miwok. Since the period of initial contact with Europeans, the main native inhabitants of the area have been the Southem Pomo. The Southem Pomo are one of the seven subdivisions within the linguistic group known as the Pomo, and are historically one of the largest groups of Native Califomia peoples. The Southem Pomo are known to have established villages in Sonoma, Lake and Napa counties. Their territory lay in Sonoma County and extended five miles south of Santa Rosa, northward for 40 miles nearly to the county border, and from the Russian River's castem drainage, westward to Kashaya and Central Pomo territory, with a narrow extension to the coast between the two different Pomo groups (Heizer 1978). The project's southern location also borders on Wappo territory, and it is known that the Wappo crossed through Pomo territory on their yearly migration to Clear Lake. Wappo territory extended from Cloverdale and Middletown in the north,

to areas around Napa's northem border. The Wappo's annual journey to Clear Lake may have lead to the formation of a pemlanent Wappo conclave located at the southern end of Clear Lake (Heizer 1978). The Lake Miwok inhabited areas near the project site, but do not seem to have inhabited or used the land that the project site is located (WSA 2005).

Cultural Studies

The proposed project area has been covered by several surveys since 1974. The most recent surveys were conducted by William Self Associates (WSA) in 2005 and 2007 for the Wildhorse Development Project area. The proposed project area falls within the area assessed for the Wildhorse Development Project. The report was prepared to identify and analyze the potential impacts to cultural resources in the area.

Twenty two cultural resource studies have been conducted in or within a 1/4 mile radius of the Wildhorse Development Project area. WSA archaeologists surveyed five block areas totaling approximately 38 acres and along existing unpaved roadways totaling approximately 17 acres. Those surveyed included a portion of the roadway that would provide access to the proposed project's location and on which the pipeline spur would be constructed. No cultural resources were found along the portion of roadway surveyed in 2005 and 2007(WSA 2005; WSA 2008).

A summary of the surveys that included portions of the project area is included below.

- The well pad site containing PS-31 and P-32 was surveyed in 1974 (Fredrickson 1974).
 No resources were found.
- The access road on which the proposed pipeline spur will be constructed, up to the junction with Seven Mile Road (leading to well Prati-9) was surveyed in 1975 (Fredrickson 1975), and resurveyed in 2005 by WSA. The additional spur up to the junction with Coldwater Creek Road and West Sqauw Creek Road was resurveyed in 2007 by WSA. No cultural resources were found in any of these surveys.
- The remaining portion of the proposed pipeline route along West Squaw Creek Road to the proposed pipeline tie-in location was surveyed in 1975 (Fredrickson 1975). Two sites were identified along this road.
 - P49-775 (initially identified as CA-SON-834 in 1975 report). This site was revisited by WSA in 2007 and is described further below.
 - P49-780 (initially indentified as CA-SON-839 in 1975 report), located on either side of Squaw Creek Road.

Site P49-775 was reevaluated by WSA in 2007. The site was found to no longer exist during this survey due to the all the previous road construction and general disturbance from historic activities associated with geothermal activity (WSA 2008). The original site included obsidian flake scatter and was a probable midden (a pre-historic refuse collection).

Site P49-780 has not been revisited since the 1970s. However, the site is described in the 1975 report and summarized in the Wildhorse A-2 Geothermal Field Development Project Draft EIR (Environmental Science Associates 1984) as a scatter of obsidian flakes having poor integrity because of heavy damage from the previous construction of the road through the area and site. The road has been in constant use for over 35 years.

3.6.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

The proposed project includes some drainage work on the existing well pad, entirely within the currently disturbed area that defines the pad. Pipeline stanchions would be installed for a 1 mile length of pipeline; however, the stanchions would be installed within the shoulder of the existing roads. All work would occur in the existing roadway and would not require disturbance of previously undisturbed areas. Staging would occur along the road and at the well pad. Pipe would be stored only in approved, previously disturbed, staging areas.

A condition from the Wildhorse Development Project has been incorporated into the proposed action to further protect cultural resources. The condition requires placing the following note on all construction plans and providing the language to all contractors and superintendents on the job site: "Should any previously unknown historic or prehistoric resources, including but not limited to charcoal, obsidian or chert flakes, grinding bowls, shell fragments, bone, pockets of dark, friable soils, glass, metal, ceramics, wood or similar debris, be discovered during grading, trenching or other on-site excavation, earthwork in the vicinity of the find shall cease, and the County of Sonoma Permit and Resource Management Department (PRMD) staff shall be notified so that the find can be evaluated by a qualified archaeologist (i.e., an archaeologist registered with the Society of Professional Archaeologists). When contacted, a member of PRMD Project Review staff and the archaeologist shall visit the site to determine the extent of the resources and to develop proper mitigation measures required for the discovery. No earthwork in the vicinity of the find shall commence until a mitigation plan is approved and completed subject to the review and approval of the archaeologist and Project Review staff."

The proposed pipeline spur along West Squaw Creek Road has not been surveyed recently; however, the road has been heavily used for greater than 35 years. Site P49-775 was determined to no longer exist in surveys conducted by WSA in 2007, and therefore, the project would not impact this site. This site is also north of the edge of the paved road, while the pipeline would be installed within the road edge. Site P49-780 was not revisited in 2007; however, in 1975 the site was described as heavily disturbed by previous road construction. The project includes a requirement that a qualified archaeological monitor be present during pipeline construction along all of West Squaw Creek Road to the tie-in location to ensure that no construction activities occur outside of the existing disturbed road shoulder and to monitor for cultural materials during construction. If a resource is found during construction, the monitor shall have the authority to stop construction until it can be further evaluated. The pipeline would be installed above-ground on stanchions, such that ground disturbance is already minimized to only the stanchion footings. The stanchions are a comprised of a piece of wood about 16 by 2 by 4 inches (the wood "sleeper"). The piece of wood is anchored into the ground by 2 pieces of rebar, which are pushed about 4 feet into the ground. Any resource found would be avoided by spanning over the resource and/or moving the pipeline to avoid the resource.

3.7 Noise

3.7.1 AFFECTED ENVIRONMENT

Noise Definitions

Noise is defined as unwanted and objectionable sound. The objectionable nature of sound can be caused by its pitch (the height or depth of a sound) or its loudness. Sounds with higher pitch seem louder to humans than sounds with lower pitch. Sound levels are usually measured and expressed in decibels (dB) with 0 dB corresponding roughly to the threshold of hearing. The method commonly used to quantify environmental sounds consists of evaluating all frequencies of a sound in accordance with a filter that reflects the fact that human hearing is less sensitive at very low and very high frequencies compared to mid-range frequencies. This is called "A" weighting, and the dB level measurement is called the A-weighted sound level (dBA).

A-weighted sound level (dBA) is expressed on a logarithmic (power of 10) scale using a frequency-weighted pattern that duplicates the human ear's sensitivity to sound. A 70 dBA sound level is approximately twice as loud as a 60 dBA sound level and four times as loud as a 50 dBA sound level. Table 3.7-1 lists the definitions of various acoustical terms used in this analysis.

Ground-borne Vibration

Vibrating objects in contact with the ground radiate energy through the ground. Vibrations from large and/or powerful objects are perceptible by humans and animals. The rumbling sound caused by vibrating surfaces is called ground-borne noise. Ground motion caused by vibration is measured as particle velocity in inches per second, and in the United States is referenced as vibration decibels (VdB) (Caltrans 1998).

The background vibration velocity level in residential and educational areas is usually approximately 50 VdB. The vibration velocity level threshold of perception by humans is approximately 65 VdB. A vibration velocity level of 75 VdB is the approximate dividing line between barely perceptible and distinctly perceptible levels for most people.

Typical outdoor sources of perceptible ground-borne vibration are construction equipment, steel-wheeled trains, and traffic on rough roads. If a roadway is smooth, the ground-borne vibration from traffic is rarely perceptible. Ground-borne vibrations generally lie within the range of approximately 50 VdB, which is the typical background vibration velocity level, to 100 VdB, which is the threshold where minor damage can occur in fragile buildings (Caltrans 1998).

Noise Sources and Receptors

The noise environment is affected by geothermal resource operations in The Geysers geothermal field. Some of the noise sources associated with geothermal operations are relatively steady (e.g., cooling towers), while others are intermittent, but very intrusive (e.g., steam blowdowns). Wells PS-31 and P-32 are 2 miles from the Geysers 11 power plant and 2.5 miles from the Aidlin 1 power plant. The nearest operating well pad is located 1.5 miles away from PS-31 and P-32.

Table 3.7-1: Definition of Acoustical Terms Used in this Report						
Terms	Definitions					
Decibel, dB	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20.					
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e.g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.					
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.					
Equivalent Noise Level, L _{eq}	The average A-weighted noise level during the measurement period. The hourly L_{eq} used for this report is denoted as dBA $L_{eq[h]}$.					
Day/Night Noise Level, L _{dn}	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.					
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.					
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content, as well as the prevailing ambient noise level.					

SOURCE: Caltrans 1998

Noise sources in the immediate vicinity of the proposed project area are typical to a rural landscape. Ambient noise is dominated by the natural setting and the baseline noise setting is similar to that found in a quiet rural area, between 30 to 40 dBA.

The project site is located within a previously developed and privately held geothermal area. The nearest potential sensitive receptor to project noise, which is a residence, is located 2 miles away from the proposed project area.

The source of ground-borne vibration in The Geysers is predominantly from heavy equipment usage.

Noise Standards and Policies

Several federal government agencies and states have developed guidelines regarding the types of land uses that are acceptable within noise-impacted areas. Where state guidelines are unavailable, local governments normally rely on the federal standards.

Sonoma County has identified geothermal development as a specific source of noise and has set a noise limit of 65 dBA at the exterior property line of any affected residential or sensitive land use. Noise standards are further established through the Use Permit process for individual geothermal development projects (Sonoma County 2008b). Calpine obtained a Use Permit from Sonoma County for the Wildhorse Development Project. The proposed project falls within the Wildhorse Development Project area.

3.7.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Noise Generation

General construction noise would result from the use of heavy equipment for construction of the SRGRP pipeline and re-grading the existing well pad. Maximum noise levels generated by construction activities typically range from about 85 to 90 dBA at a distance of 50 feet. Typical hourly average construction noise levels are about 10 dBA less than the maximum during busy construction periods (e.g., while earth moving equipment is operating). Table 3.7-2 lists the estimated maximum construction noise that may be heard at varying distances from the project activity. The nearest sensitive receptor is 2 miles away (from the pipeline and 2.75 miles away from the well pad).

Construction of the SRGRP pipeline and re-grading of the well pad would only occur during typical working hours. Maximum noise heard by the nearest residence would fall within a range compatible with a residential setting, which is approximately 49 to 60 dBA, with hourly averages from about 39 to 50 dBA. Noise generation would be below the acceptable range for daytime hours at the residence (acceptable noise range for daytime is 50 to 70 dBA) (Sonoma County 2008b). Construction would not occur during the nighttime.

Table 3.7-2: Estimated Noise Heard from Construction Activities					
Distance from Project Site	Estimated Noise Heard from Construction Activities				
100 feet	85 to 90 dBA				
1,600 feet	60 to 65 dBA				
3,200 feet	55 to 60 dBA				
~10,500 feet (2 miles, nearest residence)	45 to 50 dBA				

SOURCE: RMT Inc 2009

The conditions of the Use Permit for the Wildhorse Development Project would be implemented for the proposed project, as applicable. These conditions include measures that require noise to be controlled in accordance with the standards set in the Noise Element of the Sonoma County General Plan. The project also includes measures to address noise complaints. If investigation of noise complaints indicates that the appropriate noise standard levels have been or may be exceeded, Calpine would install, at their expense, additional professionally designed noise control measure(s).

Construction truck traffic, including haul and delivery trucks, would contribute to roadside noise levels; however, the number of truck trips per day on the private road used to access the sitewould be relatively few, and the duration that any one road would be used for construction purposes would be brief and not significantly adverse.

Vibration

Construction activities (e.g., ground-disturbing activities, including re-grading and the use of heavy construction equipment) may generate temporary localized ground-borne vibration. Construction activities would only occur during daytime hours and would result in short-term (i.e., no more than one or two days) impacts from vibration. Vibration attenuates quickly over distance. No buildings or structures are located within an area that would be affected by project-related vibration. Impacts from vibration would not be adverse.

Well Bore Modifications

Noise from re-opening and modifying the existing geothermal wells would have the most effect, as drilling would occur 24 hours per day, 7 days per week. Noise impacts from drilling would be temporary, lasting up to one month for completion of each well. The closest sensitive receptor is 2.75 miles away from the well pad. The loudest noise source while drilling a well is typically the noise emitted from air compressors (used while drilling with air). Air compressors can generate noise levels up to 85 dBA at 100 feet. Occasionally, wells are allowed to vent at full pressure for several hours to prevent the buildup of condensate. Because this operation is not usually muffled, noise levels of about 118 dBA can be produced. Well blowouts, generally caused by equipment strength being insufficient to withstand the steam pressure, can also cause noise levels similar to venting. Both of these events are very rare, especially the well blowout, which is an uncontrolled flow event.

Table 3.7-3 shows the typical noise from various drilling activities at varying distances, without the use of abatement measures.

Despite the temporary nature of the drilling, it could generate exterior noise from 85 dBA, at 100 feet; however, no noise receptors are located within 100 feet of the well pad. The closest sensitive receptor to drilling activities is located 2.75 miles from the well pad. Due to the great distance and the intervening topography of the surrounding area, drilling noise would attenuate to an acceptable level (~42 dBA), similar to a quiet suburban setting, at the closest residences. Unabated venting would generate more noise, about 75 dBA at the nearest residence. This noise may be less due to intervening topography. Venting noise would only occur for relatively short periods of

Table 3.7-3: Typical Noise from Geothermal Drilling Activities (dBA) Without Abatement									
Activity	100 ft.	200 ft.	500 ft.	1,000 ft.	2,000 ft.	5,000 ft.	*14,520 ft.		
Well drilling (include use of air compressors)	85	79	71	65	59	51	42		
Steam venting or well blowouts	118	112	104	98	92	84	75		

Notes:

Identified noise levels are given for various distances from a proposed noise-generating source. These noise levels do not account for the topographical barriers throughout the project vicinity, which may absorb or deflect sound waves, thereby reducing noise levels.

SOURCE: HIII and Phelps 1980; CEGC 1994; RMT Inc 2009

time (hours); however, unabated could exceed the acceptable noise range for daytime of 50 to 70 dBA at the nearest residence (Sonoma County 2008b).

Adverse effects would be reduced through installation of temporary noise mitigation measures associated with the drill rig motors and air compressors, as described in the County Use Permit in order to minimize noise. With abatement, venting noise would be within the acceptable range and adverse effects would not occur. Additional equipment such as the mufflers and bleed valves would also be implemented to minimize noise impacts associated with drilling activities. Calpine would also accept and work to remedy any noise complaints.

Vibration

Vibration associated with ground drilling activities and well modifications could generate maximum vibration levels up to 103 to 104 VdB at 25 feet; however, vibration levels would attenuate to an indiscernible level due to the intervening distance between the project area and the nearest sensitive receptor and would not be adverse.

Stimulation

The stimulation phase of the project would involve the continuous flow of water from the newly constructed SRGRP pipeline to the re-opened wells at varying rates. An injection program would be designed to study the response of pre-existing fractures in the HTZ varying pumping rates. Stimulation would require some steam venting; however, venting would only occur occasionally for short periods of time (8 hours). Noise would be heard by the nearest residences during venting; however, venting would only occur for 8 hour periods once every 12 months. Noise could be as much as 75 dBA at the nearest residence during venting and could temporarily exceed County standards. If noise complaints are received, Calpine would implement measures to reduce noise during venting such as through installation of a noise barrier around the pad.

^{*14,520} feet is 2.75 miles, the distance from the well pad to the nearest residence.

Noise impacts at all other times during this phase would be negligible and would not exceed County standards or stipulations set forth in the project Use Permit. No vibration impacts would occur.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Effects from noise would be similar to those described for the stimulation phase. If noise complaints are received, Calpine would implement measures to reduce noise during venting such as through installation of a noise barrier around the pad.

Monitoring and modeling techniques would be used to analyze data collected from well logging and testing. Monitoring would be continuously performed; however, noise levels would be similar to ambient conditions. Monitoring would not require the presence of any additional noise-generating equipment and no significant noise would be generated. No vibration impacts would occur.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its noise impacts could occur anyway.

3.8 Visual Resources

3.8.1 AFFECTED ENVIRONMENT

Regional Visual Setting

The Geysers are located within the Mayacmas Mountains, which are part of the Inner Coast Ranges of the California Coast Range, in Sonoma and Lake Counties. The predominant visual characteristic of the project region is rugged mountains with elevation ranges up to approximately 5,000 feet (Sonoma County 2008b). The rugged natural landscape is regularly disrupted in the region by power plants, steam collection lines, roads, cut and fill slopes, and other features of the extensive geothermal development.

Local Visual Setting

Project Area

The proposed project area is located at an elevation of approximately 2,100 feet and is surrounded by hills and mountains covered by a mixture of pine and oak forests with grassy groundcover. Visibility in the region is good, although precipitation and localized topography can all reduce regional visibility.

Viewsheds

A viewshed is an area that can be seen from a given vantage point and viewing direction. A viewshed is composed of foreground items (items closer to the viewer) that are seen in detail and background items (items at some distance from the viewer) that frame the view. The area in between is the mid-ground. The viewshed changes as a person moves along a roadway (a view corridor), with the foreground items changing rapidly and the background items remaining fairly consistent for a long period of time.

The viewshed at the project site is shaped by the regional features in the background (i.e., Ottoboni Ridge to the south-southeast, Cobb Mountain to the east) and local land uses in the foreground. The viewshed at the project site includes mountain ranges in the background and the existing unpaved roads and well pads in the foreground and mid-ground. The background of the viewshed is more aesthetically pleasing than the foreground and mid-ground in the project area.

Figure 3.8-1 depicts views of the project site and region.

Sensitive Receptors

The closest potential sensitive receptor in the proposed project area is located 2 miles from the proposed pipeline. Viewer sensitivity would be the highest for residents at elevations above the project area, in the surrounding hills found throughout The Geysers. The site is not readily visible from many other locations in the region due to lack of access to the general public (i.e., few public roads) and intervening topography.

3.8.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

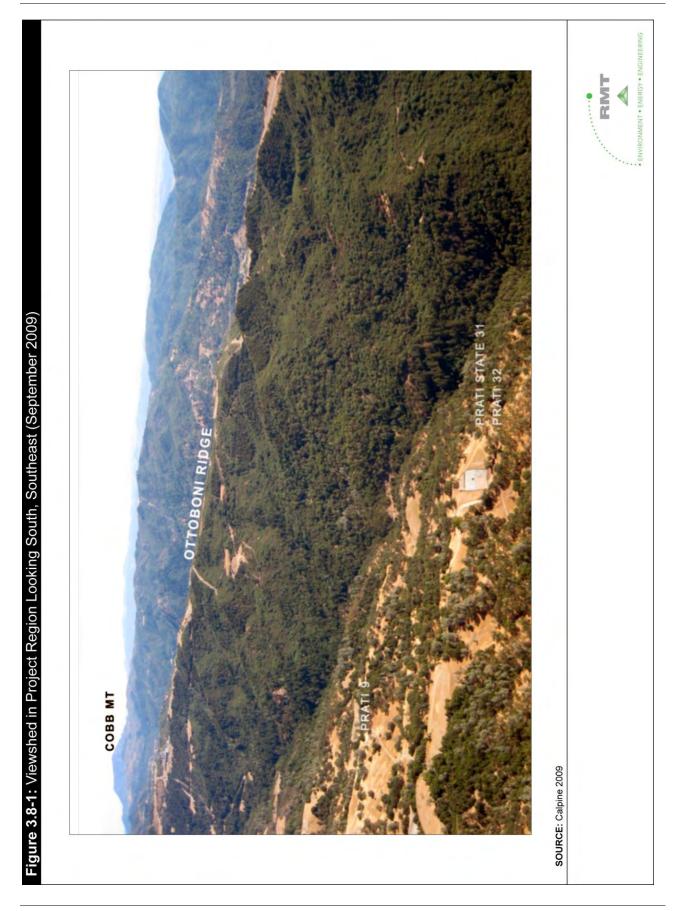
Construction Activities

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. Visual impacts from construction activities would result from:

- Views of construction equipment and facilities
- Views of disturbed ground during well pad preparation and construction of the SRGRP pipeline
- Views of the SRGRP pipeline spur

Preparation of the well pad and construction of the 1-mile long SRGRP pipeline spur would create short term visual impacts from the presence of construction equipment and ground disturbing activities. All ground disturbing activities would take place on previously disturbed areas.

Temporary visual impacts from construction would not be an issue because most of the viewshed from the project area is either private land and/or areas under controlled access. Few close-in view opportunities are available to the public (residents and visitors), whose viewing opportunities are



mainly afforded from Highway 175. These are distant views of the project area, and the site cannot be directly seen from any vantage points along the highway. The mountainous topography and lack of through roads preclude all but distant views of the project area.

The SRGRP pipeline spur would be painted in earth-tone colors if any segment is visible to the public.

Well Bore Modifications

Visual impacts from well bore modifications could result from:

- Views of drilling equipment and facilities on the re-established well pad
- View of the 135 foot tall drill rig for approximately 30 days
- View of steam plumes during well re-drilling
- Glare from lighting on the drill rig

The drill rig could be visible to surrounding land users, including distant residents. The drill rig would be visible from higher elevations, but would not interrupt the scenic background views of the surrounding hills. Drilling activities are anticipated to take approximately 30 days to complete and visual impacts from the presence of the drill rig and associated equipment would be temporary and would not be adverse. Steam plumes from the drilling could also be visible, but would not be large enough to block or obstruct background views. Drill rigs and steam plumes are generally in character with geothermal development in the project region. The remainder of the well equipment for drilling would blend into the foreground where it would not be visible to receptors (i.e., residents) due to distance.

Re-drilling would occur 24 hours a day, 7 days a week for about 1 month per well. Lighting would be required on the drill rig during nighttime drilling. Lighting could generate glare and affect the nighttime sky, due to the relative remoteness of the project; however, the project includes requirements for rig lights to be shaded and focused downwards to reduce nighttime glare from the well pads during re-drilling operations.

Visual impacts from well bore modifications of the EGS wells would not be considered adverse.

Stimulation

Stimulation is the process of injecting water into the HTZ through the new SRGRP pipeline spur and into the injection system at the well heads. This process would not be visible. Steam plumes may be visible from the well heads if venting is required during stimulation, and may extend tens of feet into the air. Given the distance of the well pad from any urban development and the surrounding topography, steam plumes would not obstruct background views for any nearby viewers. Impacts to visual resources from the steam plume would not be considered adverse and are generally in character with geothermal development in the project area.

Temporary lighting during emergencies may be required on the well pads but would be shielded, directed downward, and only on for short periods of time, so as to avoid adverse effects.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Effects to visual resources would be similar to those described for the stimulation phase and would not be adverse. There would be no new visual impacts from data collection, assessment, and monitoring. Equipment used to monitor would be existing and use of these systems would not be visible from receptors due to their distance and the small size of monitoring equipment.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impact could occur anyway.

3.9 Hazardous Materials, Waste Management, Human Health and Safety, and Risk Assessment

3.9.1 AFFECTED ENVIRONMENT

Hazardous Materials

Hazardous materials are those substances that, because of their physical, chemical, or other characteristics, may pose a risk of endangering human health or safety or of endangering the environment (California Health and Safety Code Section 25260). Types of hazardous materials include petroleum hydrocarbons, pesticides, and volatile organic compounds.

Two superfund sites are located in Sonoma County, the MGM Brakes site near Cloverdale and the Sola Optical USA site located near Petaluma. Both sites are remediated and are located far from the proposed project site (EPA 2009c). A review of the state Cortese List shows that neither the project area nor the immediate area around it is a hazardous materials release site per Government Code § 65962.5.

The project area is located in a geothermal resource area that has naturally occurring hazardous substances found in the soils, groundwater, and geothermal steam. These hazardous substances include asbestos (from serpentinite rock) and heavy metals such as mercury, sulfur, and arsenic. Other hazardous materials such as hydrocarbon fuels are used regularly as part of geothermal operations in the project region.

Waste Management

Waste Characterization

Waste must be managed and disposed of in accordance with its hazard classification. Waste can be classified as either hazardous or non-hazardous. Hazardous wastes are defined by one of three types, including:

- Resource Conservation and Recovery Act (RCRA) hazardous waste
- Non-RCRA hazardous waste
- Universal waste

Wastes classified as "hazardous" under RCRA are listed on one of the RCRA hazardous waste lists (e.g., F-list, K-list, P-list, or U-list). These wastes meet federal definitions as having one of the hazardous characteristics of ignitability, corrosivity, reactivity, or toxicity, and/or is a mixed hazardous waste as defined in 40 CFR Part 261.

Non-RCRA hazardous wastes are wastes that have hazardous characteristics, but do not meet the federal definition of a hazardous waste. In California, waste oils and wastes containing or contaminated with waste oils are considered to be a non-RCRA hazardous waste (Title 22, CCR §66261.101).

Universal wastes are materials that are hazardous upon disposal but pose a lower risk to people and the environment than other hazardous wastes (40 CFR Part 273.9 and 22 CCR § 66273.1). Generators of waste are responsible for determining whether or not the wastes they generate are classified as hazardous or not pursuant to federal and California requirements.

Waste Disposal Facilities

Waste disposal facilities in the project region include Calpine's GDMACDA Waste Management Unit and the Super Sump Solid Waste Management Facility, which is also owned and operated by Calpine in The Geysers. These facilities are permitted by the RWQCB North Coast Region and the Sonoma County Health Department to accept non-hazardous drilling wastes. Hazardous material would be transported off-site to the Kettleman Hills Landfill, managed by Chemical Waste Management, a Class I, II, and III disposal facility in Kettleman Hills, CA, which is permitted to accept hazardous wastes. (Chemical Waste Management 2008). The landfill is permitted to accept 8,000 tons of waste per day, with a remaining landfill capacity of 6 million cubic yards (CH2M HILL 2008).

Human Health and Safety

Safety Training

Safety practices and training are required for all workers at the site. Work currently performed by Calpine in other areas of The Geysers involves hazards that can result in accidents, serious injury, acute exposures, and chronic health exposures. Work that involves hazards includes operation of process equipment and heavy machinery, geothermal related work, and working with hazardous materials. Protection measures are implemented by Calpine to eliminate these hazards or

minimize the risks and include employee training on the use of procedural controls and use of protective equipment.

Emergency Response

Calpine's workers are trained on emergency response procedures involving unexpected releases and other emergency situations that may occur at the facility. Emergency response procedures are provided in Calpine's Hazardous Material Business Plans (HMBP) and SPCC Plans,. In addition, local emergency services, such as CalFire emergency services, located in Cobb and Middletown, the Sonoma County Department of Emergency Services and the Coastal Valleys Emergency Medical Services, are available to provide outside emergency response as needed (Coastal Valleys EMS Agency 2008).

Risk Assessment

In September 2006, Sonoma County Department Emergency Services prepared a Hazard Mitigation Plan. The plan analyses risks to human health and property damage from earthquakes, landslides, floods, and wildland fires. The plan serves as a guide for government officials as they determine how best to reduce impacts of these hazards.

The risk of each hazard is listed in Table 3.9-1. The plan explains how the total hazard risk was determined.

The project area is located within wildland areas that may contain substantial forest fire risks and hazards. The project region experiences long seasonal periods without rain, making the area particularly vulnerable to wild fires. Calpine has fire prevention and control procedures in place to address the potential occurrence of a fire at existing facilities.

CalFire provides service in unincorporated areas such as the project area. CalFire has a station in the nearby town of Cobb (approximately 8.8 miles from the project site).

Table 3.9-1: Relative Risk of Hazards for Lake County								
Hazard	History	Frequency	Probability	Impact				
Earthquake	Yes	Low	High	High				
Flood	Yes	High	High	High				
Landslide	Yes	Medium	Medium	High				
Severe Winter Storm	Yes	Medium	Medium	Medium				
Wildfire	Yes	High	High	High				
Windstorm	No	Low	Low	Low				
Drought	Yes	Low	Low	Medium				

SOURCE: Sonoma County 2009

3.9.2 ENVIRONMENTAL CONSEQUENCES

Proposed Action

Construction Activities

Hazardous Materials

Construction activities include preparation of the well pad and construction of the SRGRP pipeline spur. Some hazardous materials from project-related activities (i.e., fuels, oils) would be present on-site during construction activities. The likelihood of substantial spills and discharges in this area would be low due to the limited amount of chemicals that would be used or transported as part of the proposed project. Hazardous chemicals that may be transported would include fuels, oils, and lubricants and would be used during construction. Discharge of oils or petroleum products could occur from equipment leakage but would involve a very small volume.

Contamination of stormwater run-off at the drilling pad would be minimized through drainage and collection of run-off in a reserve tank. Contamination along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater. Calpine would implement a SPCC on-site to contain incidental drips and/or spills. All hazardous material storage would be surrounded by containment berms.

Asbestiform minerals may be found naturally in the soils, these could become airborne in dust particles during construction and re-grading. The Asbestos Air Toxic Control Measure for construction, grading, quarrying, and surface mining as approved by CARB would be implemented. Watering to reduce dust emissions would also help to minimize release of asbestiform minerals into the air.

Waste Management

Sonoma County has a solid waste management program in place that provides solid waste collection and disposal services for the entire County. The program can accommodate the permitted collection and disposal of the small amount of construction waste that would result from the proposed project.

Hazardous wastes such as hydrocarbon wastes or asbestos laden wastes would be disposed of at the Kettleman Hills Landfill, managed by Chemical Waste Management and permitted to accept hazardous wastes, in Kettleman Hills, California (Sonoma County 2005). Adverse effects related to waste management would not occur.

Human Health and Safety

Construction could generate considerable noise. Workers would wear hearing protection and other PPE as required by OSHA to prevent injuries.

Construction workers would comply with OSHA and CalOSHA asbestos removal worker requirements whenever serpentine rock containing over one percent asbestos is being excavated. OSHA asbestos worker safety regulations are found in 29 CFR 1910. CalOSHA regulations are found in 8 CCR. The regulations require monitoring airborne asbestos fiber levels, worker safety

training, and the use of PPE by workers when asbestos levels exceed 0.2 asbestos fibers per cubic centimeter of ambient air.

Exposure to other hazardous materials and wastes would be minimized through proper handling and training. Adverse effects to human health from construction activities would not occur.

Risk Assessment

The most substantial risk during construction activities is fire. The potential for fire is high because the project is located within undeveloped hillsides dominated by dry vegetation. Fire hazards would be minimized through the maintenance of an on-site water tank to put out any potential fires. Other measures would also be implemented as listed below.

- Fire extinguishers and shovels would be available on-site
- All brush build-up around mufflers, radiators, and other engine parts would be avoided; periodic checks would be conducted to prevent this build-up
- Smoking would only be allowed in designated smoking areas; all cigarette butts would be placed in appropriate containers and not thrown on the ground or out windows of vehicles
- Cooking, campfires, or fires of any kind would not be allowed
- Portable generators used in the project area would be required to have spark arresters

Calpine has health and safety procedures that address prevention of fires in The Geysers. Each of these plans, applicable to the proposed project, would be implemented to minimize adverse effects associated with fire hazards:

- *Fire Prevention Plan (HSP-60):* This plan identifies potential fire hazards; flammable materials; potential ignition sources; control, handling, and storage methods; and training requirements associated with geothermal operations that are applicable to all Calpine personnel and contract employees working in The Geysers.
- Hot Work Permit Procedure (No. 145): This plan sets forth a permit system for controlling primary work-related sources of fire and the potential fire hazards associated with Hot Work (i.e., welding, soldering, grinding, or use of an open flame) applicable to all Calpine personnel and contract employees working in The Geysers.
- The Calpine Geysers Emergency Preparedness and Response Plan: This plan contains the
 Response to Wild Land Fire section that provides procedures to be taken by Calpine
 employees to fight incipient fires and/or isolate and control a wild land fire until outside help
 arrives.

Well Bore Modifications

Hazardous Materials

Re-drilling would involve use of hazardous materials. These materials would include, but would not be limited to, drilling additives and mud, diesel fuel, lubricants, solvents, oil, equipment/vehicle emissions, and geothermal fluids. Use of these materials would be in compliance with all local, state, and federal regulations regarding the use, transport, storage, and

disposal of hazardous materials and wastes. Calpine would prepare a SPCC to prevent adverse impacts to the environment from release of hazardous materials.

Well blowouts and pipeline failures are rare occurrences during well drilling and can result in the release of drilling additives and fluids, as well as H₂S gas (see *Section 3.2 Air Quality* for more information on hydrogen sulfide) from the geothermal resource. Blowouts may also result in the surface release of geothermal fluids and steam containing heavy metals, acids, mineral deposits, and other pollutants.

Calpine has an existing detailed blowout prevention plan to minimize adverse effects associated with potential blowouts. (Appendix F). Measures include:

- Performing regular maintenance of wellhead, including corrosion control and inspection, pressure monitoring, and use of blowout prevention equipment such as shutoff valves;
- Preparing an emergency response plan for well blowout, including measures for containment of geothermal fluid spills;
- Preparing a contingency plan for hydrogen sulfide release events, including all necessary aspects from evacuation to resumption of normal operations;
- Providing workers with a fact sheet about the potential human health and safety impacts from exposure to liquids and gases from the production well during a blowout.

Well re-drilling would employ sumpless drilling rig operations. The drilling process may encounter serpentine-containing rocks. Dust emissions from venting steam during testing would be reduced by injecting water into the blooie line.

With implementation of the blowout prevention plan and standard safety precautions, adverse impacts from hazardous material exposure during well bore modification would be minimized.

Waste Management

Wastes generated during drilling would include solids (rock bits), mud, and cement. The entire tank and solids removal system during re-drilling would be enclosed within a berm, as would the rig substructure and auxiliary equipment. Mud or aerated mud is proposed for initial drilling operations. When mud drilling is finished, all liquid mud and solids would be collected and hauled to the geothermal drilling waste solids disposal facility in The Geysers. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit. No adverse effects from waste handling and management during well bore modifications would occur.

Human Health and Safety

Re-drilling would generate considerable noise. Workers would wear hearing protection and other PPE to prevent injuries, as required by OSHA.

Steam encountered during drilling and testing would likely contain H_2S . H_2S is a colorless, non-condensable gas with a characteristic "rotten egg" odor. H_2S is toxic at certain levels and can cause negative human and animal health effects. Exposure to H_2S can cause dizziness, headache, and

nausea at 50 ppm and death from respiratory paralysis at 1,000 ppm. Nuisance odor is of primary public concern since this distinctive odor can be easily detected at concentrations far below levels of health concern. Odor is detectable from about 0.008 ppm. Re-drilling would include H_2S abatement and implementation of the ATC and temporary PTO conditions from the NSCAPCD, such that workers would not be exposed to significant quantities of H_2S .

Exposure to asbestiform minerals would be minimal during re-drilling and testing due to abatement of dust by injecting water into the blooie line.

Exposure to other hazardous materials and wastes would be minimized through proper handling and training. Hazards related to blowouts and other emergencies would be minimized through implementation of the blowout prevention plan. Effects to human health from re-drilling activities would not be adverse with implementation of these measures.

Risk Management

Fire risks would still exist during the well bore modification phase; however, risks would be slightly less than for construction because all re-drilling activities would occur on the well pad.

Fire prevention measures identified for construction activities would be implemented during well bore modification in order to avoid adverse effects.

Stimulation

Stimulation is the process of injecting water into the HTZ through the new SRGRP pipeline spur and into the injection system at the well heads. The only hazard potential during stimulation would be H_2S emissions from venting of steam. Abatement and implementation of the temporary PTO conditions would minimize hazards from stimulation. No wastes would be generated. Microseimic and induced seimic hazards are addressed in *Section 3.3 Geology*.

Long Term Injection, Data Collection, and Monitoring

After the two year stimulation period, long-term continuous injection may occur in either or both wells, depending upon the results from the stimulation phase. Similar to stimulation, H2S emissions from vented steam would be the only hazard. Abatement and implementation of the temporary PTO conditions would minimize hazards from stimulation.

Existing equipment would be used for monitoring. No nuclear logging equipment or other equipment would be used and exposure to hazards would be minimal during the monitoring and evaluation phase of the project. No wastes would be generated. Adverse effects related to hazardous materials, waste management, health and safety, and risk assessment would not occur.

No Action Alternative

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impact could occur anyway.

4.1 Introduction

NEPA requires that agencies consider the cumulative impacts of a proposed federal action or project. NEPA regulations define a cumulative effect as the effect on the environment that results from the incremental effect of the action when added to the effects of other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes the other actions and regardless of land ownership on which the other actions occur. An individual action when considered alone may not have a significant effect, but when its effects are considered in sum with the effects of other past, present, and reasonably foreseeable future actions, the effects may be significant (40 CFR 1508.7 and 1508.8, and FSH 1909.15 Section 15.1).

This cumulative impact analysis considers impacts of the proposed action and other projects that have been proposed, or are reasonably foreseeable to take place in the vicinity of the proposed action. The primary activities considered in the analysis of cumulative impacts are other geothermal projects and other activities in the project vicinity that may occur at the same time as the proposed action.

The geographic area considered for cumulative impacts is generally considered to be a 10-mile radius from the proposed project area, although boundaries of analysis are dependent upon the type of impact to be assessed and the extent of the proposed project's impacts.

The effects of construction activities, well bore modifications, stimulation, and ongoing monitoring and evaluation of the proposed project are described in Chapter 3 of this document.

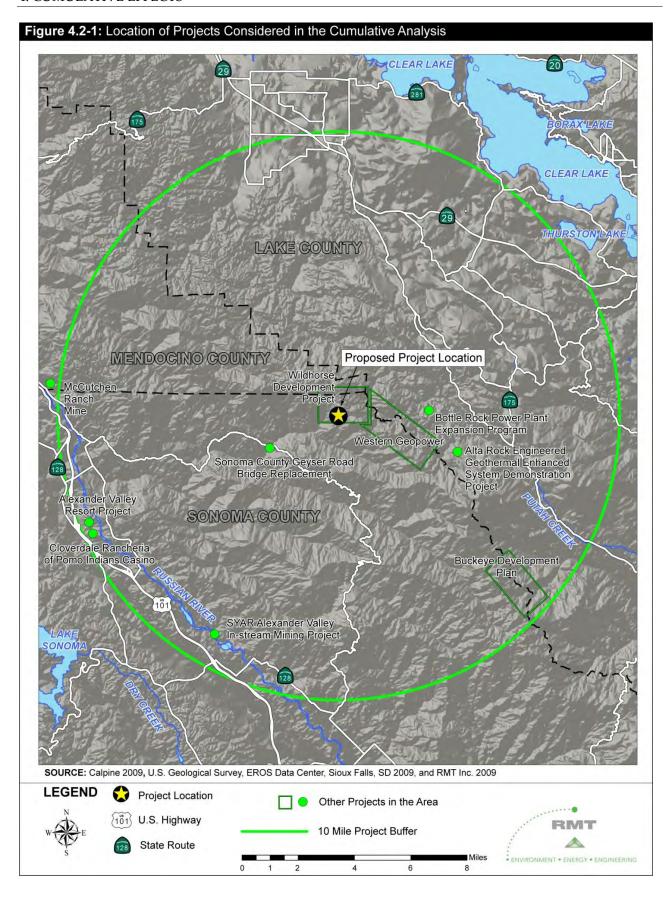
4.2 Other Projects in the Area

This section provides a brief discussion of past, present, and reasonably foreseeable future projects near the proposed project that could have some potential to result in cumulative impacts. Several upcoming renewable energy projects, pending approval and funding, have been identified within a 10-mile radius from the proposed project area as shown in Figure 4.2-1.

Cumulative impacts are not expected with implementation of the proposed environmental protection measures.

4.2.1 WILDHORSE DEVELOPMENT PROJECT

The Calpine Geysers Power Company is proposing to drill up to 58 geothermal wells from up to 14 existing well pads. This project would include the construction of up to 29,000 feet of access corridors for steam pipelines, roads, associated electrical distribution (21kV), as well as other appurtenant facilities to connect the producing and injection wells to existing geothermal infrastructure and power plants. The proposed project falls within this Wildhorse Development Project.



4.2.2 ALTA ROCK ENGINEERED GEOTHERMAL ENHANCED SYSTEM DEMONSTRATION PROJECT

The Alta Rock Engineered Geothermal Enhanced System Demonstration Project is located in the southeastern portion of The Geysers, west of Middletown. The project proposes to create additional sources of geothermal power by deepening an existing injection well and creating a new engineered steam reservoir system. A new production well would be drilled to intersect and utilize the new steam reservoir. The Alta Rock EGS Demo project is located approximately 10 miles from the proposed EGS project.

4.2.3 BOTTLE ROCK POWER PLANT EXPANSION PROGRAM

Bottle Rock Power is planning to modify its existing Bottle Rock Power Plant with the development of a new steam field on the Bottle Rock Power GeoResource Leasehold. The project would entail adding two well pads, drilling up to 24 new wells, constructing an insulated steam gathering pipeline and a condensate injection pipeline, and establishing a new access road. The project would increase the power output of the plant from a maximum of 17 MW to approximately 55 MW. No significant changes would be made to the power plant itself or the capacity of the electrical transmission system in the project area. The Bottle Rock Power project is located approximately 9.5 miles from Calpine's proposed EGS project.

4.2.4 SONOMA COUNTY GEYSER ROAD BRIDGE REPLACEMENT

The Sonoma County Department of Transportation and Public Works has proposed a project to replace the existing one-lane bridge on Geysers Road over Big Sulphur Creek with a new two-lane bridge. This project is located approximately 5 miles from the proposed project and has not yet undergone environmental review and no date for construction has been proposed.

4.2.5 SYAR ALEXANDER VALLEY IN-STREAM MINING PROJECT

Syar Industries is proposing a project to gravel mine a 6-mile stretch of the Russian River near the intersection of Gill Creek and the Jimtown Bridge, approximately 10 miles from the proposed project. No additional infrastructure would be required for the in-stream mining project. Mining equipment would be allowed to gravel mine no more than one bar at a time from April to October. Sonoma County would evaluate the project on a yearly basis to determine if mining operations can resume the following year under the conditions set forth in the project Use Permit. This project may also include an amendment to Sonoma County's Aggregate Resource Management Plan to extend the 10 year term for mining permits to 15 years. Mining operations could begin as soon as 2010. Additional restoration measures determined by governing agencies may be required as mitigation for this project and could include actions such as reconnecting Gill Creek to Russian River.

4.2.6 CLOVERDALE RANCHERIA OF POMO INDIANS CASINO

The Cloverdale Rancheria of Pomo Indians has acquired 79 acres of land next to Highway 101, immediately southeast of the Cloverdale city limits. The project is currently undergoing environmental review for a resort casino with a main hall containing 2,000 slot machines and 45 gaming tables, a 244-room hotel, a convention center, entertainment center, and restaurant. The project is approximately 10 miles from the proposed project.

4.2.7 ALEXANDER VALLEY RESORT PROJECT

Tyris Corporation has proposed a 254-acre development project located approximately 10 miles from the proposed project. Environmental review and a Specific Plan have been completed and approved by the City of Cloverdale. The project includes an 18-hole golf course with a driving range and clubhouse, a 150-room resort hotel with conference facilities, spa, and restaurant, and a 2.4 acre commercial site approved for the development of a wine tasting facility and restaurant. Additional housing has also been proposed and includes:

- 40 fractional ownership villas
- 105 detached single family homes
- 25 estate homes

Construction is estimated to begin in 2010. The project is located approximately 10 miles from the proposed project.

4.2.8 WESTERN GEOPOWER

Western GeoPower is proposing to construct a 38.5 MW geothermal power plant including three new buildings (an electrical/control building, an operator hygiene building, and a fire pump building), a 200,000 gallon water tank for fire protection, a cooling tower, and nine production and two injection wells. The project includes the construction of a steam transmission and electrical switchyard to connect to PG&E's existing 115 kV power line. The project is located at the site of a former PG&E power plant; therefore, most of the infrastructure required for the project is already in place. No major grading would be required because existing roads, well pads, and transmission line and power plant siting would be used.

4.2.9 BUCKEYE DEVELOPMENT PROJECT

Calpine's the Geysers Power Company is proposing to drill 21 geothermal wells on 5 new drill pads, requiring the development of approximately ten acres and 2, 500 feet of new roads. Calpine would construct 6,750 feet of new access corridors for the pipeline and similar geothermal infrastructure. The steam field development would connect with existing power plants or be used for general resource development including recharging the geothermal resource with re-injection.

4.2.10 MCCUTCHEN RANCH MINE

The McCutchen Ranch is an operating hard rock quarry operating for the last decade under the conditions of a Use Permit from Mendocino County. The mine is located near the southern border of the Mendocino County, approximately 10 miles from the proposed project area.

4.3 Cumulative Effects

4.3.1 OVERVIEW

The cumulative impacts of the proposed projects are described below. All defined environmental protection measures would reduce any potential impacts from the proposed action to less than significant levels.

Resources with the potential for cumulative impacts include:

- Air Resources
- Geology
- Biological Resources
- Water Resources
- Noise
- Visual Resources
- Hazardous Materials, Waste Management, Human Health and Safety, and Risk Assessment

The proposed project could contribute to some overall cumulative impacts to these resources; however, none of these cumulative impacts would be significant with implementation of the proposed environmental protection measures.

4.3.2 PROPOSED ACTION

Air Quality

The proposed project would generate some emissions during construction, including H₂S emissions, particulate matter, and precursors to ozone. Sonoma County is in attainment for federal standards for PM₁₀. The entire North Coast Air Basin is currently designated as in nonattainment for the state 24-hour and annual average PM₁₀ standards. The air basin is designated as unclassified for the state annual PM_{2.5} standard because available data is insufficient to support a designation of in attainment or nonattainment (EPA 2009). The proposed project would generate some PM₁₀ and PM_{2.5}. Cumulative impacts could occur if projects occurring simultaneously also produced enough particulate matter to exceed ambient air quality standards. Several projects within a 10 mile radius of the proposed project would involve ground disturbance. Some of these projects could overlap in the construction timeframe; however, they would occur over a 10 mile area. None of these projects would be expected to generate significant amounts of particulate matter and it is likely that measures would be enforced to reduce fugitive dust levels for each project. Cumulative impacts would not occur.

The proposed project could also generate some H₂S emissions, as would the other geothermal projects in the area. With abatement, the proposed project would not contribute to significantly adverse cumulative effects from H₂S emissions due to the small amount of emissions anticipated, the short timeframe of emissions (i.e., well drilling, testing, venting), and the distance to other projects.

Biological Resources

Cumulative impacts to biological resources would occur if the project, in relation to another or other projects, led to a substantial spread of invasive species or threatened the existence of a special status species or its habitat. The proposed project would not have adverse impacts on biological resources with the implementation of environmental protection measures including preconstruction surveys for avian species and raptors and the implementation of a SWPPP and BMPs.

All other projects in the region would be required to adhere to similar standards and regulations of Sonoma County (or Lake or Mendocino Counties), CEQA, and NEPA. This would include mitigating any potential impacts to biological resources. The proposed project would not result in any new ground disturbance in previously undisturbed areas; therefore, it would not contribute to any significant cumulative effects related to the spread of invasive species. Other projects could also impact avian species; however, given the large, undisturbed area between projects where birds could forage and breed without disturbance, and the measures incorporated into the project to protect nesting birds, adverse cumulative effects would not occur.

Geology

The IRWP EIR determined that injecting 25 million gallons per day of recycled water would increase the frequency of Modified Mercalli Intensity (MMI) V earthquakes at Cobb from 0.74 earthquakes per year to 1.15 earthquakes per year, a 55 percent increase, which was determined to be significant. Anderson Springs would experience a 45 percent increase, which was also determined to be significant under CEQA. The proposed project is a small part of the overall IRWP project. While the overall project was determined to cause a significant impact, the proposed project would not have an incrementally significant contribution to the overall effect.

The proposed project involves injection from 0.29 million gallons per day (1 percent of the total water from the IRWP) to as much as 1.15 million gallons per day (5 percent of the total water from the IRWP). This water would be injected as part of the overall IRWP project. The proposed project will move injection water into an area that is further away from communities, which may help to reduce the effects of induced seismicity on residents and community members. If the proposed project were not to occur, this water would be injected anyway as part of the IRWP and would likely be injected closer to the communities.

The Alta Rock and Bottle Rock project could also cause microseismic events. The proposed project would not generate any large-scale, damaging earthquakes, due to the nature of the project (low pressure injection to reopen existing fractures), distance from communities, and the depth of the injection related to the depth of deep earthquakes. Implementation of the Alta Rock project (or any of the other geothermal projects in The Geysers) would not change the potential for inducing large earthquakes from the proposed project. Areas such as Cobb and Anderson Springs could experience microseismic activity from all projects, but again, the proposed project would move the injection sites further away from these communities reducing the adverse effects.

Other projects in the region would not be expected to lead to aggregated impacts from other geologic hazards due to the distance between projects. With implementation of the environmental protection measures identified, the proposed project would not cause a significant cumulative impact.

Water Resources

The proposed project would not alter any surface water sources; therefore, it would not contribute to any potentially cumulative effects related to surface water hydrology in the project region.

The project would use some groundwater from Calpine entitlements; however, the groundwater system in the area is limited and not hydrologically connected to the groundwater in the other

project areas. Use of groundwater in the proposed project area would not compound with use or availability of groundwater in the other project areas and no cumulative effects would occur to groundwater quality, supply, or use. Calpine would be expected to coordinate groundwater use among its own projects.

Cumulative impacts would occur if water quality was seriously degraded due to a hazardous materials spill. The proposed project would be confined to a specific area and all spills during construction and/or operation would be contained and cleaned. The chance of a hazardous materials spill being compounded by any of the other projects in the area is unlikely. Cumulative impacts to water quality would not occur.

Noise

Cumulative impacts could occur if other noise is generated in the same area as the proposed project. The proposed project would increase noise in the region during drilling and construction; however drilling and construction would be temporary and proposed strategies, including notifying neighboring properties of noise effects and installing temporary noise protection measures associated with drill rig motors and air compressors, would prevent adverse impacts. The construction of several anticipated projects could occur at the same time as the proposed project; however, the distance between these projects and the topography would prevent cumulative noise effects.

Visual Resources

The proposed project would have temporary impacts on visual resources during construction; however, most construction would occur in foreground views and would not impact the more scenic background views. The construction activities and the drilling would not be within the same view shed as any of the other projects. Geothermal activities are very common in The Geysers and the appearance of drill rigs in the distance is not considered significantly adverse. The project would temporarily add one drill rig in the visual landscape for a 30 day period, per well, which would not be a significantly adverse contribution to a cumulative effect.

Hazardous Materials, Waste Handling, Health and Safety, and Risk Assessment

The project area is located in a geothermal resource area that has naturally occurring hazardous substances found in the soils, groundwater, and geothermal steam. These hazardous substances include asbestos (from serpentinite rock) and heavy metals such as mercury, sulfur, and arsenic. Other hazardous materials such as hydrocarbon fuels are used regularly as part of geothermal operations in the project region. Cumulative impacts would occur if projects in the same location caused the release or discharge of hazardous materials or substances in levels exceeding local, state, or federal health and safety standards. The proposed project is confined to a specific area and hazardous materials used during construction would be in compliance with all local, state, and federal regulations. All spills during construction and/or on-going monitoring would be contained and would not enter local waterways with the implementation of the proposed environmental protection measures. Hazardous materials spills would not be compounded by any other project in the area, as they would be subject to the same procedures and standards identified in *Section 3.9 Hazardous Materials, Waste Management, Human Health and Safety, and Risk Assessment*.

Exposure to asbestiform minerals would be minimal during drilling and testing due to abatement of dust by injecting water into the blooie line. Hazards related to blowouts and other emergencies would be minimized through implementation of the blowout prevention plan. These effects are all localized to the project area and a short distance around the project area. Effects from hazardous materials and wastes would therefore not contribute to any cumulative effects.

Wastes would be properly disposed. Calpine has its own permitted facilities for disposal of drilling wastes; therefore, the project's wastes would not have a cumulative effect on collection facilities in the region that could be serving other projects. Hazardous wastes would go to the Kettleman Hills Landfill, which has more than sufficient capacity to serve all projects in the region.

The proposed project has some potential to cause forest fires. Other projects could also cause forest fires; however, due to the distance between projects, and the measures include in the proposed project to prevent fires, no cumulative increase in risk is expected due to the proposed project.

4.3.3 NO ACTION ALTERNATIVE

Under the No Action Alternative, DOE would not provide funds for the proposed project. The project would not be built as part of a Federal Action. The wells would continue to be abandoned and no EGS project would be implemented on them. The use of the geothermal resource in the region would remain the same.

It is possible that other sources of funding, including private funds, could be obtained by Calpine to build this project. In that case, the project and its impacts, including cumulative effects identified here, could occur anyway.

Irretrievable/Irreversible Commitment of Resources

This section describes the major irreversible and irretrievable commitments of resources that can be identified at the level of analysis conducted for this EA. A commitment of resources is irreversible when its primary or secondary impacts limit the future options for a resource or limit those factors that are renewable only over long periods of time. Examples of non-renewable resources are soils; minerals, including petroleum; and cultural resources.

An irretrievable commitment of resources refers to the use or consumption of a resource that is neither renewable nor recoverable for use by future generations. Examples of irretrievable resources are the loss of production, harvest, or recreational use of an area. While an action may result in the loss of a resource that is irretrievable, the action may be reversible. For instance, paving over farmland results in the irretrievable loss of harvests from that land; however, the parking lot could be removed and crops could be grown again. This action would be reversible.

The proposed project would require the irreversible and irretrievable commitment of construction materials. Construction water would be irretrievable and irreversible. The use of water from the SRGRP for injection would be an irretrievable irreversible commitment of reclaimed water; however, it may be retrieved as geothermal steam for energy production.

Injection could generate seismic activity; however, this is believed to be reversible through the cessation of activity on the EGS system.

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APPENDIX A: SCOPING MATERIALS

TO: Distribution List

SUBJECT: Notice of Scoping – Geysers Power Company, LLC (Calpine)

Demonstration of an Enhanced Geothermal System at the Northwest Geysers

Geothermal Field, Sonoma County, California

The U.S. Department of Energy (DOE) is proposing to provide Congressionally Directed Federal Funding to the Geysers Power Company, LLC (Calpine) to fund the demonstration of an enhanced geothermal system at the Northwest Geysers Geothermal Field in Sonoma County, California. Pursuant to the requirements of the National Environmental Policy Act (NEPA), the Council on Environmental Quality regulations for implementing the procedural provisions of NEPA (40 CFR Parts 1500-1508), and DOE's implementing procedures for compliance with NEPA (10 CFR Parts 1021), DOE is preparing a draft Environmental Assessment (EA) to:

- Identify any adverse environmental effects that cannot be avoided should this proposed action be implemented.
- Evaluate viable alternatives to the proposed action, including a no action alternative.
- Describe the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.
- Characterize any irreversible and irretrievable commitments of resources that would be involved should this proposed action be implemented.

Project Description

The proposed EGS project includes the injection of water into wells to enhance the permeability of an existing, high temperature, hydrothermal reservoir that will be harnessed to produce electrical energy. The purpose of the project is to establish the feasibility of stimulating the productivity of high temperature rocks by monitoring their early response to carefully designed injection tests. The project will be a collaborative effort between scientist and engineers of Calpine Corporation and the Lawrence Berkeley National Laboratory.

The proposed project includes the following phases:

- Phase I: Pre-stimulation
 - Creation of geological model
 - Analysis of existing injection-induced EGS
 - Pre-stimulation modeling of the EGS stimulation
 - Presentation of the stimulation plan
 - Reopening and conversion of two wells for deep injection back to back(known as Prati-State 31 and Prati-32) and perform the necessary wellbore modifications (i.e., open and complete the selected wells and potentially deepen the wells)

- Public Outreach and Enhanced Public Awareness of EGS Projects
- Phase II: Stimulation
 - Assessment of changes in wellbore properties
 - Evaluation and monitoring of created EGS
- Phase III: Long Term Data Collection and Monitoring

The project will use water supplied by the Santa Rosa Geysers Recharge Project via a pipeline extension of less than one mile along existing roads. The project will include reopening abandoned exploration wells on an existing pad, with access via existing roads. No new ground surface disturbance in previously undisturbed areas is proposed.

Monitoring of the EGS project will occur using Calpine's extensive existing seismic monitoring network which is now used to monitor Calpine's Santa Rosa Pipeline Monitoring Project. Four monitoring stations that are currently being developed as part of another project will also be available by the time the proposed project is implemented.

Project Location

The proposed project area is located in the northeastern portion of Sonoma County. The well locations and pipeline route are shown in Figure 1.

The project components would be located in the northwest corner of Section 35, Township 12 North, Range 9 West of the Mount Diablo Meridian The project site is located within an undeveloped 10 square-mile area of the Northwest Geysers between the Aidlin and Ridgeline Power Plants. The proposed project would reopen and convert two existing wells: Prati State 31 and Prati 32 (PS-31, PS-32), as shown on Figure 1.

Probable Environmental Effects/Issues Scoped for the Environmental Assessment (EA)

The EA will describe all potential impacts on the environment caused by the project and will identify possible mitigation measures to reduce or eliminate those impacts. The EA will describe the potentially affected environment and the impacts that may result to:

- Air Quality
- Geology and Geothermal Resources
- Seismicity and Induced Seismicity
- Biological Resources
- Water Resources
- Noise
- Aesthetics and Visual Resources
- Human Health and Safety and Risk Assessment
- Cumulative Impacts

Development of a Reasonable Range of Alternatives

DOE is required to consider a reasonable range of alternatives to the proposed action during the environmental review. The definition of alternatives is governed by the "rule of reason." An EA must consider a reasonable range of options that could accomplish the agency's purpose and need and reduce environmental effects. Reasonable alternatives are those that may be feasibly carried out based on environmental, technical, and economic factors.

The No Action Alternative will be addressed. The need for project redesign, or a project alternative, will be determined during the course of environmental review.

Public Scoping/Public Meetings

This letter will be available to all interested state, local, and federal agencies to supply input on issues to be discussed in the EA. Agencies should identify the issues, within their statutory responsibilities, that should be considered in the EA. The general public is also invited to submit comments on the scope of the EA on or before **January 11th**, **2010**.

DOE will offer an optional public scoping meeting or additional consultations with the public if members of the public request its necessity. Please have this request submitted no later than **December 28**th, **2009** to allow for meeting planning. DOE also anticipates holding a public meeting after issuance of the Draft Environmental Assessment. Specific dates for these meetings have not been determined.

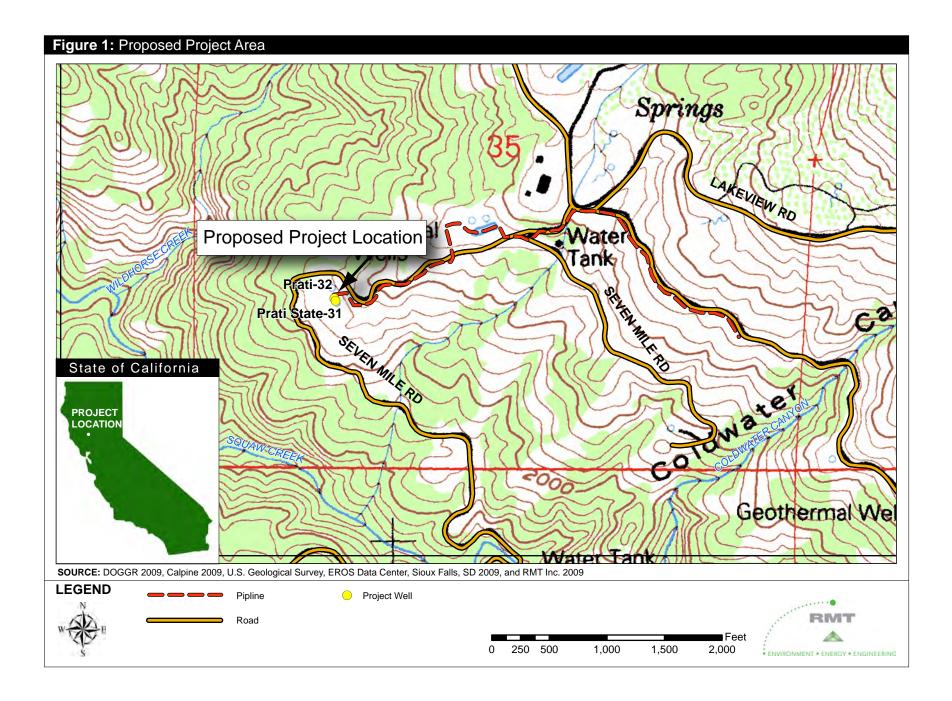
Please send your scoping meeting request and comments regarding the scope and content of the EA, along with the name and address of the appropriate contact person to:

Laura Margason
Department of Energy
Golden Field Office
1617 Cole Blvd, Golden, CO 80401
laura.margason@go.doe.gov

This letter and the draft EA, when available, will be posted to the Golden Field Office electronic reading room: http://www.eere.energy.gov/golden/reading room.aspx.

Sincerely,

Steve Blazek NEPA Compliance Officer





NOTICE OF SCOPING

The U.S. Department of Energy (DOE) is requesting public input on the scope of environmental issues and alternatives to be addressed in the:

Environmental Assessment
Demonstration of an Enhanced Geothermal System
Northwest Geysers Geothermal Field
Sonoma County, California

Geysers Power Company, LLC is proposing to use Congressionally Directed Federal Funding from DOE for the demonstration of an enhanced geothermal system at the Northwest Geysers Geothermal Field in Sonoma County, California. An Environmental Assessment (EA) will be prepared by DOE pursuant to the requirements of the National Environmental Policy Act (NEPA). The notice of scoping and description of the proposed project is available for review at the DOE Electronic Public Reading Room at

http://www.eere.energy.gov/golden/Reading_Room.aspx.

Public comments on the NEPA process, proposed action and alternatives, and environmental issues will be accepted until **January 4th, 2010**. Please send comments to Laura Margason, Department of Energy's Golden Field Office, 1617 Cole Blvd, Golden, CO 80401 or by email to laura.margason@goe.doe.gov.



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Sonoma County, California

Geysers Power Company, LLC is proposing to use Congressionally Directed Federal Funding from DOE for the demonstration of an enhanced geothermal system at the Northwest Geysers Geothermal Field in Sonoma County, California. An Environmental Assessment (EA) will be prepared by DOE pursuant to the requirements of the National Environmental Policy Act (NEPA). The notice of scoping and description of the proposed project is available for review at the DOE Electronic Public Reading Room at

http://www.eere.energy.gov/golden/Reading Room.aspx.

Public comments on the NEPA process, proposed action and alternatives, and environmental issues will be accepted until **January 4th, 2010**. Please send comments to Laura Margason, Department of Energy's Golden Field Office, 1617 Cole Blvd, Golden, CO 80401 or by email to laura.margason@goe.doe.gov.



NOTICE OF SCOPING

The U.S. Department of Energy (DOE) is requesting public input on the scope of environmental issues and alternatives to be addressed in the:

Environmental Assessment
Demonstration of an Enhanced Geothermal System
Northwest Geysers Geothermal Field
Sonoma County, California

Geysers Power Company, LLC is proposing to use Congressionally Directed Federal Funding from DOE for the demonstration of an enhanced geothermal system at the Northwest Geysers Geothermal Field in Sonoma County, California. An Environmental Assessment (EA) will be prepared by DOE pursuant to the requirements of the National Environmental Policy Act (NEPA). The notice of scoping and description of the proposed project is available for review at the DOE Electronic Public Reading Room at

http://www.eere.energy.gov/golden/Reading_Room.aspx.

Public comments on the NEPA process, proposed action and alternatives, and environmental issues will be accepted until **January 4th, 2010**. Please send comments to Laura Margason, Department of Energy's Golden Field Office, 1617 Cole Blvd, Golden, CO 80401 or by email to laura.margason@goe.doe.gov.

Appendix A: Mailing List for the Calpine EGS EA

Public, Agencies, and Interested Parties

Mr. Bruce Carlsen Mr. Joe 'Dillon

Geysers Power Company, LLC NMFS

10350 Socrates Mine Road 777 Sonoma Avenue, Room 325

Middletown, CA 95461 Santa Rosa, CA 95404

Ms. Sigrid Swendenborg Mr. Alex Saschin

County of Sonoma Permit and Resource Northern Sonoma County Air District

Management Department 150 Matheson Street 2550 Ventura Avenue Healdsburg, CA 95448

Santa Rosa, CA 95403

Mr. Ali Kahn SCEHD, Mr. Bob Swift

Department of Oil, Gas and Geothermal Resources

50 D Street

Santa Rosa, CA 95404

Mr. Guy Childs Mr. David H. Oppenheimer

California Regional Water Quality Control Board, USGS

Central Valley Region 345 Middlefield Rd MS 977

11020 Sun Center Drive #200 Menlo Park, CA 94025

Rancho Cordova, CA 95670-6114

Mr. Richard Estabrook Mr. Dan Carlson

Bureau of Land Management City of Santa Rosa

2550N. State Street 100 Santa Rosa Avenue Ukiah, CA 95482 Santa Rosa, CA 95402

Warden Karen Maurer Ms. Judy Brown

California Department of Fish and Game State Lands Commission

P.O. Box 1165 100 Howe Avenue, Suite 100 South

Cloverdale, CA 95425 Sacramento, CA 95825

Calpine EGS Project A-1
Environmental Assessment April 2010

Mr. Mark Dellinger Anderson Springs Homeowners Association

Lake County Special Districts PO Box 43

230-A Main Street Middletown, CA 95461-0043

Lakeport, CA 95453

Mr. Jim Bybee Attn: Joan Clay

NMFS Anderson Springs Community Investment Fund

Committee 777 Sonoma Avenue, Room 325

Santa Rosa, CA 95404 Middletown, CA 95461

Mr. Gene Serafine Attn: Robert Stark

1061 Arlington Lane Cobb Area Community Investment Fund

Committee San Jose, CA 95129

P.O. Box 540. Cobb, CA 95426

Mr. Joseph W. Aidlin Cobb Area District Water

5143 Sunset Boulevard PO Box 284

Los Angeles, CA 90027 16595 Highway 175

Cobb, CA 95426

P.O. Box 995

Ms. Nicola Ferrari Johnson **Attn: Hamilton Hess**

P.O. Box 1084 Friends of Cobb Mountain

Cloverdale, CA 95425 PO Box 131

Cobb, CA 95426

M. Ali Khan

Mr. Peter Flood Attn: Scott Gergus, North Coast Region

WHR Inc. California Regional Water Quality Control Board

P.O. Box 229 5550 Skylane Boulevard, Suite A

Sun Valley, ID 83353 Santa Rosa, CA 95403

Denise Hale Trust Anderson Springs Community Alliance

PO Box 884 945 Green Street #6

San Francisco, CA 94133-3601 Middletown, CA 95461

Anderson Springs Community Service District

P.O. Box 929 DOGGR

11401 Anderson Springs Rd 50 D Street, Room 300

Middletown, CA 95461 Santa Rosa, CA 95404

Anderson Springs Community Alliance

PO Box 884

Middletown, CA 95461

Richard Coel

Community Development Department

255 N. Forbes St. Lakeport, CA 95453

Murray Grande

NCPA

PO Box 663

12000 Ridge Road

Middletown, CA 95461

Rena Thiagarajan

AltaRock Energy Inc.

2320 Marinship Way, Suite 300

Sausalito, CA 95965

Robert Giguiere

BRP Steam Holdco, LLC

PO Box 1250 Cobb, CA 95426

Jeff Gospe

Eric K. Hass, Branch Chief

Geothermal Technologies Program
U.S. DOE Golden Field Office

Native American Contacts

Eric Wilder, Chairperson

Stewarts Point Rancheria

3535 Industrial Dr., Suite 82

Santa Rosa ,CA 95403

tribalofc@stewarlspointrancher

Dawn S. Getchell

P.O. Box 53

Jenner, CA 95450

Ya-Ka-Ama

6215 Eastside Road

Forestville, CA 95436

yakaarnaJndian.ed@ att.net

Steve Nevarez Jr., Environmental Coordinator

Redwood Valley Rancheria of Pomo

3260 Road I

Redwood, CA 95470

redwoodres@paciflc.net

Earl·Couey, Cultural Resources Manager

Mishewal-Wappo Tribe of Alexander Valley

P.O. Box 5676

Santa Rosa, CA95402

ecouey.1 @netzero.net

Harvey Hopkins, Chairman

Dry Creek Rancheria

Band of Pomo Indians

Board of Directors

190 Foss Creek Circle, Ste A

Healdsburg, CA 95448

PO Box 607

Geyserville, CA 95441

Reno Franklin, Tribal Historic Preservation Officer

Stewarts Point Rancheria THPO 3535 Industrial Dr. Suite 62 Santa Rosa, CA 95403

Lynne Rosselli, Environmental Planning Department

Stewarts Point Rancheria 3535 Industrial Dr. Suite 82 Santa Rosa, CA 95403

Lois Lockart, Tribal Administrator

Redwood Valley Rancheria of Pomo 3250 Road I Redwood, CA 95470

Zhao Qui, Cultural Resources Coordinator

Redwood· Valley Rancheria of Pomo 3250 Road I Redwood, CA 95470

FRIENDS OF COBB MOUNTAIN P.O. Box 131 Cobb. CA 95426

January 11, 2010

Ms. Laura Margason Department of Energy's Golden Field Office 1617 Cole Blvd. Golden, CO 80401

Dear Ms. Margason:

Friends of Cobb Mountain is grateful for the opportunity to comment on the Enhanced Geothermal System project proposed by the Geysers Power Company, LLC, in the Northwest Geysers Geothermal Field in Sonoma County, California.

As we understand the proposed project, one of its objectives is to determine as closely as possible the physical conditions, mechanisms and processes involved in the induction of seismic activity by water injection into a naturally occurring geothermal reservoir. We applaud this aspect of the project, for from the standpoint of local residents closely neighboring The Geysers geothermal field this is a necessary study that is long overdue. Our decades-long experience of earthquakes in The Geysers field, which are provenly caused by geothermal operations, has brought psychological trauma, structural damage, and the recent submission of nuisance charges to the Board of Supervisors of the County of Lake, California. As long as this phenomenon continues it will inevitably invoke increasing opposition at The Geysers and elsewhere to an expanded development of geothermal energy. The elimination of the seismic phenomenon is absolutely necessary for a widespread future expansion of enhanced or engineered geothermal systems, and also by more conventional geothermal production technology.

Regarding the environmental issues pertaining to the proposed project itself, here presented as scoping issues, we are concerned with the following. The project site is on an existing pad, from which runoff must be prevented by a continuous berm around it, with rainwater and other water and drilling fluids disposed of in accordance with the regulations of the State of California Water Quality Control Board, and by the conditions of a Sonoma County Use Permit. Federal, State, and County Use Permit conditions must be observed for the handling and storage of all machine fuels and chemical materials. Local Air District rules must apply to all gaseous emissions from steam produced from the reservoir. It is stated in the project description that the water to be used will be Santa Rosa waste water. Is this absolutely the case? If additional water is used, what will be its source? Although the site is relatively remote from habitations, County noise standards must be observed for all operations for worker safety and wildlife considerations. Bonding to cover all possible damages from unexpectedly large earthquakes triggered by the project must be established and maintained for the life of the project. All earthquake data relating to the project must be accessible to the public, as well as scientific findings regarding the phenomenon of induced seismicity and its elimination or control.

Copy following by postal delivery.

Yours sincerely,

Hamilton Hess Chair

cc: Dr. E.L Majer, Lawrence Berkeley Laboratory Bruce Carlsen, Geysers Power Company, LLC Sigrid Swedenborg , Geothermal Coordinator, County of Sonoma Jeffrey D. Gospe, President, Anderson Springs Homeowners Assn.

October 30, 2009

Cathy Zoi
Assistant Secretary
Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

The residents of Anderson Springs have concerns over the level of felt seismicity in our community located near the Geysers geothermal field. Recent plans by Altarock to experiment with an engineered geothermal system project at the edge of our community amplified those concerns. We appreciate that injection of water into the reservoir is necessary to sustain the output from the geothermal resource; we only request that injection be done in a responsible manner that seeks to minimize the impact to our community.

We understand that Calpine has a proposed enhanced geothermal system plan that involves moving water from their current Geysers production area, and injecting that water to the far north end of the field farther away from our community. We are encouraged by Calpine's plan which initially involves the development of the Prati 31 and 32 wells, and consider these type of projects which involve either distributing the water further from our community, or in such a fashion that lessens the impact on our community, as an example of "pro-community" geothermal development and as such, would like to offer our support for this project.

We appreciate the continuing efforts of Calpine to communicate with us on their development plans and look forward to working with them in the future to ensure both of our goals are met.

Sincerely,

Joan K Clay, President

Anderson Springs Geothermal

Impact Mitigation Committee

Bob Marelli, President

Anderson Springs Homeowners Association

cc: Edward J. Wall

Program Manager
Office of Geothermal Technologies

Energy Efficiency & Renewable Energy

U.S. DOE

Supervisor District 1 Jim Comstock

Meriel L. Medrano, Manager Anderson Springs Community

Service District

Jeffrey D. Gospe, President Anderson Springs Alliance

Mike Rogers
Senior Vice President - Geothermal
Calpine Corporation

APPENDIX B: REFERENCES

Appendix B: References

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APPENDIX C: LIST OF PERSONS CONTACTED

Appendix C: List of Agencies and Persons Contacted

The following agencies and persons were contacted during the preparation of this document:

US Army Corps of Engineers, Eugene Field Office

Shelly Hanson Specialist

U.S. Fish and Wildlife Service

Ryan Olah Coast Bay Branch Chief, Sacramento Fish and Wildlife Office

Sonoma County

Crystal Acker Sonoma County Permit and Resource Management Department

Bob Gaiser Sonoma County Permit and Resource Management Department

Melinda Grosch Sonoma County Permit and Resource Management Department

Laura Peltz Sonoma County Permit and Resource Management Department

Lake County

Alan Flora Assistant Planner, Lake County Community Development

Department

Mendocino County

Frank Lynch Chief Planner, Planning and Building Services

City of Cloverdale

Betsi Lewitter City Planner, Planning and Community Development Department

Cloverdale Fire Protection District

Rick Blackmon Battalion Chief



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APPENDIX D: AIR PERMITS FOR WELL PS-31



150 Matheson Street, Healdsburg, CA 95448

PH: (707) 433-5911

FX: (707) 433-4823

September 21, 2009

Geysers Power Company, LLC c/o Calpine Corporation 10350 Socrates Mine Road Middletown, CA 95461

ATTENTION: Brian Berndt

SUBJECT: Application # 09-26A and B; Prati State 31 Well

Dear Mr. Berndt:

Attached is your Authority to Construct/Temporary Permit to Operate, 09-26A and B. Please review the Authorities to Construct/Temporary Permits to Operate for any omissions or errors. Per Rule 250, the applicant may appeal the decision of the Air Pollution Control Officer within ten (10) days of issuance of the Authority to Construct/Temporary Permit to Operate.

A copy of the Authority to Construct/Temporary Permit to Operate must be displayed near the source. In the event that the Authority to Construct cannot be so placed, the Authority to Construct shall be maintained readily available at all times on the operating premises.

Please notify the District by letter at least three (3) days before initial operation of the equipment is to take place so that we may observe the equipment in operation and verify compliance with the Authority to Construct.

If you have any questions regarding this matter please call the District at (707) 433-5911.

Sincerely

Alex V. Saschin

Air Quality Engineer

s:\corresp\as\ac\ltr0926.doc

NORTHERN SONOMA COUNTY AIR POLLUTION CONTROL DISTRICT

150 Matheson Street Healdsburg CA 95448 Telephone (707) 433-5911

Authority to Construct/Temporary Permit to Operate 09-26A

COMPANY: Geysers Power Company, LLC

c/o Calpine Corporation 10350 Socrates Mine Road Middletown CA 95461

EQUIPMENT DESCRIPTION:

Air Pollution Control System for Geothermal Well, Prati State 31, consisting of:

- S-1 Blooie line
- S-2 Tangential muffler/separator (cyclone), 14' in diameter with an 8' diameter stack, 19' in height.
- S-3 Tangential muffler/separator (cyclone), 12' in diameter, 10' in height with an 8' diameter stack, 16' in height.
- S-4 Tangential muffler/separator (cyclone), 12' in Diameter, 15' in height with a 6' diameter stack, 15' in height.
- S-5 Tangential muffler/separator (cyclone), 12' in Diameter, 15' in height with a 6' diameter stack, 15' in height.

LOCATED AT: 1046' East and 3,921' South of the of the Northwest corner of Section 35, Township 12 North Range 9 West, M.D. B&M, Sonoma Co. California

Whereas application for an Authority to Construct and temporary Permit to Operate has been made by the Geysers Power Corporation, LLC (hereinafter called the permit holder) pursuant to Regulation 1 of the Rules and Regulations of the Northern Sonoma County Air Pollution Control District (hereinafter call the District), and said application has been reviewed and considered by the Air Pollution Control Officer of said District (hereinafter referred to as the Control Officer), an Authority to Construct and temporary Permit to Operate is hereby granted to the following terms and conditions:

This shall be your Authority to Construct and temporary Permit to Operate once construction is complete. The permit holder shall allow District representatives to enter upon the premises in order to perform testing and inspections as is necessary to determine compliance with the rules and regulations of the District and the conditions of this Authority to Construct and temporary Permit to Operate.

Permit Conditions

A. Emissions Limits

- 1. S-1; Blooic line: the permit holder shall limit H2S emissions from this geothermal well to an average hourly mass emission rate not to exceed 5.5 lbs/hr, except as allowed in Condition Number A.2.
- 2. During a hot installation of a perforated or slotted liner total H2S emissions shall not exceed 1,493 pounds over the duration of the installation. If the concentration of H2S and steam flowrate result in projected H2S emissions greater than 1,007 pounds for the installation of a perforated or slotted liner, the well shall first be killed with water prior to installing the liner.
- 3. S-2, S-3; Tangential muffler/separator (cyclone): Visible emissions shall not exceed Ringlemann 2 for an aggregated total of three minutes in any hour.

B. Operational Requirements

- 1. S-1; Blooie line: Emissions of H₂S from the line shall be limited by the injection of hydrogen peroxide and caustic into the blooie line. A mole ratio of 6.0 moles of hydrogen peroxide for each mole of H₂S over the calculated 5.5 lbs/hr limit shall be maintained. A mole ratio of 4.0 moles of caustic for each mole of H₂S over the calculated 5.5 lbs/hr limit shall be maintained. The minimum caustic mole ratio may be reduced in accordance with the Hydrogen Sulfide Abatement Plan outlined in Section 4 as long as a minimum of 4 moles of hydroxide from the injection water and caustic is maintained for every mole of H₂S over the calculated 5.5 lb/hr limit.
- 2. During a hot installation of a perforated or slotted liner, the steam that travels outside the liner and through the abatement system shall be treated to the maximum extent possible to reduce overall H2S emissions.
- 3. Each hot installation of a perforated or slotted liner shall be limited to a period not to exceed 18 hours. The permit holder may, in the event of difficulties, and with prior approval of the Control Officer, extend this limit to a maximum of 24 hours.
- 4. Beginning 48 hours prior to a hot installation of a perforated or slotted liner, the permit holder shall obtain a meteorological forecast by a meteorological consultant acceptable to the District if H2S emissions are calculated to be greater than 15 pounds per hour. The forecast shall be forwarded to the District for evaluation and updated daily. The installation of the perforated liner shall only proceed after approval by the District.

ΛTC 09-26Λ 2

- 5. Beginning 48 hours prior and updated 24 hours prior to a hot installation of a perforated or slotted liner, the permit holder shall provide updated II2S emission estimates to the District if calculations indicate emissions of H2S are to exceed 15 pounds per hour. The updates shall be based on the most recent steam flows and H2S concentrations obtained during the workover.
- 6. S-1; Blooie line: Total suspended solids in the injection water shall not exceed 0.1 lbs/gal unless the permit holder can demonstrate the point source limit of rule 420(e) would not be exceeded.
- 7. S-1; Blooie line: The line shall have a calibrated flowmeter installed in the water supply line. Any method equivalent to a flowmeter must be first approved by the Control Officer. The draw down method of flow determination is approved by the Control Officer as an equivalent method of measurement. A calibration curve (if applicable to the type of meter) must be available on site, as well as a statement of calibration showing meter serial number, date of calibration, results of calibration and the person's name and signature who performed the calibration.
- 8. S-1; Blooic line: The line shall be equipped with a water injection system with a minimum water injection rate of 30 gal/min. at steam flow rates less than 80,000 lbs/hr, and a minimum water injection rate of 60 gal/min. at steam flow rates greater than 80,000 lbs/hr. Special exemption from these injection rates may be obtained in advance from the Control Officer. These exemptions are restricted to specific cases and are subject to additional conditions as determined by the Control Officer.
- 9. The permit holder shall maintain the well pad area in such a manner as to prevent excess fugitive dust emissions. If the District deems fugitive dust emissions to be a problem at the site, the permit holder may be required to submit a Fugitive Dust Control Plan, install a sprinkler system, have a water truck on site, and/or any other controls needed to eliminate the problem.
- 10. All engines and compressors used in conjunction with this permit shall be registered with the California Air Resources Board (CARB) Portable Engine Registration program unless this permit is modified to include such equipment.

C. Monitoring and Recordkeeping

1. S-1; Blooie line: The following points will be required of the permit holder with regards to the H2S Abatement Plan as submitted to the NSCAPCD.

A. Calibration

- 1. The permit holder shall see that its employees or contractors provide on site calibration data as requested below:
 - a. Chemical injection pumps: date of calibration, and calibration graphs (feed rate vs. stroke count setting).
 - b. Air compressor meter: a certificate stating, meter serial number, date of calibration, place of calibration, and the technician's name and signature who performed the calibration.
- 2. The permit holder shall see that its contractor or employees perform daily zero and span checks and a weekly multipoint calibration on any continuous monitor used to detect H2S concentrations in association with the blooic line/muffler. The fact that these calibrations were performed is to be so noted in the log at the time of calibration.

B. H2S Concentration Confirmation Upon Steam Production

1. The permit holder shall see that its contractor or employees perform wet chemical tests upon steam entry and at least once per day following, or upon any subsequent steam entry. For District purposes, significant entry shall be defined as "an entry which would yield an increase of 1 (onc) pound per hour H2S (based upon the most recent H2S analysis)." The frequency of this testing may not be reduced unless the permit holder can demonstrate the point source limit of rule 455(b) would not be exceeded.

C. Analysis of Steam Constituents

1. The permit holder shall ensure that its contractor or employees obtain a representative sample of the well steam after the drilling is completed and shall have the sample analyzed to determine operational flow concentrations of: H₂S, ammonia, methane, total VOC, benzene, toluene, ethyl benzene, and xylene, toxic metals and radon. Results of this testing shall be submitted to the District within 30 days of completion of the liner installation.

D. Permanent Records

- 1. The permit holder shall see that its contractor or employees maintain a permanent hardbound log book at the location during drilling. All entries are to be legible and made in ink. Records must be maintained in good condition for at least 5 years following the last date of entry in the log. Records must be accessible by District personnel within the same working day of the inspection of the location.
- 2. The following measurements and determinations shall be made, and records maintained, when steam flow is initiated through the separator/muffler, and subsequently, at least once per day or upon each subsequent steam entry.
 - a. Operator shall measure the H2S concentration in the steam exiting the well using the wet chemistry methods outlined in the Abatement Plan submitted with the permit application. Method is specified in Section 3.1 of the Plan, (H₂S Concentration Determination). The H2S concentration, including all measured values used to determine the H₂S concentration shall be recorded in a District-approved log.
 - b. Operator shall determine the flow rate of the steam exiting the well during the H2S concentration sampling using the methods outlined in Section 3.2 (Steam Flow Determination) of the Abatement Plan submitted with the permit application. The calculated flow rate, including all measured values used to determine the flow rate shall be recorded in a District-approved log.
 - c. Operator shall determine the unabated mass emission rate of H2S (lbs/hr) using the measured and calculated values from (a) and (b) above. The calculated unabated mass emission rate of H2S shall be recorded in a District-approved log.
 - d. Operator shall determine the excess unabated mass emission rate of H2S (lbs/hr) from the steam well using the value calculated in (c) above. The calculated excess unabated mass emission rate shall be recorded in a District-approved log.

- 3. The following data is to be recorded at the start of each shift. The same data shall be logged upon new steam entries and include steam entry size as recorded by the air compressor meter (e.g. 25 lb. entry).
 - a. II2S ppm(wt) upstream of chemical injection.
 - b. Air injection rate, lbs/hr.
 - c. Steam flow rate, lbs/hr.
 - d. Injection rates of caustic and hydrogen peroxide
 - ·c. pH of injection water
 - f. II2S emission rate
 - g. rig status at time of log entry
- 4. Daily wet chemical tests results and results of tests performed subsequent to significant entries are to be entered as a part of the permanent log. These log entries will also note the rig status at the time of testing.
- 5. Any breakdown of abatement equipment shall be recorded. This entry shall state time of breakdown, duration, cause, and the estimated emission rate during this outage. This recording shall not relieve the permit holder from the reporting requirements of Rule 540.
- 2. The following data shall be forwarded to the District within 30 days of completion of the well drilling operation:
 - a. final production H2S concentration in ppm(wt).
 - b. total rig engine hours used during the well drilling activity.
 - c. total compressor engine hours used during the well drilling activity.
 - d. total pounds of total organic gas (including methane) emitted during the well drilling activity (including flow test)
 - e. final production steam flow from the well.
 - f. the total mass of H2S and particulate matter released during the well drilling activity.

E. Administrative Requirements

- 1. The permit holder shall notify the District at least 24 hours prior to drilling on air.
- 2. The permit holder shall notify the District at least 48 hours prior to the beginning of any hot installation of a perforated or slotted liner.

3. Facilities Operation

- a. Operation under this permit must be conducted in compliance with all data and specifications included in the application which attest to the operator's ability to comply with District Rules and Regulations. This permit must be posted in a conspicuous place nearby or, as per rule 240.
- b. All equipment of this PERMIT shall at all times be maintained in good working order and be operated as efficiently as possible so as to minimize air pollutant emissions.

NSCAPCD Rule 240.d

4. Permit Expiration

This Authority to Construct/Temporary Permit to Operate is valid for one year and may be extended by an additional year with the payment of the annual renewal fee. [NSCAPCD Rule 300.5.1]

5. Severability

The provisions of this PERMIT are severable, and, if any provision of this PERMIT is held invalid, the remainder of this PERMIT shall not be affected.

6. Reporting Requirements

Within thirty (30) days of a request by the District, the Operator shall furnish an annual summary report in a form acceptable to the District.

7. Notification Requirements

- a. Upsets and Breakdowns In the event of any failure of process or abatement equipment to operate in a normal manner which results in an increase in emissions above any allowable emissions limit stated in District Rules or in conditions to this PERMIT the Operator may notify the District as provided by Rule 540 regarding upset breakdown conditions to petition for shelter from enforcement actions. In order to qualify for such shelter an initial notification of the equipment failure must be reported to the District Office no later than one (1) hour after its detection during normal office hours (8:00 am to 4:30 pm) or one (1) hour after the start of the next regular business day, whichever is sooner. [NSCAPCD Rule 540]:
- b. Transfer of Ownership In the event of any changes in control or ownership of facilities to be constructed, modified or operated, this PERMIT together with its terms and conditions is transferable and shall be binding on all subsequent owners and operators. The permit holder shall notify the succeeding owner and operator of the existence of this PERMIT and its conditions by letter, a copy of which shall be forwarded to the Control Officer. [NSCAPCD Rule 240.j.]

8. Right to Entry

The Control Officer, The Chairman of the California Air Resources Board, The Regional Administrator of USEPA, and/or their authorized representatives, upon the presentation of credentials, shall be permitted:

- a. To enter upon the premises where the source is located or in which any records are required to be kept under the terms and conditions of this PERMIT; and
- b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this PERMIT; and
- c. To inspect any equipment, operation, or method required in this PERMIT; and
- d. To sample emissions from the source. [NSCAPCD Rule 240.c]

THIS PERMIT BECOMES VOID UPON ANY ALTERATION OF EQUIPMENT

This permit does not authorize the emission of air contaminants in excess of those allowed by the Health and Safety Code of the State of California or the Rules and Regulations of the Northern Sonoma County Air Pollution Control District. This permit cannot be considered as permission to violate existing laws, ordinances, regulation or statutes of other governmental agencies. The violation of any of these terms and conditions shall be grounds for revocation of this PERMIT, and shall be a violation of District Rules and Regulations under Rule 240. This permit can be reviewed annually and can be amended by the District as allowed by Rule 240(h).

DATE: 9/21/09

Permit Number 09-26A

Barbara A. Lee

Air Pollution Control Officer

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NORTHERN SONOMA COUNTY AIR POLLUTION CONTROL DISTRICT

150 Matheson Street Healdsburg CA 95448 Telephone (707) 433-5911

Authority to Construct/Temporary Permit to Operate 09-26B

COMPANY: Geysers Power Company, LLC

c/o Calpine Corporation 10350 Socrates Mine Road Middletown CA 95461

EQUIPMENT DESCRIPTION:

Geothermal Well, Designated Prati State 31

LOCATED AT: 1046' East and 3,921' South of the of the Northwest corner of Section 35,

Township 12 North Range 9 West, M.D. B&M, Sonoma Co. California

Whereas application for an Authority to Construct and temporary Permit to Operate has been made by the Geysers Power Corporation, LLC (hereinafter called the permit holder) pursuant to Regulation 1 of the Rules and Regulations of the Northern Sonoma County Air Pollution Control District (hereinafter call the District), and said application has been reviewed and considered by the Air Pollution Control Officer of said District (hereinafter referred to as the Control Officer), an Authority to Construct and temporary Permit to Operate is hereby granted to the following terms and conditions:

This shall be your Authority to Construct and temporary Permit to Operate once construction is complete. The permit holder shall allow District representatives to enter upon the premises in order to perform testing and inspections as is necessary to determine compliance with the rules and regulations of the District and the conditions of this Authority to Construct and temporary Permit to Operate.

Permit Conditions

A. Emission Limits

- 1. Wellhead II2S emissions are not to exceed the limitations of Rule 455 (a), no person shall discharge into the atmosphere from any geothermal operation sulfur compounds, calculated as sulfur dioxide, in excess of 1,000 ppmv.
- 2. Wellhead H2S emissions are not to exceed the limitations of Rule 455 (b), H2S emissions shall not exceed 0.5 kilograms per hour (1.1 pounds per hour), except as allowed under B.1.
- 3. Fugitive dust emissions from this well pad and access roads under the Permit holders responsibility are to be controlled to meet the requirements of Rule 430 and 410(a).

B. Operational Requirements

- 1. The permit holder shall notify the District prior to initiating any planned venting operation of this geothermal well which is associated with testing, power plant outages, wellhead or wellbore maintenance. The permit holder shall also present to the Control Officer, and receive approval of, an emissions release protocol governing emissions and notifications for such operations. Until such time as this protocol is approved the Permit holder shall obtain permission from the District for each venting operation at least 24 hours prior to starting the venting operation. Operations resulting in an excess of 15 pounds per hour of H2S shall be subject to a meteorological forecast, by a meteorological consultant acceptable to the District and shall only proceed after approval by the Control Officer.
- 2. The permit holder shall apply for and receive an Authority to Construct/Temporary Permit to Operate for an air pollution control device prior to reworking or redrilling this well unless the permit holder holds a valid wellfield maintenance permit.
- 3. The permit holder shall properly maintain the wellhead, its associated valves, flanges, fittings, liquid lines and other components including the wellhead blooie line muffler so as to eliminate leakage of steam, condensate and non-condensable gases as noted below:

- 3a. Liquid leak rate shall not exceed 20 ml in 3 minutes. Liquid leak rates in excess of 20 ml in 3 minutes shall be identified and be repaired within 15 calendar days.
- 3b. Non-condensable gas leaks shall not (i) exceed (as measured within 1 cm of such leak) 1000 ppm(vol) H2S nor 10,000 ppm(vol) TOG (expressed as methane) nor (ii) exceed emission limits of Rule 455. Non-condensable gas leak rates in excess of 1000 ppm (vol) H2S or 10,000 ppm (vol) TOG shall be repaired with 24 hrs.
- 4. All wells shall be identified in a manner acceptable to the Control Officer.

C. Monitoring

- 1. At the request of the Control Officer and per Rule 240, the Permit holder will perform, or have performed, source test(s) for air contaminants as specified. District concurrence with test procedure and method(s) is to be obtained prior to testing. The permit holder shall provide the District 48 hours notification prior to any sampling requested by the Control Officer. The Permit holder shall provide adequate facilities for District sampling.
- 2. If this well employs an aspirator as allowed under rule 455(aa) and operates for greater than 24 consecutive hours it shall be source tested annually to determine H2S mass emissions and exit concentration. If an aspirator is utilized for less than 24 consecutive hours the well shall be source tested for H2S once every 5 years.
- 3. Any instrument used for the measurement of II2S or Total Organic Gases (TOG) shall be approved by the Control Officer.

D. Recordkeeping and Reporting

1. A quarterly report shall be submitted to the District which contains the following information:

Well Bleeds

- Source name.
- b. Hours of bleed emissions.
- c. Amount of H2S, ammonia and total organic gases (expressed as methane) released during bleed.
- d. Reason for bleed.

Wells employing an aspirator

- e. Hours of bleed through an aspirator.
- f. H2S emission rate expressed as lb/hr, H2S exit concentration and date tested.

ATC 09-26B 3

Wellbore maintenance (blowdowns)

- g. Time and date of event.
- h. Duration of event.
- i. Emissions rate during event, steam and H2S, expressed as pounds per hour.
- j. Total mass of H2S, ammonia and TOG (expressed as methane) released during event.
- k. Reason for event.

The quarterly report shall be submitted to the District within 30 days of the end of each calendar quarter.

E. ADMINISTRATIVE REQUIREMENTS

1. Facilities Operation

- a. Operation under this permit must be conducted in compliance with all data and specifications included in the application which attest to the permit holder's ability to comply with District Rules and Regulations. This permit must be posted in a conspicuous place nearby or, as per rule 240.
- b. All equipment of this PERMIT shall at all times be maintained in good working order and be operated as efficiently as possible so as to minimize air pollutant emissions.

NSCAPCD Rule 240.d

2. Permit Expiration

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3. Severability

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- a. Upsets and Breakdowns In the event of any failure of process or abatement equipment to operate in a normal manner which results in an increase in emissions above any allowable emissions limit stated in District Rules or in conditions to this PERMIT the Permit holder may notify the District as provided by Rule 540 regarding upset breakdown conditions to petition for shelter from enforcement actions. In order to qualify for such shelter an initial notification of the equipment failure must be reported to the District Office no later than one (1) hour after its detection during normal office hours (8:00 am to 4:30 pm) or one (1) hour after the start of the next regular business day, whichever is sooner. [NSCAPCD Rule 540]:
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5. Right to Entry

The Control Officer, the Executive Officer of the California Air Resources Board, the Regional Administrator of USEPA, and/or their authorized representatives, upon the presentation of credentials, shall be permitted:

- a. To enter upon the premises where the source is located or in which any records are required to be kept under the terms and conditions of this PERMIT; and
- b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this PERMIT; and
- c. To inspect any equipment, operation, or method required in this PERMIT; and
- d. To sample emissions from the source. [NSCAPCD Rule 240.e]

THIS PERMIT BECOMES VOID UPON ANY ALTERATION OF EQUIPMENT

This permit does not authorize the emission of air contaminants in excess of those allowed by the Health and Safety Code of the State of California or the Rules and Regulations of the Northern Sonoma County Air Pollution Control District. This permit eannot be considered as permission to violate existing laws, ordinances, regulation or statutes of other governmental agencies. The violation of any of these terms and conditions shall be grounds for revocation of this PERMIT, and shall be a violation of District Rules and Regulations under Rule 240. This permit can be reviewed annually and can be amended by the District as allowed by Rule 240(h).

DATE: 9/21/09

Permit Number 09-26B

Barbara A. Lec

Air Pollution Control Officer

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APPENDIX E:PIPELINE DRAWING PLANS

CALPINE OPERATING SERVICES COMPANY INC.

Construction Drawings

For

PRATI STATE-31 AND PRATI-32 INJECTION WELL LINE TIE-INS

Sonoma County, California

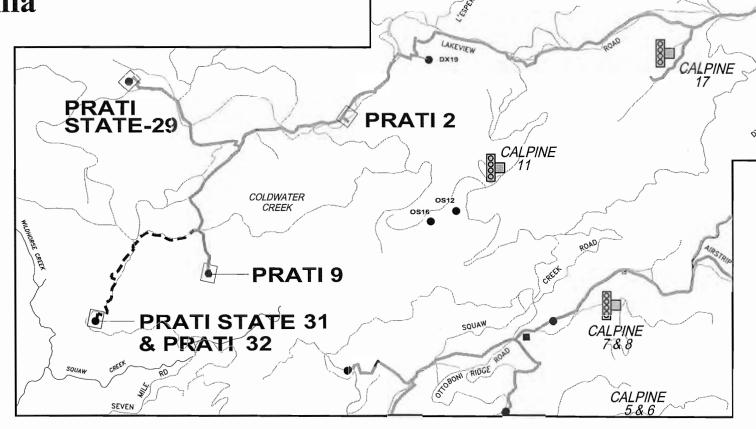
P.O. No.

DRAFT

September 2009



CALPINE



VICINITY MAP

DRAWING INDEX

DESCRIPTION

To Gate #2

DRAWING NO.

TITLE SHEET

GENERAL NOTES

GENERAL PLAN

PLAN & PROFILE #

PLAN & PROFILE #2 METERING STATION PLAN

METERING STATION ELEVATION & DETAIL

INJECTION WELL PLAN & ELEVATION

INJECTION WELL HEAD PIPING DETAILS

PIPE SUPPORT DETAILS

TYPICAL PIPING DETAILS

BALFUZER ASSEMBLY DETAILS

THESE DRAWINGS ARE INSTRUMENTS OF PROFESSIONAL DESIGN SERVICES PERFORMED BY VEIZADES & ASSOCIATES INC. FOR THIS SPECIFIC PROJECT. ANY UNAUTHORIZED CHANGES OR USE OF THESE DRAWINGS FOR ANY OTHER PROJECT IS PROHIBITED. THE CLIENT AGREES TO INDEMNIFY VEIZADES & ASSOCIATES, INC. FOR ANY CLAIMS OR DAMAGES ARISING OUT OF SUCH UNAUTHORIZED CHANGES OR USE VEIZADES & ASSOCIATES, INC, RETAINS ALL RIGHTS INCLUDING

					WARNING IF BAR BELOW
					DOES NOT MEASURE
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o.	REVISIONS	BY	APPR.	DATE	1 INCH

VEIZADES & ASSOCIATES, INC. CONSULTING ENGINEERS

5 THIRD STREET . SUITE 400 . SAN FRANCISCO . CA 94103

RAFTED BY PROVED BY

HECKED BY

CALPINE OPERATING SERVICES COMPANY

THE GEYSERS, CALIFORNIA

PRATI STATE-31 & PRATI-32 INJECTION WELL LINE TIE-INS

TITLE SHEET

ADFILE NO. 141-01 HEET NO.

ROJECT NO. 176-141

GENERAL NOTES

- NO CHANGES TO THE WORK DEPICTED ON THESE DRAWINGS SHALL BE MADE WITHOUT THE EXPRESS WRITTEN AUTHORIZATION OF THE ENGINEER. ANY DISCREPANCIES BETWEEN THE PLANS, DETAILS OR SPECIFICATIONS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER FOR ADJUSTMENT PRIOR TO PROCEEDING WITH THE WORK.
- 2. HEAVY TRUCK TRAFFIC IS LIMITED AS STATED IN THE CONSTRUCTION
- 3. THE GENERAL SPEED LIMIT THROUGHOUT THE GEYSERS IS 25 MPH. LOWER SPEED LIMITS MAY BE REQUIRED IN THE VICINITY OF CONSTRUCTION OR MAINTENANCE ACTIVITIES AND/OR WEATHER
- 4. EXISTING UTILITIES SHOWN ARE BASED ON BEST AVAILABLE INFORMATION. THE CONTRACTOR SHALL VERIFY THE EXACT LOCATION, SIZE, TYPE AND ELEVATION OF ALL UTILITIES PRIOR TO CONSTRUCTION AND SHALL INFORM THE ENGINEER OF ANY CONFLICTS.
- INSULATION OF EXISTING STEAM PIPELINES IS EASILY DAMAGED. CONTRACTOR IS RESPONSIBLE FOR REPAIRING OR REPLACING INSULATION DAMAGED AS A RESULT OF ITS OPERATIONS.

SURVEY NOTES

1. CONTRACTOR IS RESPONSIBLE FOR SETTING ALL CONTROL POINTS ALONG THE PIPELINE ALIGNMENT AS REQUIRED FOR CONSTRUCTION.

EARTHWORK CONSTRUCTION NOTES

- EXCAVATION LIMITS SHOWN IN THE DETAILS ARE GRAPHICAL REPRESENTATIONS ONLY. ACTUAL GRADING LIMITS ARE TO BE DETERMINED BY CONTRACTOR TO PROVIDE FINAL PAD, ROAD, AND RIGHT-OF-WAY
- THE CONTRACTOR IS SOLELY RESPONSIBLE FOR CONFORMANCE WITH THE LOCAL AND FEDERAL CODES GOVERNING SHORING AND BRACING OF EXCAVATIONS AND TRENCHES.
- ANY REQUIRED CONSTRUCTION RIGHT OF WAY CLEARING AND GRADING FOR INSTALLING CROSS-COUNTRY PIPING (OTHER THAN PIPING INSTALLED ON SIDES OF ROADS AND ALONG EXISTING PIPING) WILL BE PERFORMED BY THE OWNER. HOWEVER, THE CONTRACTOR WILL BE RESPONSIBLE FOR GRADING REQUIRED FOR THE SUPPORT CONSTRUCTION AND PIPING INSTALLATION.

PIPELINE NOTES

- ALL STATIONING AND DISTANCES SHOWN ON THE DRAWINGS ARE BASED ON HORIZONTAL MEASUREMENTS.
- 2. LOCATIONS OF AIR VALVES AND OUTLETS ARE SHOWN IN THEIR APPROXIMATE LOCATION. THE EXACT LOCATION MAY BE ALTERED IN THE FIELD BY THE ENGINEER BASED ON TOPOGRAPHIC READING.
- 3. THE MAXIMUM FABRICATED SPOOL LENGTHS SHALL BE 40 FEET NOMINAL THE MINIMUM LENGTH SHALL BE 10 FEET NOMINAL.
- 4. THE PIPELINE ALIGNMENT SHOWN ON THE DRAWINGS MAY BE CHANGED AT THE CONTRACTOR'S OPTION AND WITH APPROVAL BY THE ENGINEER. THE CONTRACTOR WILL BE RESPONSIBLE FOR ANY COSTS ASSOCIATED WITH ALIGNMENT CHANGES.
- 5. THE PIPELINE AND APPURTENANCES SHALL BE TESTED TO THE TEST PRESSURE SHOWN DRAWINGS. ALL PIPELINE MATERIALS AND APPURTENANCES SHALL BE DESIGNED TO WITHSTAND THE FULL TEST PRESSURES. MATERIALS SHOWN OR SPECIFIED WITH HIGHER RATING SHALL BE DESIGNED AS SUCH.
- 6. ALL PIPELINES SHALL BE SUPPORTED ON SLEEPER TYPE PIPE SUPPORT AT SPACINGS INDICATED, UNLESS OTHERWISE NOTED.

THESE DRAWINGS ARE INSTRUMENTS OF PROFESSIONAL

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COPY RIGHTS.

PIPELINE MATERIALS

- 1. ALL PIPING MATERIAL SHALL BE CARBON STEEL, ANSI A53 OR API 5L,
- 2. THE MINIMUM THICKNESS OF PIPE SHALL BE AS SHOWN ON THE
- 3. THE CONTRACTOR MAY SUPPLY PIPE WITH THICKER WALL THICKNESS
- 4. EXCEPT AS OTHERWISE SPECIFIED ALL PIPING SHALL BE UNCOATED BARE
- 5. ALL FITTING SHALL BE FORGED STEEL FITTINGS. ELBOWS SHALL BE LONG RADIUS. THICKNESS OF FITTINGS SHALL BE AT LEAST EQUAL TO PIPE THICKNESS CONNECTED TO THEM, UNLESS OTHERWISE NOTED.
- 6. FLANGES SHALL BE FORGED STEEL FLANGES ASTM A105 AND ANSI B16.5 CLASS 300 WELDING NECK RAISE FACE (WNRF) UNLESS OTHERWISE
- 7. ALL CHANGES IN PIPING DIRECTIONS SHALL BE DONE USING LONG RADIUS WELDING FITTINGS. FOR ANGLES LESS THAN 45' THE CONTRACTOR MAY UTILIZE BENDING OF PIPE IN LIEU OF FITTINGS TO FFFFCT CHANGES IN HORIZONTAL AND VERTICAL DIRECTION OF THE PIPE THE BEND RADIUS SHALL NOT BE LESS THAN 10 PIPE DIAMETERS. THIS OPTION IS PERMISSIBLE FOR CROSS COUNTRY PIPING AND WILL NOT BE ALLOWED AT WELL SITES, AT VALVE STATIONS AND WHEN THE BENDING WILL PLACE THE PIPE WITHIN TRAVEL WAYS.
- 8. SEE SPECIFICATION FOR ADDITIONAL REQUIREMENTS FOR PIPELINE MATERIALS AND INSTALLATION.
- 9. ALL PIPING 4" AND SMALLER SHALL BE SCHEDULE 80 (EXTRA STRONG), UNLESS OTHERWISE NOTED.
- 10. PIPING INDICATED ON THE DRAWINGS AS STAINLESS STEEL (SS) SHALL BE SEAMLESS ANSI/ASTM A312 GRADE TP316L. WELDING FITTINGS AND FLANGES SHALL MATCH PIPING MATERIALS, UNLESS OTHERWISE NOTED.

(CONT'D)

PIPE JOINT TYPES

- ALL PIPING SHALL BE INSTALLED UTILIZING FULL PENETRATION BUTT WELDING OR FLANGES.
- 2. THE BEVEL FOR BUTT WELDING SHALL BE 37 1/2' UNLESS OTHERWISE SHOWN ON THE DRAWINGS OR APPROVED BY THE ENGINEER.

LININGS & COATINGS

- 1. EXCEPT AS OTHERWISE NOTED ABOVE GROUND PIPING SHALL BE UNLINED AND UNCOATED.
- BELOW GROUND PIPING SHALL BE WRAPPED WITH A PROTECTIVE EXTERIOR COATING OF EITHER POLYETHYLENE TAPE SYSTEM OR AN EXTRUDED POLYOLEFIN SYSTEM
- 3. ALL STUDS, BOLTS, NUTS, AND WASHERS SHALL BE BLUE XYLAN COATED. MFG BY DANIELS INDUSTRY.



APPURTENANCES

- THE CONTRACTOR SHALL SUBMIT FOR APPROVAL THE CONFIGURATION MATERIAL SELECTION, SIZES AND OTHER PERTINENT INFORMATION FOR EACH VALVE STATION.
- VALVES

SHALL BE 300 OR 600 CLASS, AS SHOWN ON THE DRAWINGS AND AS SPECIFIED IN SECTION 15100

BUTTERFLY VALVES

UNLESS OTHERWISE NOTED ON THE DRAWINGS:

300 OR 600# CLASS AS SHOWN ON THE DRAWINGS FOR ALL PIPINGS.

ALL BUTTERFLY VALVES SHALL BE LUGGED WAFER TYPE.

PIPING VALVES

FOR ALL BUTTERFLY VALVES:

GEAR REDUCTION OPERATOR SHALL BE INSTALLED ON B" OR LARGER VALVES.

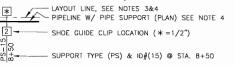
GATE VALVE GV GLOBE VALVE GLV EXPANDING GATE VALVE W1S SLAB GATE VALVE W2S BALL VALVE N BUTTERFLY VALVE **BTFLV** V BALL CONTROL VALVE VBCV PLUG VALVE PV NEEDLE VALVE NV DIAPHRAGM VALVE DPHV CHECK VALVE CHKV Y STOP CHECK VALVE VCHKV STOP CHECK VALVE SCHKV ANGLE VALVE ASV 3 -WAY VALVE THREE WAY BALL 3WBV

ABBREVIATIONS

AB	ANCHOR BOLT	LR	LONG RADIUS
L	ANGLE	LT	LEFT
API ASSY	AMERICAN PETROLEUM INDUSTRY ASSEMBLY	LTPC ML	LIQUID TIGHT FLEXIBLE CONDUIT MITERED ANGLE
BC	BOLT CIRCLE	MA	PIPE ANCHOR, TYPE MA (MODIFIED)
BOP BR	BOTTOM OF PIPE	MCC	MOTOR CONTROL CENTER
BV	BRINE BALL VALVE	MH MAX.	MANHOLE MAXIMUM
C	CONDUIT, CHANNEL	MIN.	MINIMUM
CC	CUT ANGLE CONDENSATE COLLECTION	N NCG	NORTH COORDINATE NON-CONDENSIBLE GAS
C-C	CENTER TO CENTER	NIC	NOT IN CONTRACT
CAPIL	CAPILLARY	NPT	NATIONAL PIPE THREAD NATIONAL PIPE THREAD, FEMALE
CDP CL	CONDENSATE DROP POT CENTER LINE OR CLASS	NPTF NTS	NATIONAL PIPE THREAD, FEMALE NOT TO SCALE
CLR	CLEARENCE	OC	ON CENTER
CMP	CORRUGATED METAL PIPE	OD	OUTSIDE DIAMETER
CON RED	CONCENTRIC REDUCER CONCRETE	P PB	POWER PULL BOX
COND	CONDENSATE	PG	PIPE GUIDE POINT OF INTERSECTION
CONN CONT	CONNECTION CONTINUOUS	PI PL	POINT OF INTERSECTION PLATE
CR	CONDENSATE RETURN	POL	POINT ON LINE
CS	CARBON STEEL	PS	PIPE SUPPORT
CV CYL	CONTROL VALVE CYLINDER	R RA	RADIUS PIPE ANCHOR, TYPE RA (ROTATIONAL)
Ø	DIAMETER	RC	REINFORCED CONCRETE
D DIA	DIAMETER DIAMETER	RED RF	REDUCING FITTINGS
DISC	DISCHARGE	RFSO	RAISED FACE RAISED FACE SLIP—ON
DWG	DRAWING	RFWN	RAISED FACE SLIP-ON RAISED FACE WELDING NECK
DS DWS	DESUPERHEATING DOMESTIC WATER SYSTEM	RT RTU	RIGHT REMOTE TERMINAL UNIT
E	EAST COORDINATE	RTJ	RING TYPE JOINT RING TYPE JOINT WELDING NECK
EA ECC RED	EACH FOCENTRIC REDUCER	RTJWN	RING TYPE JOINT WELDING NECK
EF RED	ECCENTRIC REDUCER EACH FACE	S SCH	SINGLE SCHEDULE
EL	ELEVATION	SHT	SHEET
EQ ERW	EQUAL ELECTRIC RESISTANCE WELDED	SIM SMLS	SIMILAR SEAMLESS
EW	EACH WAY	SN	SOLID NEUTRAL
EXIST EXP	EXISTING EXPANSION	SO SS	SLIP ON
FA	PIPE ANCHOR, TYPE F (FIXED)	SS STA	STAINLESS STEEL STATION
FAB	FABRICATION	STD	STANDARD
FIG FLG	FIGURE FLANGE	SQ SYM ABT	SQUARE SYMMETRICAL ABOUT
FIN. GR.	FINISH GRADE	T&B	TOP AND BOTTOM
FOF	FACE OF FLANGE	TC	TAP CONNECTION
FT GA	FEET GAUGE	THRD TOC	THREADED TOP OF CONCRETE
GALV	GALVANIZED	TOS	TOP OF CONCRETE TOP OF STEEL
GB GRND	GRADE BREAK GROUND	TS TSP	STRUCTURAL TUBING TWISTED SHIELDED PAIR
GV	GATE VALVE HORIZONTAL	TYP	TYPICAL
HORIZ HL	HORIZONTAL	UG	UNDER GROUND
HPS	HORIZONTAL ANGLE HIGH PRESSURE STEAM	U.O.N. V&A	UNLESS OTHERWISE NOTED VEIZADES & ASSOCIATES, INC.
INS	INSTRUMENT AIR SYSTEM	VAC	VOLTS ALTERNATING CURRENT
ID IN	INSIDE DIAMETER INCHES	VERT WB	VERTICAL WELL BLEED
INJ	INJECTION	WIO	WHERE IT OCCURS
INSL	INSULATION	W/ W/O	WITH
IS LA	INTERMEDIATE SUPPORT PIPE ANCHOR, TYPE LA (LONGITUDINAL)	WN	WITHOUT WELD NECK
LPS	LOW PRESSURE STEAM	WP	WELD NECK WORK POINT
		WT XS	WEIGHT EXTRA STRONG

LEGEND

(SEE TYPICAL SUPPORT SHEETS FOR DETAILS)



FIXED ANCHOR (TYPE FA U.O.N.) SEE NOTE 4

ROTATIONAL ANCHOR (TYPE RA U.O.N.) SEE NOTE 4

FLOW TRANSMITTER PRESSURE INDICATOR

DETAIL 2 SHOWN ON SHEET 10

SECTION A SHOWN ON SHEET 12

BY APPR, DATE

WARNING **VEIZADES & ASSOCIATES, INC** CONSULTING ENGINEERS DOES NOT MEASURE INCH

1 INCH

5 THIRD STREET . SUITE 400 . SAN FRANCISCO . CA 94103 TEL: 415. 394.8855

ANGLE BLOWDOWN VALVE

KNIFE GATE VALVE

ANGLE STOP CHECK VALVE ACHKV

AFTED BY No. 12451 NP Exp: 3-31-09/ PROVED BY HEV 7/27/09 SCALE

CALPINE OPERATING SERVICES COMPANY THE GEYSERS, CALIFORNIA

> PRATI STATE-31 AND PRATI 32 INJECTION WELL LINE TIE-INS

 $\frac{2}{10}$

EV. NO.

176-141

141-02

CONTRACT NO.

CADEILE NO.

SHEET NO.

GENERAL NOTES, LEGEND & ABBREVIATIONS

ASSOCIATES INC. FOR THIS SPECIFIC PROJECT ANY JNAUTHORIZED CHANGES OR USE OF THESE DRAWINGS FOR ANY OTHER PROJECT IS PROHIBITED. THE CLIENT AGREES TO INDEMNIFY VEIZADES & ASSOCIATES, INC FOR ANY CLAIMS OR DAMAGES ARISING OUT OF SUCH UNAUTHORIZED CHANGES OR USE. VEIZADES & ASSOCIATES, INC, RETAINS ALL RIGHTS INCLUDING

THEN DRAWING TO SCALE ISSUED FOR CONSTRUCTION MAP HEV 09/01/

FAX: 415, 394,8866

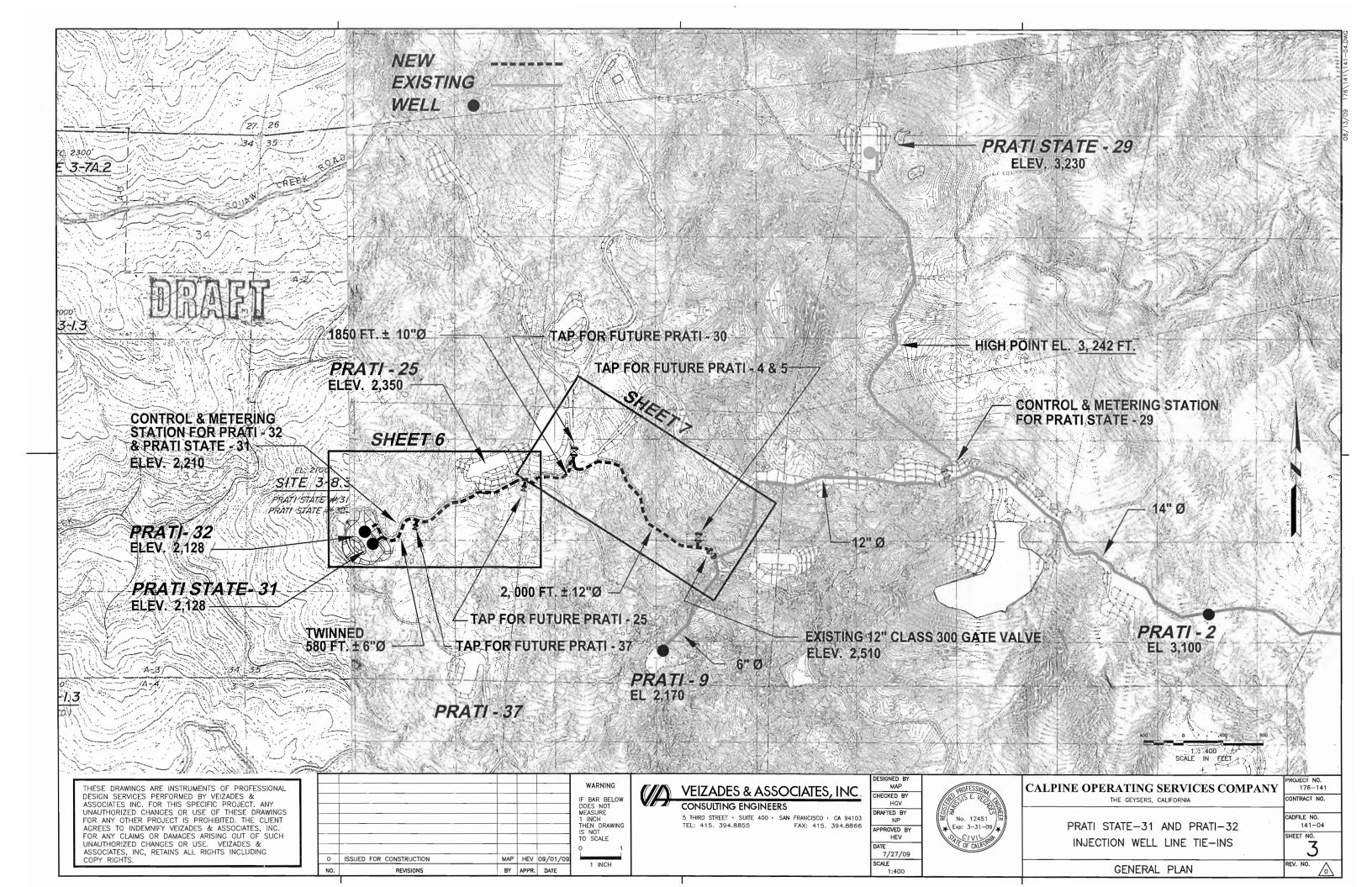
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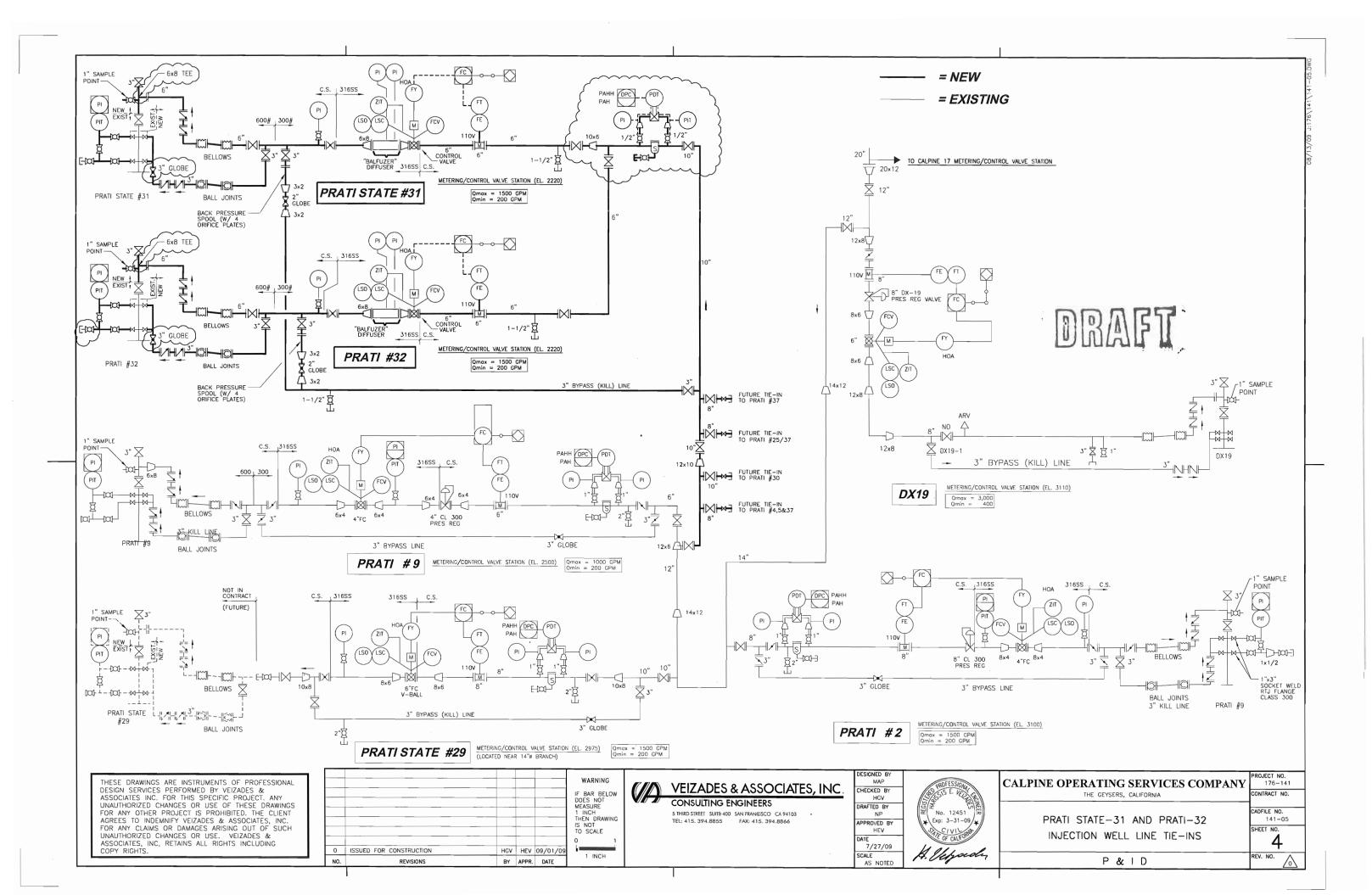
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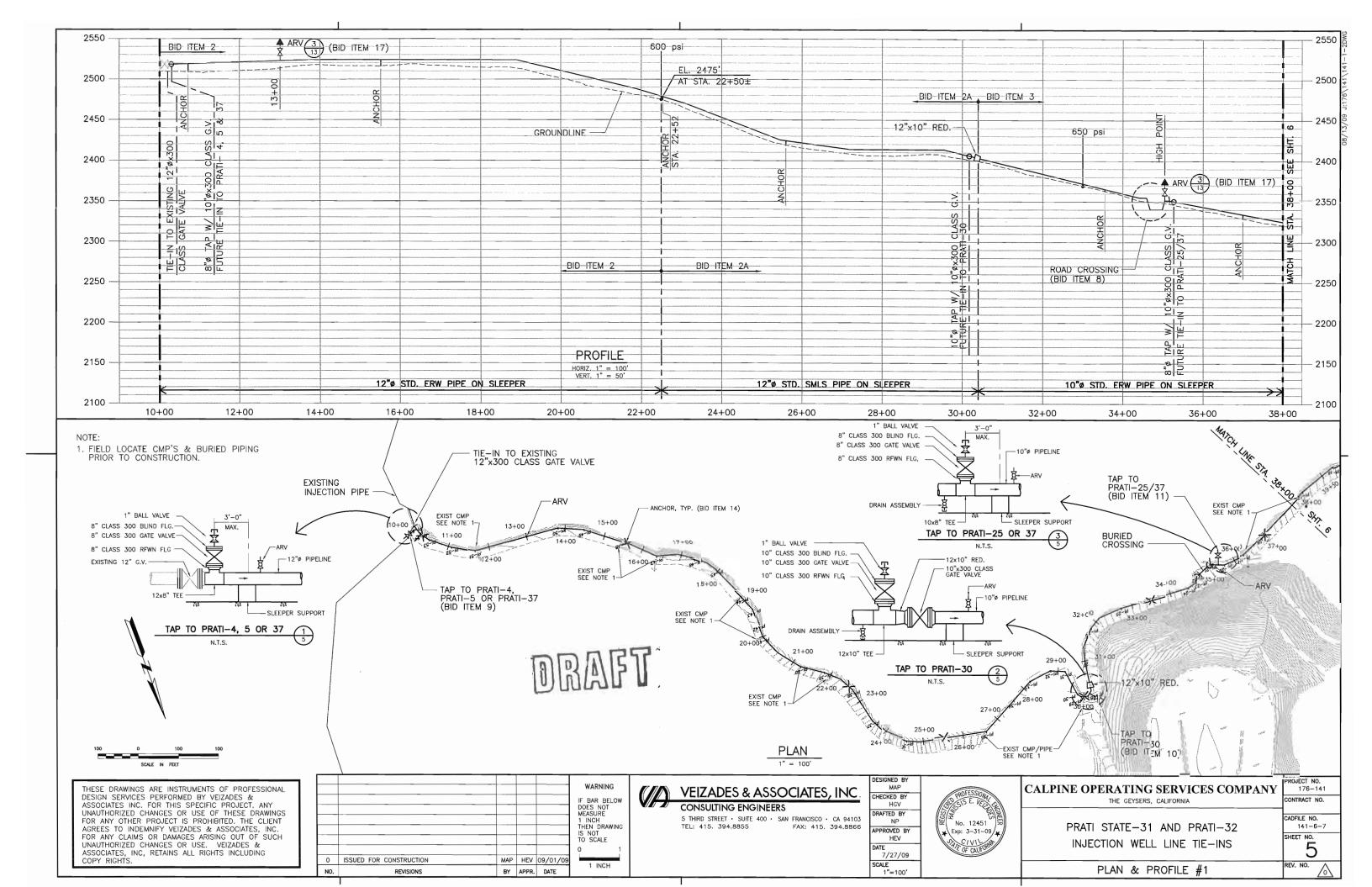
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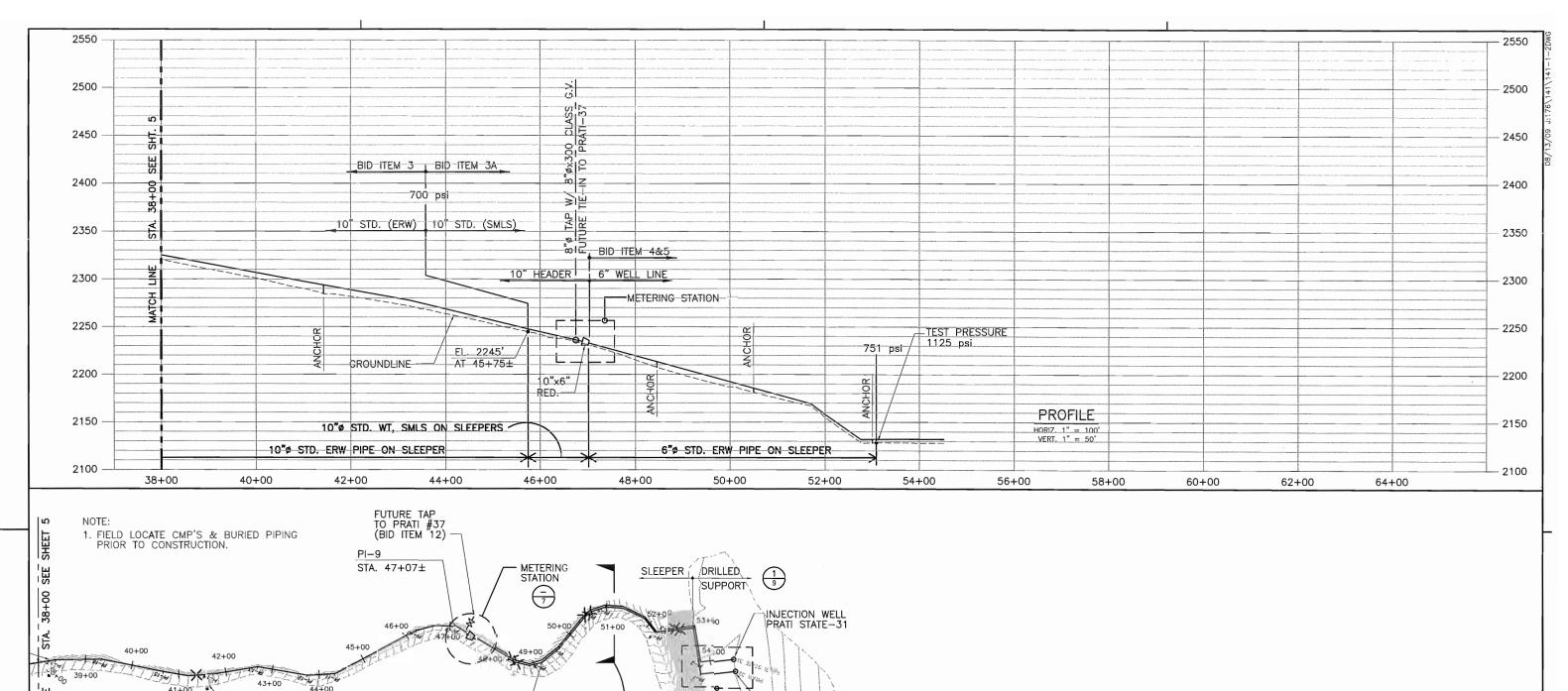
KGV

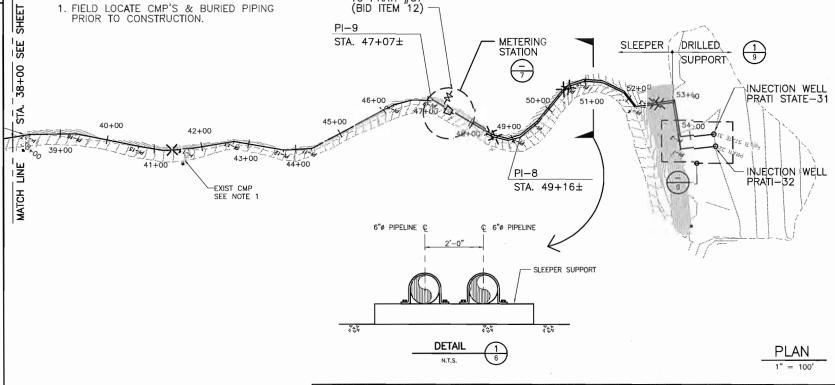
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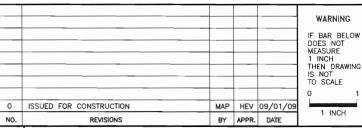






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CALPINE OPERATING SERVICES COMPANY

THE GEYSERS, CALIFORNIA

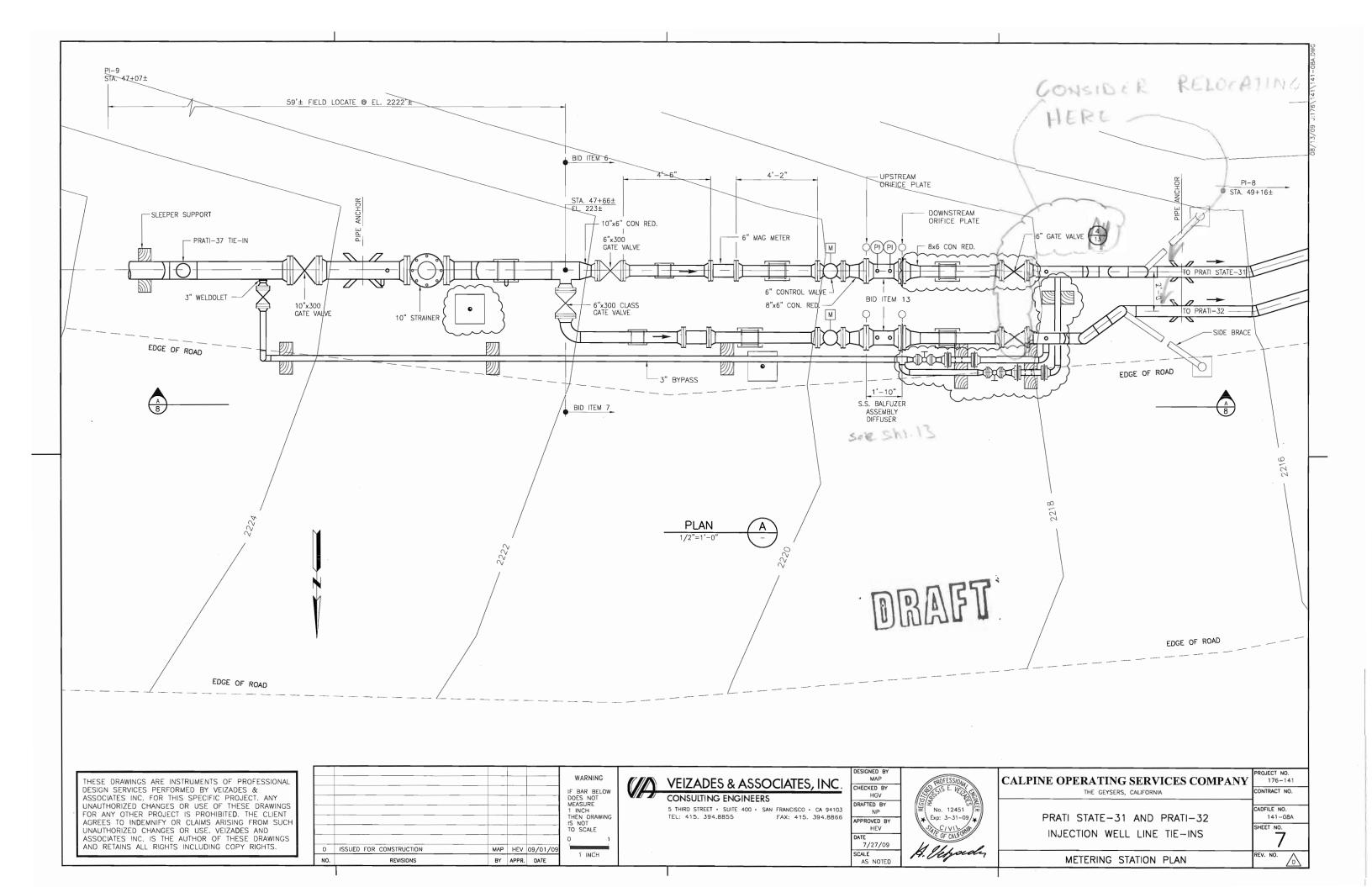
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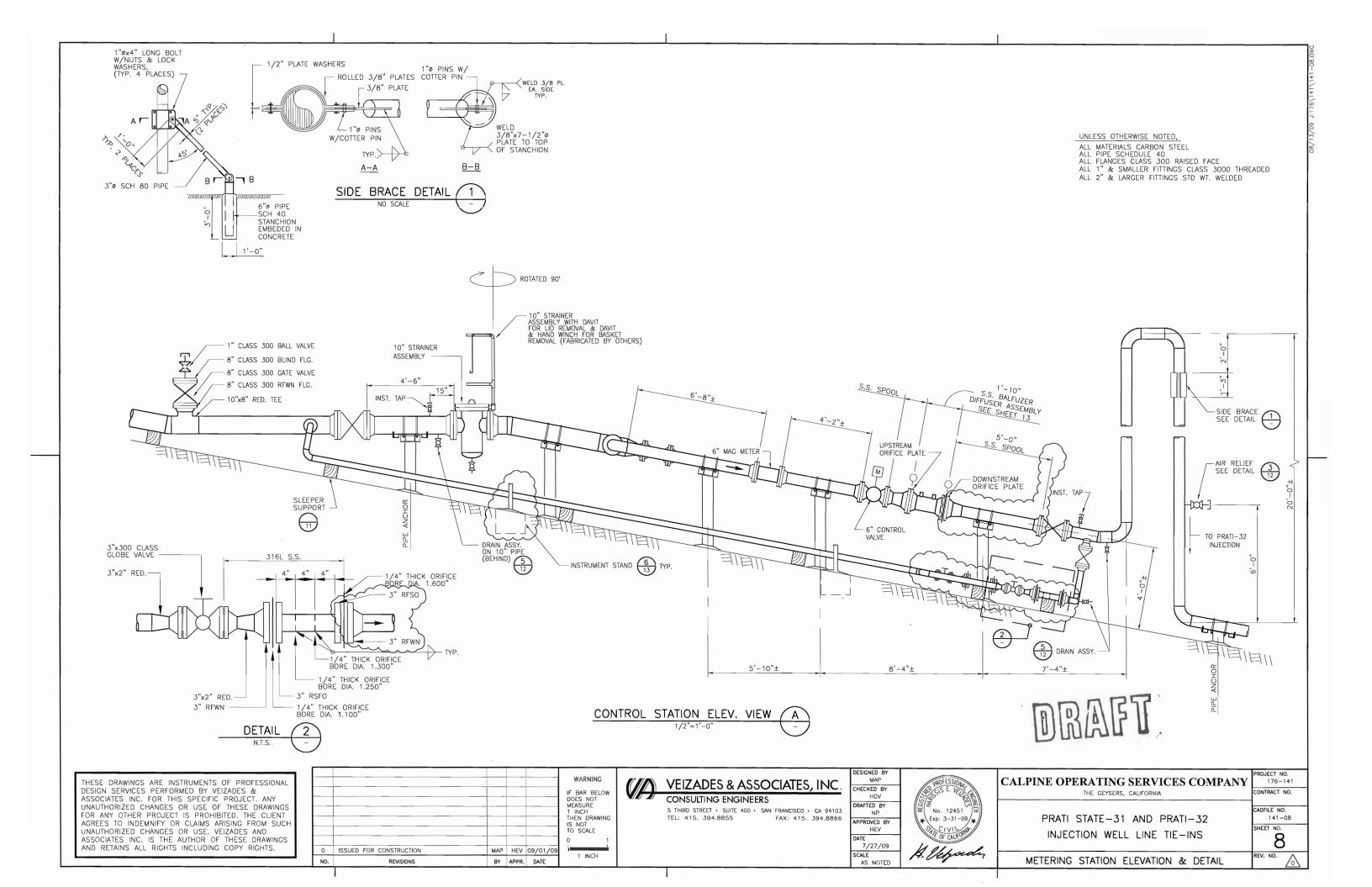
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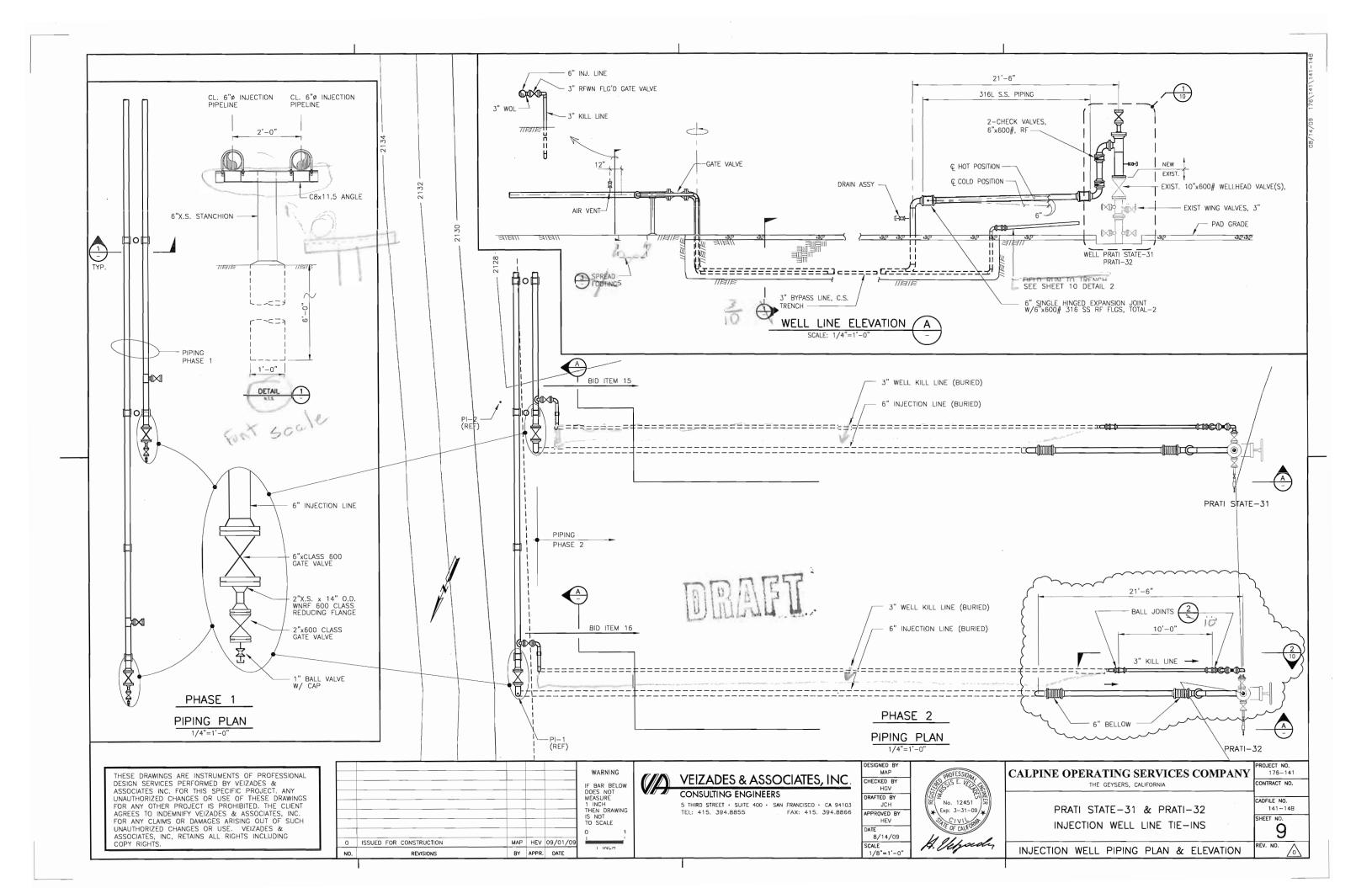
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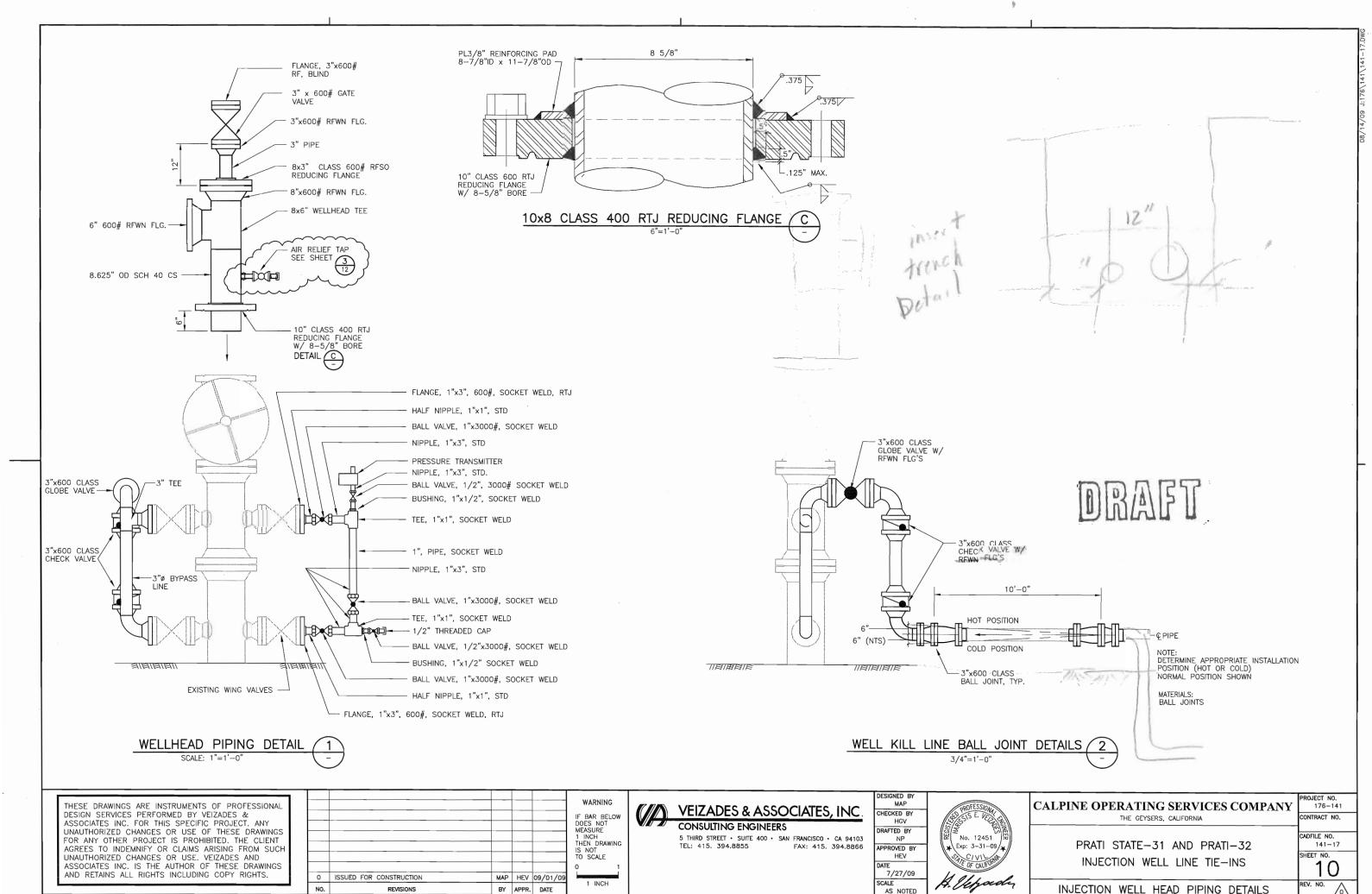
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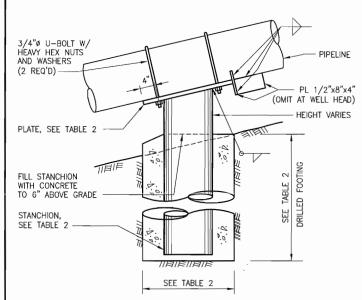


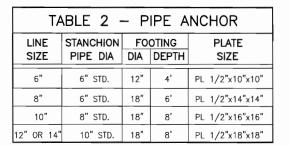
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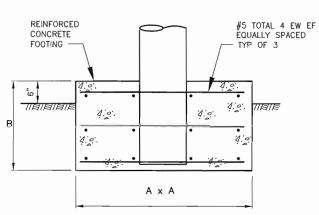
REVISIONS

INJECTION WELL HEAD PIPING DETAILS





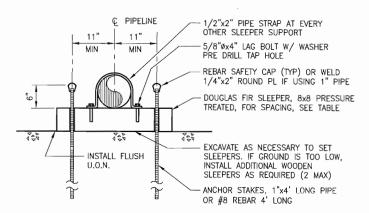




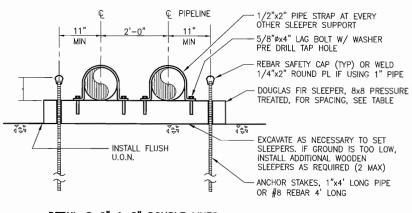
FOOTING DIMENSIONS	SUPPORT TYPE A&B		ANCHOR	
INJECTION LINE	Α	В	Α	В
8" INJ. LINE	2'	2'	3'	2.5'
10" INJ. LINE	2.5'	2'	3.5'	2.5'
12" INJ. LINE	3'	2'	4'	2.5'

ALTERNATE SPREAD FOOTING FOUNDATION

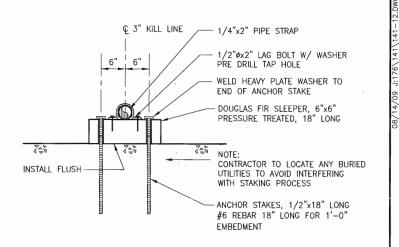
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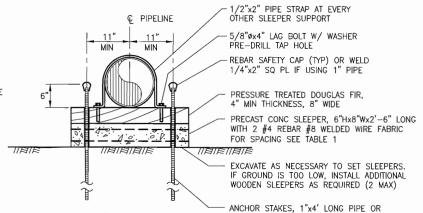
DETAIL @ 6" & 8" LINES

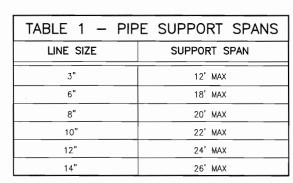


DETAIL @ 6" & 8" DOUBLE LINES



DETAIL @ 3" LINE





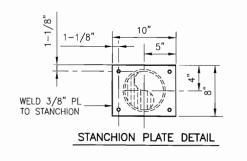
SLEEPER TYPE PIPE SUPPORT NO SCALE

PIPELINE 1/2"ø U-BOLTS W/ PIPELINE HEAVY HEX NUTS AND WASHERS -STANCHION PLATE PL 1/2x 18"x18" FAN 12" OR 14" PIPE PL 1/2"x10"x16" FOR 10" PIPE SUPPORT SHOE 2" XS BEARING BAR (AS REQUIRED) FOR KILL LINE SUPPORT) -- FILL STANCHION WITH - FILL STANCHION WITH CONCRETE TO 6" BELOW STANCHION PLATE CONCRETE TO 6"BELOW SHOE PLATE PIER DEPTH IN FEET PIER DEPTH IN FEET X.S. STANCHION SIZE X.S. STANCHION SIZE - DRILLED PIER DIA. IN INCHES - DRILLED PIER DIA, IN INCHES TYPE A TYPE B

DRILLED PIPE SUPPORT FOR 10",12" OR 14" PIPE

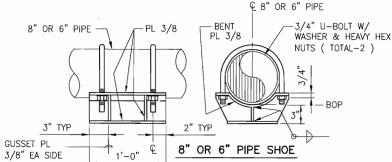
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DRILLED PIPE SUPPORT FOR 6" AND 8" PIPE NO SCALE

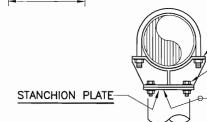


PIPE SHOE STANCHION STANCHION PLATE

AS NOTED



#8 REBAR 4' LONG

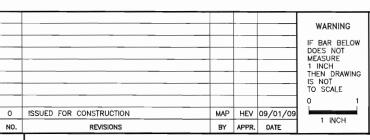


PIPE SHOE 5/8" BOLT NUT & PLATE WASHER TOTAL-4

SUPPORT SHOE & STANCHION PLATE INSTALLATION

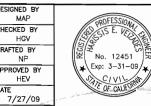
DETAIL @ 10", 12" OR 14" LINES

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CALPINE OPERATING SERVICES COMPANY THE GEYSERS, CALIFORNIA

NO SCALE

PRATI STATE-31 AND PRATI-32 INJECTION WELL LINE TIE-INS

PIPE SUPPORT DETAILS

SHEET NO. REV. NO.

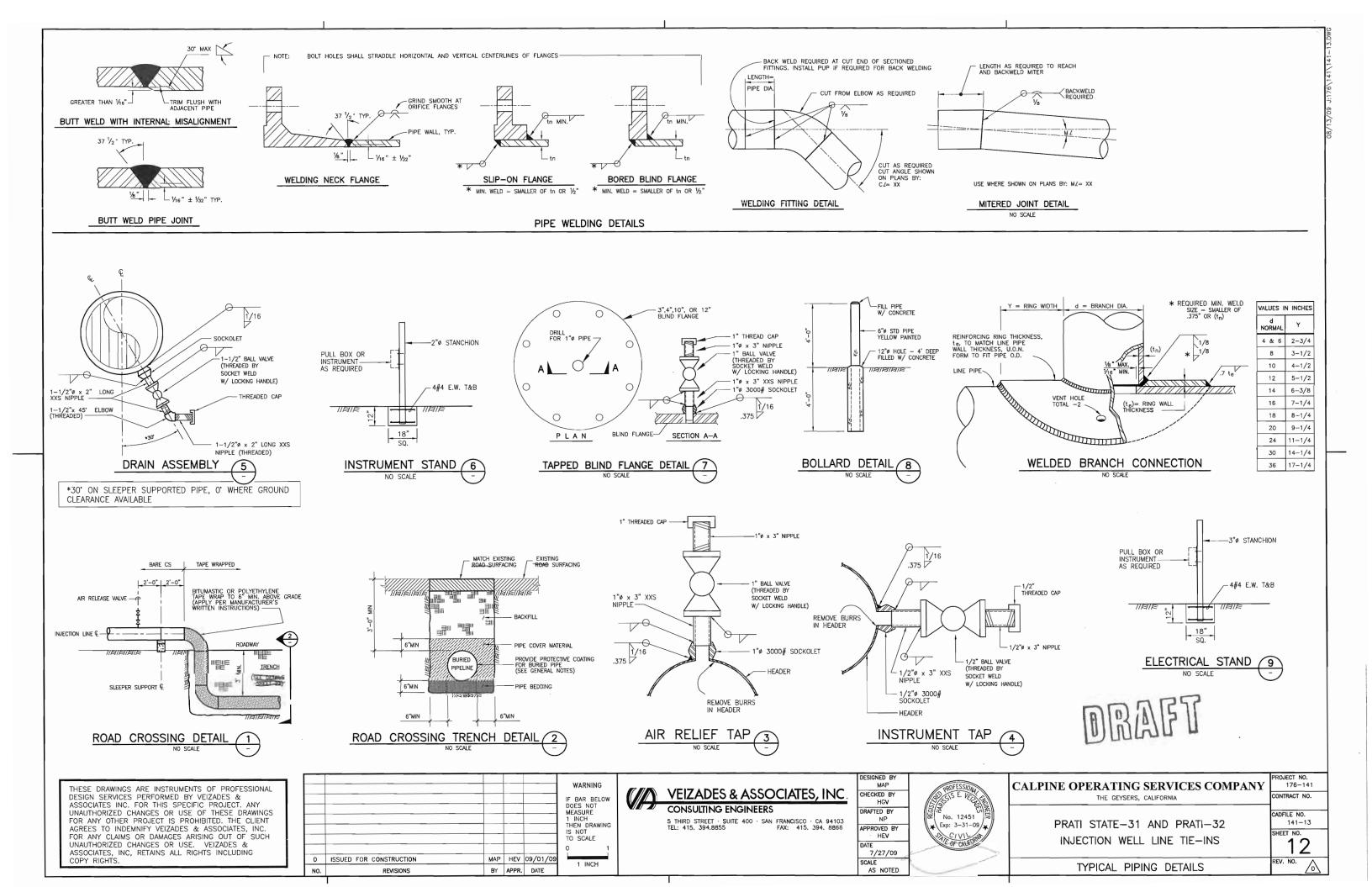
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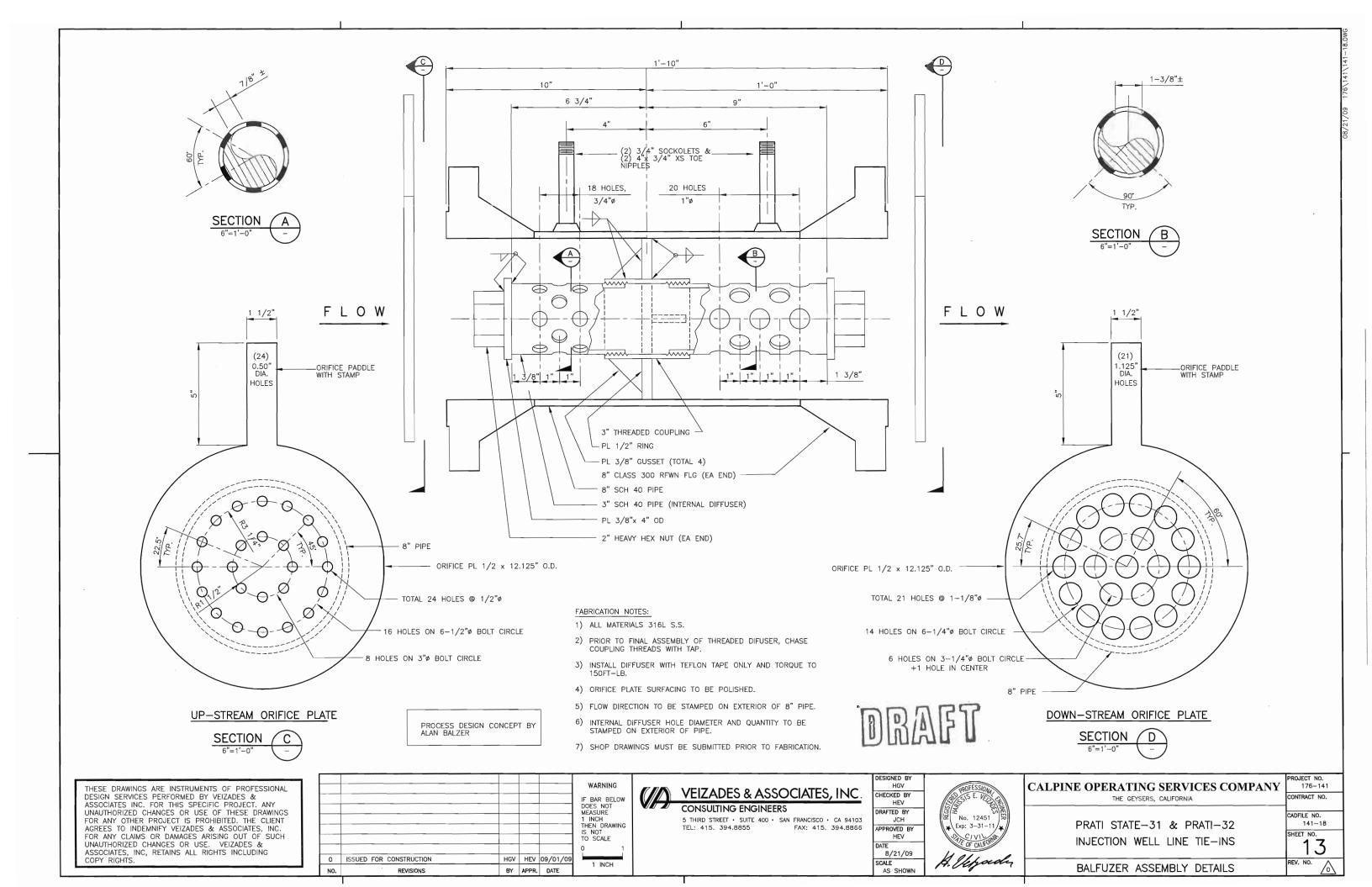
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ONTRACT NO.

CADFILE NO.

176-141





APPENDIX F:EMERGENCY PLANS

CALPINE GEYSERS EMERGENCY PREPAREDNESS AND RESPONSE PLAN No. 9.7 RESPONSE TO CHEMICAL RELEASES

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1.0 PURPOSE

- 1.1 This procedure provides direction for trained personnel to respond to chemical releases (solid, liquid or gas) within the Calpine Geysers facility.
- 1.2 Off lease responses must be coordinated with applicable agencies, but the initial response may be similar to that of releases within the Geysers, based on location and/or chemical released.
- 1.3 To establish notification and reporting requirements for unplanned releases of materials and wastes within the Geysers.

2.0 <u>DISCUSSION AND APPLICATION</u>

- 2.1 Calpine uses and disposes of a variety of potentially hazardous materials and wastes in the Geysers.
- 2.2 These materials and wastes may be commercial products, naturally occurring, or a by-product of the geothermal process. and may be potentially hazardous to people, the environment or property based on chemical and physical characteristics.
- 2.3 Response to hazardous materials / waste releases may be conducted only by personnel from within the facility appropriately trained in hazard communication and Emergency Response.
- 2.4 Unidentified chemicals must be handled as extremely hazardous until their identity is known.
- 2.5 A hazardous materials or waste release may be classified as an emergency response event requiring a greater level of training and protective equipment if it poses an immediate health threat to responding personnel and/or exceeds threshold quantities.
- 2.6 Small hazardous material or waste releases that can safely and readily be cleaned up by trained personnel at hand are regarded as incidental.
- 2.7 Non-hazardous material spills (e.g., steam condensate) that may pose a threat to the environment will be handled by Emergency Responders in accordance with these procedures and other applicable Health and Safety Programs and Procedures.

3.0 PROCEDURE

- 3.1 Upon discovering a hazardous materials or waste release, the first responder shall notify Control 1 (6911) immediately and give as much of the following information to Control one as possible to determine further actions:
 - 3.1.1 Source of the spill
 - 3.1.2 Material being released
 - 3.1.3 Approximate rate of release
 - 3.1.4 Location of the release
 - 3.1.5 Terrain
 - 3.1.6 Access to release point
 - 3.1.7 Distance from the nearest culvert / drainage ditch / surface water
 - 3.1.8 Safe access to surface water for sampling
 - 3.1.9 Area hazards
 - 3.1.10 Personnel threatened or injured
 - 3.1.11 Personnel and equipment immediately available to contain & control the release
 - 3.1.12 Actions reccommended / taken
- 3.2 Upon receiving the report of a possible release of hazardous materials or waste, Control 1 shall:
 - 3.2.1 Obtain the information required on the Operator on Duty Checklist: Chemical Response.
 - 3.2.2 If people have been injured or the public is immediately threatened call 911 to advise them of the situation with as much relevant information as possible following the steps in the Operator on Duty Checklist.

- 3.2.3 Initiate other responses (e.g., medical) in accordance with the appropriate Emergency Response Procedures and checklists.
- 3.2.4 Immediately notify the on call EH&S representative if the release is a liquid and is running into or is in proximity of a drainage ditch or culvert and is being released in a quantity that makes it probable that the material will reach a surface water.
- 3.2.5 Dispatch spill sampling kit and support personnel and equipment as needed.
 - 3.2.5.1 As appropriate, dispatch an employee to connect the GERT Vehicle to the Spill Response Trailer and proceed to the spill scene.
- 3.2.6 Call for additional outside resources as is deemed necessary (e.g. vacuum trucks or spill response companies).
- 3.2.7 Dispatch personnel to appropriate guard gates to guide any outside response personnel to the site of the chemical release.
- 3.2.8 Provide map with highlighted surface water locations and access roads to the responders if needed.

3.2.9

Page !GPP Emergency to notify response and management personnel in accordance with notification guidelines.

INSTRUCTIONS TOTHE INCIDENT COMMANDER

- 2.1 The first trained emergency responder **ON SCENE**, will act as interim IC until released by a designated IC. Initial responsibilities in order of **PRIORITY** are:
 - 2.1.1 If outside responders have been requested, provide an assessment of release location through Control 1. Include: injuries, potential for fire, location, terrain, amount released, rate of spread, watercourses threatened, weather, and other exposures.
 - 2.1.2 Conduct a hazard analysis of the situation to determine safety of Calpine or outside responders. See Chemical Information Sheets for information on each Chemical:

RELEASE OFFENSIVE VS DEFENSIVE ACTIONS				
Offensive Response actions can be initiated provided ALL of the following criteria are met:				
1. PERSONNEL TRAINING	Four Hazardous Material Technicians are available to respond using the buddy system with back-up. Unidentified materials must be regarded as extremely			
2. MATERIAL IDENTIFIED	hazardous and require thorough planning in conjunction with a trained Safety Officer.			
3. FLAMMABILITY LOW	Personnel cannot enter flammable atmospheres (> 10% LEL).			
4. PPE	PPE specific to the released material is on site. Suitable decontamination equipment must be set up			
5. DECONTAMINATION	before entry.			
6. OUTCOME	Plan established for offensive response must have a high probability of stopping continued release. All personnel have a planned, accessible escape route			
7. ESCAPE ROUTE	and safety zone at all times.			

If any of these criteria cannot be met, then only take defensive response actions. Defensive actions well back from the spill may include building berms to prevent spread or direct materials away from sensitive exposures. PPE will be worn.

- 2.1.3 In the absence of the Health and Safety Supervisor, the IC shall upon arrival appoint a designated SAFETY OFFICER for the incident.
- 2.1.4 The IC shall communicate to incoming responders any changes in release status, and the location and assignment of all emergency responders.
- 2.1.5 It is the IC's and the Safety Officer's responsibility to insure that all responders at the incident are using the required and appropriate safety equipment. Responders without proper protective equipment shall not be allowed to participate in spill response activities.

3.0 CHANGES IN INCIDENT COMMAND

3.1 Upon arrival of the outside agency(s), the acting IC shall inform the responders that it is Calpine Policy to form a Unified Command comprised of the outside agency Commander and the Calpine IC.

- 3.2 After the arrival of the outside agency(s), Calpine responders may continue to assist provided:
 - 3.2.1 The Geysers IC shall have primary jurisdiction over any Calpine personnel assignments to be sure they do not exceed their level of training.
 - 3.2.2 The requested response activities are within the training and capabilities of the Calpine responders.
 - 3.2.3 The continued use of Calpine personnel does not jeopardize facility operations/load.

4.0 POST INITIAL RESPONSE OPERATIONS

- 4.1 Calpine shall continue to provide an on-site liaison throughout the duration of any outside response.
- 4.2 Calpine shall continue to provide resources, including personnel, for the duration of the event or until released by the agency IC.
 - 4.3 Calpine non-motorized equipment can be left on scene for use by outside agencies at their request, if, the outside agency commander signs an inventory detailing what equipment is being left under their supervision.
 - 4.4 Upon termination Calpine personnel participation in the incident, it is the responsibility of the IC to:
 - 4.4.1 Ensure that all equipment is returned to service. Vehicles and equipment should be decontaminated, all tools and protective equipment stored properly, any hose cleaned and placed to dry. Spare hose should be used to replace any out of service hose.
 - 4.4.2 Any mechanical defects to vehicles should be noted and reported to the garage so repairs can be made.
 - 4.4.3 Any lost, missing, or damaged response equipment should be reported to the Calpine IC.
 - 4.4.4 Notify Control 1 of incident termination, and report any out of service emergency response vehicles.

4.4.5 Assist outside agencies with decontamination of their equipment, if needed.

RESPONSE STANDARD OPERATING PROCEDURES

1. IDENTIFICATION OF THE MATERIALS INVOLVED

Identification of materials involved in an incident is critical to a safe, effective response. Look at labels or placards, using binoculars if not safe to approach. If possible ask personnel working at the incident scene for material identities. Members of the EHS Department and crew supervisors can provide assistance. Material Data Sheets (MSDS) are available from the 3E Company for all products used by Calpine at The Geysers. These are a valuable resource for identification as well as hazard, protective equipment and response information.

In the case of vehicle accidents, it is possible that materials may be involved which are not intended for The Geysers. The following steps should be used to determine identity:

Do not approach a damaged tank or truck without proper training and controls if you do not know the identity of the material or if you know that it is hazardous. Some materials capable of extreme health and safety hazards are carried in trucks or tank trailers.

Check the shipping papers (manifest) located in the cab of the vehicle to help identify the spill. Department of Transportation (DOT) regulations require that hazardous substances be described on the shipping paper. The shipping papers must be carried within immediate reach of the driver and be readily available to persons entering the driver's compartment. Do not overlook this means of spill identification if the truck causing the spill is still at the scene or can be tracked down.

Trucks hauling qualifying amounts of hazardous materials are required to be marked by a prominent diamond shaped placard carrying a 4 digit ID Number. Identify the contents of a load by looking up this number in the DOT publication Emergency Response Guidebook. If a placard and this number are clearly visible, note them before evacuating the area. Be prepared for hazardous materials even if a placard is not present.

The following information will help to identify materials in common use at The Geysers.

1.1 WET CHEMICALS

Nearly all of the wet chemicals transported and stored at The Geysers are used for hydrogen sulfide abatement or chloride corrosion mitigation. Power plant abatement chemicals include Stretford solution, hydrogen peroxide, caustic soda (sodium hydroxide), iron compounds and polymers.

Because many chemical substances have health and safety dangers, emergency response to wet chemical spills at The Geysers shall be handled only by personnel trained and certified in accordance with 29 CFR 1910.120. Incidental spills may be cleaned up by personnel trained in the hazards of the chemicals and the use of the proper protective clothing.

Liquid chemicals used at The Geysers present health and safety concerns generally associated with direct skin or eye contact, or inhalation of vapors. Refer to the Chemical Information Sheets for more specific information about health and safety measures. In all cases, some form of protective clothing is required when working in direct contact with wet chemicals. Understand the MSDS before working with any chemical. Chemical Information Sheets also describe locations and amounts of chemicals present.

Smaller quantities of hazardous wet chemicals are used in Calpine laboratories.

1.2 DRY CHEMICALS

Dry chemicals are packaged, transported and stored in smaller quantities than wet chemicals. Only trained personnel should approach and contain the spilled material.

Many construction materials and drilling mud additives are manufactured and sold as dry, powder-like substances. Some are hazardous materials while others are of little concern. Dry chemicals used in abatement processes at power plants all have certain health hazards. Because of the complexities involved in trying to identify spilled chemical substances, it is good practice to treat all chemical spills as potential health and safety hazards until proper identification is made. Container labels, if safely approached, can provide identity.

Stay upwind of dry chemical spills and avoid breathing any dust or powder. Isolate the road at the next intersection and do not allow vehicles to enter to minimize blowing and spreading of the substance. Emergency Response to dry chemical spills at The Geysers which may present a danger to personnel or property or

the environment will be handled only by personnel trained and certified in accordance with 29 CFR 1910.120 Emergency Response Procedures. Incidental dry chemical spills may be cleaned up by personnel trained in the hazards of the material and the use of appropriate personal protective equipment.

1.3 PETROLEUM PRODUCTS

Petroleum products used at The Geysers include fuel, such as gasoline, diesel and LPG, solvents and oils for lubrication or heat transfer, corrosion inhibitors, dispersants, used oil, and road oil. These substances pose various safety hazards and if released into the environment, may cause long term damage to plant and animal life. LPG is discussed further under GASES.

Hydrocarbons consist of various volatile components or fractions. At ambient temperatures some of these fractions will evaporate, leaving behind heavier, less volatile components. This ability to vaporize is directly related to how easily an oil or fuel can burn or explode. Gasoline is especially flammable. On cool, damp days fuel is less likely to vaporize and burn than on hot, dry days. This is an important consideration when containment and clean up are in progress.

Evacuate the area around gasoline releases because of high explosion potential. A calibrated flammable gas monitor should be use to approach any petroleum release. Entry is not allowed if 10% of the Lower Explosive Limit is exceeded. Call the fire department to apply foam to reduce the airborne concentration. Conduct containment operations to prevent spread of fuel at a safe distance. If a gasoline tank truck is involved, the 2000 North American Emergency Response Guidebook recommends evacuating the area for a ½ mile radius.

Use non-sparking tools for clean up and keep all ignition sources away. Wear PPE to prevent skin contact and inhalation of vapors. See Chemical Information Sheets for additional information.

1.4 GASES

Gases present at The Geysers may be naturally produced in the steam, or by chemical reactions with those non-condensable gases or commercially produced compressed gases.

Commercial compressed gases are divided into two major groups: nonliquified and liquefied. Nonliquified gases do not liquefy at ordinary temperatures under pressures up to 2000 to 2500 psig. They have boiling points below -150° F. When these gases are

cooled below their boiling points, they do become liquids and are referred to as cryogenic liquids. Oxygen, helium and nitrogen are widely used as nonliquified gases or cryogenic liquids. Cryogenic nitrogen may be used to gas cap geothermal wells at The Geysers. Liquefied gases become liquids at ordinary temperatures and pressures from 25 to 2500 psig. These solidify at cryogenic temperatures; for instance, carbon dioxide becomes dry ice. A third group is dissolved gas that includes acetylene. Acetylene gas is dissolved in acetone in a porous tank filling. This is necessary because acetylene is unstable at pressures above 15 psig and explosive conditions can result.

Gases are divided into major families:

<u>Atmospheric gases</u>: nitrogen, oxygen, argon, helium, neon, krypton, xenon and radon as well as hydrogen and carbon dioxide. <u>Fuel gases</u>: hydrocarbon gases; LPG, natural gas, methane, hydrogen and acetylene.

Refrigerant gases: halogenated hydrocarbons which are inert.

Gas uses can cross family lines.

Gases such as hydrogen sulfide, sulfur dioxide and carbon monoxide are also classified as poison gases.

All compressed gases get cold when pressure is released and present a frost bite hazard. All except oxygen present an asphyxiation hazard by displacing air. Use proper connections, regulators and containers to avoid accidents.

Geothermal noncondensible gases can be toxic, flammable, or displace oxygen, presenting the same hazards as commercial gases.

1.4 WASTES

Geysers wastes may be contained in vacuum trucks, roll-off bins or drums. The majority of the wastes are associated with hydrogen sulfide abatement processes or facility maintenance activities. All of these wastes should be assumed to contain heavy metals, such as arsenic, mercury and vanadium. They should also be assumed to contain sufficient sulfur or sulfur compounds to be flammable or capable of producing toxic sulfur dioxide gas. Personal Protective Equipment is required to prevent skin contact or inhalation.

Flammable wastes from paint, fuel or solvents may also be present. These are generally packaged in drums, but may be in 5 gallon pails. These wastes may be toxic by contact or inhalation.

Septic wastes are present in pipelines, vacuum trucks and portable toilets. Protection against biohazards is a primary concern with these materials.

2. HAZARD AND RISK ANALYSIS

Once the identity of a released material is known, the hazards must be identified, and the risk of harm to responders established. Material Safety Data Sheets on all products used at The Geysers are available through 3E Company. Reference books on hazardous materials are available from the EHS Group personnel. Information is available through internet sources. Summarized hazard and risk analysis as well as chemical and physical properties, recommendations on protective clothing, medical treatment and toxicology information is available through the Chemical Information sheets in this document.

Based on the material hazards and the release size and location, areas of control must be established around the incident. The following guidelines should be used to establish these control zones:

The hot zone is the area immediately around the incident where containment and clean-up will take place. The warm zone is the area surrounding the hot zone where decontamination takes place.

The Hot Zone/Warm Zone line will be delineated by the following parameters:

- Combustibles = 0% Lower Explosive Limit (LEL)
- Oxygen content = 20.9%
- Air contaminants = 1/2 Permissible Exposure Level

Respiratory protection must be worn in the Hot Zone. The Safety Officer will establish appropriate respiratory protection for the Warm Zone.

Accumulation of hydrocarbon vapors, gases and smoke can have an adverse effect on personnel. Symptoms of exposure may include the following: olfactory fatigue, headaches, irritation of the eyes, suffocation, paralysis, and death. For this reason, the Hot Zone/Warm Zone must be established and the appropriate personal protective equipment must be used.

An entry team may proceed into the Hot Zone when the combustible gases exceed 0% LEL, however, when the combustibles reach greater than 10% LEL the entry team must leave the Hot Zone and proceed to the Warm Zone. Control measures must be taken to reduce the combustible gases below 10% of the Lower Explosive Limit prior to reentering the Hot Zone.

Oxygen content may be less than 19.5% at the work area; however, all personnel must wear a supplied air or self contained breathing apparatus with a 10 minute reserve or enough to get back to the Warm Zone, whichever is greater.

Air contaminants may exceed the Permissible Exposure Limits in the immediate work area (Hot Zone). However, personnel must wear self contained or supplied air breathing apparatus.

If the release is known to be corrosive to skin or to be absorbed into the skin, appropriate controls must be used to prevent worker injury.

The Incident Commander, Operations Chief and Safety Officer must determine the specific engineering and administrative controls and PPE required for each situation.

Support activities and the staging area are located in the cold zone. PPE is not required.

The Warm Zone/Cold Zone shall be delineated by the following parameters:

- Combustibles = 0% LEL
- Oxygen content = 20.9%
- Air contaminants less than 1/4 Permissible Exposure Limit

HOT ZONE	Line Delineation	WARM ZONE	Line Delineation	COLD ZONE
WORK AREA 1. Combustibles=				
0% up to 10%	0		0	
2. Oxygen % up to 23.5%	20.9%		20.9%	
3. Air Toxics-may exceed I.D.H.L.	1/2 P.E.L.		< 1/4 P.E.L.	

<u>2.1 THREAT OF FIRE OR EXPLOSION: FACTORS TO CONSIDER</u>

In the initial evaluation of a fuel or solvent spill, flammable gas or waste release incident, the Incident Commander shall assess the threat of fire and explosion.

Because hydrocarbons are combustible, there always is the threat that fire or explosion may occur during control and/or response operations. Volatile components in the spilled material will evaporate giving rise to a hydrocarbon/air mixture. Because these hydrocarbon vapors are more dense than air, they will accumulate, particularly in confined or poorly ventilated areas. The risk of fire and explosion is greatest just after the release when the evaporation rate is at a maximum, and will normally diminish rapidly with time.

Ignition may be caused not only by the more obvious sources, such as a fire, but also by an electrical system, the hot exhaust of an internal combustion engine, by sparks from electrical equipment, mechanical or friction sources, hot flying particles from burning embers, welding and cutting equipment, and the discharge of static electricity. Great care must be taken to eliminate **all** possible sources of ignition.

Although heavier petroleum products become more and more difficult to ignite with time, oil impregnated floating debris may act as a wick increasing the flammability hazard of heavy products, especially when layers are thin. Care must be taken, therefore, to ensure that the spilled oil is not ignited.

Equipment used in a flammable atmosphere must be explosion proof or intrinsically safe.

Hot work must be strictly controlled to prevent ignition. Hot work means cutting, welding, or other ignition source causing work.

Hot Work Parameters:

- Combustibles = 0% LEL
- Oxygen content greater than 19.5% and less than 23.5%.
- Airborne contaminants less than the Permissible Exposure Limits.

2.2 H₂S THREAT: FACTORS TO CONSIDER

Be familiar with the Calpine, <u>HYDROGEN SULFIDE SAFE WORK</u> PROCEDURE. In case of an emergency involving H₂S, these procedures apply.

a. OSHA allows exposure to H₂S concentrations up to 15 ppm for 15 minutes. Exposures to higher concentrations are allowed for shorter times, however Calpine policy requires supplied air equipment for extended work in concentrations above 10 ppm. Contact your supervisor before proceeding if PAM alarms.

- b. If H₂S is being emitted in high concentrations with condensate or non-condensable gas from a source, personnel are not to enter the Hot Zone area without SCBA or air supplied system.
- c. Monitoring is to be done with a reliable measuring device, such as a direct reading H₂S meter, Drager tube or personal H₂S monitor (PAM). For personal safety, the concentration of H₂S must be monitored by instrument and not judged by the degree of odor, as the ability to smell H₂S is lost after short term exposure to high concentrations.
- d. Measurements will be taken to delineate the Hot Zone/Warm Zone line, following procedures outlined in Section 2, Hazard and Risk Analysis. In an emergency situation, H₂S measurement should always involve two people, one taking the measurements and the other positioned for safety watch.
- e. Portable breathing air is to be worn by each person involved in the monitoring.
- f. The concentration of H₂S or other noncondensable gases will be highest if the wind is low. The greater the agitation from the wind the quicker the dispersion of these gases.
- g. When the H₂S concentration is determined by instrument to be below the Permissible Exposure Limit (10 ppm) personnel may enter area for clean-up activities without SCBA or air line. A PAM should continue to be used.
- h. Although the cleanup team exposure to H₂S should be below the Permissible Exposure Limit, air packs should be available for each member.
- Continued ambient concentrations above 1/2 the Permissible Exposure Level (5ppm for H₂S) is considered the action level. The Incident Commander, Operations Chief and Safety Officer will establish engineering and administrative controls or personal protective equipment to reduce worker exposure.

j. A designated safe area will be established in the Cold Zone. This area will be at least 100 feet up wind from the gas source or leak.

3. ENVIRONMENTAL ANALYSIS

Chemical releases may pose risks to the environment. In fixed locations, berms provide protection against runoff into watercourses. Transportation accidents, which may occur anywhere within or off the lease cannot be tightly preplanned. Certain assumptions can be made about the behavior of releases, and preplanned actions recommended. The oil spill containment areas described in Section 7.3.1, 3), b. are an example of such preplanning. These access points to the creek may also afford an opportunity to mitigate other types of releases, as well as points to assess impact.

Creek water extraction facilities, BSC 1, 2, and 3 may also provide the opportunity to remove both water and a spilled substance if this is safe, in order to prevent downstream damage. EHS should be consulted before beginning injection.

Animals living in the vicinity of spills or creeks receiving spills must be prevented from entering the spilled material, or if contaminated must be captured and cared for appropriately. Contact California Department of Fish and Game and then the Sonoma County Wildlife Rescue, P.O. Box 9360, Santa Rosa, CA 95405,707-526-9453 (WILD) to request skilled assistance in animal care.

4. EVALUATION OF PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT

Emergency Response at The Geysers could involve exposure to fire, high temperature steam, or chemicals. A thorough evaluation of the specific hazards, amount and type of air-borne hazards, breakthrough time of any particular PPE and scope of tasks for an emergency response must be considered in order to select the appropriate PPE. See the Calpine HSP 170 PPE for more information. Section 9.11 Chemical Information Sheets also contains PPE guidelines. The following general guidelines will be followed.

- Only trained personnel will select PPE appropriate to hazards.
- Only trained personnel will respond to hazmat incidents wearing PPE.
- All equipment will be inspected prior to donning for emergency response.

- All contaminated equipment will be properly cleaned before being returned to service.
- Any damaged equipment or equipment which cannot be cleaned will be disposed of properly and replaced.
- Fire: Fire response shall be only to incipient stage fires. By definition,
 PPE is not required for response to incipient stage fires. If you feel you
 need PPE to respond to a fire, do not respond. Obtain assistance from
 professional fire fighters. An exception is wearing an SCBA to put out
 sulfur fires within the scope of your training.
- High temperature steam: Calpine does not maintain or train on PPE for entering high temperature steam environments. Obtain assistance from professional fire fighters for this type of response.
- Chemical:

When selecting respiratory protection for a specific response, the following should always be considered:

Self Contained Breathing Apparatus should be utilized for atmospheres above the level designated as "Immediately Dangerous to Life and Health (IDLH), unknown airborne hazard contaminant, oxygen deficient atmospheres or levels above the air purifying cartridge limit.

MSA Full face (FF APR) are available for use in atmospheres up to the IDLH or 100 times the PEL for a specific chemical.

In addition, four levels of protection are stocked and available in the Emergency Spill Response Trailer and in the East Administration warehouse. The IC should consider the following criteria when determining the level of PPE for a particular response:

- a. **Level** "A" Level A protection includes a totally encapsulating suit, SCBA, chemical resistant inner and outer gloves, chemical resistant boots and hard hat (under suit). This PPE should be selected when the greatest level of skin, respiratory, and eye protection is required. The following points should be considered:
 - The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and respiratory system and has the measured or potential for high concentration of atmospheric vapors, gases, or particulates.
 - Substances with a high degree of hazard to the skin are known or suspected to be present and skin contact is possible.
 - Operations are being conducted in confined or poorly ventilated areas and the existence of conditions requiring Level "A" protection has not been ruled out yet.
 - Response to unknown substances.

- b. **Level** "B" Level "B" protection includes hooded chemical resistant clothing, SCBA, chemical resistant inner, and outer gloves, chemical resistant boots, and hard hat with splash shield. This PPE should be selected when the highest level respiratory protection is required but a lesser level of skin protection is needed. The following points should be considered:
 - The type and atmospheric concentration of substances have been identified. The atmosphere currently has or may have the potential to contain less than 19.5% oxygen. The presence of incompletely identified vapors or gases is indicated by a direct reading instrument but the vapors or gases are not suspected to be harmful to the skin or skin absorptive.
 - Equipment compatibility to hazardous material must be assured before entry.
- c. Level "C" Level C protection includes full face or half-mask air purifying respirators, hooded chemical resistant clothing, chemical resistant inner and outer gloves, chemical resistant boots or covers, and hard hat with splash shield. This PPE should be selected when the concentration and type of airborne contamination is known and the criteria for using air purifying respirators are met. The following should be considered:
 - The atmospheric contaminants, liquid splashes or other direct contact will not adversely affect or be absorbed through exposed skin.
 - The types of air contaminants have been identified, concentrations measured and an air-purifying respirator is available that can remove the contaminants.
 - All criteria for use of an air purifying respirator are met.
 - Periodic air monitoring must be performed.
- d. **Level** "D" Level D is a work uniform affording minimal protection and is used for nuisance contamination only. The following point should be considered:
 - The atmosphere contains no known hazard and work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

5. INFORMATION AND RESOURCE COORDINATION

Efficient, safe response to spills depends on accurate, timely information transfer from those who collect it to command staff and responders. The following guidelines describe this process briefly.

- (1) Preparedness begins with planning before an emergency occurs, which is one purpose of these <u>Emergency Preparedness and Response Programs</u>. In the event of an emergency, these documents should be utilized for background information, identification, and Standard Operating Procedures (SOP's).
- (2) Command Staff should identify the following HazMat Factors and communicate these to Operations. The <u>Operator on Duty Checklist: Chemical Response, Section</u>, should be used.
 - a. Chemical Hazard
 - 1) Identity
 - 2) Quantity
 - 3) Container type / condition
 - 4) Physical properties
 - 5) Chemical properties
 - 6) Health considerations
 - 7) PPE
 - 8) Control measures
 - 9) Decontamination procedures
 - b. Occupancy
 - 1) Number of persons involved
 - a) Calpine Personnel
 - b) Contractors
 - c) Landowners / visitors
 - c. Structure
 - 1) Calpine
 - 2) Other
 - d. Life Hazard
 - e. Resources
 - 1) Manpower / equipment on scene
 - 2) Manpower / equipment responding
 - 3) Response times
 - 4) Condition of responders / equipment
 - Perform and record medical data prior and after entry.
 - 5) Capability of personnel
 - 6) Capability of commanders
 - f. Special Circumstances
 - 1) Time of day
 - 2) Day of week
 - 3) Season
 - 4) Special hazards

5) Weather

6. RELEASE CONTROL, CONFINEMENT AND CONTAINMENT

All emergencies and potential emergencies will be reported to Control 1. The Incident Commander (IC) will institute the desired course of action in a spill as listed in descending order of importance below. Judgment must be exercised by personnel involved as to proper implementation of the plan.

- Assure Personnel Safety The safety of people is of primary importance. No action should be taken which will place people at risk.
- <u>Secure Help</u> Call Control 1 to secure help as soon as possible, depending on the nature and magnitude of spill. This will trigger implementation of the Emergency Response Plan.

Identify Material

- a. Use Chemical Information Sheets, placards, labels, shipping papers, etc.
- b. Use identity for hazard analysis.
- c. Use identity to determine proper PPE for any response.
- Control at Source of Spill Simply stated, if a spill is occurring, stop
 it by any safe means available. This might include closing a valve,
 shutting off a pump, or plugging a leaking tank or tank fittings with a
 rag, wooden bung, sack, gel or other makeshift devices normally
 found around a production or drilling operation.
 - a. Wear proper PPE for any response.
 - b. Perform proper medical monitoring for environmental conditions and PPE selected.
- <u>Collect Required Samples</u> The IC will assign a trained person to collect spill samples in accordance with the sampling procedure. Samples of the spilled substance should not be collected for hazardous materials. Creek samples must be taken as soon as possible in accordance with the Spill Stream Sampling Plan.
- Containment of Spill Isolate and contain the spilled product. Most spills are small and can be easily contained with hand tools which are carried on all company trucks or are available from the tool room. Supplies are stored in the Spill Response Trailer at the GAC. Palletized sand bags are stored at the West Geysers Field Office Warehouse to aid in containment. If the spill cannot be

contained with hand tools or if secondary containment facilities are in danger of failing, larger equipment will be called in as appropriate. This equipment may include backhoes, front loaders, graders or bulldozers.

- Spill Cleanup Cleanup operations should begin as soon as containment has been put into effect using only trained personnel. Cleanup will depend on the nature of the spill, and may range from absorbing spilled product with dirt and properly disposing of dirt, to picking up product with small portable pumps and empty drums, or utilizing vacuum trucks. Oil that has entered a watercourse may be picked up with oil absorbant pads stored in the Spill Response Trailer or the West Geysers Field Office Warehouse. The Geysers Waste Coordinator shall be consulted before disposal of any solid or liquid material.
- Repair of Damage and Return to Normal Operations Upon completion of cleanup, the reason for the spill will be determined and remedial action will be taken to prevent future occurrences.
- A Critique of the Response Operation A critique will be conducted and necessary changes to plans and/or training to improve the response will be made.

7. RELEASE SPECIFIC RESPONSE PROCEDURES:

7.1 CONDENSATE

- a. Pipelines and Ponds
 - 1) Initial Response STOP THE DISCHARGE, IF POSSIBLE, BY ANY SAFE AVAILABLE MEANS.
 - 2) Special Considerations

If a catastrophic failure of the condensate system occurs, stop or reduce the inflow to the system. There are four ways to accomplish this:

- a) Divert pond inflow into a bypass line.
- b) Reduce or stop flow from the condensate vent system.
- c) Reduce or stop discharge from the cooling towers to the pond. Cooling towers have enough excess capacity to allow the power plant to operate for a considerable length of time with no discharge to a condensate pond.

d) Curtail the power plant or, in extreme cases, force the unit out.

3) Containment

Shut off the source of a condensate spill and contain the spilled fluids to prevent them from reaching a stream or other watercourse. Spill containment steps are varied and depend upon the magnitude of the spill, local topography and proximity to a stream. Procedures can range from the use of pick and shovel in blocking a ditch, culvert or dry watercourse, to the use of heavy equipment. The Incident Commander will determine the exact method and means of executing a containment operation.

4) Cleanup

Cleanup decisions will be a joint effort between the Incident Commander and the Operations Chief, and will depend on site, weather and time of day.

b. Trucks and Tanks

 Initial Response STOP THE DISCHARGE, IF POSSIBLE, BY ANY SAFE, AVAILABLE MEANS.

2) Special Considerations

If the truck is disabled or the tank is unable to hold liquid, call another vacuum truck to the scene and transfer the remaining condensate to it.

3) Containment

A condensate spill from a vacuum truck would involve no more than 4,200 gallons. Contain spilled liquid by building a temporary berm, stacking sandbags, or blocking a ditch. Prevent condensate from reaching a stream. The Incident Commander best determines the method and means of containment.

4) Clean Up

Clean up decisions will be a joint effort between the Incident Commander and the Operations Chief and will depend on site, weather and time of day.

7.2 DRILLING MUD

a. Initial Response

- 1) IF POSSIBLE, STOP OR RESTRICT THE DISCHARGE OF SUMP LIQUIDS WITH DIRT, GEL SACKS, SANDBAGS OR OTHER MATERIALS ON HAND.
- 2) NOTIFY DRILLING DEPARTMENT SUPERVISOR AND CONTROL 1 TO INITIATE INCIDENT COMMAND SYSTEM.

b. Special Considerations

If hazardous materials are or potentially may be involved in the response action, follow instructions for <u>WET CHEMICAL</u> response.

If necessary to reduce fluid level in the sump to achieve containment, do the following:

- 1) Use vacuum trucks to haul excess drilling mud to another open sump, the Waste Management Unit or a baker tank.
- Use drill rig pumping equipment to transfer clean sump fluids to a condensate pond through the rig water line. Control 1 must be notified.

c. Containment

Small spills can be contained using hand tools. Large spills will require personnel and equipment available from the Production Department.

d. Cleanup

Cleanup decisions will be made by the Incident Commander, Operations Chief, and the Drilling Supervisor. The best course of action will depend on site, weather and time of day.

Spill cleanup will include the following procedures:

- For Drill Water: Contain spillage with dikes when possible and haul to disposal sump or to a power plant pond with vacuum trucks.
- For Drilling Mud: Repair sump or contain with dikes. Haul liquid to an approved disposal site. Dry and solidified material should be compacted as solids and buried at approved sites.
- 3) If spill does not reach a stream, mud can be hosed off vegetation, the wash water collected in ditches and hauled to a sump. Soil containing drilling sump fluids may be shoveled by hand or with heavy equipment, and disposed of in a

drilling sump or at the Geyser Rock Waste Management Unit.

7.3 <u>HYDROCARBONS</u>

Response to hydrocarbon releases is divided into two major parts, for regulatory compliance:

- a. Visible product leakage
- b. Leak Alert audible or visual alarm activated: Go to Section 9-12, <u>Underground Storage Tank Leaks</u>.

CAUTION: Gasoline or solvent fumes and propane gas can travel some distance from their origin and collect in low areas of terrain and buildings. For this reason restrict all motor vehicles, smoking materials and other ignition sources from the vicinity of these releases.

7.3.1 VISIBLE PRODUCT LEAKAGE

 Initial Response STOP OTHERS FROM ENTERING THE SPILL AREA. Gasoline, solvents and diesel fuel are highly flammable. Breathing will be impaired in poorly ventilated areas. Isolate far back from the spill. Used oil and other lubricants are combustible. Take precautions to prevent ignition.

- 2) Special considerations
 - a) For large spills, confirm fire department has been called
 - b) Deactivate fueling system or other potential ignition sources, if applicable.
 - c) Obtain Combustible Gas Meter from Chemical Group to measure %LEL and establish Hot, Warm, and Cold Zones before commencing any product confinement or containment activities.
 - d) Determine potential impacts to:
 - i) Personnel
 - ii) Water
 - iii) Property
 - e) Decide whether fluid flow can be safely stopped, or whether confinement structures can be safely built to keep flow from sensitive areas.
 - f) Utilize only intrinsically safe or explosion proof equipment to recover spilled product. Observe proper grounding to prevent ignition.

g) Methyl Ethyl Ketone (MEK) solvent will float on water and also mix with it.

3) Containment

- a) If Safe: Use dirt, sandbags, and absorbant pads to confine spill on land.
- b) If Safe: For oil or fuel in or threatening a stream, oil containment booms will be deployed at one or more of the following designated stations or at other suitable locations.

These creeks are in very steep canyons. During rain storms, the streams peak and return to stable flow very quickly. During periods of peak or high flow, there is high turbulence with no pools where spill containment is possible. Therefore, containment and cleanup at specific watercourse locations is addressed to low or intermediate flow conditions. Personal safety should not be jeopardized to install spill containment equipment.

When an oil spill has occurred or is likely, and the Incident Commander determines that oil could possibly enter a watercourse, a containment device will be deployed at the first containment station downstream of the spill.

It may be possible to install more than one containment device at some of the containment stations. If, in the opinion of the IC, all of the oil cannot be contained at the first station, additional devices will be deployed at downstream stations as required. Initial efforts should utilize the oil boom - absorbant pads, and be followed with the chain link fence - absorbant pad containment device.

Install the containment device at as steep an angle as possible across the flow of the creek, in the calmest water available. If the boom is straight across the creek, oil will collect at the center and then wash out underneath. Angle the boom to direct oil to the side of the creek with vacuum truck access to facilitate pick-up.

Evaluate the actual placement of the containment devices, both within containment stations and along

the creeks because the creek and creek bed conditions continually change.

Station 1 - Lies below the concrete bridge southeast of Guard Post One on Big Sulphur Creek. In low and intermediate flows a pond exists below the bridge. Install the vinyl oil boom across the pond. Remove oil with sorbent pads and a skimming device as required. Drive pipe stakes on both sides of Big Sulphur Creek to anchor the oil boom (ATTACHMENT 1).

Station 1a - Lies 0.2 mile downstream from Station 1. Access to Station 1a is a road that junctions 0.1 mile west of Guard Gate 1. A locked bright yellow Calpine Gate (keys for the lock are available at Guard Gate 1) controls access to the road. The road winds through several switchbacks down to the creek. At low flows, utilize heavy equipment to construct a dam equipped with underflow pipes to contain the oil. During higher flows install an oil boom between the fresh water pipeline running up the hill to GDC 53-13 and the access point to move the oil toward vacuum truck access. Tie-off for the oil boom will be established by personnel walking down from GDC 53-13 (ATTACHMENT 1).

Station 2 - At the Olin Whitescarver metal bridge on upper Squaw Creek. Lower wooden boom into place between two upstream vertical bridge supports with installed hand operated winch located under the bridge . Sandbags or local soil may be used as necessary to seal the wooden dam to establish a pond. Three valved plastic pipes installed in the wooden dam can be used to control flow in order to maintain the level appropriately to contain the oil for recovery (ATTACHMENT 1).

Station 3 - On Squaw Creek upstream of its confluence with Big Sulphur Creek. Access is from the Cloverdale Road and a wooden bridge crossing Big Sulphur Creek. In low and intermediate flow, install boom in the pond at this location. Remove oil with sorbent pads or obtain a skimming device as required. Drive pipe stakes on both sides of Squaw Creek to anchor the oil boom (ATTACHMENT 1).

Station 4 - Downstream of the Cloverdale Road bridge crossing on Big Sulphur Creek. In low and intermediate flow, this section of Big Sulphur Creek meanders in gravel and sand banks. Place a containment device across the stream to form a barrier to floating oil. Excavate lagoons upstream of the containment to collect the diverted floating oil for pick-up and removal. Remove oil with sorbent pads and skimming devices (ATTACHMENT 1).

<u>Station 5</u> - On Big Sulphur Creek upstream of its confluence with Frasier Creek. At this location the watercourse broadens and slows upstream of a ford crossing. Install containment device using pipe stakes driven on both sides of Big Sulphur Creek as anchors. Remove oil with sorbent pads or skimming devices (ATTACHMENT 1).

4) Cleanup

Cleanup of petroleum products requires attention to ignition prevention. Non-sparking tools and proper grounding of pumps and containers are required. Contact The Geysers Waste Coordinator for assistance in characterization of the waste and to arrange for disposal. For small spills oil absorbant pads will be used for cleanup. Calpine will utilize contractors for large spills.

7.3.2 LEAK ALERT AUDIBLE OR VISUAL ALARM ACTIVATED

If the Leak Alert system visual or audible alarm on any underground storage tank is activated, regulations specify strict procedures that **must** be followed. Timing is critical, so it is important that the situation be assessed as soon as possible, the findings recorded and if necessary, regulatory notifications made.

- 1) Personnel should immediately notify Control 1 if the Leak Alert visual or audible alarm is activated.
- 2) Control 1 will notify the Manager Environmental, Health and Safety during normal work hours or evenings. On holidays and weekends notify the on-call EHS personnel.
- 3) Refer to EPRP Section 9.12 for procedures to be followed.

4) Take precautions to prevent ignition of vapors from a leak. Keep all ignition sources away from the alarmed tank until the situation is investigated and controlled.

7.4 WET CHEMICALS

- a. SODIUM HYDROXIDE Ria 03c.
 - Initial Response STOP OTHERS FROM ENTERING THE SPILL AREA.
 - 2) Special Considerations

Contact with liquid or mist is very dangerous. Do not enter without protective equipment.

For Distribution Emergencies, the caustic supplier's procedure should be followed to obtain direct assistance from them. See bill of lading, or contact point of sale if bill of lading is not available. Also notify:

CHEMTREC 1-800-424-9300

3) Containment

Build berms, plug culverts or dam dry creeks to prevent spreading of caustic. Repeat damming downhill to provide multiple containments to prevent caustic from reaching creeks. Use PPE to prevent skin contact.

4) Neutralizing

Trained personnel only, may neutralize caustic soda solution spills by applying boric acid powder directly on the spill, resulting in the following reaction:

Boric Acid + Caustic = "Borax" + Water H₃BO₃ + 3 NaOH = Na₃BO₃ + 3 H₂O

On a weight basis, 61.8 pounds of H_3BO_3 neutralizes 120.0 pounds of caustic, so 1 pound of boric acid is needed to neutralize 2 pounds of caustic. Utilize the <u>Caustic Soda Handbook</u> to determine the total pounds of caustic spilled, based on the concentration and the amount. Pour the boric acid powder or crystals directly on the spill and allow time for the boric acid to react with the caustic. A little excess boric acid does not pose any serious hazard. Measure pH to assure proper neutralization.

5) Clean Up

Clean up of neutralized caustic salts is not required. Any soils having pH 12 or higher should be neutralized in place or moved to an acceptable location for neutralization or properly disposed of as hazardous waste.

b. LABORATORY CHEMICALS

1) Initial Response

RESTRICT NON-ESSENTIAL VEHICLES AND PERSONNEL FROM ENTERING THE SPILL AREA.

- a) ON ROADS: BLOCK TRAFFIC
- b) IN BUILDINGS: EVACUATION OF OFFICES BELOW OR ADJACENT TO LAB MAY BE REQUIRED. CLOSE DOORS, TURN OFF VENTILATION SYSTEM TO PREVENT FUME SPREAD THROUGHOUT BUILDING.

2) Special Considerations

In general, avoid breathing mist or vapors, eye contact and prolonged skin contact with any chemical.

3) Containment

Outdoors: build berms, plug culverts and dam dry watercourses to prevent liquid chemicals from reaching streams.

Indoors: use floor sweep or chemical absorbants to prevent spread of liquids and to minimize evaporation. Spill cleanup kits are located in the lab. Obtain additional floor sweep from the auto shop and warehouse.

4) Clean Up

Clean up of laboratory chemicals may involve neutralization or absorption and placing in a compatible container for offsite disposal. The Geysers Waste Coordinator should be involved in this decision. Damaged building materials may require removal, disposal and replacement.

c. HYDROGEN PEROXIDE RIA 10q.

 Initial Response STOP OTHERS FROM ENTERING THE SPILL AREA.

2) Special Considerations

Contact with liquid or mist will cause severe irritation. DO NOT ENTER WITHOUT PROTECTIVE EQUIPMENT. For contact: Wash with large amounts of water.

Control 1 should summon a water truck to the scene. If personnel are injured dispatch fire truck to spray water fog on rescuers. Do not use foam additive.

3) Containment

Incidental spills on road can be washed off with water truck; Spills that are flowing and may enter a watercourse must be initially contained and diluted. Do not pick up hydrogen peroxide with steel vacuum trucks.

Construct berms, block drainage ditches and culverts, dam stream channels to prevent flow of undiluted chemical into creeks.

4) Cleanup

Hydrogen Peroxide deteriorates to water and oxygen. Cleanup will not typically be required unless other materials are involved. The area must be isolated for a sufficient period of time to allow the solution to deteriorate to prevent injury to people or animals.

d. ETHYLENE GLYCOL

 Initial Response STOP OTHERS FROM ENTERING THE SPILL AREA.

2) Special Considerations

In general, avoid breathing mist or vapors, eye contact and prolonged skin contact with any chemical. OSHA ceiling limit is 50 ppm for mists or vapors. Ethylene glycol is poisonous to animals. Spills should be promptly absorbed. Remove ignition sources from spill area.

3) Containment

Construct berms, block drainage ditches and culverts, dam stream channels to prevent flow of undiluted chemical into creeks. Use dirt or floor sweep as absorbant. Oil absorbant pads are not effective.

4) Cleanup

Shovel absorbed material into drums for transport to hazardous waste bin at LF 13.

e. See Chemical Information Sheets for specific liquid chemical response information.

7.5 DRY CHEMICALS

Dry drilling rig chemicals are used in large volumes. A large variety of laboratory chemicals is used, but volumes are generally small. Dry chemicals are used in power plant abatement processes. Basic containment techniques are the same for all dry chemical releases. Water will generally complicate dry chemical spill response, so its use should be carefully evaluated.

a. Initial Response

STOP OTHERS FROM ENTERING THE SPILL AREA. Isolate the area at a safe distance to prevent spreading by vehicles.

b. Special Considerations

Avoid contact with unidentified chemicals. Be aware of wind direction and stay upwind to avoid contact with airborne material.

c. Identify

Use product labels, manifests, or descriptions in RIAs, Section 9-11.

d. Containment

- 1) Wear appropriate protective equipment for the chemical while cleaning up the spill. Avoid creating dust, but do not wet the material. Wetting makes cleanup more difficult.
- 2) Dry chemicals should be protected from wind to avoid further spreading. Cover the material with a tarp, sheets of plywood, etc. Most dry chemicals are packaged in sacks or canisters and unlikely to cause large spills. If a rainstorm causes the chemicals to dissolve and flow, then the standard methods of liquid spill containment can be employed; build a berm, plug a culvert, and dam a watercourse to prevent the contaminated water from reaching a stream.

e. Cleanup

Clean up will depend on chemical, site, weather and time of day. Sweeping and collection for reuse or waste disposal will be evaluated. HEPA vacuum cleaners may be appropriate for asbestos, arsenic or vanadium containing materials.

7.6 GASES

a. FLAMMABLE GASES

1) PROPANE

- a) STOP OTHERS FROM ENTERING THE SPILL AREA. Propane is heavier than air and will travel downhill and down wind. It will accumulate in low areas. Isolate far back from the release.
- b) Ignition sources must be kept away. If a fire has started, only extinguish it by closing the valve at the source. This will prevent the build-up of an explosive atmosphere.
- c) Propane sources at The Geysers are small. Unless the leak can be safely stopped by shutting a valve, the best course of action is probably to allow the propane to dissipate. Keep all ignition sources away.
- d) Use combustible gas meter for any activities.
- e) Explosion may occur if ignited. Stay well clear of ends of tanks.

2) HYDROGEN

Hydrogen gas is used in power plants. Precautions for hydrogen are similar to propane. Hydrogen, however is lighter than air and if contained will concentrate in high places.

b. POISON GASES

- 1) Hydrogen Sulfide (H₂S)
 - a) STOP OTHERS FROM ENTERING THE RELAEASE AREA. H₂S is heavier than air and will travel downhill and down wind. It will accumulate in low areas. Isolate far back from the release.
 - b) High concentrations of H₂S are combustible. Ignition sources must be kept away.
 - c) Tanks of H₂S at The Geysers are small. Unless the leak can be safely stopped by shutting a valve, the best course of action is probably to allow the gas to dissipate.
 - d) H₂S from injection wells and lines may require repair of equipment to stop the leak.
 - e) Use a personal alarm monitor for any activities.
 - f) The buddy system is required for H₂S concentrations requiring supplied air equipment. See the Respiratory Protection Program HSP 100 and Hydrogen Sulfide HSP 30 and HSP For Employee Orientation for additional information.

c. NON-FLAMMABLE GASES

1) AIR, ARGON, NITROGEN, HELIUM, CARBON DIOXIDE

- a) All of these gases are present in small quantity cylinders. Evacuate area of leak and allow gas to bleed off.
- b) Wear supplied air if rescue is required as these gases present a suffocation hazard.

7.7 WASTES

a. PRODUCTION FACILITY WASTE

(pipelines, separators, water knockouts, rock catchers, turbines etc.)

1) Initial Response

- a) STOP THE DISCHARGE IF POSSIBLE BY ANY SAFE AVAILABLE MEANS.
- b) RESTRICT VEHICULAR TRAFFIC IN ORDER TO PREVENT SPREAD OF THE MATERIAL.

2) Identify

Trained personnel will use the 4-gas monitor available from the Chemical Group, to determine whether hazardous levels of SO₂, a toxic gas, are present.

Because of the chemical content of sludge, protective clothing should be worn during containment and clean-up operations. Avoid eye and prolonged skin contact. Avoid breathing mists, sprayed liquids or dust. SO₂ gas may be generated. See <u>Respiratory Protection Plan</u>, EHP 100, for additional details on selecting proper respiratory protection.

3) Containment

Contain by building berms, plugging culverts and damming watercourses receiving the spilled materials. Prevent the wastes from entering a watercourse. Stay upwind of dry materials. Cover to prevent spreading by wind.

4) Clean Up

Clean up by shoveling and sweeping into barrels or bin as indicated by waste profile. Utilize vacuum truck to pick up liquids.

b. CONDENSATE POND AND COOLING TOWER SLUDGE

1) Initial Response

a) STOP THE DISCHARGE IF POSSIBLE BY ANY SAFE AVAILABLE MEANS.

b) RESTRICT VEHICULAR TRAFFIC IN ORDER TO PREVENT SPREAD OF THE MATERIAL.

2) Identify

Identify the hazards. Sludges consist of sediments removed from the bottom of condensate ponds and cooling towers. They contain inorganic arsenic and can also contain abatement chemicals. Some pond sludges may contain high levels of sulfide. These may react with atmospheric oxygen releasing hazardous levels of SO₂, a toxic gas.

3) Special Considerations

Wear appropriate PPE. Avoid eye and prolonged skin contact. Avoid breathing mists, sprayed liquids, gases or dusts.

4) Containment

Contain by building berms, plugging culverts and damming watercourses receiving the spilled liquids. Prevent the liquids from entering a watercourse.

5) Cleanup

Trained personnel will cleanup by shoveling and sweeping into containers. Wear respiratory protection if dust may be created or SO₂ is present.

c. SEPTIC AND OTHER WASTES

1) Initial Response

BLOCK TRAFFIC AND RESTRICT NON-ESSENTIAL VEHICLES AND PERSONNEL FROM THE SPILL AREA.

2) Special Considerations

Septic and other wastes may contain materials which are hazardous and should only be handled by properly equipped and trained personnel.

In general, avoid breathing mist or vapors, eye contact and skin contact with any chemical.

3) Containment

Containment will be accomplished by trained and properly equipped emergency response personnel once material and hazards are identified.

4) Cleanup

Cleanup will depend on material. In most cases a qualified contractor will perform cleanup of septic or other wastes.

d. POWER PLANT ABATEMENT WASTES

Initial Response STOP OTHERS FROM ENTERING THE SPILL AREA.

2) Special Considerations

In addition to the presence of heavy metals, power plant wastes contains sulfur that is easily ignited.

Power Plant Wastes include:

- a) Sulfur: Collected and transported in dumpsters from Stretford Units. Material is combustible.
- b) Cooling Tower Sludge: From all Units, transported by vacuum truck. Hazards include arsenic, mercury, nickel and vanadium.
- 3) If necessary to enter contaminated area, use PPE to avoid skin and eye contact. If dust is present use a respirator. An air supplied respirator is required for fumes or smoke from combustion.

4) Containment

Contain by building berms, plugging culverts and damming watercourses receiving the spilled liquids. Prevent the liquids from entering a watercourse.

5) Cleanup

Trained personnel will cleanup by shoveling and sweeping into containers. Wear respiratory protection if dust may be created or SO₂ is present.

<u>DEFINITIONS</u>

CHEMICAL:

Chemical means any manufactured chemical or product, petroleum products, geothermal solids or condensate, drilling fluids or other products used or produced at The Geysers which may be released to the environment as a liquid, solid or gas.

EMERGENCY RESPONSE:

A coordinated response effort by employees from outside the immediate work release area or by outside responders (e.g., mutual aid groups, local fire departments, contractors, etc.) to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance and which poses an immediate threat to people, the environment, or property.

HAZARDOUS:

Any substance listed as hazardous by various California or Federal regulations, or to which exposure may result in adverse affects on the health or safety of employees. MSDS lists indicate whether a chemical is hazardous.

IDLH:

Immediately dangerous to life and health.

INCIDENTAL RELEASES:

Any hazardous material release within the work area that can be safely contained and cleaned up by the employees stationed there, utilizing PPE and other equipment readily available at the site. Response to an incidental release that can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area is not considered to be emergency response within the scope of 29 CFR 1910.120. Response to a hazardous substance release where the concentration of substances is below the established permissible exposure limits is not considered to be an emergency response. A steam condensate spill, because it does not involve a hazardous material is defined as an incidental release.

LOWER EXPLOSIVE LIMIT (LEL):

The minimum concentration of a flammable substance in air below which spread of flame does not occur.

MAJOR SPILL:

- * Significant media event, i.e. radio or television coverage, or non-local newspapers.
- * Clean up and remediation cost or potential fines exceeding \$500,000.

MINOR SPILL:

Any reportable spill that does not fit in serious or major category. For condensate, this means an amount greater than 250 gallons, or any amount that has or could enter a watercourse, or any size that causes a present or potential hazard to health, safety or the environment.

NON-HAZARDOUS:

Non-hazardous substances, such as steam condensate, are not immediately dangerous to employees. These substances may cause environmental damage.

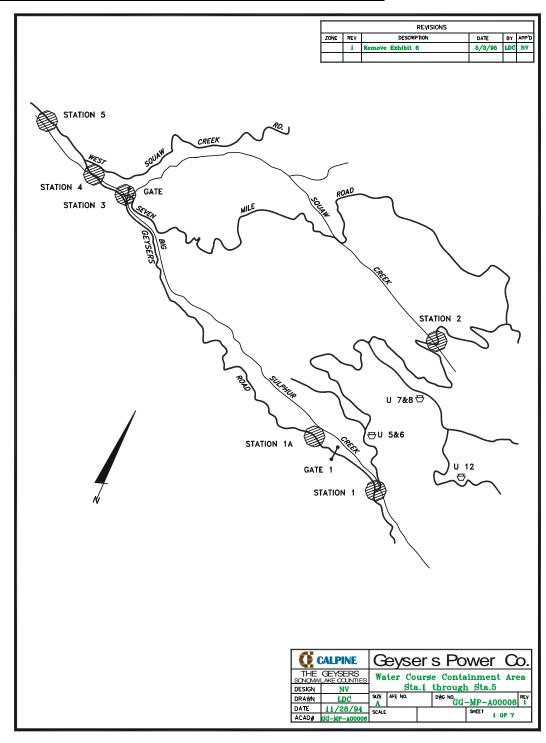
SERIOUS SPILL:

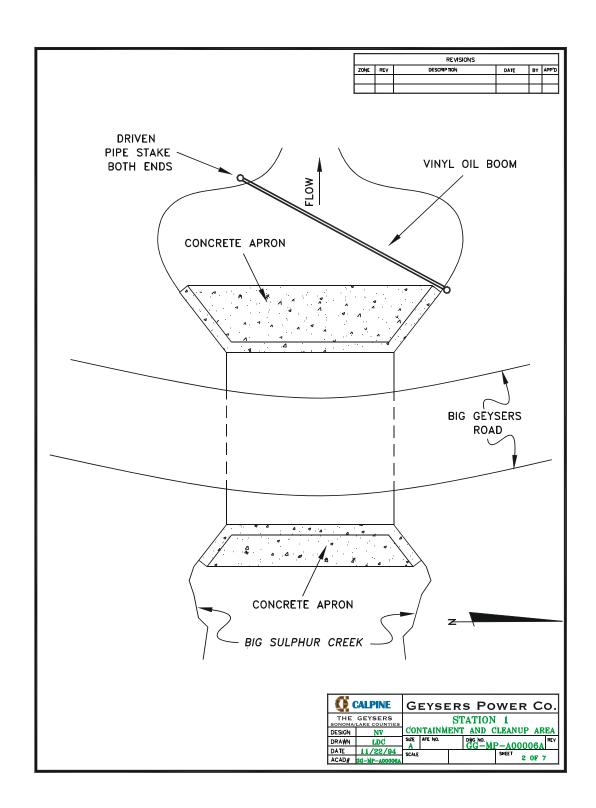
- Local media coverage only.
- Clean up and remediation cost or potential fines exceeding \$25,000.

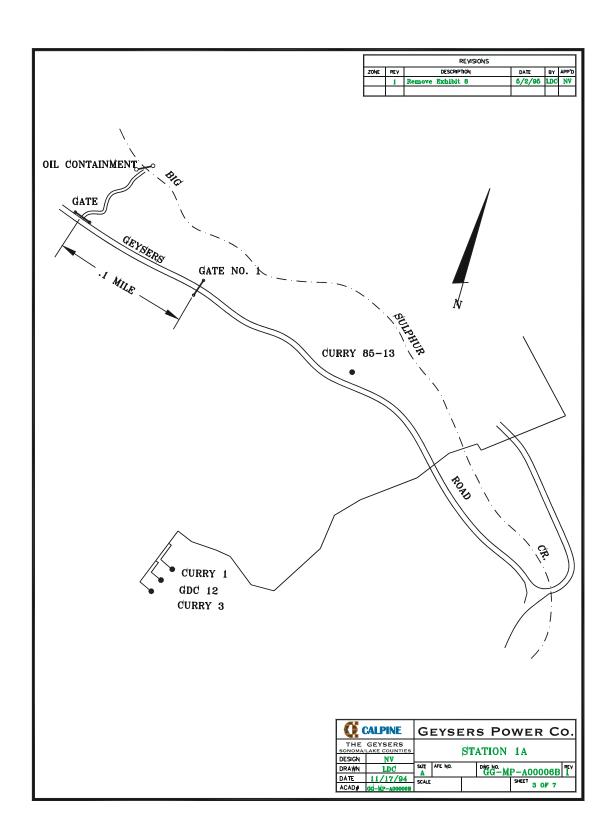
WATERCOURSE:

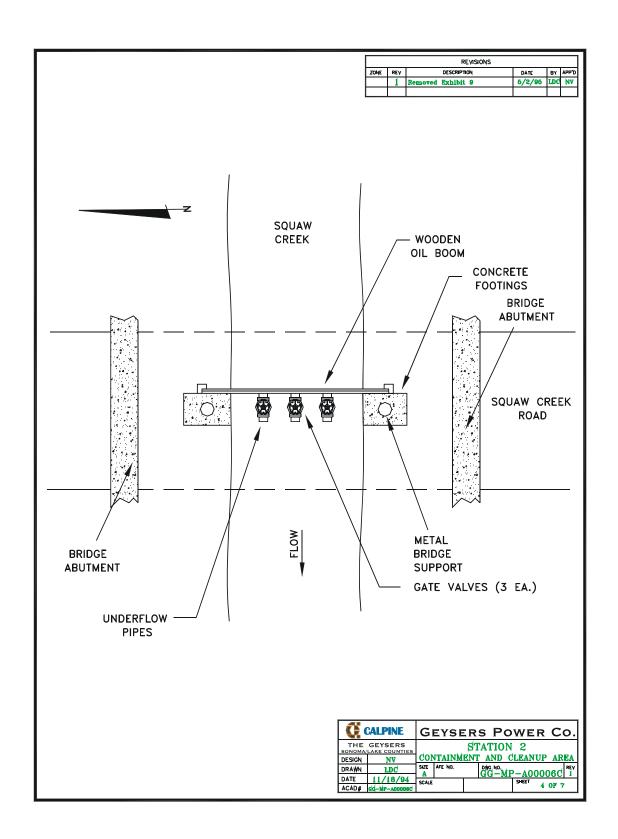
A watercourse is flowing or standing water, or any seasonally dry channel or bed where there could reasonably be flow during rainfall. A drilling sump is <u>not</u> a watercourse.

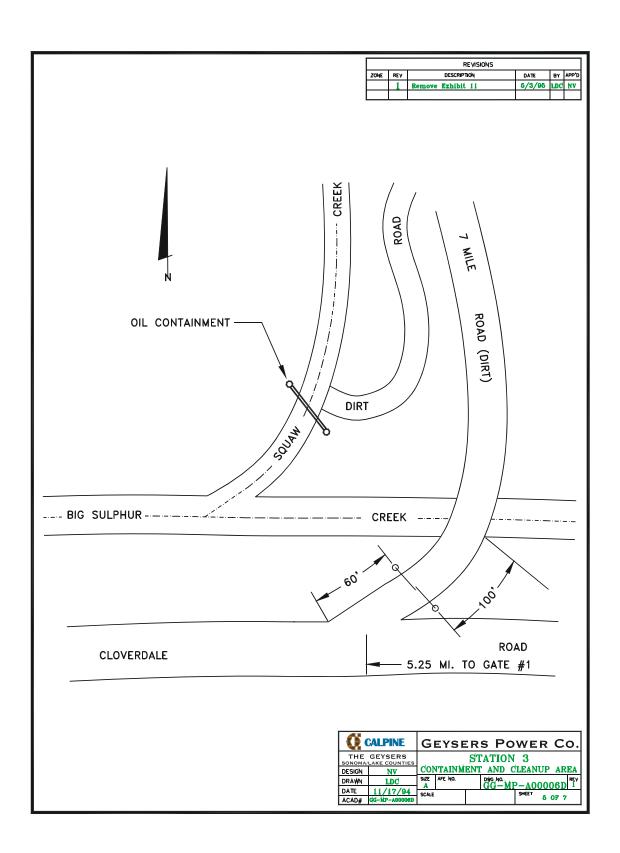
ATTACHEMENT 1: STREAM SPILL CONTAINMENT AREAS

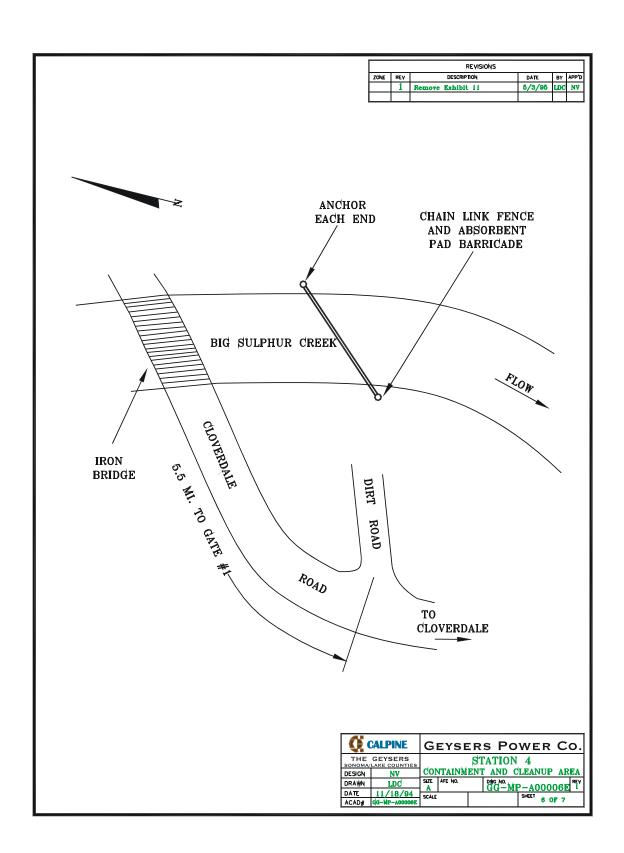


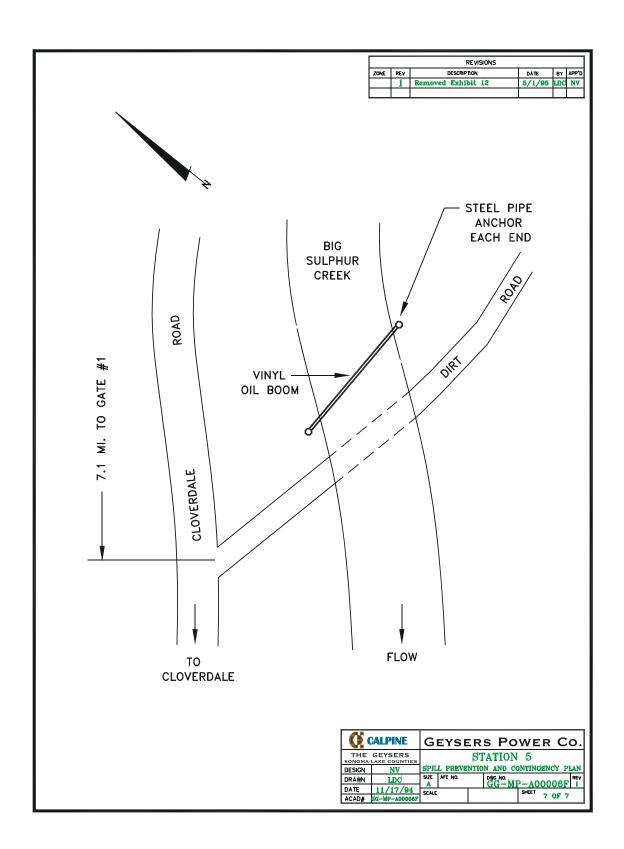














CP-GY-TSV-HSP-ERP-9.8 EMERGENCY PREPAREDNESS AND RESPONSE PLAN

SPILL STREAM SAMPLING PLAN

1.0 DOCUMENT HISTORY

Revision	Date	Author	Description	
1	12/27/01			
2	8/27/02	CMD	Revision	
3	1/16/03	CMD	Revision	
4	2/18/09	Allen Sonneville Jody Spooner	Revision	

2.0 PURPOSE

2.1 This plan will be used as a guideline for collecting samples when liquids (e.g. condensate, chemicals or hydrocarbons) are released and enter or may enter any watercourse.

3.0 SCOPE / APPLICATION

- 3.1 Collection of samples of any release of liquid materials is required by regulatory permits issued by the North Coast Regional Water Quality Control Board (NCRWQCB) on the Sonoma County side of The Geysers and by Central Valley Regional Water Quality Control Board (CVRWQCB) on the Lake County side. Analysis of the samples collected in accordance with this plan help to evaluate the impact of a release on affected watercourse. Proper sample collection, handling and analysis are all important to obtain valid information.
- 3.2 Personal safety during collection of samples must be considered. During inclement weather and darkness a buddy system should be used. If conditions are too hazardous at some sample points, personnel safety takes priority over sample collection. Log conditions that preclude sampling for reporting to the agencies.

4.0 PROCEDURE

4.1 Sampling Information

4.1.1 Samples of released material shall be collected when a release of any size enters or threatens to enter a watercourse. The samples will be collected by a person designated by the Operations Shift Manager / Incident Commander (IC) as soon as possible after the incident occurs. A Hazardous Material Technician will collect source samples in a hazardous material spill (when the hazards exceed the training and experience of available operations personnel). The IC or designee will advise the Control Operator of



all relevant information to document on the <u>Operator on Duty Checklist: Chemical Response</u> form, including sampling, weather, spill data and will complete the appropriate <u>Release to Surface Water Data Sheet</u>. Copies of the completed forms will be provided to the EHS contact / Liaison Officer.

<u>Type of Samples</u> - The types of samples taken are grab samples, which means that the fluid collected at a particular time and place can represent only the composition of the source at that time and place.

Sample Containers - The sample kits are located at area hubs: Aidlin, Bear Canyon and Geysers Administration Center (GAC) Control Room. Extra sample containers are at the GAC warehouse. The labels on the bottles and the Spill Data Sheet for the appropriate county should be filled out at the time of sampling. Required information is provided in the spill kit instructions.

Sample Bottles are: Plastic cubetainers; 5 Gallon capacity and 2 ½ Gallon capacity. In addition, Lake County contains 100 ml sterile bottles for coliform analysis.

4.2 Sampling Procedure

In the event of a spill of any liquid waste to land impacting surface water or that poses an imminent threat to surface water, samples must be collected at the following three separate locations. Each of these samples will require its own spill kit.

- Source of the spill representative of the material spilled. It shall be sampled as soon after the spill as possible (Spill kit designated as SP001);
- 2. Affected surface water upstream from the area influenced by the spill. It shall be sampled once as soon after the spill as possible (Spill kit designated as SP002);
- 3. Affected surface stream within the affected zone influenced by the spill and shall be relocated as the influenced zone proceeds downstream (Spill kit designated as SP003).

Fill all bottles in each spill kit as full as possible!

Source of the Spill

- 1. If the spill material consists of steam condensate, liquid from drilling mud, or other non-hazardous liquid, fill all bottles in the kit with the source liquid as soon after the spill as possible. Fill all sample containers as full as possible and label.
- If the spilled material consists of chemicals, fuels, liquid from abatement sludge, or other potentially hazardous materials, <u>DO</u> <u>NOT</u> attempt to collect a sample unless you have been appropriately trained in hazardous materials and waste handling.



- Notify a Hazardous Material Technician or Specialist (listed in Notifications, Section 6.1.1 of this manual).
- 3. If the spilled material cannot be readily identified, <u>DO NOT</u> attempt to collect a sample. Notify one of Hazardous Material Technicians.

If the spill can be traced, additional samples are required in the affected zone as the spill progresses downstream. Collect a full kit every 5 hours as long as the spill can be traced, up to a maximum of 4 additional downstream samples.

Bring the samples to the GAC Lab for transport or storage as soon as possible after collection. Samples must be chilled as soon as possible after collection.

On weekends or other off-days, contact the EHS representative on call for assistance in sample preparation and transport.

The GAC Lab will transport the kits to one of the labs listed, for analysis:

Brelje and Race Analytical Labs	Alpha Analytical Laboratory
425 South E Street	208 Mason Street
Santa Rosa, CA 95404	Ukiah, CA 95482
(707) 544-8807	(707) 468-0401

The laboratory will perform chemical and biological analyses of the samples and return copies of the results to the Geysers Chemistry Senior Chemist.

The Geysers Senior Chemist will forward copies of the spill sample analysis and bioassays to the EHS Manager.

5.0 ENCLOSURES / LINKS

5.1 Attachment 1 – Suggested Sample Points



Attachment 1 - Suggested Sampling Points

Note: the following sample points have been safely used in the past and may used as applicable.

Designator Key:								
So	Sonoma County	KC	Kelsey Creek					
BSC	Big Sulphur Creek		HoSC	Hot Springs Creek		HVC	High Valley Creek	
CoC	Cobb Creek		GuC	Gunning Creek		SWC	Sweetwater Creek	
La	Lake County		AIC	Alder Creek				
AnC	Anderson Creek		LeC	Lee Creek				

Designator	Name	Description
SONOMA C	OUNTY	
BIG SULFU	R CREEK DRAINAGE	
SoBSC01		NW Corner Section 11, R 10W, T11N trail crosses creek, may provide access
SoBSC02		SW Corner Section 6, R 9W, T11N trail crosses creek, may provide access
SoBSC03	Iron Bridge	Big Sulphur Creek at Cloverdale Road Iron Bridge.
SoBSC04	Sulphur Creek Gate	Just outside Post #1 enter through gate for creek access.
SoBSC05	Unit 14 bridge	Big Sulphur Creek at Big Sulphur Creek Road, access at extraction facility.
SoBSC06	Pine Flat Bridge	Big Sulphur Creek at Pine Flat Road.
SoBSC06		500 feet down Big Sulfur Creek from the Pine Flat Road and Big Sulfur Creek Crossing
SoBSC07	(1862-A pad area)	At point where unnamed tributary and Big Geysers Road intersect. Approximately ½ mile NW from turn off to 1862-A pad along Big Geysers Road.
SoBSC08	(1862-B pad area)	Collecting pond/concrete skirt located approximately ¼ mile east off access road below Calpine well pad, 63A-B-C (approximately 1 mile east of 1862-A pad).
	Solid Waste Management	
SoBSC09	Unit (SWMU)	500 feet below drainage culvert on west side of Ridge Road adjacent to monitor well #2 location
SoCoC01	(1862-3 and C pads area)	500 feet up Cobb Creek from John Kincade Road (Old Burmah Road) crossing and Cobb Creek.
SoSQC01		Squaw Creek at Squaw Creek Road, Olin Whitescarver Bridge.
SoSQC02		Squaw Creek at entrance to DX-23 well location.



CACHE CREEK DRAINAGE (Clearlake)

<u> </u>	LEIT DITTINGE (GIGGIN	
LaAlC01		Sawmill Road mile post 1.34. Bridge over Alder Creek.
LaAlC02		14747 Bottle Rock Road. Entrance road bridge over Alder Creek.
		High Valley Creek immediately west of Guard Post #4. During the summer this section of High Valley
LaHVC01		Creek may be dry, in which case LaHVC02 is an alternate.
LaHVC02		1.5 miles downstream of the Binkley Ranch sign located at the 'Y' just north of Guard Post #4.
LaHVC03		Sampling Point #15 is the bridge over High Valley Creek at the Howard Higgins Ranch.
LaKC01		Bottle Rock Road at Glenbrook. Bridge over Kelsey Creek.
		Immediately downstream of the confluence of High Valley Creek and Kelsey Creek. Access from LaKC03
LaKC02		by driving along the east side of Kelsey Creek, or from LaHVC03 by driving north of Higgins' greenhouse.
LaKC03		At the Higgins Ranch bridge over Kelsey Creek just north of the confluence with High Valley Creek.
		At the confluence of Kelsey Creek and Rabbit Valley Creek. It may be accessible by going to LaKC03,
		Higgins's bridge over Kelsey Creek and following the road on the east side of the creek north to the gate.
LaKC04		Rabbit Valley Creek comes into Kelsey Creek across from the gate and slightly downstream.
		At the confluence of Sweetwater and Kelsey Creeks. At this point the Sweetwater Ranch has a horizontal
LaKC05		well in the creek bed for domestic water.
		Sweetwater Ranch bridge over Kelsey Creek. From Hwy. 29, turn south on Kelsey Creek Drive. The ranch
LaKC06		drive is 5.35 miles south. The bridge is 0.2 miles south of Kelsey Creek Drive.
LaLeC01		Sawmill Road mile post 1.94. Bridge over Lee Creek.
		4-wheel drive Required. In bad weather it may not be accessible. Located on Sweetwater Creek at a dam
LaSWC01	delete if no area drilling	that provides domestic water to the Sweetwater Ranch. Permission necessary to enter.



Geysers Document/Procedure Library Approval & Routing

Procedure Name:	Spill Stream Sampling Plan	n	
Written By:		_ Date:	
Revised By:	ly Spooner	Date: _	02/18/2009

CP-GY-TSV-HSP-ERP-9.8

Approved by:

Procedure Number:

Charlotte M. Dorrity, CSP Health and Safety Manager	an What Don't	Date:	02/25/2009
Larry Sessions, General Manager, Area 1	lang Som	Date:	2/25/2009
Terry Mahoney, General Manager, Area 2	Juny Makey	Date:	02/25/09
Dave Jackson, General Manager, Area 3	Dave Juchan	Date:	2/25/2009
Kevin Petersen, Manager Central Operations	for file	Date:	2/25/2009
Frank Obertance, General Manager, Central Maintenance	Spank He bertance	Date:	2/25/09
Karl Urbank, VP Technical Services	fillale	Date:	2/25/09
Mike Rogers, Sr. Vice President Geothermal Region	mite hoger	Date:	2/25/2009



Geysers Document/Procedure Library Approval & Routing

Procedure Number: Procedure Name:	
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X	Geysers	1							
X	Management	Х	Technical Services	X	Business Services	X	SH&E, Legislative & Community Relations	X	Generation
X	HR		Performance Engineering		Accounting		Health & Safety	X	Central Operations
	Support	T	Development	\Box	Lcgal	П	Environmental	X	Central Maintenance
			Drilling		Commercial		Legislative Affairs & Community Relations		Area 1
			Plant Improvement		Sales & Marketing			П	Aidlin
			Overhauls		Land	7		\Box	Sulphur Springs
			Planning & Engineering Support						McCabe
			Technology	1		1			Ridge Line
			Resource	1				X	
				1		1			Eagle Rock
								X	Cobb Creek
				1					Lake View
						1			Grant
									Socrates
									Fumerole
				1				X	Area 3
						ì			Bear Canyon
									West Ford Flat
				1				\Box	Calistoga
		1				1			Sonoma
									Big Geysers
									Quicksilver

CALPINE GEYSERS EPRP 9.9

EARTHQUAKE PREPAREDNESS AND RESPONSE PLAN

1.0 PURPOSE

- 1.1 To define measures to prevent or minimize damage or injuries in the event of earthquakes.
 - 1.2 To identify facilities and equipment with a higher potential to suffer damage, cause chemically induced environmental damage, and ignite or fuel fires.
- 1.3 To introduce general preventive measures to take to protect facilities and equipment, and the environment.
- 1.4 To identify immediate responses to be taken in the event of a serious earthquake.
- 1.5 To identify post-emergency actions for inspection and resolution of earthquake damage.

2.0 BACKGROUND AND APPLICATION

- 2.1 The Geysers is located in a seismically active portion of the Mayacamas Mountains. Ground motion from earthquake activity is frequent but predominantly registers between 0 4 on the Richter scale.
 - 2.1.1 Earthquakes at The Geysers have not historically and are not anticipated to create significant damage to either the generating units or their associated facilities or equipment because buildings, piping and tanks at The Geysers are designed to withstand expected events.
 - 2.1.2 Pre-planning and inspections can reduce damage that occurs during an earthquake.
- 2.2 Because the possibility exists for earthquake related ground motion to cause fire, injury from displaced items, or adversely affect those areas where hazardous materials are located, this Plan has been developed to offer a general overview of pre- and post-earthquake actions and shall apply to all facilities and personnel at the Geysers; it is supplemented by the other E.P.R.P. sections.

3.0 PROCEDURE

3.1 Planning.

- 3.1.1 General: Employees must be familiar with the evacuation plans for facilities where they work.
- 3.1.2 Damage to equipment and materials within buildings can be reduced by properly securing them.
- 3.1.3 Routine inspections will be conducted to verify that emergency lights, fire systems, fire doors, and alarms are all in working order.
- 3.1.4 Hazardous material storage areas are inspected with the intent to ensure potentially incompatible materials are stored separately.
- 3.1.5 Additional efforts should be taken periodically at each facility to verify the general readiness of the site. Specifically:

3.1.5.1 All Areas:

- Areas outside exit doors should be cleared of snow/debris.
- Walkways will remain clear allowing access and egress.
- Fire lanes will remain clear for emergency vehicles.
- Doors not part of the fire door protection system will be latched open when it is not necessary they be closed.
- Sensitive electronic equipment should be protected by a surge suppressor.
- Heavy and/or glass items should be stored on low shelves.
- Chemicals must be stored properly and incompatible chemicals should be segregated and separated.
- Materials should not be stored, even temporarily, on top of cabinets.
- Shelving and racks should be secured to walls and/or flooring to minimize movement.
- Roll up doors must be secured when opened.
- Cylinders not in use will always be stored securely with the caps
- Hazardous materials will be kept in appropriate lockers when not in direct use.
- Heavy machinery such as upright equipment like drill presses will be secured to the floor.

3.1.5.2 Powerplants:

 Hazardous materials stored in quantities which could cause harm to personnel or the environment if impacted by significant earthquake related ground motion are identified by type and location in the chemical inventory section of the Hazardous Materials Management Plan (HMMP). The inventories are reviewed annually to verify the accuracy of contents of the plan.

- Procedures for plant-specific actions to take in an emergency are included in the HMMP.
- Materials storage areas, including maintenance buildings and turbine bays will be inspected to comply with the requirements of Section 3.1.5.1 above.
- A set of grounds and hot sticks must always be kept in the plant, inspected and ready for use in the event of downed lines.

3.1.5.3 Administrative Centers:

- File cabinets should be against walls or secured to the floor and should never be close enough to a desk that they can fall onto the occupant.
- Bookcases 6' tall and higher and shelves should be attached to the wall.
- Heavy or potentially dangerous items should not be placed on top of file cabinets and shelves.

3.1.5.4 Fueling Facilities

- Emergency shut off switches must be clearly identified.
- Emergency lighting should be in place.
- Manual operation instructions should be available.

3.1.5.5 Corrosion Mitigation Facilities:

- Deliveries of Hazardous Materials will be coordinated through Control One.
- Observers will always be prepared (PPE) to respond to caustic spills.

3.2 During an Earthquake:

- 3.2.1 In the event of a large earthquake, immediately duck beneath a strong surface like a desk or table to avoid falling items such as ceiling tiles and light fixtures.
- 3.2.2 Do not take shelter in doorways with unsecured doors as doors may close violently during earthquakes. Move away from windows.
- 3.2.3 If inside, remain inside until shaking has stopped as glass may be falling outside. If outside, move out from under power lines or other structures where debris may fall.

3.3 After an Earthquake:

3.3.1 General:

- 3.3.1.1 Be prepared for aftershocks. After a severe earthquake, move to the area's pre-designated Staging Area.
- 3.3.1.2 Follow the local Evacuation Response Plan to account for all personnel. Roadways may be impassable in places.
- 3.3.1.3 Wait for clearance to leave The Geysers to avoid obstructing access for emergency and maintenance vehicles.

- Employees shall not leave The Geysers after an earthquake without personally notifying their supervisor.
- Supervisors shall receive authorization to release employees from the Incident Commander or their designee.
- Visitors and contractors shall account for their staff and shall notify their Calpine Sponsor before releasing employees or leaving.
- 3.3.1.4 Persons observing in-progress deliveries of hazardous materials at the time of the earthquake should check in with Control One and report the status.
- 3.3.2 Identification of subsequent emergency situations
 - 3.3.2.1 Due to the remote location of The Geysers, a major earthquake that results in widespread damage may prevent outside responders from accessing The Geysers in a timely manner and/or with adequate resources.
 - 3.3.2.2 Widespread natural disasters may result in a critical need for reliable sources of electrical energy to help and protect the public; Plants will be kept on line after a major earthquake to the extent that it is safe for personnel, property, and the environment to keep them functioning.
 - 3.3.2.3 In accordance with other Emergency Preparedness and Response Plans, all medical, fire, and hazardous materials release emergencies requiring assistance shall be called in to **6911** or (by radio) to **Control One**.
 - 3.3.2.4 Based on the information available, an Incident Command Post shall be established in the GAC or other suitable location and the Incident Commander and other Central Control staff shall prioritize emergency responses:
 - The safety of the responders shall always be the first priority
 - Preventing additional injuries and rendering emergency medical aid shall be the next priority
 - Controlling hazardous materials releases and fires shall be prioritized in accordance with the level of risk that they present to people, the environment, and property
- 3.3.3 Notification of Emergency Situation and Response
 - 3.3.3.1 Scene assessment, response, and follow-up actions to be followed are outlined in the appropriate Operator on Duty Checklists and Plant Operating Procedures.

- 3.3.3.2 Once an assessment of need has been made, notifications for outside assistance, as well as to internal personnel and external regulatory agencies shall be made following the appropriate Incident Response Checklist for the emergencies caused by the earthquake.
- 3.3.3.3 Based on the extent of the post-earthquake emergency, Control One may request that personnel on the !GPP Emergency Page call **6002** or **6005** to receive assignments from the Incident Commander.
 - To facilitate emergency reporting and communications, Responders shall not call down to the Control Room on 6911.
 - Control room phones shall be used for emergency communications only and will not be a contact point for families.
- 3.3.3.4 The Incident Commander may designate a Public Information Officer who shall:
 - Record general information and status on the Road Information Number (6019).
 - Contact the designated Geysers' Public Relations Manager in San Jose.
 - As needed, make a media notification for families, referencing the 431-6019 information line.

3.3.4 Post Incident Inspection Procedures

- 3.3.4.1 Once the situation is stabilized and emergencies that may present hazards to people, environment, or property are controlled, post-earthquake inspections may be made as appropriate to the magnitude of the earthquake and the impact that it may have had on structures and facilities within the Geysers. They shall be conducted in a manner to determine if:
 - Equipment has been damaged in a way that has resulted or could result in injuries or additional damage due to structural failure or collapse;
 - Equipment has been damaged in a way that has resulted or could result in personnel or environmental exposure to hazardous materials such as non-condensable gases, strong bases or acids, or other materials;
 - Compressed gases in bottles have fallen or otherwise been damaged;
 - Hazardous materials have been spilled or released.
 - Sites to be inspected for hazardous materials releases include, but are not limited to:
 - chemical abatement facilities;
 - oil storage sites;
 - fueling facilities;
 - warehouses:

- hazardous waste storage areas;
- liquefied petroleum gas storage areas); and
- laboratories.
- An effort shall then be made to determine the integrity of steam lines, water lines (well water, SEGEP and SR1) and secure any disruptions.
- Other damage has occurred that has resulted or could result in, damage to people, the environment, or property.

4.0 Training

- 4.1 All Geysers personnel shall be trained in this procedure as well as in the evacuation procedures for their work area.
- 4.2 Personnel who may respond to any emergency situation within the Geysers shall be trained to a level appropriate to their anticipated response duties prior to responding to such events; this training shall include, but not be limited to:
 - 4.2.1 Emergency Preparedness and Response Procedures;
 - 4.2.2 Hazardous Materials and Waste Management and Emergency Response;
 - 4.2.3 Hazard Communication;
 - 4.2.4 Task specific safety information:
 - 4.2.5 Fire Control safety;
 - 4.2.6 Incident Command System.

5.0 REFERENCES

- 5.1 Calpine-Geysers' Emergency Preparedness and Response Plans
- 5.2 Calpine-Geysers Health & Safety Procedures
- 5.3 FEMA website: http://www.fema.gov/library/prepandprev.shtm#earthquakes
- 5.4 California Seismic Safety Committee Website: http://www.seismic.ca.gov/ssclink.htm

APPENDIX G: ENVIRONMENTAL COMMITMENTS

GEYSERS POWER COMPANY, LLC

10350 Socrates Mine Road Middletown, CA 95461 707.431.6000

GWQ-10-076

April 5, 2010

Mr. Steve Blazek US Department of Energy 1617 Cole Boulevard Golden, CO 80401

RE: Environmental Commitments for the Calpine EGS project

Dear Mr. Blazek,

Attached is a list of environmental protection measures that have been incorporated into the project description of the Calpine EGS Environmental Assessment (EA). Calpine agrees to implement all of these measures during implementation of the project. The measures have been incorporated into the project description of the EA prepared by RMT as part of the proposed action.

This letter serves to document the concurrence of Calpine to conduct the attached environmental protection measures as part of the project. If you have any questions, please contact me at (707) 431-6198.

Sincerely,

Bruce Carlsen

EHS Director

Calpine-Geysers

Enclosure

Environmental Protection Measures for the Calpine EGS Project

Air Quality

- Devegetated areas would be watered or other methods would be employed to entrain dust, in order to minimize any adverse impacts from particulate matter emissions during ground disturbance, including asbestiform minerals.
- 2. All trucks hauling soils or other dusty materials would be covered and two feet of freeboard would be maintained in the trucks
- Inactive construction areas would be hydroseeded or covered with non-toxic soil stabilizers. "Inactive" areas are previously graded areas that are inactive for 10 days or more.
- 4. Traffic would be limited to 15 miles per hour on unpaved roads.
- 5. Painting of the steam pipelines and supports would conform to NSCAPCD Rule 485 for use of compliant architectural coatings.
- 6. The Asbestos Air Toxic Control Measure for construction, grading, quarrying and surface mining as approved by the California Air Resources Board (CARB) would be implemented to avoid adverse effects associated with the emissions of serpentine/asbestiform minerals.
- 7. All conditions of the ATC and temporary PTO from the NSCAPCD would be implemented.
- 8. Dust emissions from venting steam would be reduced by injecting water into the blooie line
- 9. H₂S control would be accomplished through the installation of a NSCAPCD approved chemical abatement system
- 10. Calpine will implement all measures required in the Authority to Construct and Permit to Operate permits issued by the NSCAPCD (included in Appendix D of this EA).
- 11. Calpine will notify the NSCAPCD 24 hours prior to initiating any planned venting operations until such time that an emissions release protocol governing emissions and notifications for such operations is prepared and provided to the NSCDAPCD

Geology

- 12. The SRGRP pipeline spur would be constructed using Standard Engineering Methods for Expansive Soils, as necessary.
- 13. Calpine will comply with the DOE's"Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems" (Majer et al. 2008).

14. The stanchions for the SRGRP pipeline will be constructed using Standard Engineering Methods for Expansive soils, as necessary.

Biological Resources

- 15. In order to protect yellow warblers and Common Yellowthroats, any work proposed within riparian woodland habitat between April 1 and August 31 would be surveyed by a qualified biologist. If a nest of either species is discovered within 200 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.
- 16. In order to protect sharp-shinned hawks, any work proposed within riparian woodland series such as white alder or cattails series, between April 1 and August 31 would be surveyed by a qualified biologist. If an active nest is found within 500 feet of proposed construction activities, construction would be delayed until after August 31 or until a qualified biologist has determined the young have fledged.
- 17. If construction or re-drilling is to occur between April 1 and August 31 preconstruction surveys would be performed in all construction areas and the drilling area within 500 feet of suitable habitat for raptors. If active nests are found, work within these areas would be halted until after August 31 or a qualified biologist has determined the nest is no longer active and the young have fledged.
- 18. No trees would be removed during construction of the SRGRP pipeline.

Water Resources

- 19. Erosion control methods and Best Management Practices (BMPs) in accordance with a Stormwater Pollution Prevention Plan (SWPPP) would be utilized (such as certified weed-free straw waddle) to reduce erosion or siltation on or off-site during grading of the well pad and construction of the SRGRP pipeline spur.
- 20. No water would be released to the surface from the pipeline during testing or operation of the pipeline.
- 21. A SWPPP would be developed and a Notice of Intent submitted to the California State Water Resources Control Board, prior to grading or construction activities.
- 22. A Spill Prevention, Control, and Countermeasure Plan (SPCC) would be maintained on-site and implemented to contain incidental drips and/or spills. The plan will identify equipment and procedures used for containment and recovery of accidental spills

- 23. Contamination during construction along the pipeline corridor would be minimized through containment of any spills before they could be released into stormwater.
- 24. Containment berms will be constructed around all hazardous material or potentially hazardous material storage for both construction and operation.
- 25. A drainage system will be installed around the well pad to contain stormwater.
- 26. BOPE will be installed to minimize blowouts or contamination of the localized shallow aquifer as required by CDOGGR regulations.
- 27. Calpine will obtain an updated Waste Discharge Order that will address injection of effluent and condensate into the EGS wells. Calpine will submit injection reports to CDOGGR. Injection of water and disposal of waste discharge due to drilling will comply with all requirements outlined in the permit

Cultural Resources

- 28. A condition from the Wildhorse Development Project has been incorporated into the proposed action to further protect cultural resources. The condition requires placing the following note on all construction plans and providing the language to all contractors and superintendents on the job site:
 - "Should any previously unknown historic or prehistoric resources, including but not limited to charcoal, obsidian or chert flakes, grinding bowls, shell fragments, bone, pockets of dark, friable soils, glass, metal, ceramics, wood or similar debris, be discovered during grading, trenching or other on-site excavation, earthwork in the vicinity of the find shall cease, and the County of Sonoma Permit and Resource Management Department (PRMD) staff shall be notified so that the find can be evaluated by a qualified archaeologist (i.e., an archaeologist registered with the Society of Professional Archaeologists). When contacted, a member of PRMD Project Review staff and the archaeologist shall visit the site to determine the extent of the resources and to develop proper mitigation measures required for the discovery. No earthwork in the vicinity of the find shall commence until a mitigation plan is approved and completed subject to the review and approval of the archaeologist and Project Review staff"
- 29. A qualified archaeological monitor will be present during pipeline construction along all of West Squaw Creek Road to the tie-in location to ensure that no construction activities occur outside of the existing disturbed road shoulder and to monitor for cultural materials during construction. If a resource is found during construction, the monitor shall have the authority to stop construction until it can be further evaluated. The pipeline would be installed above-ground on stanchions, such that ground disturbance is already minimized to only the stanchion foundations. Any resource found would be avoided by spanning over the resource and/or moving the pipeline to avoid any resource.

Noise

- 30. Calpine would adopt the following measures to minimize noise from the drill rig during re-drilling and testing operations:
 - Shielding of drill rig motor and air compressors: When practicable, set up the drill rig so that it acts as a barrier to shield noise from the motor and compressors from receptors.
 - Buffer metallic surfaces: If needed, cover V-door and drill rig floor with rubber or wood to reduce impact noise from pipes against these metal surfaces.
 - Enclose Rig Floor: If needed, enclose rig floor with metal panels including the V-door opening.
 - Muffle connection equipment: Install mufflers around pipe connection equipment such as air tuggers and winches.
 - Install check valve: Install a check valve in the drill string to slowly bleed off air pressure and reduce high pressure release noise.
 - Bleed air pressure through cyclone muffler: Reduce pressure release noise by bleeding air pressure through the blooie line rather than the rig floor.
 - Pipe Handling: Implement procedures for handling drill pipe that minimize contact with metal surfaces (i.e., on the V-door and catwalk).
 - During air drilling, the rig will be outfitted with a blooie line and cyclonic separator/muffler designed to reduce noise from the release of steam. Similarly, during well testing a portable blooie line and muffler will be utilized to reduce steam release noise.
 - Rig Crew training: Train all rig crews in noise awareness.
- 31. Noise would be controlled in accordance with the standards set in the Noise Element of the Sonoma County General Plan.
- 32. If noise complaint investigations indicate the appropriate noise standard levels have been or may be exceeded, Calpine would be required to install, at their expense, additional professionally designed noise control measure(s).
- 33. Well pad, road, and pipeline construction/grading activities would not occur during the nighttime.

Visual Resources

34. Pipelines would be painted in earth-tone colors.

35. Rig lights and any other temporary lighting would be shaded and focused downwards to reduce nighttime glare from the well pads during drilling operations. Temporary lighting would only be on for short periods of time, as necessary.

Hazardous Materials, Waste Handling, Human Health and Safety, and Risk Management

- 36. Fire hazards would be minimized through the maintenance of an on-site water supply that can be used to put out any potential fires. Other measures to reduce fire hazards would be implemented and include:
 - a. Fire extinguishers and shovels would be available on-site.
 - b. All brush build-up around mufflers, radiators, and other engine parts must be avoided; periodic checks must be conducted to prevent this build-up.
 - c. Smoking would only be allowed in designated smoking areas; all cigarette butts would be placed in appropriate containers and not thrown on the ground or out windows of vehicles.
 - d. Cooking, campfires, or fires of any kind would not be allowed.
 - e. Portable generators used in the Project Area would be required to have spark arresters.
- 37. Existing Calpine health and safety procedures provide plans that address prevention of fires in The Geysers. These plans would be implemented, including:
 - Fire Prevention Plan (HSP-60)
 - Hot Work Permit Procedure (No. 145)
 - The Calpine Geysers Emergency Preparedness and Response Plan
- 38. Calpine would remove and clear away dry, combustible vegetation from construction sites in the project area that contains substantial forest fire risks and hazards, or are very high fire hazard severity zones as defined by California Division of Forestry and Fire Protection. Grass and other vegetation less than 18 inches in height above the ground may be maintained where necessary to stabilize the soil and prevent erosion. Vehicles would not park in areas where exhaust systems contact combustible materials. Fire extinguishers would be available on the construction site when working in high fire hazard areas to assist in quickly extinguishing any small fires. The Construction Manager would have on site the phone number for the local fire department(s) and would have a phone available when working in high fire hazard areas should additional fire fighting capabilities be required.

- 39. Calpine would implement the Asbestos Air Toxic Control Measure for construction, grading, quarrying and surface mining as approved by CARB.
- 40. Workers would wear hearing protection and other personal protection equipment (PPE) as required by the Occupational Health and Safety Organization (OSHA) to prevent injuries.
- 41. Construction workers would comply with OSHA and CalOSHA asbestos removal worker requirements whenever serpentine rock containing over one percent asbestos is being excavated.
- 42. Calpine would implement its blowout prevention plan.
- 43. When cementing jobs are performed, excess cement slurry would be directed to a separate waste tank where it would be chemically retarded for later removal to Calpine's designated waste management unit

APPENDIX H:SPECIAL STATUS SPECIES

Appendix H: Special Status Species

Name	Listing Status	Habitat Requirements	Potential to Occur in the Project Area
Plants			
Socrates Mine jewel-flower Streptanthus brachiatus	Federal: None State: None CNPS: 1B.2	Perennial herb found within closed- cone coniferous forests or Chaparral (usually serpentinite) Blooms: May-June Elevation: 545-1,000m	Low to moderate
Colusa layia Layia septentrionalis	Federal: None State: None CNPS: 1B.2	An annual herb found in chaparral, cismontane woodlands, or valley and foothill grasslands with sandy serpentinite soils Blooms:April-May Elevation 100-1095 m	Low to moderate
Legenere Legenere limosa	Federal: None State: None CNPS: 1B.1	Annual herb most commonly associated with vernal pools. Blooms: April-June Elevation: 1-880m	None. No suitable habitat present.
Many-flowered navarretia Navarretia leucocephala ssp. Plieantha	Federal: FE State: SE CNPS: 1B.2	Annual herb most commonly associated with vernal pools. Blooms: May-June Elevation: 30-950m	None. No suitable habitat present.
Boggs Lake hedge-hyssop Gratiola heterosepala	Federal: None State: SE CNPS: 1B.2	Annual herb associated with aquatic sources such as lake margins, swamps, marshes, or vernal pools with clay substrates. Blooms: April-August Elevation: 10-2,375 m	None. No suitable habitat present.

Name	Listing Status	Habitat Requirements	Potential to Occur in	
	g	1	the Project Area	
Geysers dichanthelium Dichanthelium lanuginosum var. thermale	Federal: None State: SE CNPS: 1B.1	Perennial herb most often found in riparian forest, geothermally-altered soils or streamsides near valley and foothill grasslands. Blooms: June-August Elevation: 305-825m	Low to moderate	
Glandular western flax Hesperolinon adenophyllum	Federal: None State: None CNPS: 1B.2	An annual herb found in chaparral, cismontane woodlands, or valley and foothill grasslands with sandy serpentinite soils. Blooms: May-August Elevation: 150-1,315m	Low to moderate	
Marsh checkerbloom Sidalcea oregano ssp. hydrophila	Federal: None State: None CNPS: 1B.2	A perennial herb that is found within meadows, seeps, and mesic riparian forests. Blooms: July-August Elevation: 1,100-2,300m	Low to moderate	
Cobb Mountain lupine Lupinus sericatus	Federal: None State: None CNPS: 1B.2	A perennial herb that can be found in broadleaf upland forest, chaparral, cismontane woodlands, or lower montane coniferous forests. Blooms: March-June Elevation 275-1,525m	Low to moderate	
Brandegee's eriastrum Eriastrum brandegeeae	Federal: None State: None CNPS: 1B.2	Annual herb found in volcanic or sandy soils in cismontane woodlands or chaparral. Blooms: April-August Elevation: 305-1,030m	Low to moderate	
Morrison's jewel- flower Streptanthus morrisonii ssp. morrisonii	Federal: None State: None CNPS: 1B.2	A perennial herb found in serpentinite, rocky, and talus chaparral habitats Bloom: May-September Elevation: 120-585m	Low to moderate	
Bolander's horkelia Horkelia bolanderi	Federal: None State: None CNPS: 1B.2	Habitats include chaparral, lowe montane coniferous forest, meadows and seeps, and vernally mesic edges or areas of valley and foothill grasslands.	Low to moderate	

Name	Listing Status	Habitat Requirements	Potential to Occur in the Project Area
		Blooms: June-August	
		Elevation: 450-1,100m	
Few-flowered navarretia Navarretia	Federal: FE State: ST CNPS: 1B.1	This annual herb can be found near vernal pools containing volcanic ash flow.	None. No suitable habitat present.
leucocephala ssp. pauciflora		Blooms: May-June Elevation: 400-855m	
slender Orcutt grass Orcuttia tenuis	Federal: FT State: SE CNPS: 1B.1	This annual herb is commonly associated with vernal pools. Blooms: May-September Elevation: 35-1760m	None. No suitable habitat present.
Konocti Manzanita Arctostaphylos manzanita ssp.	Federal: None State: None CNPS: 1B.3	This evergreen shrub is typically found in chaparral, cismontane woodlands, or volcanic lower montane coniferous forest habitats.	Moderate
elegans		Blooms: March-May Elevation: 395-1,615m	
Rincon Ridge ceanothus Ceanothus confusus	Federal: None State: None CNPS: 1B.1	This evergreen shrub is often found in closed-cone coniferous forests, chaparral, or volcanic or serpentinite cismontane woodlands.	Low to moderate
		Blooms: February-June Elevation: 75-1,065m	
Snow Mountain buckwheat Eriogonum nervulosum	Federal: None State: None CNPS: 1B.2	A rhizomatous herb that is found serpentinite chaparral habitats. Blooms: June-September Elevation: 300-2,105m	Low to moderate
Sonoma canescent Manzanita Arctostaphylos canescens ssp. sonomensis	Federal: None State: None CNPS: 1B.2	An evergreen shrub that prefers chaparral or lower montane coniferous forests. It is sometimes associated with serpentinite soils. Blooms: January-June	Low to moderate
serpentine cryptantha Cryptantha	Federal: None State: None CNPS: 1B.1	Elevation: 180-1,675m An annual herb found in serpentinite-containing chaparral environments. Blooms: April-June	Low to moderate

Name	Listing Status	Habitat Requirements	Potential to Occur in
			the Project Area
clevelandii var. dissita		Elevation: 395-580m	
Insects			
Ricksecker's water scavenger beetle Hydrochara rickseckeri	Federal: None State: CSC	Found in pond habitats scattered around the San Francisco Bay area, including Marin, Sonoma, Alameda, and Contra Costa counties.	Absent
Amphibians and Re	ptiles		
Western pond turtle Actinemys marmorata	Federal: None State: CSC	Found in aquatic habitats. Diurnal, but hibernates underwater in muddy pool bottoms.	Absent
Foothill yellow- legged frog Rana boylii	Federal: None State: CSC	Frequents shallow, slow, gravelly streams and rivers with sunny banks in forests, chaparral, and woodlands.	Low
California red- legged frog Rana aurora draytonii	Federal: FT State: CSC	Breeds in ponds and pools in slow- moving streams with emergent vegetation; adjacent upland habitats are often used for refuge.	Low
Birds			
Purple martin Progne subis	Federal: FE State: CSC	Roosts in abandoned woodpecker holes, tree cavities, rock crevices, and birdhouses. It frequently lives near towns and bodies of water.	Moderate to High
Yellow Warbler Dendroica petechia	Federal: FE State: CSC	Requires woodland	Moderate to High
Common Yellowthroat Geothlypis trichas	Federal: None State: CSC	This bird finds cover and food primarily in wetland habitats and occasionally nests in riparian and grassland habitats.	Moderate to High
Northern Spotted Owl Strix occidentalis caurina	Federal: FT State: None	Inhabit cool, moist, well-shaded forest habitat	Moderate
White-tailed Kite Elanus leucurus	Federal: None State: CFP	Nests in oak, willow, or other trees and forages over open grasslands.	Moderate to High

	Special Status Species with Potential to Occur in the Project Vicinity (Continued)				
Name	Listing Status	Habitat Requirements	Potential to Occur in the Project Area		
Sharp-shinned Hawk Accipiter striatus	Federal: None State: CSC	Prefers cool, moist, well-shaded forest with access to water.	Moderate to High		
Cooper's Hawk Accipiter cooperii	Federal: None State: CSC	Inhabits open woodland near water where hawks can ambush prey from cover. Nest in large trees within riparian woodlands.	Moderate to High		
Ferruginous Hawk Buteo regalis	Federal: None State: CSC	Habitat is usually an isolated perch overlooking an open grassland or scrubland that provides suitable hunting territory.	Moderate to High		
Tricolored Blackbird Agelaius tricolor	Federal: None State: CSC	Nests in freshwater marshes containing emergent vegetation.	Low		
Golden Eagle Aquila chrysaetos	Federal: BGEPA State: FP	Found in rolling foothills, mountain areas, and desert. Cliff-wall canyons used for nesting.	Low		
Peregrine Falcon Falco peregrinus	Federal: None State: SE	Prefers woodland and forest habitats near water for breeding and will nest yearlong in riparian areas.	Low		
Fish					
Steelhead-central coast California ESU	Federal: FE State: CSC	Suitable habitat available in Squaw Creek,	Present		
Oncorhynchus mykiss irideus					
Mammals					
Pallid Bat Antrozous pallidus	Federal: None State: CSC	Prefers open, dry habitats such as grasslands, shrublands, and woodlands with rocky substrate.	Low		

Note:

CNPS Designations:

- 1B: Plants rare, threatened, or endangered in California or elsewhere.
- 2: Plants rare, threatened, or endangered in California, but more common elsewhere.
- 3: Plants for which more information is needed a review list.
- 4: Plants of limited distribution a watch list.

Special Status Species with Potential to Occur in the Project Vicinity (Continued) Name **Listing Status Habitat Requirements** Potential to Occur in the Project Area **CNPS Threat Designations** Seriously endangered in California. 0.2 Fairly endangered in California.

Federal Designations:

FE: Listed as Endangered under the Endangered Species Act FT: Listed as Threatened under the Endangered Species Act FC: Listed as Candidate under the Endangered Species Act

SOC Species of Concern

0.3 Not very endangered in California.

State of California Designations:

SE: California Fish and Game Code Endangered Species ST: California Fish and Game Code Threatened Species CFP: California Fish and Game Code Fully Protected Species

CSC: California Department of Fish and Game Species of Special Concern

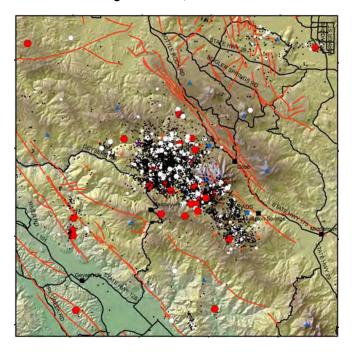
CCC: California Candidate Species as Threatened or Endangered

SOURCE: Northwest Biosurvey 2007; CNDDB 2009; USFWS 2009

APPENDIX I: REPORT ON INDUCED SEISMICITY

FINAL REPORT

Evaluation of the Environmental Impacts of Induced Seismicity at the Calpine Enhanced Geothermal System Project, The Geysers, California



prepared for RMT, Inc.

4 West Fourth Avenue, Suite 303 San Mateo, California 94402

11 January 2010



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SECTIONONE Introduction

At the request of RMT, Inc., the following report presents an evaluation of the potential for induced seismicity and its environmental impacts at Calpine's proposed Enhanced Geothermal System (EGS) Project site at The Geysers. This study is part of an Environmental Assessment being prepared by the U.S. Department of Energy, in accordance with the National Environmental Policy Act (NEPA) of 1969. Seismicity induced by The Geysers steam production and injection has been identified as an environmental impact in previous projects.

The proposed EGS site is part of an undeveloped 10 square-mile area of the northwest Geysers between the Aidlin and Ridgeline Power Plants (Units 7 and 8; Figure 1). The candidate wells to be reopened and converted to injection are Prati State 31 (PS-31) and Prati 32 (PS-32). In the project area, the High Temperature Zone (HTZ) is at its shallowest depth at 1,676 to 1,829 m (5,500 to 6,000 ft).

In this study, the potential for seismicity induced by the injection of fluids at the EGS site and potential associated adverse environmental impacts to local residents and communities have been evaluated. Adverse impacts to local residents in Anderson Springs and Cobb will be due to ground shaking and so this effect is quantified in this study. The future rate of injection at the EGS site is a key parameter for assessing the onset of induced seismicity and this is factored into our analysis. The seismotectonic setting of The Geysers and active faults also are described to provide a framework for the discussion of induced seismicity.

1.1 SCOPE OF WORK

The following tasks have been performed as part of this study:

- **Task 1.** Review the available information and data relevant to the seismotectonic setting, active faults, historical seismicity, and induced seismicity at The Geysers to evaluate its potential adverse impacts on the local population.
- **Task 2.** Evaluate the seismicity at The Geysers particularly at the nearby Prati State 9 (PS-9) well as recorded by the U.S. Geological Survey's (USGS) Northern California Seismic Network (NCSN) and the Lawrence Berkeley National Laboratory (LBNL) seismic network since 1970 when adequate seismographic coverage came into existence.
- **Task 3.** Based on data collected by Calpine strong motion stations and an evaluation of felt reports collected by Calpine since 2003, assess the potential for local resident disturbance and property damage from ground shaking as a result of induced earthquakes.
- **Task 4.** Prepare a final report describing the results of these analyses.

1.2 **ACKNOWLEDGMENTS**

Our thanks to Tania Treis and RMT Inc. for support of this study. Our appreciation to Melinda Lee for assisting in the preparation of this report and Keith Knudsen for his review.

The following describes the seismotectonic setting, active faulting, and historical seismicity of The Geysers and the surrounding region.

2.1 SEISMOTECTONIC SETTING

The Geysers geothermal area is located within the Coast Ranges geomorphic and tectonic province of northern California. The region is underlain primarily by highly deformed and metamorphosed volcanic and sedimentary rocks of the Jurassic-Cretaceous Franciscan assemblage, which are juxtaposed against similar aged Great Valley Sequence rocks along the Coast Range thrust fault. These older rocks were intruded and overlain by Pleistocene igneous rocks during a phase of late-stage volcanism attributed to the northward migration of the Mendocino triple junction. The Pleistocene rocks crop out to the northeast of The Geysers near Clear Lake and to the east on Cobb Mountain as the Clear Lake Volcanics. Within The Geysers area itself, the igneous rocks are largely confined below the surface. The heat source driving The Geysers geothermal system is postulated to be a steam reservoir heated by a magma chamber located at mid-crustal depths. Overlying the bedrock are a variety of Quaternary deposits, including recent alluvium along river valleys and landslide deposits, which are ubiquitous in areas of steep topography underlain by sheared Franciscan assemblage rocks.

The Coast Ranges are characterized by steep and rugged topography with a pronounced northwest fabric. This fabric, of northwest-trending ranges separated by subparallel river valleys, is controlled by the northwest-striking structures of the San Andreas fault system (Figure 2). The San Andreas fault system is a 100-km-wide swath of subparallel, primarily right-lateral strike-slip faults along the western edge of California. It comprises the boundary between the North American and Pacific tectonic plates and accommodates most of the transform motion between the two plates. The San Andreas fault is the dominant fault in the system, but numerous smaller faults accommodate some portion of the plate motion (Figure 2).

2.2 **ACTIVE FAULTS**

The Geysers lies within a zone of right-lateral shear and localized extension between two Holocene active faults of the San Andreas fault system: the Maacama fault to the southwest and the Bartlett Springs fault to the northeast (Figure 2). Both these faults have documented Holocene (< 11,700 years) activity, and the Maacama fault is actively creeping along much of its length. Significant seismicity (Figure 3) and crustal deformation has been documented in The Geysers area (Lofgren, 1978; Ludwin et al., 1982; Oppenheimer, 1986; Mossop, 1997). Studies attribute most of the activity to the withdrawal and injection of fluids associated with development of the geothermal resource (e.g., Lofgren, 1978; Marks et al., 1978; Oppenheimer, 1986). However, geodetic studies suggest that there is active right-lateral shear, ESE-directed extension and natural regional tectonic subsidence occurring between the Maacama fault and Clear Lake. Extension also is reflected in normal faulting mechanisms and the presence of depositional, pull-apart basins within the region. Regional tectonic deformation rates are about an order of magnitude slower than induced rates (Lofgren, 1978). Faults within The Geysers area include numerous inactive bedrock faults associated with earlier tectonic regimes, as well as a number of faults active in the Quaternary. Several of these faults are discussed below.

Maacama Fault

The right-lateral, strike-slip Maacama fault, which extends from near Santa Rosa to at least Laytonville, is the northern extension of the Hayward-Rodgers Creek fault zone (Figure 2). North of Laytonville the fault is not well expressed geomorphically but strikes into the Garberville-Briceland fault at about latitude 40°N. The slip rate on the Maacama fault is not well constrained, and the California probabilistic seismic hazard maps use the slip rate of the Hayward-Rodgers Creek fault (9 \pm 2 mm/yr) for the Maacama-Garberville fault assuming the slip to carry through (Cao et al., 2003). Recent GPS studies in the region suggest that about 14 mm/yr of slip occurs on the Maacama fault (Freymueller et al., 1999), while the Garberville extension accommodates a much smaller 5.3 ± 3.5 mm/yr (Freymueller et al., 2002). The Maacama fault is creeping at rates of about 6 to 7 mm/yr near Willits and 4 to 5 mm/yr near Ukiah (Galehouse, 2002). Geologic studies indicate long-term geologic surface slip rates of 8.7 to 13.4 mm/yr near Ukiah (Sickler et al., 2005) and a minimum of 8 mm/yr near Willits (Larsen et al., 2005), suggesting the fault is storing some of its total strain to be released in earthquakes. Prentice and Fenton (2005) report paleoseismic evidence for four to five surface rupturing earthquakes (moment magnitude [M] > 6.5) in the Holocene near Willits.

Collayomi Fault Zone

The Collayomi fault zone is a northwest-striking right-lateral fault zone that defines the southwestern edge of the Clear Lake basin. It also marks the northeastern extent of The Geysers reservoir area. McLaughlin (1978) and Hearn et al. (1976) map it as a broad (up to 1-km-wide), complex zone of faults that have predominantly right-lateral slip with a component of dip-slip. Hearn et al. (1976) reported it as predominantly normal, but offset features and geomorphic expression are more consistent with a dominant right-lateral sense of slip. Hearn et al. (1995) mapped the fault as right-lateral. The fault offsets Pleistocene Clear Lake Volcanics and late Quaternary (< ca. 130,000 years) terrace deposits. Bryant (1982), however, concluded that the geomorphic expression of the fault is not pronounced along most of its length and is not consistent with Holocene displacement, nor is there evidence of latest Quaternary (< 15,000 years) displacement. The late Quaternary slip rate on the fault is poorly known, but is most likely less than 1 mm/yr. Hearn et al. (1988) report 1.1 km of offset on 1.5 million year old Clear Lake Volcanic rocks, and Hearn et al. (1976) show about ca. 400 m offset of a 600,000-year-old rhyolite, suggesting a slip rate of about 0.7 mm/yr (Bryant, 2000). The Working Group on Northern California Earthquake Potential (1996) used a slip rate of 0.6 ± 0.3 mm/yr, based on Clark et al. (1984). No paleoseismic studies have been carried out on the Collayomi fault, and the age of the most recent rupture of the fault is unknown. The Working Group assigned a maximum magnitude of M 6.5 to the fault.

Faults Between the Maacama and Collayomi Faults

McLaughlin (1974; 1978) mapped several northwest-striking faults, some of which have apparent Quaternary (< 2.58 million years) activity, in The Geysers area between the Maacama and Collayomi faults. From northeast to southwest, these include the Squaw Creek and Burned Mountain fault zones, Dianna Rock fault, Big Sulphur Creek fault, Mercuryville fault zone,

Geyser Peak fault zone, and Little Sulphur Creek fault (Figure 4). Most of these faults are exposed only in Franciscan bedrock, so there is little information as to their recent activity. Quaternary deposits along many of them are restricted to landslide deposits, whose morphology often masks fault-related geomorphology and makes identification of fault features difficult to identify. Along most of these faults, McLaughlin (1974; 1978) mapped the landslide deposits as covering the fault, indicating that the most recent faulting occurred prior to deposition of the landslide material. However, he asserts that given the lack of Quaternary materials and the complicated geomorphology, Quaternary activity is unknown for many faults (R. McLaughlin, USGS, personal communication, 2009).

The Mercuryville fault (Figure 4) defines the southwestern edge of The Geysers reservoir, where it forms a hydrothermal alteration boundary (Miller et al., 1980). McLaughlin (1974; 1978) maps it as right-lateral oblique-slip fault with a component of east-side up motion and does not provide a dip. Its mapped expression suggests it may be relatively low angle and have a reverse or thrust component of slip. No Quaternary activity has been identified along this fault.

The Big Sulphur Creek fault is east of and subparallel to the Mercuryville fault (Figure 4) and may be the controlling structure in The Geysers area (Bacon et al., 1974). The fault zone has been defined to include older low-angle thrust faults and/or younger high-angle strike-slip faults (Thomas et al., 1981). The fault has also been identified as being high-angle in boreholes drilled as part of geothermal exploration. The right-lateral oblique fault loosely follows Big Sulphur Creek and, unlike the long and continuous Mercuryville fault, comprises numerous short, discontinuous, en echelon fault strands, linked by north-striking normal faults. It merges to the north with the Squaw Creek fault. Thomas et al. (1981) consider it to be part of a deep-seated wrench fault system analogous to the Maacama fault. McLaughlin (1974; 1978) mapped the fault as offsetting late Quaternary, possibly Holocene (R. McLaughlin, USGS, personal communication, 2009) terrace deposits within Big Sulphur Creek drainage. It is, however, locally overlain by unfaulted Quaternary landslide deposits. No slip rate is reported for the fault, and no paleoseismic investigations have been carried out. The fault is not included in the USGS Quaternary fault and fold database.

The Geyser Peak and Cobb Mountain faults (Figure 4) are included in the USGS Quaternary fault database. The Geyser Peak fault is subparallel to and about 1 to 2 km west of the Mercuryville fault; the Cobb Mountain fault is to the east of The Geysers and just west of the Collayomi fault. Little detailed information is available about these faults. They are mapped as undifferentiated Quaternary (< 2.58 million years), except for a couple of small cross faults of the Geyser Peak fault northwest of The Geysers, which are mapped as late Quaternary (< 130,000 years). McLaughlin (1974; 1978) mapped the Geyser Peak fault as steeply dipping and right-lateral, with a component of west-side-up dip-slip.

Of unknown activity and minor length are a series of northeast-striking faults that developed subsequent to the dominant northwest-striking faults in The Geysers area. Rodriguez (1995) and Stanley et al. (1998) attribute development of these faults to localized northwest-directed extension associated with the migration of the Mendocino triple junction through the area about 3 million years ago.

2.3 HISTORICAL SEISMICITY

The historical earthquake record of north-central California dates back to the early 1800's when this portion of the State became settled. Until the early 1900's, when the first seismographic stations were installed by the University of California at Berkeley (UCB), the historical record was based on observed intensities.

Seismographic coverage of The Geysers to detect earthquakes smaller than M_L 3 (Richter local magnitude [M_L] is approximately equivalent to M) did not come about until mid-1975 when the USGS Central California Seismic Network (CALNET) reached The Geysers area (Oppenheimer, 1986). Prior to that time, dating back to the early part of the 1900s, there was only regional coverage of northern California by the UCB Seismographic Network.

Currently the USGS operates an array in The Geysers, which is part of the much larger regional network operated by the USGS (Figures 5 and 6). Since 1976, station density in The Geysers area has been sufficient to achieve location thresholds ranging from M_I 1.2 to 1.5, therefore recording virtually all events likely to be felt by humans. The system records and locates about 9,000 events per year in The Geysers area. Recently, data from a new Lawrence Berkeley National Laboratory (LBNL) network (described below) have been integrated into the NCSN system, significantly lowering the magnitude threshold and thereby increasing the number of events captured in the dataset.

In 1989, a 22-station network was established by Unocal, and later was assumed (along with Unocal's steamfield holdings) by Calpine in 1999. The network provided coverage of most of the field, with the notable exception of the Aidlin area in the extreme northwest end. Data were transmitted continually via analog telemetry to a central processing facility in a Calpine field office, where events were automatically identified, recorded, and located. The location threshold for the array ranged from M_L 0.9 to 1.0. The system recorded and located about 12,000 events per year, of which the majority were too small to be felt by humans. The Calpine network was discontinued in mid-January 2008 and has been superseded by the LBNL/USGS system.

The initial 26 modern digitally telemetered LBNL stations were installed near those of the Calpine array, with minor adjustments including expansion to the southeast to improve coverage of the Anderson Springs community. Currently the network includes 23 stations (Figures 5 and 6). The LBNL network began recording data in April 2003, and has been operational since 14 October 2003. By the end of 2004, the LBNL data flow had been integrated into the NCSN system, providing public access to the data via the Internet. The integrated NCSN/LBNL dataset appears to be reliably recording earthquakes down to M_L 1.0. The LBNL network is being expanded to the northwest by 5 stations, which will cover the EGS site (Figure 1). This will provide the needed coverage to calculate high-precision event locations and other analyses.

Two strong motion stations were installed by Calpine in February and March 2003 to record ground shaking in the towns of Cobb (COB) and Anderson Springs (ADS), the communities affected by The Geysers earthquakes (Figures 1, 5, and 6). In September 2009, a third strong motion instrument (ADS2) was installed in Anderson Springs by Alta Rock (Figure 1). Recording is individually triggered at each station and the stations operate in a dial-out mode to a



processing site at the USGS allowing near-real time access to a summary listing of event parameters.

Accuracy of the hypocentral locations of earthquakes observed in The Geysers is largely dependent upon the seismographic coverage, thus the accuracy has improved through time. The horizontal and vertical precision of earthquakes located using data from the USGS network has been about 400 m and 600 m, respectively, since 1975 (Oppenheimer, 1986).

The Geysers and surrounding region exhibited a low level of known seismicity prior to 1970 (Figure 7). However, seismographic coverage north of San Francisco Bay was only sufficient to record and locate events M_L 4 and larger. A number of significant earthquakes have occurred in California prior to 1970 that have probably impacted The Geysers and surrounding region. The two most significant events are the 1906 Great San Francisco earthquake, because of its size and location along the northern San Andreas fault to the west (Figure 2), and an earthquake in 1955 near The Geysers (Figure 7).

The 1906 M 7.9 earthquake was the most destructive earthquake to have occurred in northern California in historical times. The earthquake was felt from southern Oregon to south of Los Angeles, and as far east as central Nevada. It ruptured the northernmost 430 km of the San Andreas fault, from San Juan Bautista to the Mendocino Triple Junction. Damage was widespread in northern California and injury and loss of life was particularly severe. Ground shaking and fire caused the deaths of more than three thousand people and injured approximately 225,000. The intensity of shaking in the vicinity of The Geysers was about Modified Mercalli (MM) intensity VII-VIII (Stover and Coffman, 1993). Descriptions from towns such as Geyserville include downed brick walls and generally cracked brick buildings (Lawson, 1908). The local butcher shop lost one side of the building and several walls. Over half the chimneys in town were reported down.

An earthquake of M_L 4.2 on 7 May 1955 occurred 10 km north of the locations of PS-31 and PS-32 (Figure 7). The earthquake had a maximum intensity of MM VI, which was felt in Anderson Ranch, Kelseyville, Clearlake and Lower Lake (Murphy and Cloud, 1957). Damage included cracked ceilings and fallen plaster, damage to light fixtures, fallen grocery store stock, and jarred chimneys. In Middletown, the earthquake was felt at MM V (Murphy and Cloud, 1957). The earthquake was felt as far away as Kenwood.

Other significant earthquakes in the region surrounding The Geysers included two 1 October 1969 Santa Rosa earthquakes, M_L 5.6 and 5.7, which were felt at MM V in Middletown (von Hake and Cloud, 1971). The earthquakes occurred at the juncture of the Rodgers Creek and Healdsburg faults (Wong and Bott, 1995).

The Geysers geothermal area is the site of a vapor-dominated steam field from which electric power has been generated since the early 1960's. It is also among the most seismically active areas in north-central California (Figure 2). Earthquakes are concentrated at the steam production field (Figures 2 and 3) and extend to a depth of 6 km (Eberhart-Phillips and Oppenheimer, 1984). Prior to the onset of power production, the region surrounding The Geysers was characterized by a very low level of seismicity (Figure 7), albeit seismographic coverage was poor (Section 2).

The USGS NCSN catalog lists a total of 25 probable Geysers induced earthquakes of M_L or M 4.0 and greater (Table 1; Figure 2). (M_L and M are assumed to be equivalent.) This translates to a rate of one $M \ge 4.0$ event per 1.5 years since 1972. The rate, however, has significantly increased since 2002 to about one $M \ge 4.0$ event every 7 to 8 months (Figure 8) after a dramatic increase in injection.

The largest earthquake observed in The Geysers has been an estimated M_L 4.6 on 9 May 1973 (Figures 9 and 10). This event occurred on the northwestern edge of the concentrated induced seismicity although its location is poorly constrained because seismographic coverage of The Geysers was relatively poor at the time. Its depth was estimated at about 12 km. Thus whether this was induced or not cannot be determined. Its magnitude is also uncertain (David Oppenheimer, USGS, written communication, November 2009). A M 4.5 event occurred on 20 October 2006 on the northern margin of The Geysers area (Figures 9 and 10). It had a shallow focal depth (3.5 km) and is thought to have been induced.

3.1 **CAUSATIVE MECHANISMS**

A causative relationship between steam production and fluid injection was suggested in the late 1970's by USGS scientists. That relationship has now been accepted based on numerous studies (e.g., Denlinger and Bufe, 1982; Eberhart-Phillips and Oppenheimer, 1984; Oppenheimer, 1986; Stark, 1990; Greensfelder, 1993). Although it is clear that steam production and injection causes The Geysers seismicity, the exact causative mechanism is still not well defined. Eberhart-Phillips and Oppenheimer (1984) found no direct correlation between the volume of cold water injected or the volume of steam withdrawn and the number of earthquakes per month. Correlations have been subsequently observed at some wells by others. Eberhart-Phillips and Oppenheimer (1984) suggested that there are two plausible mechanisms, which could explain the induced seismicity at The Geysers: (1) volumetric contraction due to mass withdrawal, which could perturb the stress field and cause faulting in the reservoir rock already near failure due to the regional stress field, and (2) aseismic deformation due to regional tectonism may be converted to strike-slip deformation due to an increase in the coefficient of friction along fault surfaces (Eberhart-Phillips and Oppenheimer, 1984). For both mechanisms, Eberhart-Phillips and Oppenheimer (1984) expected seismicity to continue to increase in spite of declining reservoir production and for seismicity to occur in areas where new production is initiated.

Stark (1990) made several significant observations on The Geysers seismicity: (1) earthquake clusters associated with injection wells image the injected fluid and this correlation is more apparent for hypocentral depths deeper than about 2 km; (2) temporal correlation between the onset of injection and seismicity is generally observed; and (3) not all injection is accompanied by seismicity and some seismicity, especially shallower events, does not correlate with injection.

In a comprehensive review of the literature on induced seismicity in The Geysers, Greensfelder and Parsons (1996) concluded that there exists a relationship between injection and seismicity, although the correlation is highly variable and poorly understood. The relationship is clearer for some wells and some portions of The Geysers than for others and it appears to vary with time. Induced seismicity also is related to production, although the correlation is less clear (Greensfelder and Parsons, 1996). Greensfelder and Parsons (1996) concluded that there may be multiple causes of induced seismicity but they involve both increases and decreases in the reservoir rock strength caused by changes in confining pressure (normal stress across cracks) or in the coefficient of friction. For steam withdrawal, the induced seismicity may be caused by an increase in rock strength while for injection it is a decrease. Although the two processes would seem to be contradictory, they appear to operate independently over distinct reservoir volumes located within 1 km of any well (Greensfelder and Parsons, 1996).

Most recently, Rutquist and Oldenburg (2007) state based on coupled thermal-hydrologicalmechanical modeling that the most important cause for injection-induced seismicity is injectioninduced cooling and the associated thermal-elastic shrinkage that alters the stress state such that mechanical failure can occur. Several investigators have previously suggested that cooling played a role in induced seismicity (e.g., Stark, 1991). Cooling shrinkage results in an unloading and associated loss of shear strength in critically shear-stressed fractures, which are then reactivated (Rutquist and Oldenburg, 2007). Results also indicate that there is a time lag of a few months related to the time it takes for the injected cold water to induce local cooling of the rock. The Rutquist and Oldenburg (2007) modeling is in agreement with observations that most of the injection seismicity occurs near injection and production wells and can spread several km below injection wells. The deeper seismicity may be due to both thermal-elastic cooling and increased pore pressure.

Greensfelder (2003) estimated conservatively that the maximum induced earthquake at The Geysers is a M 5.0. At the time of his assessment, the largest reported event was a M_L 4.2. The value of M 5.0 is still generally agreed upon by experts knowledgeable with induced seismicity at The Geysers (Majer et al., 2007).

3.2 TEMPORAL AND SPATIAL PATTERNS OF INDUCED SEISMICITY

In response to reservoir pressure declines, steamfield operators have turned to supplemental water injection projects to sweep heat from the rock and thereby sustain the geothermal resource. Some of these projects, including the Santa Rosa Geysers Recharge Project (SRGRP) (Figure 6), have been subject to environmental impact analysis, with induced seismicity studied as a potentially important impact (Greensfelder and Parsons, 1996; 2003).

As The Geysers field expanded during the 1960's and 1970's, earthquake activity increased along with production and injection (Figure 11). Steam production peaked in 1987, declined steeply through 1995, and has been fairly stable since then. During the early history of the field, water injection closely followed steam production, because condensed steam was virtually the only water injected. On average, only about 25% (by mass) of the steam used in power production is condensed, with the remaining 75% evaporated in the cooling towers. Starting in the 1980's, development of supplemental water sources (creek extraction) allowed higher levels of mass replacement, and during the late 1980's and early 1990's, injection increased in spite of declining steam production (Figure 11).

From 1975, when the location threshold of the USGS network was about M_L 1.5, seismicity at The Geysers steadily increased till 1985 corresponding to the dramatic increase in steam production (Figure 11). From 1985 to 1998, seismicity at the $M_L \ge 1.5$ level was relatively stable corresponding to a decline in steam production with two spikes in activity in 1985 and 1987. Since 1995, steam production has been nearly level (Figure 11). In late 1997 and 1998, there was an increase in $M_L \ge 1.5$ seismicity coinciding with the startup of the Southeast Geysers Effluent Project (SEGEP) injection. With the startup of SRGRP in 2003, injection of supplemental water increased although there has been a slight decline since 2005 to present (Figure 11).

From the mid-1980's through the startup of SRGRP, seismicity has averaged about 830 events of M 1.5 or greater per year, and 23.3 events of M 3.0 or greater per year (URS, 2009) (Figure 11). From 2004 through 2008, the years of SRGRP operation, the field averaged 1,171 events of M 1.5 or greater, and 19.2 events of M 3.0 or greater. For 2008, the numbers were 1,027 and 15, respectively. Thus there has been an increase in earthquake activity compared with pre-SRGRP years, but the incidence rate of M 3.0 to 4.0 has, if anything, decreased slightly since SRGRP came online (Figure 11). As stated previously, the rate of M 4.0 to 4.5 events has increased since 2002 (Figure 8).

Figures 9 and 10 illustrate the distribution of induced seismicity at The Geysers within 10 km of the EGS injection wells PS-31 and PS-32. Injection-induced seismicity generally occurs within a few hundred meters of the injection well (Oppenheimer, 1986). Note that $M \ge 4.0$ earthquakes are distributed throughout The Geysers area. Interestingly, the area in the immediate vicinity of the two EGS wells has exhibited few events larger than M 3.0 (Figure 10). The three earthquakes of $M \ge 4.0$ in 2000 to the southwest of the EGS site (Figures 9 and 10) are deep (~12 km) and thus of tectonic origin.

The planned EGS injection in PS-31 and PS-32 will be at a low rate. SRGRP water will be diverted from existing SRGRP injectors to the two wells. No pumping will be performed. Depending on the ability of the fractures to accept the fluid, the injection rate will be increased in stages such as 100, 200, 400, and 800 gpm (0.14 to 1.15 mgd). The rate of the fluid injection is designed to evaluate if pressure increases will result in the opening of pre-existing fractures in the HTZ and whether the changes are reversible. High-resolution seismic monitoring of the induced seismicity will be performed by LBNL to image how the injection response moves through the reservoir over time.

The characteristics of the induced seismicity from the EGS is expected to be similar to the induced seismicity observed at other injection wells such as PS-9 (Figure 1), although the rate of seismicity may be even lower. Injection of SRGRP water began on 20 November 2007 at PS-9 (Figure 12). The average injection rate at the well has been 625 gpm (0.90 mgd) but with seasonal fluctuations. At the end of 2008, injection peaked at over 2 mgd (1,380 gpm). The monthly rate of induced seismicity for events of both $M \ge 1.2$ and ≥ 2.0 increased dramatically in response to injection and the correlation with injection rate is obvious (Figure 12). The seismicity induced by PS-9 is located west of the well-course (Figure 13). In cross-section the seismicity is located west of and near the bottom of the well (Figure 14). For the year preceding injection, there were only two observed earthquakes, in stark contrast to the injection-associated activity (Figure 13). The magnitude of induced events also increased with the rate of injection peaking in 2008 and 2009 (Figure 12). The largest event observed to date at PS-9 has been a M 2.8 on 2 December 2008 (Figure 13).

Greensfelder (2003) estimated based on past behavior that injection rates of 0.69 to 1.38 mgd will probably induce earthquakes in any given well at The Geysers. These rates have some uncertainty, since lower rates in the Calpine lease area, 0.4 mgd, have been observed to induce seismicity. According to Greensfelder (2003), higher rates may result in 10 to 30 events of $\mathbf{M} \ge$ 0.7 per month and the rate increases with greater injection. Thus it is expected that induced seismicity will occur at the EGS wells. However, because of the comparatively lower injection rates, the rate of seismicity is expected to be comparatively low and dramatic increases in seismicity such as observed at PS-9 can be mitigated by the planned staged increases in injection.

It is difficult to estimate what the largest possible earthquake might be at the EGS wells. According to Bromely and Mongillo (2008), the largest earthquakes associated with EGS projects worldwide have ranged from M 2.9 to 3.7, with the largest event occurring in the Cooper Basin of Australia. There is no apparent correlation between the largest earthquake to date and the amount and rate of injection at the existing SRGRP wells. The maximum earthquake is probably controlled by the size of pre-existing fractures near the well and thus is not so much affected by injection rather the injection acts as the trigger. The maximum earthquake, however, is unlikely to be larger than M 4.5 and most likely lower. The average maximum earthquake observed near the 15 SRGRP wells is M 3.45 (URS, 2009).

4.1 MAXIMUM EARTHQUAKE AT THE PROPOSED ALTA ROCK EGS

ICF Jones & Stokes has proposed to test several technologies for an EGS Project in the northern California Power Agency (NCPA) leasehold. Unlike the proposed Calpine EGS Project where no pumping of water will be performed, Alta Rock proposes to inject water at pressures sufficient to cause slip of pre-existing fractures (hydroshearing) to create a reservoir (ICF Jones & Stokes, 2009). These pressures will not be high enough, however, to cause tension fracture in the rock. Seismicity associated with the hydroshearing is expected to be significantly smaller than M 1.0 (ICF Jones & Stokes, 2009).

ICF Jones & Stokes (2009) estimates that the largest event that will be associated with their EGS Project is unlikely to exceed a M 2.3 or more likely a M 2.0. Their "maximum probable event" is a M 2.9 comparable to the largest event observed at the Soultz EGS Project in France (ICF Jones & Stokes, 2009). They believe an event larger than M 4.0 is impossible at the Alta Rock EGS Project based upon three different geomechanical models they evaluated. ICF Jones & Stokes will be using the NCPA well E-7 as the injection well. The well will be deepened to a depth between 3,500 to 3,800 m (11,500 to 12,500 ft) into the felsite. The Geysers normal steam reservoir is contained in the metasediments above the felsite (ICF Jones & Stokes, 2009). Most of the induced seismcity is expected to occur during the hydroshearing and little to no seismicity is expected during the long-term data collection and monitoring period or during the long-term production phase if there is one (ICF Jones & Stokes, 2009).

The most significant environmental impact resulting from induced seismicity at the proposed Calpine EGS Project will be ground shaking. Ground motions can be expressed in terms of acceleration, velocity, or displacement and by several different parameters. The most commonly used engineering parameter is peak horizontal ground acceleration (PGA).

PGAs can be roughly correlated to perceived shaking or intensity using the classification of Wald et al. (1999). They have classified the following levels of ground shaking.

PGA(g)	Perceived Shaking
< 0.002	Not felt
0.002 - 0.014	Weak
0.014 - 0.039	Light
0.039 - 0.092	Moderate
0.092 - 0.18	Strong

Correlations between any single ground motion parameter and intensity are highly uncertain. The above correlation is very approximate for The Geysers since it was developed based upon eight larger California earthquakes of $M \ge 5.8$ (Wald et al., 1999) that were tectonic events, which occur much deeper than the shallow Geysers earthquakes.

Calpine has operated two strong motion stations in or near The Geysers since 28 February 2003 at Anderson Springs (ADS) and 14 March 2003 at Cobb (COB) (Figure 1). The stations continuously measure three components of ground acceleration (east-west, north-south and vertical). They are configured to trigger, record, and store the time series data for any event during which the PGA exceeds a preset trigger. For each component of each recorded event, a PGA is measured.

Figure 15 shows the PGA values from PS-9 recorded by the ADS and COB instruments since the two strong motion instruments were installed. PS-9 is somewhat closer to the two communities than PS-31 and PS-32 (Figure 1). Although there are only about two years of recording since injection began at PS-9, the ground shaking as indicated by PGA has been low and probably not felt by residents of Cobb and Anderson Springs (Figure 15).

The traditional approach in predicting ground shaking or ground motions at a site utilizes empirical attenuation relationships, which are derived from strong motion data. Attenuation is defined as the decrease in amplitude or intensity of seismic waves with distance. This decrease results from a number of factors including geometrical spreading, damping or absorption by the earth, scattering, reflection, refraction, diffraction, and wave conversion.

Empirical attenuation relations have been developed in regions where there are numerous strong ground motion recordings by applying statistical regression methods to these data. Because the data correspond to geologic conditions and earthquakes typical of the region, they are generally applicable only in that region. Because the vast majority of strong motion records available in the U.S. are of California earthquakes, numerous attenuation relationships have been developed However, almost all attenuation models have been developed based on earthquakes M 5.0 and larger because only events of this size typically produce any structural damage. An attenuation model for small earthquakes in California has been developed by

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Estimating Ground Shaking From Induced Seismicity

Campbell (1989) but again it is for the generally deeper tectonic events. The strong motion data is not consistent with the Campbell (1989) model (URS, 2009).

The PGA data are very site-specific and hence the ground shaking at even nearby locations to these two strong motions sites may vary considerably due to local site effects. preliminary analyses appears to indicate that ADS records higher than expected ground shaking. Based on the strong motion data recorded to date, the largest PGA has been 0.21 g from a M_L 3.0 induced earthquake at a distance 2.0 km from ADS. Based on preliminary analyses of the strong motion data, for a M 3.0, which is slightly larger than the maximum event observed at PS-9, the PGA values at ADS and COB would be about 0.005 g corresponding to weak ground shaking. The relatively long distances from the EGS injection wells result in lower ground shaking in these two communities than other Calpine injection wells.

ShakeMap is a product of the USGS that provides near real-time estimates of ground shaking intensity following an earthquake. A ShakeMap of the 20 October 2006 M 4.5 event (Figure 10) is shown in Figure 16. As indicated on the ShakeMap, moderate ground shaking of MM V was felt locally out to about 10 km and weak to light shaking out to 50 km or more. This is consistent with the PGAs recorded at COB (distance 4.5 km) and ADS (distance 12.5 km), which were 0.13 g and 0.07, respectively.



The proposed EGS injection operations at PS-31 and PS-32 will result in induced seismicity, as has been observed elsewhere in The Geysers. However, based on comparisons with other Geysers injection wells, the seismicity is expected to be comparatively low due to the low injection rates (≤ 800 gpm). PS-9 averages 1.5 events of M 2.0 and larger per month with an average injection rate of 1,380 gpm. The monthly average for 15 SRGRP injector wells is 1.3 events of M 2.0 and larger. Injector wells 87G-21 since February 2007, CA1862-4 since August 2007, Aidlin 11 since February 2008, and DX-47 since February 2007 have had injection rates averaging less than 800 gpm and the monthly rates of M 2.0 and larger events during those periods have been less than 1. M 3.0 where events only produce weak ground shaking at ADS and COB.

The largest earthquake recorded at PS-9 in the nearly two years of injection has only been a M 2.8 and the induced earthquakes at PS-9 have not generated any significant shaking (PGA < 0.005 g) at ADS and COB due to relatively long distances.

The ground shaking from induced events at PS-31 and PS-32 is expected to be even less than at PS-9 because they are slightly more distant to Anderson Springs and Cobb (Figure 1). Even if the maximum event, a M 4.5, was to be generated at the EGS wells, the ground shaking (median PGA ~0.05 g) will only be at a moderate level and such an event is unlikely to occur given that only one induced M 4.5 event has occurred over the past 40 years over the entire area of The Geysers.

Injection at the EGS wells will be performed in stages from 200 to 800 gpm and will be closely monitored by the LBNL seismic network. The resulting induced seismicity will be evaluated looking for patterns that might indicate an increased rate of larger events that might be felt in Cobb and Anderson Springs. If such patterns emerge, the injection can be changed to possibly mitigate for such effects.



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Table 1 Induced Earthquakes at The Geysers ($M \ge 4.0$) 1970 to Present

ID	Vaan	Month	Day	Time	Latitude	Longitude	Depth	Magnituda	Magnitude	No. of	Gap	D _{MIN}	RMS
1	Year				(degrees)	(degrees)	(km)	Magnitude	Scale	Stations	(degrees)	(km)	(sec)
1	1982	5	29	1:02:25 PM	38.801	-122.822	2.2	4.0	$M_{\rm L}$	50	25	3	0.07
2	1984	9	22	6:52:03 PM	38.798	-122.823	2.8	4.0	$M_{ m L}$	43	30	3	0.06
3	1985	8	8	7:03:11 PM	38.792	-122.778	0.0	4.0	M_d	36	34	2	0.37
4	1985	11	12	4:06:57 PM	38.848	-122.772	0.0	4.1	$ m M_{L}$	5	263	3	0.05
5	1990	8	14	7:05:13 PM	38.825	-122.792	2.4	4.1	$ m M_{L}$	45	37	2	0.07
6	1992	9	19	11:04:47 PM	38.860	-122.792	3.9	4.4	M_d	50	34	6	0.06
7	1995	1	16	1:34:38 AM	38.823	-122.797	2.0	4.0	M_d	46	36	2	0.04
8	1996	12	4	9:21:15 PM	38.792	-122.757	2.9	4.1	M_d	47	30	4	0.06
9	1999	2	18	8:58:36 AM	38.785	-122.770	2.2	4.1	M	36	39	3	0.05
10	2000	12	8	7:41:11 AM	38.782	-122.767	4.3	4.2	$ m M_{L}$	51	29	4	0.07
11	2003	5	20	4:50:42 PM	38.801	-122.803	0.6	4.1	M	55	35	1	0.09
12	2003	8	3	12:00:53 PM	38.799	-122.769	0.9	4.2	M	46	37	1	0.06
13	2004	2	18	8:37:46 PM	38.834	-122.768	1.9	4.4	M	53	42	1	0.09
14	2004	12	27	10:36:23 AM	38.749	-122.726	3.7	4.3	$ m M_{L}$	46	26	3	0.08
15	2005	5	9	10:37:39 PM	38.789	-122.755	0.3	4.4	M	63	32	2	0.12
16	2006	5	12	10:37:29 AM	38.816	-122.817	2.9	4.4	$ m M_{L}$	61	31	2	0.09
17	2006	5	12	10:38:36 AM	38.843	-122.854	2.6	4.2	$ m M_{L}$	21	54	8	0.04
18	2006	10	20	5:00:08 PM	38.867	-122.787	3.5	4.5	M	62	39	5	0.08
19	2007	4	24	9:08:29 PM	38.795	-122.797	2.5	4.4	M	55	23	1	0.09
20	2008	2	24	5:32:10 AM	38.819	-122.810	3.0	4.0	M	60	41	2	0.08
21	2008	5	30	4:48:30 AM	38.779	-122.768	1.0	4.3	M	38	61	2	0.06
22	2008	5	30	4:48:37 AM	38.739	-122.752	2.1	4.2	M	49	127	15	0.57
23	2009	1	4	17:27:10 PM	38.7823	-122.773	4.7	4.3	M	66	25	1	0.08

 $M_d \equiv Duration magnitude$

 $M_L \equiv Local Richter magnitude$

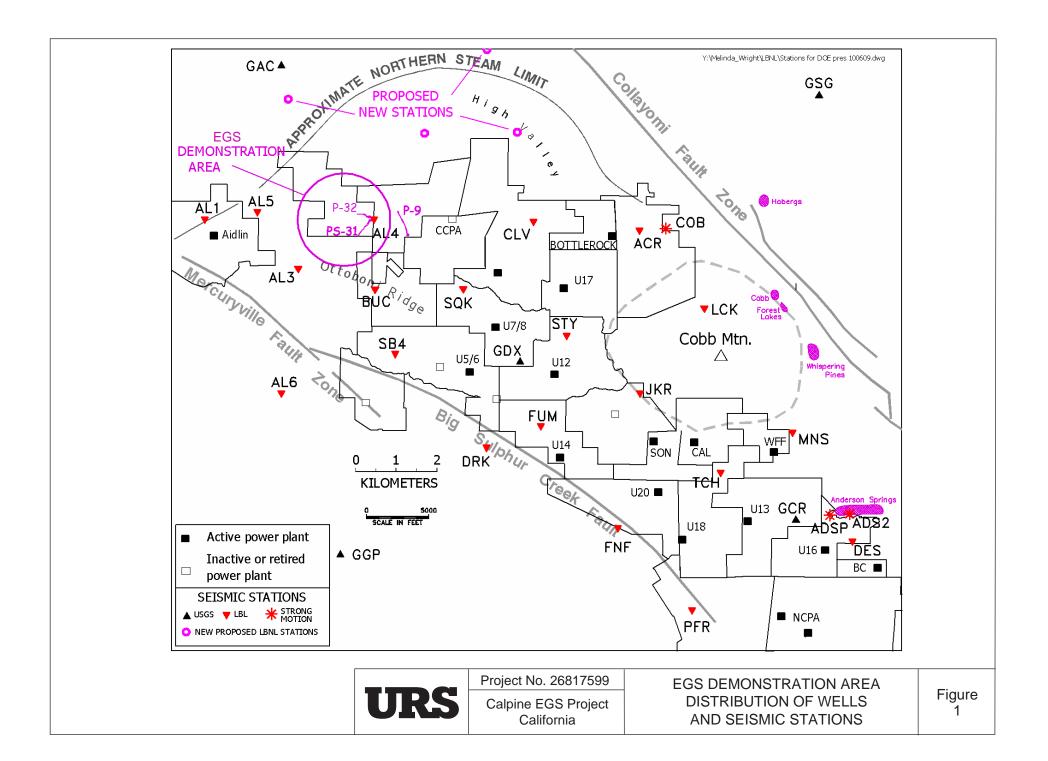
 $\mathbf{M} \equiv \text{Moment magnitude}$

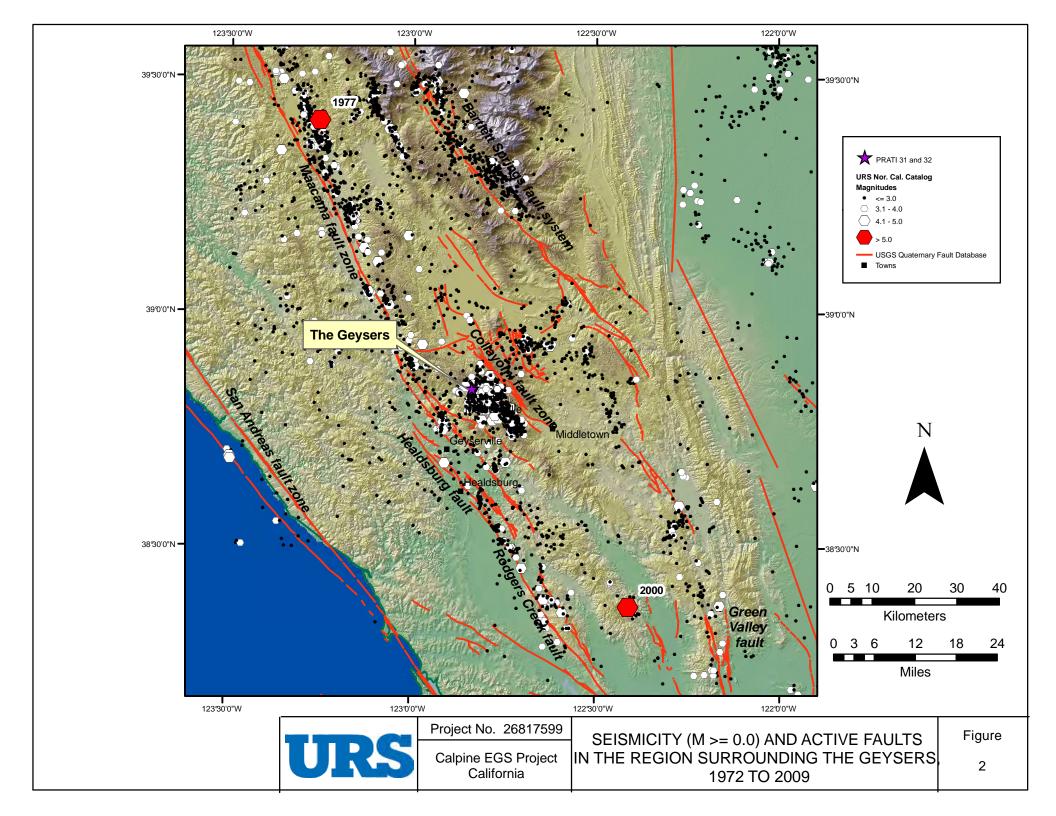
 $D_{MIN} \equiv Closest station to the epicenter$

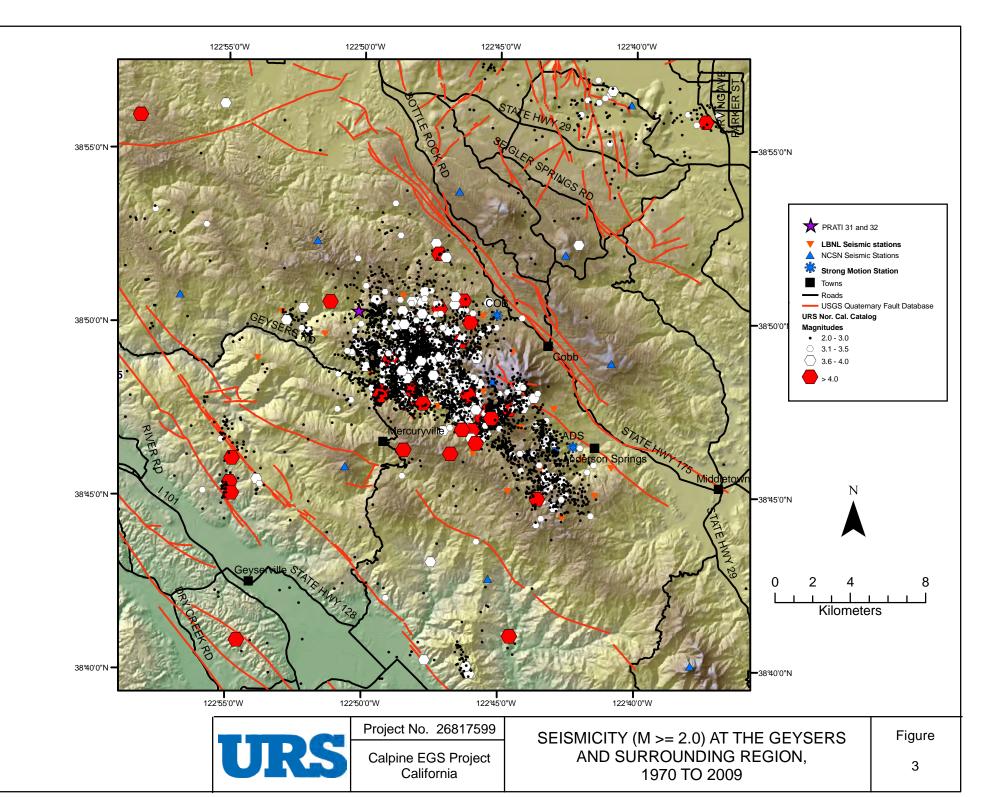
 $RMS \equiv Root\text{-}mean - square \ error$

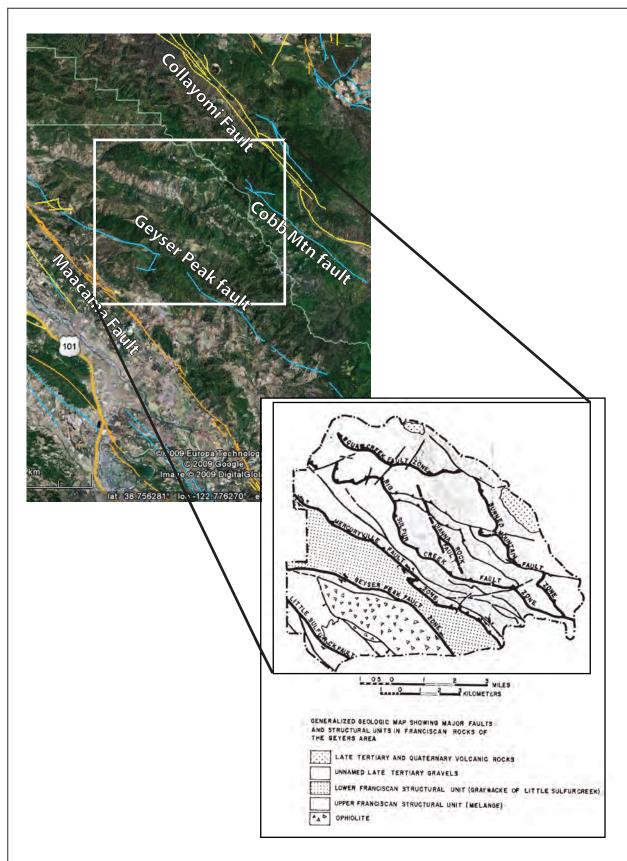
 $Gap \equiv Widest gap in azimuth where there is no seismographic coverage$





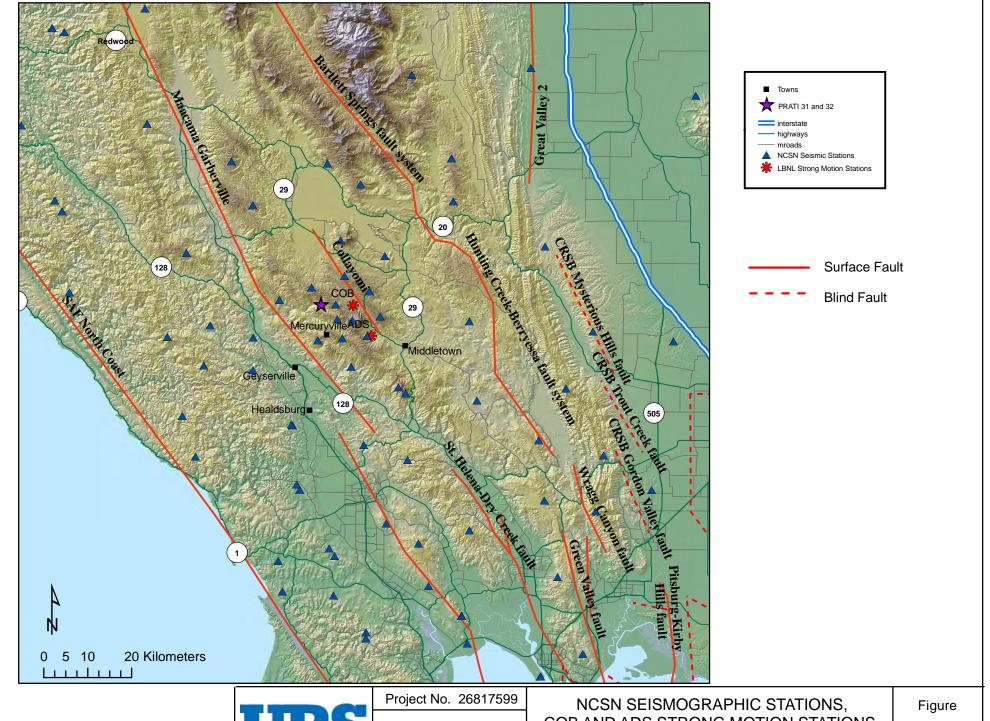






Source: McLaughlin, 1978.

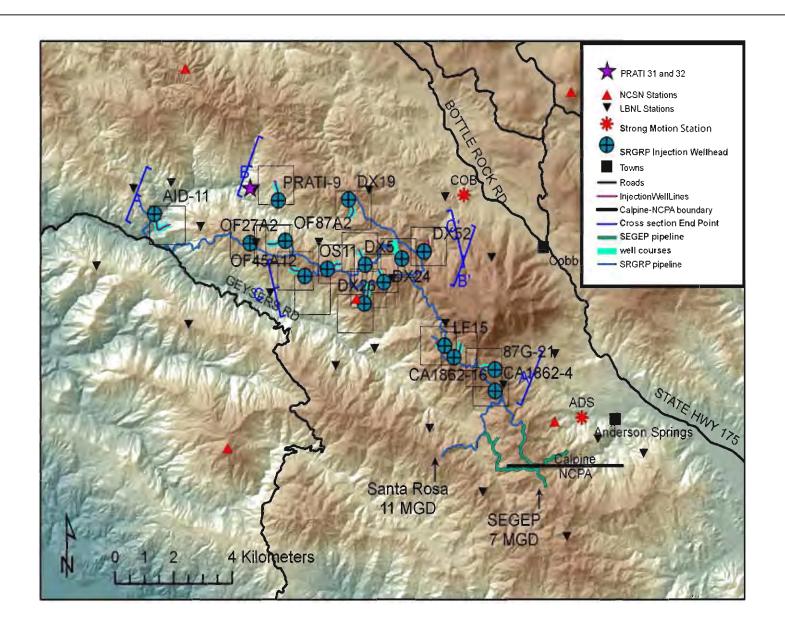




URS

Capline EGS Project California

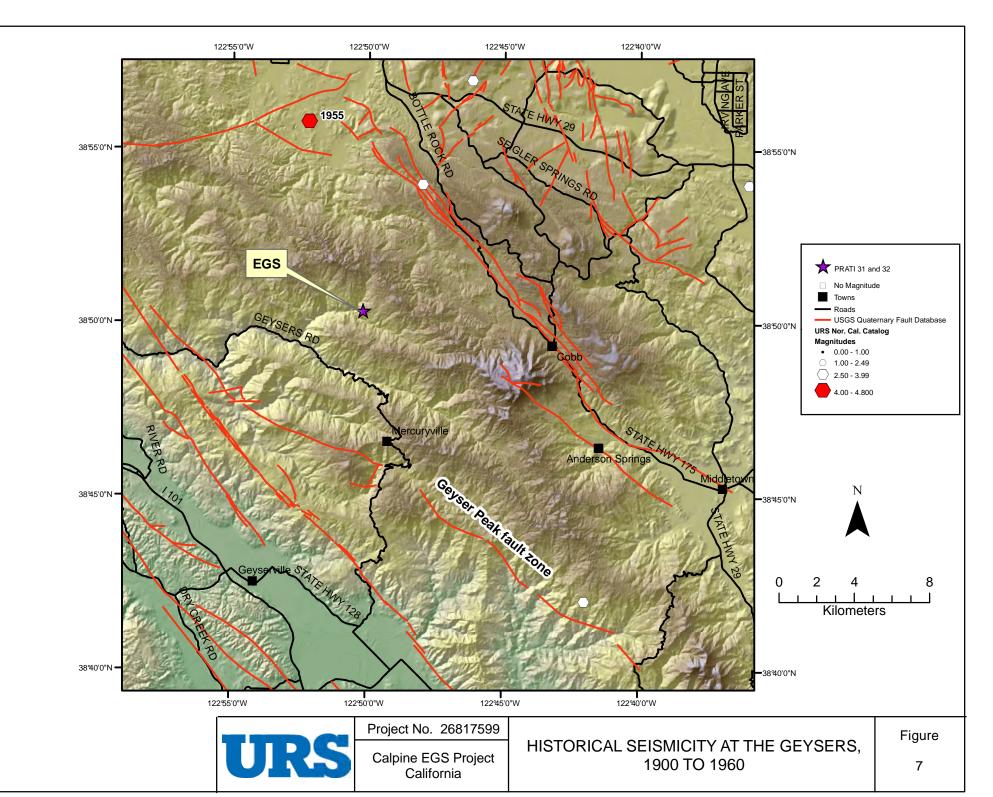
COB AND ADS STRONG MOTION STATIONS, AND LATE QUATERNARY FAULTS

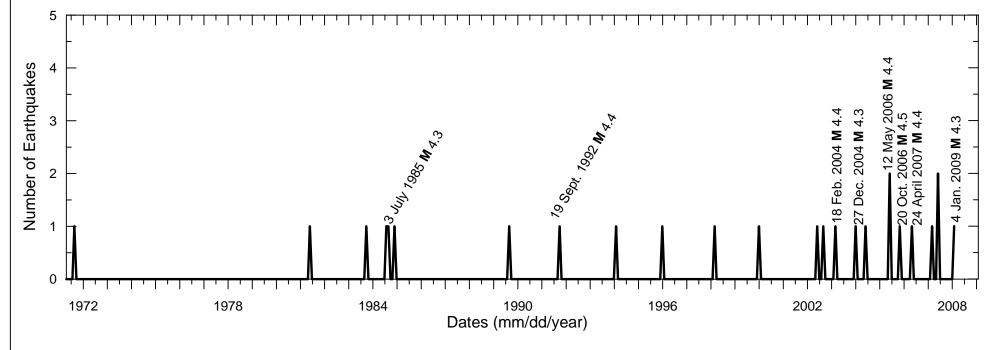




Project No. 26817599

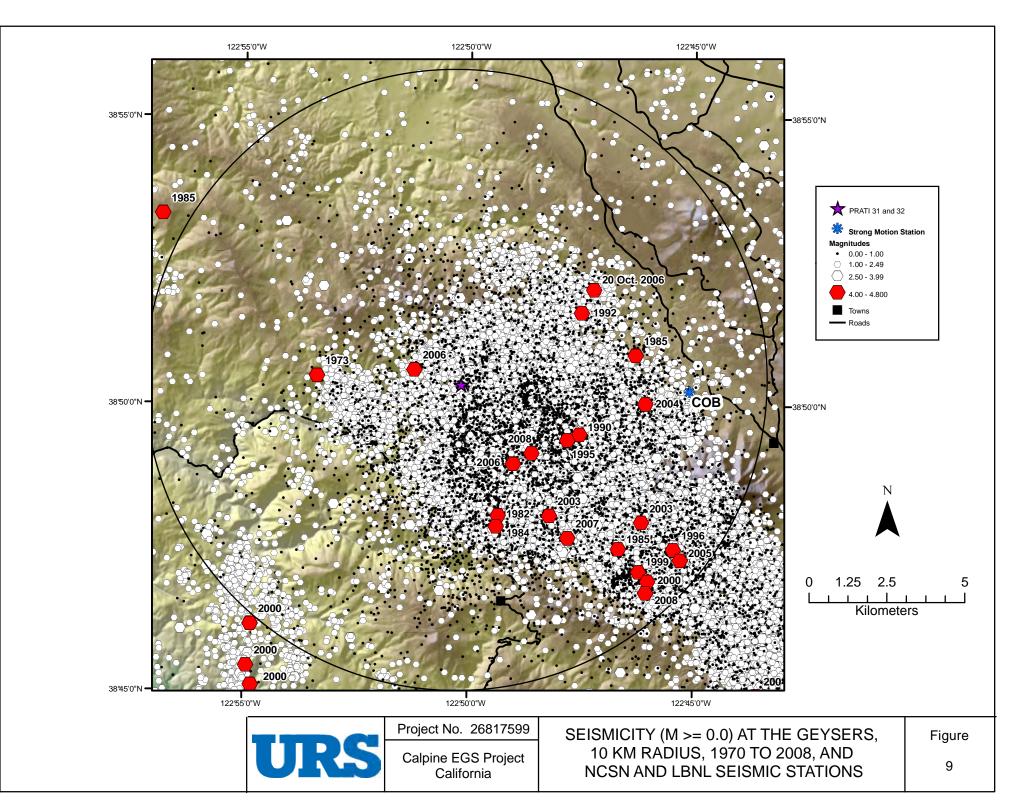
Calpine EGS Project California SEISMIC MONITORING STATIONS, SRGRP INJECTION SYSTEM, AND STUDY AREAS SURROUNDING SRGRP INJECTION WELLS

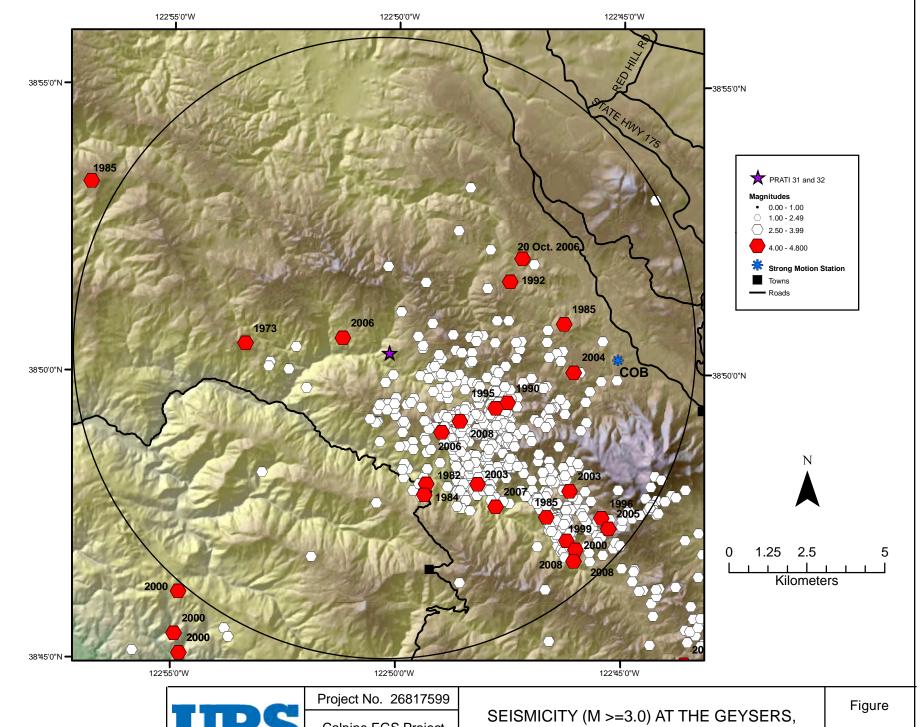




Please Note: Events above M4.3 are labeled above.



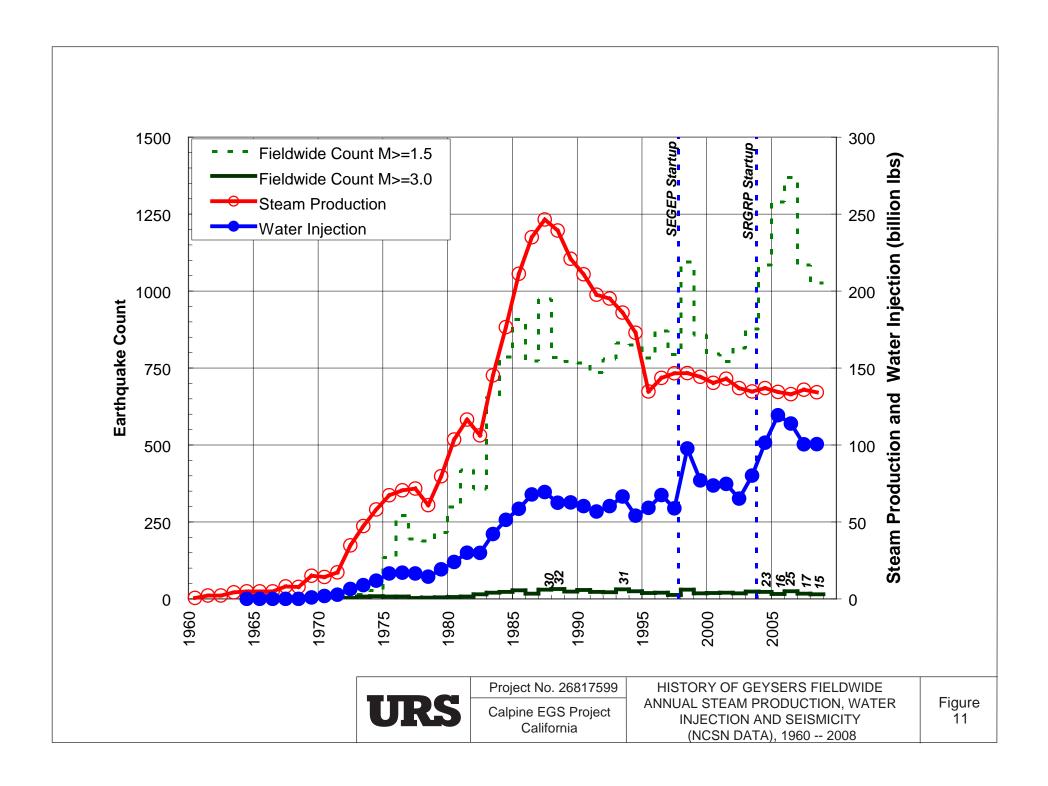


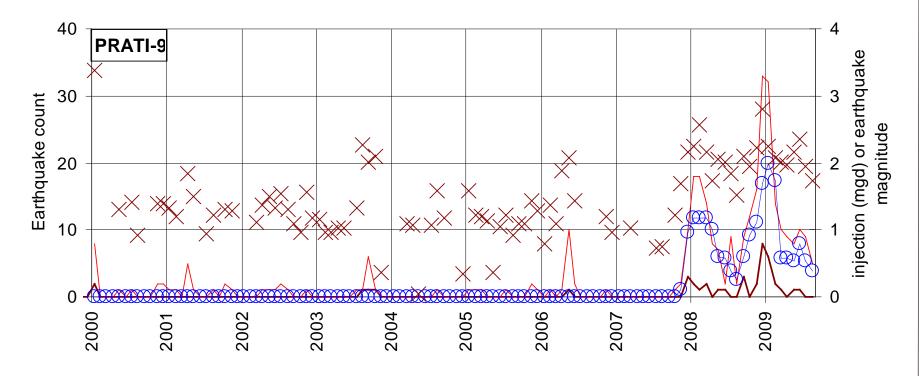


Calpine EGS Project California

10 KM RADIUS, 1970 TO 2008

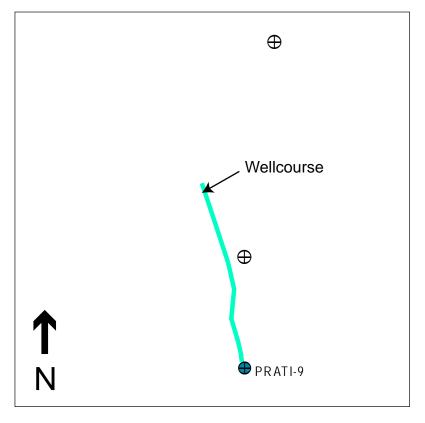
10





Line with circles is monthly water injection. Light (red) line is monthly count of earthquakes of M>=1.2. Thick (brown) line is monthly count of earthquakes of M>=2.0. x's show maximum magnitude each month.

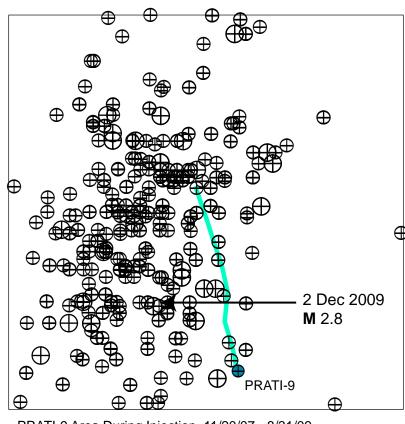




PRATI-9 Area Pre-Injection, 11/20/06 - 11/19/07

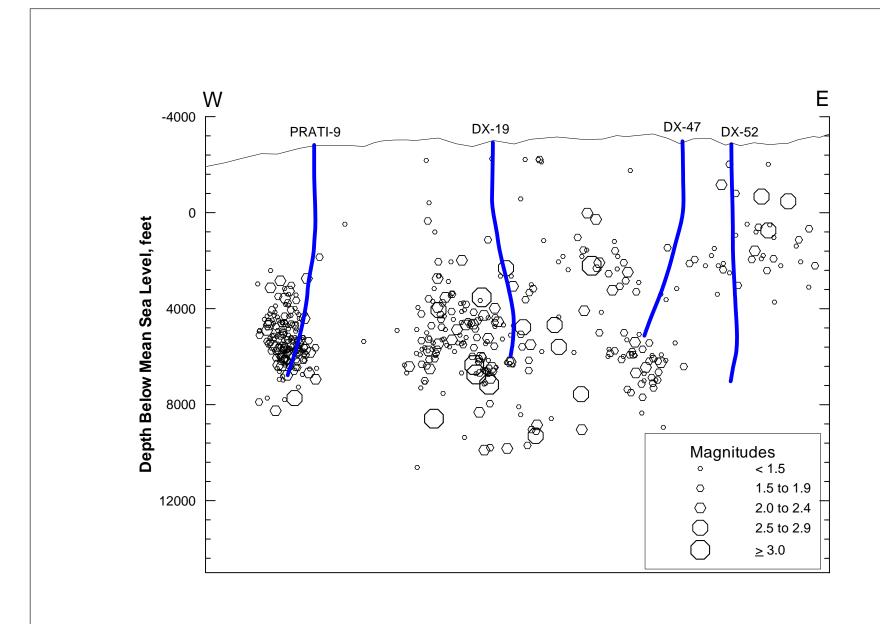
Earthquake Magnitudes

⊕ 1.2



PRATI-9 Area During Injection, 11/20/07 - 8/31/09



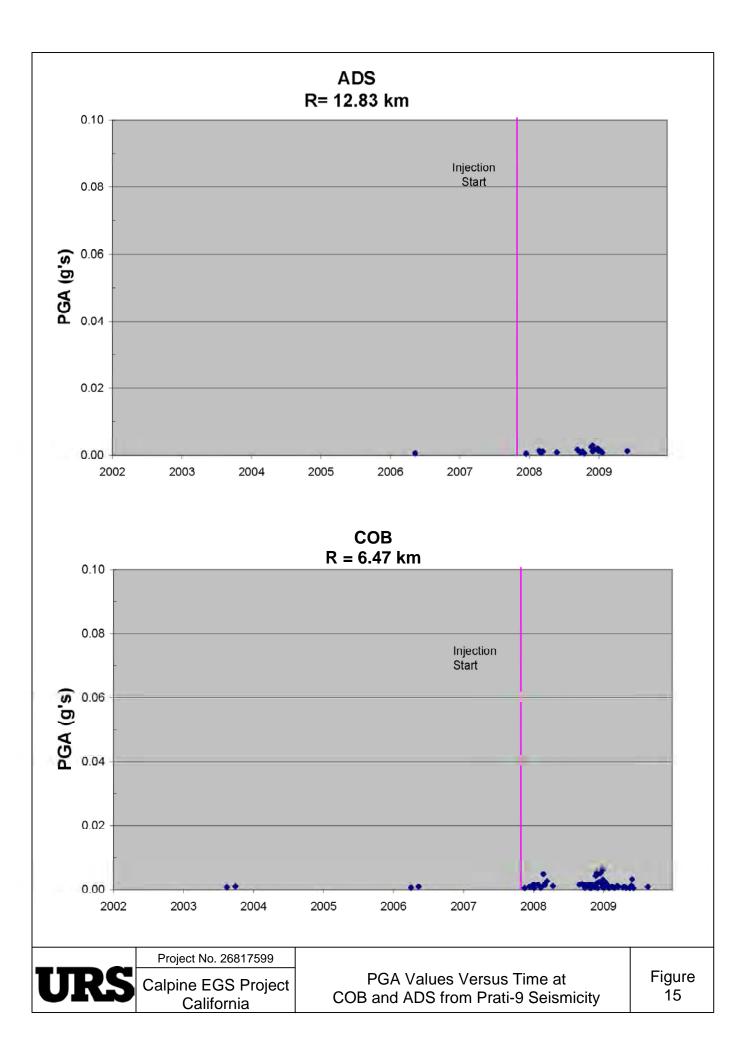


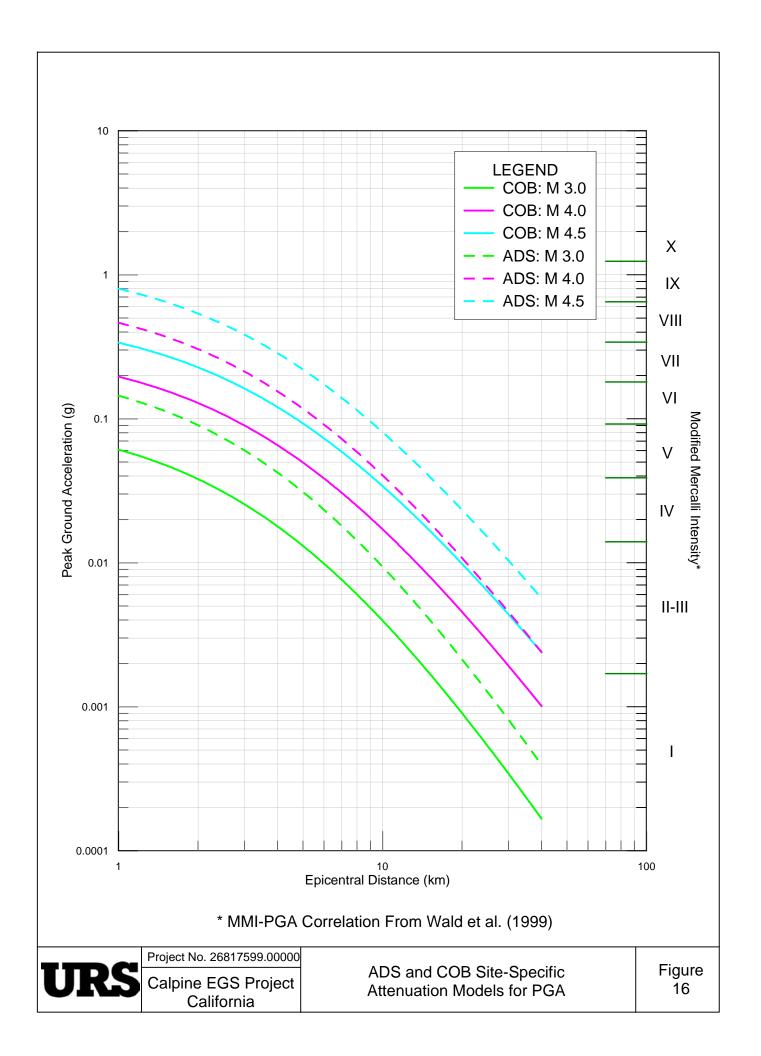
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Project No. 26817599

Calpine EGS Project California CROSS SECTION SHOWING
EARTHQUAKES AND SRGRP INJECTION
WELLCOURSES,
1 SEPTEMBER 2008 – 31 AUGUST 2009

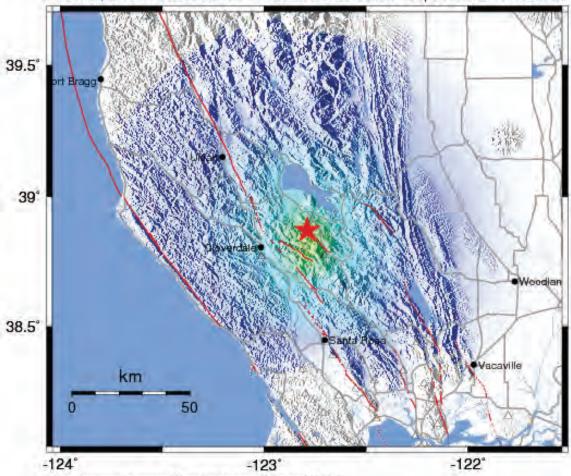
Figure 14





CISN ShakeMap: 8 km N of The Geysers, CA

Fri Oct 20, 2006 10:00:08 AM PDT M 4.5 N38.87 W122.79 Depth: 4.2km ID:40190077



Map Version 4 Processed Mon Oct 23, 2006 07:56:29 AM PDT,

INSTRUMENTAL INTENSITY	1	H-III	IV	V	VΙ	VII	VIII	IX	X+
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PERCEIVED	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme

Source: USGS Shakemap



APPENDIX J: STATEMENT OF COMPLIANCE WITH DOE SEISMICITY PROTOCOL

Calpine Corporation's response to DOE's required compliance with the "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems".

Calpine Corporation and other Geysers geothermal operators have long been actively involved in addressing induced seismicity, especially prior to and in conjunction with the startup of supplemental injection of reclaimed waste water into the reservoir. The following outlines Calpine's current practices in addressing seismicity at The Geysers in relation to the "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems" authored by Majer, E., Baria, R. and Stark, M. (2008). Calpine's current approach to seismicity will envelop any new Enhanced Geothermal System (EGS) injection well(s) initiated as a result of a DOE grant award.

"Step One: Review Laws and Regulations"

As explained in greater detail below Calpine Corporation's proposed EGS projects comply with all applicable local, state and federal laws and regulations. Beginning decades ago the subject of induced seismicity in the area became the subject of various scientific studies, and more recently has been part of various environmental impact evaluations imposed by the California Environmental Quality Act ("CEQA"). After completion of those seismicity impact evaluations Calpine Corporation received various governmental permits and authorizations to explore, develop and operate geothermal operations in the proposed project area, and is subject to numerous seismicity mitigation requirements pursuant to both the environmental review conduct for those operations, and pursuant to conditions in its permits and authorizations. Calpine continues to remain in compliance with its permits and authorizations. Calpine also remains in compliance with local and state laws and regulations governing its operations.

Calpine Corporation's projects to inject reclaimed waste water, which have been in operation for many years, include the Southeast Geysers Effluent Pipeline (SEGEP) and the Santa Rosa Geysers Recharge Project (SRGRP). Prior to construction and operation, each of these two large projects underwent an extensive environmental impact evaluation which resulted in an Environmental Impact Report (EIR). These evaluations were first for the initial projects and again for later stage increased water deliveries. These processes included evaluation of the induced seismicity associated with the injection of SEGEP and SRGRP water into the Geysers geothermal reservoir. Induced seismicity related mitigation measures were defined in those EIR's and Calpine continues to comply with these requirements.

In addition, Sonoma County recently completed two CEQA Environmental Mitigated Negative Declarations (MND) regarding the potential environmental impacts from geothermal exploration and development of Calpine's Buckeye and Wildhorse steamfield areas. The MNDs reviewed the applicability of the Santa Rosa Incremental EIR (SRIEIR) induced seismicity study to these projects and found the projects to be within the scope of the SRIEIR. In June 2009, relying upon the MNDs, the County granted Geysers Power Company, LLC two conditional use permits for exploration and development of these steamfields. These year-long environmental evaluations included

input from numerous local and state governmental agencies, as well as public comments. Calpine Corporation is unaware of any governmental entity or person asserting the proposed exploration and development of these steamfields would result in a violation of any applicable local or state law, ordinance or regulation. Calpine Corporation prudently operates its geothermal facilities and firmly believes its proposed project would not subject it to liability under local or state law.

"Step Two: Assess Natural Seismic Hazard Potential" and "Step Three: Assess Induced Seismicity Potential"

As stated above, the EIR's for SEGEP and SRGRP assessed and addressed induced seismicity associated with the increased injection.

The seismic monitoring that evolved out of the first SEGEP EIR process resulted in the formation of the Seismic Monitoring Advisory Committee (SMAC). This committee is made up of representatives from community/environmental interest groups, California Division of Oil, Gas and Geothermal Resources, US Bureau of Land Management, US Geologic Survey (USGS), NCPA, Calpine, and Lake County Sanitation District (LACOSAN). The committee meets twice annually. Calpine participates by monitoring seismic activity in the southeast Geysers and presenting the seismicity and injection information to the members at each meeting. The second SEGEP EIR process also included a seismicity study as part of the EIR process titled "Potential Production Benefits and Changes in Seismicity Associated with Increased SEGEP Injection in the NCPA Area, The Geysers Geothermal Field" prepared by GeothermEx, Inc. (2002).

For the SRGRP project, the EIR's included seismicity studies titled "Induced Seismicity Study, Geysers Recharge Alternative" prepared by Greensfelder & Associates and Parsons Engineering (1996), and "Induced Seismicity Analysis" prepared by Greensfelder & Associates and Parsons Engineering (2003). The EIR process resulted in a number of seismic related mitigation measures to be implemented as the SRGRP became operational. These mitigation measures were:

- 1) "... the local seismographic station network maintained by the Geysers operators ... shall be upgraded to focus coverage around the wells proposed for injection."
- 2) "Accelerograph stations shall be added in Cobb and Anderson Springs to allow operators to determine relationships between seismic events within the Geysers steamfield and felt effects in nearby communities."
- 3) "Software shall be improved to enable routine automated locating and mapping of epicenters ... and analysis of data"
- 4) "The Geysers operators shall analyze this data and determine which injection wells are more susceptible to felt induced seismicity. Injection shall be decreased at wells that produce higher levels of felt induced seismicity ... Success of redistribution of water and any other modifications in operations in reducing felt seismic events shall be continually evaluated."

5) "Biannual reports shall be prepared by the Geysers operators and submitted to the City of Santa Rosa. Reports shall include plots of daily volumes of injection at each well, tables and plots of seismicity located within an agreed control radius of the well (e.g., 1 km) and planned operational responses."

Mitigative actions have been taken by Calpine and others to fulfill these measures including:

- (1) A new digital microearthquake network funded by the California Energy Commission was installed and operated by the Lawrence Berkeley National Laboratory (LBNL) and incorporated into the USGS Northern California Seismic Network (NCSN) allowing for public access of the data;
- (2) The strong motion stations in the communities of Cobb and Anderson Springs were installed in 2003 and the data are evaluated on a routine basis and uploaded to a USGS FTP site allowing public access of the data;
- (3) the dataflow from the LBNL earthquake data are integrated into the NCSN system providing reliable detection and location of earthquakes down to magnitude (**M**) 1.0; and (4) All SRGRP wells are analyzed on a monthly basis and the injection-induced seismicity is evaluated to determine whether operational responses (e.g., decreased injection) are required. The results are summarized in a biannual report that is provided to the City of Santa Rosa.

Calpine's grant applications for DOE-funded EGS injection wells will utilize existing water from the SEGEP and SRGRP projects. The amount of reclaimed waste water to be delivered to the Geysers will not be increased above previously analyzed levels in the EIR's. Therefore, the proposed DOE funded EGS injection will be a redistribution of existing water, lowering the overall injection rate in other Calpine Geysers injection wells. Seismicity associated with these EGS projects will be incorporated in the established monitoring for SEGEP and SRGRP wells. EGS wells that receive SEGEP will fall within the boundaries of the SMAC and seismicity will be monitored and data presented biannually at the SMAC meeting. For EGS wells receiving SRGRP water, the wells will be enveloped in the SRGRP biannual seismic monitoring and reporting. Injection in EGS wells will be carried out in the same manner as other Calpine injection wells. Injection is initiated by briefly (over a few minutes) pumping water into the well. This causes a "collapse" of the steam to liquid water in the well bore and near-well bore fractures. The volume change of this phase transition is approximately 99%, which causes the well to "go on vacuum". Subsequently, injection is under vacuum conditions at the well head (without pressure applied to the fluid by surface pumping). Injection rates will be low to moderate. Induced seismicity is expected to be as predicted in previous seismicity studies.

The LBNL seismic network already in operation in conjunction with the strong motion instruments and the semiannual reporting obligations associated with the SEGEP and SRGRP projects are sufficient to monitor and report on induced seismicity associated with operation of the EGS projects.

"Step Four: Establish a Dialogue with Regional Authority" and "Step Five: Educate Stakeholders"

If Calpine is awarded EGS grant(s) from the DOE, there are several public outreach forums that are already in place for Calpine to communicate project information. As previously discussed, Calpine is a committee member of SMAC, which also includes community groups, seismological experts, regulatory agencies and local government participation. Calpine will make use of these biannual meetings to inform meeting attendees of the upcoming EGS project(s). Other forums Calpine could utilize are inclusion of project plans in annual newsletters that are mailed to all local residents. Calpine also holds annual community meetings which could be used to disseminate project information. In addition, at various times throughout the year Calpine has conducted free tours Geysers facilities which could be used as a forum for educating participants on future plans. Calpine operates a visitor center in the nearby community of Middletown. The visitor center has operating hours from 10am to 4pm, Wednesday through Saturday. The center has numerous geothermal displays including a seismicity display. The visitor center could also be used as a place to display information on any EGS grant award Calpine receives. Calpine also provides a toll-free seismic voicemail hotline available to the public so that people can report experiences and observations about an earthquake or can request a call back. Calpine transcribes every message and uses the information to better understand how seismicity affects our neighbors.

"Step Six: Establish Microseismic Monitoring Network"

An established seismic network already exists at The Geysers. There is a combination of seismic stations operated by the USGS and LBNL. Both types of stations are incorporated into the NCSN, which is a much larger regional network operated by the USGS. This data is available to the public via the USGS website. In the immediate Geysers vicinity there are 23 LBNL stations and 6 USGS stations. In addition, at least four new stations are planned to be installed in August 2009 by LBNL to extend the network to the north. These stations will allow better coverage for potential development in the north Geysers and will also be incorporated into the NCSN.

"Step Seven: Interact with Stakeholders"

See Calpine's existing seismicity community outreach discussed in "Step Four" and "Step Five".

"Step Eight: Implement Procedure of Evaluating Damage"

Calpine is committed to being regarded as a partner in every community where we have power plants, offices or other facilities. We recognize the importance of demonstrating our good intentions through concrete actions.

In an effort to renew the company's commitment to its closest neighbors, Calpine has offered to provide funds to address the needs and concerns of the two nearest

communities to the Geysers, Anderson Springs and Cobb. Both the County of Lake and Northern California Power Agency (NCPA) have offered to establish community funds as well. Because of their differing backgrounds and structures, each of the three entities that are providing these funds has different criteria for the granting/distribution of its funds. The County has established the "Geothermal Impact Mitigation Fund Committee" (GIMFC) to govern the disposition of their funds (AB 1905 Geothermal Funds).

Calpine provides its funds to a "Calpine Community Investment Committee" (CCIC) for each community. The CCIC monitors and addresses the disposition of the Calpine community investment funds.

NCPA's funds are distributed through the County's GIMFC.

There is a separate GIMFC and CCIC for each of the two communities. The make-up of the Anderson Springs GIMFC consists of:

Lake County District 1 Supervisor Anderson Springs Community Services District Northern California Power Agency Anderson Springs Community Alliance Anderson Springs Homeowners Assn Calpine Corporation (consulting only) County of Lake (facilitator only)

The Cobb GIMFC consists of the following members:

Lake County District 5 Supervisor
Cobb Area County Water District
Two Cobb Community Member at Large
Calpine Corporation (consulting only)
County of Lake (facilitator only)

The Calpine Community Investment Committees for each community are made up of the same community members and the Calpine representative only.

Funds are requested by members of the communities using an application process created by the community committees.

The Calpine representative on the County GIMFC serves on the committee as a "silent" member, available to answer questions or provide technical expertise to the County on matters regarding geothermal power generation. The Calpine representative does not have a vote on how funds are to be dispersed from the County (or NCPA) funds.

On the CCICs, the Calpine representative acts as a facilitator and provides guidance (pursuant to Calpine's community investment fund guidelines) on the type of projects Calpine will (and will not) fund, but will not generally vote on the distribution of funds for a specific project.

The following table summarizes the three funds available to the communities and how they are to be administered:

	County	Calpine	NCPA
Type of Entity	Local Government	Private Company	Public Power Agency
Source	Federal Royalties distributed in accordance with AB 1905	Annual Operating Budget	Funds approved by the NCPA Commission
Funding Criteria	By law, funding is for mitigation of impacts associated with geothermal development	Infrastructure and/or service. Benefit to the entire community is preferred	Mitigation of direct verifiable impacts associated with geothermal development; may result in incidental private benefit
Funding Level	Subject to Board of Supervisor approval	\$70,000 for 2009, \$35,000 each for Cobb and AS	\$30,000 for Anderson Springs
Fund Administration	Lake County Board of Supervisors	Calpine Community Investment Committee	Northern California Power Agency

REFERENCES

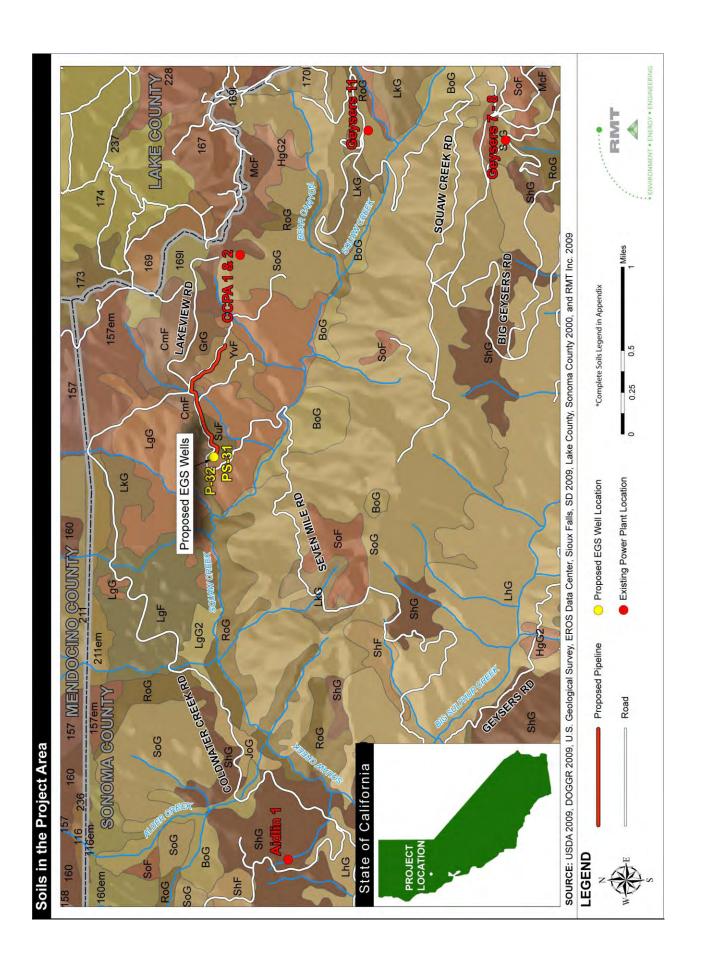
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APPENDIX K: SOILS INFORMATION





Natural Resources Conservation Service A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants Custom Soil Resource
Report for
Lake County, California;
Mendocino County, Eastern
Part and Southwestern Part
of Trinity County, California;
and Sonoma County,
California



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://soils.usda.gov/sqi/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app? agency=nrcs) or your NRCS State Soil Scientist (http://soils.usda.gov/contact/state_offices/).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Soil Data Mart Web site or the NRCS Web Soil Survey. The Soil Data Mart is the data storage site for the official soil survey information.

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Custom Soil Resource Report

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How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the

individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

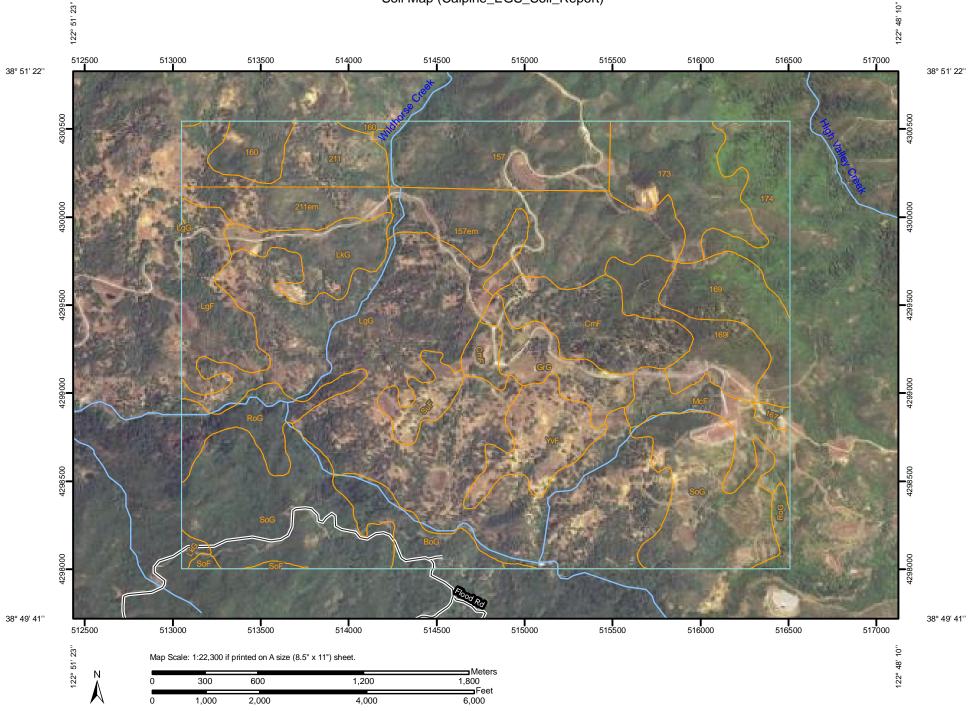
While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.



MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Units

Special Point Features

Blowout

■ Borrow Pit

Clay Spot

Closed Depression

X Gravel Pit

Gravelly Spot

A Landfill

∧ Lava Flow

علد Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

+ Saline Spot

"." Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

20

Gully

Short Steep Slope

Other

Political Features

0

Cities

Water Features



Oceans

_

Streams and Canals

Transportation

+++

Rails



Interstate Highways



US Routes



Major Roads



Local Roads

MAP INFORMATION

Map Scale: 1:22,300 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for accurate map measurements

Source of Map: Natural Resources Conservation Service Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov Coordinate System: UTM Zone 10N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lake County, California Survey Area Data: Version 7, Aug 31, 2009

Soil Survey Area: Mendocino County, Eastern Part and Southwestern Part of Trinity County, California

Survey Area Data: Version 6, Jan 4, 2008

Soil Survey Area: Sonoma County, California Survey Area Data: Version 4, Dec 12, 2007

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Date(s) aerial images were photographed: 6/22/2005

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend (Calpine_EGS_Soil_Report)

Lake County, California (CA033)				
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI	
167	MAYMEN-ETSEL-MAYACAMA COMPLEX, 30 TO 75 PERCENT SLOPES	5.8	0.3%	
169	MAYMEN-ETSEL-SNOOK COMPLEX, 30 TO 75 PERCENT SLOPES	70.3	3.2%	
173	MAYMEN-HOPLAND-MAYACAMA ASSOCIATION, 30 TO 50 PERCENT SLOPES	103.3	4.8%	
174	MAYMEN-HOPLAND-MAYACAMA ASSOCIATION, 50 TO 75 PERCENT SLOPES	71.8	3.3%	
Subtotals for Soil Survey Area		251.3	11.6%	
Totals for Area of Interest		2,174.1	100.0%	

Mendocino County, Eastern Part and Southwestern Part of Trinity County, California (CA687)				
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI	
157	MAYACAMA-HOPLAND-ETSEL COMPLEX, 30 TO 75 PERCENT SLOPES	122.5	5.6%	
160	MAYMEN-ETSEL-SNOOK COMPLEX, 30 TO 75 PERCENT SLOPES	35.9	1.7%	
211	WITHERELL-HOPLAND-SQUAWROCK COMPLEX, 50 TO 75 PERCENT SLOPES	71.6	3.3%	
Subtotals for Soil Survey Area		230.0	10.6%	
Totals for Area of Interest		2,174.1	100.0%	

Sonoma County, California (CA097)				
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI	
157em	MAYACAMA-HOPLAND-ETSEL COMPLEX, 30 TO 75 PERCENT SLOPES	153.8	7.1%	
1691	MAYMEN-ETSEL-SNOOK COMPLEX, 30 TO 75 PERCENT SLOPES	70.8	3.3%	
211em	WITHERELL-HOPLAND-SQUAWROCK COMPLEX, 50 TO 75 PERCENT SLOPES	56.1	2.6%	
BoG	BOOMER LOAM, 50 TO 75 PERCENT SLOPES	49.4	2.3%	
CmF	COHASSET GRAVELLY LOAM, 30 TO 50 PERCENT SLOPES	103.0	4.7%	
GrG	GUENOC GRAVELLY SILT LOAM, 30 TO 75 PERCENT SLOPES	54.7	2.5%	
LgF	LAUGHLIN LOAM, 30 TO 50 PERCENT SLOPES	78.5	3.6%	
LgG	LAUGHLIN LOAM, 50 TO 75 PERCENT SLOPES	550.1	25.3%	
LkG	LOS GATOS LOAM, 30 TO 75 PERCENT SLOPES	64.5	3.0%	

Sonoma County, California (CA097)				
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI	
McF	MAYMEN GRAVELLY SANDY LOAM, 30 TO 50 PERCENT SLOPES	58.2	2.7%	
RoG	ROCK LAND	63.8	2.9%	
SoF	STONYFORD GRAVELLY LOAM, 30 TO 50 PERCENT SLOPES	5.2	0.2%	
SoG	STONYFORD GRAVELLY LOAM, 50 TO 75 PERCENT SLOPES, ERODED	290.2	13.3%	
SuF	SUTHER-LAUGHLIN LOAMS, 15 TO 50 PERCENT SLOPES	28.7	1.3%	
YvF	YORKVILLE-LAUGHLIN COMPLEX, 30 TO 50 PERCENT SLOPES	65.6	3.0%	
Subtotals for Soil Survey Area		1,692.8	77.9%	
Totals for Area of Interest		2,174.1	100.0%	

Map Unit Descriptions (Calpine_EGS_Soil_Report)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An association is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Lake County, California

167—MAYMEN-ETSEL-MAYACAMA COMPLEX, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 6,000 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 45 to 68 degrees F

Frost-free period: 90 to 330 days

Map Unit Composition

Maymen and similar soils: 35 percent Etsel and similar soils: 25 percent Mayacama and similar soils: 20 percent

Minor components: 20 percent

Description of Maymen

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Gravelly loam

12 to 16 inches: Unweathered bedrock

Description of Etsel

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 10 to 14 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.8 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 3 inches: Gravelly loam 3 to 10 inches: Very gravelly loam 10 to 14 inches: Unweathered bedrock

Description of Mayacama

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 31 to 35 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 2.2 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 5 inches: Very gravelly sandy loam 5 to 31 inches: Very gravelly loam 31 to 35 inches: Unweathered bedrock

Minor Components

Henneke

Percent of map unit: 3 percent

Millsholm

Percent of map unit: 3 percent

Montara

Neuns

Percent of map unit: 2 percent

Sanhedrin

Percent of map unit: 2 percent

Snook

Percent of map unit: 2 percent

Speaker

Percent of map unit: 2 percent

Rock outcrop

Percent of map unit: 2 percent

Unnamed

Percent of map unit: 2 percent

169—MAYMEN-ETSEL-SNOOK COMPLEX, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 6,000 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 45 to 68 degrees F

Frost-free period: 90 to 330 days

Map Unit Composition

Maymen and similar soils: 35 percent Snook and similar soils: 20 percent Etsel and similar soils: 20 percent Minor components: 17 percent

Description of Maymen

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Gravelly loam

12 to 16 inches: Unweathered bedrock

Description of Etsel

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 8 to 12 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 3 inches: Gravelly loam 3 to 8 inches: Very gravelly loam 8 to 12 inches: Unweathered bedrock

Description of Snook

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 5 to 9 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water capacity: Very low (about 0.7 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 5 inches: Loam

5 to 9 inches: Unweathered bedrock

Minor Components

Bressa

Percent of map unit: 2 percent

Hopland

Percent of map unit: 2 percent

Mayacama

Percent of map unit: 2 percent

Millsholm

Percent of map unit: 2 percent

Neuns

Percent of map unit: 2 percent

Speaker

Percent of map unit: 2 percent

Rock outcrop

Percent of map unit: 2 percent

Unnamed

Percent of map unit: 2 percent

Unnamed

Percent of map unit: 1 percent

173—MAYMEN-HOPLAND-MAYACAMA ASSOCIATION, 30 TO 50 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 4,250 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 46 to 68 degrees F

Frost-free period: 130 to 330 days

Map Unit Composition

Maymen and similar soils: 40 percent Mayacama and similar soils: 20 percent Hopland and similar soils: 20 percent

Minor components: 20 percent

Description of Maymen

Setting

Landform: Mountains, ridges

Landform position (two-dimensional): Backslope, shoulder, summit

Landform position (three-dimensional): Mountainflank

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Gravelly loam

12 to 16 inches: Unweathered bedrock

Description of Hopland

Setting

Landform: Mountains

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Mountainflank

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 34 to 38 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 6 inches: Loam 6 to 34 inches: Clay loam

34 to 38 inches: Weathered bedrock

Description of Mayacama

Setting

Landform: Mountains

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Mountainflank

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 31 to 35 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 2.2 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 5 inches: Very gravelly sandy loam 5 to 31 inches: Very gravelly loam 31 to 35 inches: Unweathered bedrock

Minor Components

Bressa

Percent of map unit: 4 percent

Etsel

Percent of map unit: 4 percent

Henneke

Percent of map unit: 2 percent

Millsholm

Percent of map unit: 2 percent

Montara

Percent of map unit: 2 percent

Sanhedrin

Percent of map unit: 2 percent

Speaker

Percent of map unit: 2 percent

Unnamed

174—MAYMEN-HOPLAND-MAYACAMA ASSOCIATION, 50 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 4,250 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 46 to 68 degrees F

Frost-free period: 130 to 330 days

Map Unit Composition

Maymen and similar soils: 40 percent Mayacama and similar soils: 20 percent Hopland and similar soils: 20 percent Minor components: 20 percent

Description of Maymen

Setting

Landform: Mountains, ridges

Landform position (two-dimensional): Backslope, summit, shoulder

Landform position (three-dimensional): Mountainflank

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Gravelly loam

12 to 16 inches: Unweathered bedrock

Description of Hopland

Setting

Landform: Mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 34 to 38 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 6 inches: Loam 6 to 34 inches: Clay loam

34 to 38 inches: Weathered bedrock

Description of Mayacama

Setting

Landform: Mountains

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Mountainflank

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 31 to 35 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 2.2 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 5 inches: Very gravelly sandy loam 5 to 31 inches: Very gravelly loam 31 to 35 inches: Unweathered bedrock

Minor Components

Bressa

Etsel

Percent of map unit: 4 percent

Henneke

Percent of map unit: 3 percent

Montara

Percent of map unit: 3 percent

Sanhedrin

Percent of map unit: 3 percent

Speaker

Mendocino County, Eastern Part and Southwestern Part of Trinity County, California

157—MAYACAMA-HOPLAND-ETSEL COMPLEX, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 6,000 feet

Mean annual precipitation: 30 to 60 inches Mean annual air temperature: 45 to 59 degrees F

Frost-free period: 90 to 250 days

Map Unit Composition

Mayacama and similar soils: 40 percent Hopland and similar soils: 30 percent Etsel and similar soils: 15 percent Minor components: 15 percent

Description of Mayacama

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 24 to 28 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.8 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 4 inches: Gravelly loam 4 to 24 inches: Very gravelly loam 24 to 28 inches: Unweathered bedrock

Description of Hopland

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 31 to 35 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 5.1 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Loam 12 to 31 inches: Clay loam

31 to 35 inches: Weathered bedrock

Description of Etsel

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope, shoulder Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 7 to 11 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 3 inches: Gravelly loam3 to 7 inches: Very gravelly loam7 to 11 inches: Unweathered bedrock

Minor Components

Cummiskey

Percent of map unit: 2 percent

Dunsmuir

Henneke

Percent of map unit: 2 percent

Maymen

Percent of map unit: 2 percent

Hopland

Percent of map unit: 2 percent

Montara

Percent of map unit: 1 percent

Snook

Percent of map unit: 1 percent

Witherell

Percent of map unit: 1 percent

Rock outcrop

Percent of map unit: 1 percent

Unnamed

Percent of map unit: 1 percent

160—MAYMEN-ETSEL-SNOOK COMPLEX, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 6,000 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 45 to 68 degrees F

Frost-free period: 90 to 330 days

Map Unit Composition

Maymen and similar soils: 35 percent Snook and similar soils: 25 percent Etsel and similar soils: 25 percent Minor components: 15 percent

Description of Maymen

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave

Across-slope shape: Concave, convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 11 to 15 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.4 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 11 inches: Sandy loam

11 to 15 inches: Unweathered bedrock

Description of Etsel

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 7 to 11 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 3 inches: Gravelly loam 3 to 7 inches: Very gravelly loam 7 to 11 inches: Unweathered bedrock

Description of Snook

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 5 to 9 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.7 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 5 inches: Gravelly loam

5 to 9 inches: Unweathered bedrock

Minor Components

Bearwallow

Percent of map unit: 2 percent

Cummiskey

Percent of map unit: 2 percent

Henneke

Percent of map unit: 2 percent

Hopland

Percent of map unit: 2 percent

Montara

Percent of map unit: 2 percent

Rock outcrop

Percent of map unit: 2 percent

Squawrock

Percent of map unit: 1 percent

Witherell

Percent of map unit: 1 percent

Unnamed

Percent of map unit: 1 percent

211—WITHERELL-HOPLAND-SQUAWROCK COMPLEX, 50 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 500 to 2,500 feet

Mean annual precipitation: 35 to 55 inches Mean annual air temperature: 54 to 59 degrees F

Frost-free period: 175 to 250 days

Map Unit Composition

Witherell and similar soils: 35 percent Hopland and similar soils: 25 percent Squawrock and similar soils: 20 percent

Minor components: 20 percent

Description of Witherell

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave, convex

Across-slope shape: Convex

Parent material: Colluvium derived from sandstone and/or residuum weathered from

sandstone

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.5 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: Shallow Loamy (Annual Grass) (R015XD103CA)

Typical profile

0 to 7 inches: Sandy loam

7 to 12 inches: Gravelly sandy loam

12 to 16 inches: Bedrock

Description of Hopland

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Colluvium derived from sandstone and shale and/or residuum

weathered from sandstone and shale

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 31 to 35 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water capacity: Low (about 5.1 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Loam 12 to 31 inches: Clay loam 31 to 35 inches: Bedrock

Description of Squawrock

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Colluvium derived from sandstone and/or residuum weathered from

sandstone

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 21 to 25 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.9 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: Very Gravelly Loamy (Annual Grass) (R015XD104CA)

Typical profile

0 to 7 inches: Cobbly loam

7 to 16 inches: Very cobbly clay loam 16 to 21 inches: Very gravelly clay loam

21 to 25 inches: Bedrock

Minor Components

Bearwallow

Percent of map unit: 3 percent

Etsel

Percent of map unit: 3 percent

Maymen

Percent of map unit: 2 percent

Yorktree

Percent of map unit: 2 percent

Yorkville

Rock outcrop

Percent of map unit: 2 percent

Witherell

Percent of map unit: 2 percent

Squawrock

Percent of map unit: 2 percent

Hopland

Sonoma County, California

157em—MAYACAMA-HOPLAND-ETSEL COMPLEX, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 6,000 feet

Mean annual precipitation: 30 to 60 inches Mean annual air temperature: 45 to 59 degrees F

Frost-free period: 90 to 250 days

Map Unit Composition

Mayacama and similar soils: 40 percent Hopland and similar soils: 30 percent Etsel and similar soils: 15 percent Minor components: 15 percent

Description of Mayacama

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 24 to 28 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.8 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 4 inches: Gravelly loam 4 to 24 inches: Very gravelly loam 24 to 28 inches: Unweathered bedrock

Description of Hopland

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 31 to 35 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 5.1 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Loam 12 to 31 inches: Clay loam

31 to 35 inches: Weathered bedrock

Description of Etsel

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope, shoulder

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 7 to 11 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 3 inches: Gravelly loam 3 to 7 inches: Very gravelly loam 7 to 11 inches: Unweathered bedrock

Minor Components

Cummiskey

Percent of map unit: 2 percent

Dunsmuir

Percent of map unit: 2 percent

Henneke

Maymen

Percent of map unit: 2 percent

Hopland

Percent of map unit: 2 percent

Montara

Percent of map unit: 1 percent

Snook

Percent of map unit: 1 percent

Witherell

Percent of map unit: 1 percent

Rock outcrop

Percent of map unit: 1 percent

Unnamed

Percent of map unit: 1 percent

169I—MAYMEN-ETSEL-SNOOK COMPLEX, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 6,000 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 45 to 68 degrees F

Frost-free period: 90 to 330 days

Map Unit Composition

Maymen and similar soils: 35 percent Snook and similar soils: 20 percent Etsel and similar soils: 20 percent Minor components: 17 percent

Description of Maymen

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Gravelly loam

12 to 16 inches: Unweathered bedrock

Description of Etsel

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 8 to 12 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.6 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 3 inches: Gravelly loam 3 to 8 inches: Very gravelly loam 8 to 12 inches: Unweathered bedrock

Description of Snook

Setting

Landform: Hillslopes, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sandstone and shale

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 5 to 9 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 0.7 inches)

Interpretive groups

Land capability (nonirrigated): 7s

Typical profile

0 to 5 inches: Loam

5 to 9 inches: Unweathered bedrock

Minor Components

Bressa

Percent of map unit: 2 percent

Hopland

Percent of map unit: 2 percent

Mayacama

Percent of map unit: 2 percent

Millsholm

Percent of map unit: 2 percent

Neuns

Percent of map unit: 2 percent

Speaker

Percent of map unit: 2 percent

Rock outcrop

Percent of map unit: 2 percent

Unnamed

Percent of map unit: 2 percent

Unnamed

Percent of map unit: 1 percent

211em—WITHERELL-HOPLAND-SQUAWROCK COMPLEX, 50 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 500 to 2,500 feet

Mean annual precipitation: 35 to 55 inches Mean annual air temperature: 54 to 59 degrees F

Frost-free period: 175 to 250 days

Map Unit Composition

Witherell and similar soils: 35 percent Hopland and similar soils: 25 percent Squawrock and similar soils: 20 percent

Minor components: 20 percent

Description of Witherell

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave, convex

Across-slope shape: Convex

Parent material: Colluvium derived from sandstone and/or residuum weathered from

sandstone

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 12 to 16 inches to lithic bedrock

Drainage class: Somewhat excessively drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.5 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: Shallow Loamy (Annual Grass) (R015XD103CA)

Typical profile

0 to 7 inches: Sandy loam

7 to 12 inches: Gravelly sandy loam

12 to 16 inches: Bedrock

Description of Hopland

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Colluvium derived from sandstone and shale and/or residuum

weathered from sandstone and shale

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 31 to 35 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water capacity: Low (about 5.1 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 12 inches: Loam 12 to 31 inches: Clay loam 31 to 35 inches: Bedrock

Description of Squawrock

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Colluvium derived from sandstone and/or residuum weathered from

sandstone

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 21 to 25 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.9 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: Very Gravelly Loamy (Annual Grass) (R015XD104CA)

Typical profile

0 to 7 inches: Cobbly loam

7 to 16 inches: Very cobbly clay loam 16 to 21 inches: Very gravelly clay loam

21 to 25 inches: Bedrock

Minor Components

Bearwallow

Percent of map unit: 3 percent

Etsel

Percent of map unit: 3 percent

Maymen

Percent of map unit: 2 percent

Yorktree

Percent of map unit: 2 percent

Yorkville

Rock outcrop

Percent of map unit: 2 percent

Witherell

Percent of map unit: 2 percent

Squawrock

Percent of map unit: 2 percent

Hopland

Percent of map unit: 2 percent

BoG—BOOMER LOAM, 50 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 600 to 5,500 feet

Mean annual precipitation: 30 to 60 inches Mean annual air temperature: 54 to 59 degrees F

Frost-free period: 120 to 260 days

Map Unit Composition

Boomer and similar soils: 85 percent Minor components: 15 percent

Description of Boomer

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from metavolcanics

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 40 to 60 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high

(0.01 to 0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Moderate (about 8.1 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Typical profile

0 to 19 inches: Loam 19 to 37 inches: Clay loam

37 to 55 inches: Gravelly clay loam 55 to 59 inches: Weathered bedrock

Minor Components

Hugo

Percent of map unit: 5 percent

Josephine

Percent of map unit: 5 percent

Red hill

Percent of map unit: 5 percent

CmF—COHASSET GRAVELLY LOAM, 30 TO 50 PERCENT SLOPES

Map Unit Setting

Elevation: 2,000 to 5,000 feet

Mean annual precipitation: 50 inches Mean annual air temperature: 55 degrees F

Frost-free period: 220 to 250 days

Map Unit Composition

Cohasset and similar soils: 85 percent

Minor components: 15 percent

Description of Cohasset

Setting

Landform: Hills, mountains

Landform position (two-dimensional): Backslope

Landform position (three-dimensional): Mountainflank, side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from igneous rock

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 30 to 60 inches to paralithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately

low (0.00 to 0.06 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Moderate (about 7.1 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Typical profile

0 to 19 inches: Gravelly loam 19 to 50 inches: Gravelly clay loam 50 to 59 inches: Weathered bedrock

Minor Components

Forward

Percent of map unit: 5 percent

Kidd

Percent of map unit: 5 percent

Red hill

Percent of map unit: 5 percent

GrG—GUENOC GRAVELLY SILT LOAM, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 3,000 feet

Mean annual precipitation: 25 to 50 inches Mean annual air temperature: 57 to 63 degrees F

Frost-free period: 260 to 280 days

Map Unit Composition

Guenoc and similar soils: 85 percent Minor components: 15 percent

Description of Guenoc

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from igneous rock

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately

low (0.00 to 0.06 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: STEEP LOAMY (R015XD116CA)

Typical profile

0 to 12 inches: Gravelly silt loam 12 to 25 inches: Gravelly clay

25 to 29 inches: Unweathered bedrock

Minor Components

Boomer

Percent of map unit: 5 percent

Spreckels

Percent of map unit: 5 percent

Rock outcrop

Percent of map unit: 5 percent

LgF—LAUGHLIN LOAM, 30 TO 50 PERCENT SLOPES

Map Unit Setting

Elevation: 800 to 3,500 feet

Mean annual precipitation: 35 to 70 inches Mean annual air temperature: 54 to 57 degrees F

Frost-free period: 240 to 260 days

Map Unit Composition

Laughlin and similar soils: 85 percent Minor components: 15 percent

Description of Laughlin

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sedimentary rock

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 3.3 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Ecological site: SHALLOW LOAMY UPLANDS (R004XB065CA)

Typical profile

0 to 4 inches: Loam

4 to 22 inches: Sandy clay loam 22 to 26 inches: Unweathered bedrock

Minor Components

Hugo

Percent of map unit: 5 percent

Maymen

Percent of map unit: 5 percent

Suther

Percent of map unit: 5 percent

LgG—LAUGHLIN LOAM, 50 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 800 to 3,500 feet

Mean annual precipitation: 35 to 70 inches Mean annual air temperature: 54 to 57 degrees F

Frost-free period: 240 to 260 days

Map Unit Composition

Laughlin and similar soils: 85 percent Minor components: 15 percent

Description of Laughlin

Settina

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sedimentary rock

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water capacity: Low (about 3.3 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: STEEP SHALLOW LOAMY UPLANDS (R004XB067CA)

Typical profile

0 to 4 inches: Loam

4 to 22 inches: Sandy clay loam 22 to 26 inches: Unweathered bedrock

Minor Components

Hugo

Percent of map unit: 4 percent

Maymen

Percent of map unit: 4 percent

Suther

Percent of map unit: 4 percent

Yorkville

Percent of map unit: 3 percent

LkG—LOS GATOS LOAM, 30 TO 75 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 4,000 feet

Mean annual precipitation: 30 to 70 inches Mean annual air temperature: 52 to 55 degrees F

Frost-free period: 200 to 300 days

Map Unit Composition

Los gatos and similar soils: 85 percent Minor components: 15 percent

Description of Los Gatos

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sedimentary rock

Properties and qualities

Slope: 30 to 75 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to

0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: VERY SHALLOW (R015XD131CA)

Typical profile

0 to 7 inches: Loam

7 to 17 inches: Gravelly loam 17 to 25 inches: Gravelly clay loam 25 to 29 inches: Unweathered bedrock

Minor Components

Hugo

Percent of map unit: 4 percent

Josephine

Percent of map unit: 4 percent

Maymen

Percent of map unit: 4 percent

Boomer

Percent of map unit: 3 percent

McF-MAYMEN GRAVELLY SANDY LOAM, 30 TO 50 PERCENT SLOPES

Map Unit Setting

Elevation: 400 to 4,250 feet

Mean annual precipitation: 22 to 70 inches Mean annual air temperature: 46 to 68 degrees F

Frost-free period: 130 to 330 days

Map Unit Composition

Maymen and similar soils: 85 percent Minor components: 15 percent

Description of Maymen

Setting

Landform: Mountains

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Convex Across-slope shape: Convex

Parent material: Residuum weathered from sedimentary rock

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 1.4 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: VERY SHALLOW (R015XD131CA)

Typical profile

0 to 12 inches: Gravelly sandy loam 12 to 18 inches: Gravelly loam 18 to 22 inches: Unweathered bedrock

Minor Components

Rock outcrop

Percent of map unit: 10 percent

Henneke

Percent of map unit: 2 percent

Hugo

Percent of map unit: 1 percent

Huse

Percent of map unit: 1 percent

Los gatos

Percent of map unit: 1 percent

RoG—ROCK LAND

Map Unit Setting

Elevation: 650 to 4,000 feet

Mean annual precipitation: 8 to 15 inches

Mean annual air temperature: 45 to 52 degrees F

Frost-free period: 110 to 180 days

Map Unit Composition

Rock land: 85 percent

Minor components: 15 percent

Description of Rock Land

Setting

Parent material: Residuum weathered from igneous, metamorphic and sedimentary rock

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 0 to 10 inches to lithic bedrock

Drainage class: Excessively drained

Available water capacity: Very low (about 0.0 inches)

Interpretive groups

Land capability (nonirrigated): 8

Typical profile

0 to 10 inches: Unweathered bedrock

Minor Components

Unnamed

Percent of map unit: 15 percent

SoF—STONYFORD GRAVELLY LOAM, 30 TO 50 PERCENT SLOPES

Map Unit Setting

Elevation: 800 to 3,000 feet

Mean annual precipitation: 30 inches Mean annual air temperature: 61 degrees F

Frost-free period: 260 to 280 days

Map Unit Composition

Stonyford and similar soils: 85 percent *Minor components*: 15 percent

Description of Stonyford

Setting

Landform: Mountains

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from basic igneous rock

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high

(0.01 to 0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: VERY SHALLOW (R015XD131CA)

Typical profile

0 to 5 inches: Gravelly loam 5 to 12 inches: Gravelly clay loam 12 to 19 inches: Very gravelly clay loam 19 to 23 inches: Unweathered bedrock

Minor Components

Goulding

Percent of map unit: 4 percent

Henneke

Percent of map unit: 4 percent

Laughlin

Percent of map unit: 4 percent

Unnamed

Percent of map unit: 3 percent

SoG—STONYFORD GRAVELLY LOAM, 50 TO 75 PERCENT SLOPES, ERODED

Map Unit Setting

Elevation: 800 to 3,000 feet

Mean annual precipitation: 30 inches Mean annual air temperature: 61 degrees F

Frost-free period: 260 to 280 days

Map Unit Composition

Stonyford and similar soils: 85 percent *Minor components*: 15 percent

Description of Stonyford

Settina

Landform: Mountains

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Concave

Parent material: Residuum weathered from basic igneous rock

Properties and qualities

Slope: 50 to 75 percent

Depth to restrictive feature: 10 to 20 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high

(0.01 to 0.57 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Very low (about 2.0 inches)

Interpretive groups

Land capability (nonirrigated): 7e

Ecological site: VERY SHALLOW (R015XD131CA)

Typical profile

0 to 5 inches: Gravelly loam 5 to 12 inches: Gravelly clay loam 12 to 19 inches: Very gravelly clay loam 19 to 23 inches: Unweathered bedrock

Minor Components

Goulding

Percent of map unit: 3 percent

Henneke

Percent of map unit: 3 percent

Laughlin

Percent of map unit: 3 percent

Los gatos

Percent of map unit: 3 percent

Unnamed

Percent of map unit: 3 percent

Suf-Suther-Laughlin Loams, 15 to 50 percent slopes

Map Unit Setting

Elevation: 300 to 3,500 feet

Mean annual precipitation: 35 to 70 inches Mean annual air temperature: 54 to 57 degrees F

Frost-free period: 200 to 300 days

Map Unit Composition

Suther and similar soils: 60 percent Laughlin and similar soils: 35 percent

Minor components: 5 percent

Description of Suther

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sandstone

Properties and qualities

Slope: 15 to 50 percent

Depth to restrictive feature: 20 to 40 inches to paralithic bedrock

Drainage class: Moderately well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to

moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 4.1 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Ecological site: STEEP CLAYPAN (R015XD134CA)

Typical profile

0 to 3 inches: Loam 3 to 14 inches: Clay loam 14 to 36 inches: Gravelly clay 36 to 40 inches: Weathered bedrock

Description of Laughlin

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sedimentary rock

Properties and qualities

Slope: 15 to 50 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 3.3 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Ecological site: STEEP SHALLOW LOAMY UPLANDS (R004XB067CA)

Typical profile

0 to 4 inches: Loam

4 to 22 inches: Sandy clay loam 22 to 26 inches: Unweathered bedrock

Minor Components

Unnamed

Percent of map unit: 5 percent

YvF—YORKVILLE-LAUGHLIN COMPLEX, 30 TO 50 PERCENT SLOPES

Map Unit Setting

Elevation: 50 to 3,500 feet

Mean annual precipitation: 35 to 70 inches Mean annual air temperature: 54 to 57 degrees F

Frost-free period: 175 to 270 days

Map Unit Composition

Yorkville and similar soils: 55 percent Laughlin and similar soils: 35 percent Minor components: 10 percent

Description of Yorkville

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from igneous and metamorphic rock

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 40 to 60 inches to paralithic bedrock

Drainage class: Moderately well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately

low (0.00 to 0.06 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)

Available water capacity: Moderate (about 7.9 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Ecological site: STEEP CLAYPAN (R015XD134CA)

Typical profile

0 to 14 inches: Clay loam 14 to 58 inches: Clay

58 to 62 inches: Weathered bedrock

Description of Laughlin

Setting

Landform: Hills

Landform position (two-dimensional): Backslope Landform position (three-dimensional): Side slope

Down-slope shape: Concave Across-slope shape: Convex

Parent material: Residuum weathered from sedimentary rock

Properties and qualities

Slope: 30 to 50 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high

(0.20 to 1.98 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None Frequency of ponding: None

Available water capacity: Low (about 3.3 inches)

Interpretive groups

Land capability (nonirrigated): 6e

Ecological site: SHALLOW LOAMY UPLANDS (R004XB065CA)

Typical profile

0 to 4 inches: Loam

4 to 22 inches: Sandy clay loam 22 to 26 inches: Unweathered bedrock

Minor Components

Unnamed

Percent of map unit: 9 percent

Unnamed

Percent of map unit: 1 percent Landform: Drainageways

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APPENDIX L: COMMENTS AND RESPONSES ON THE DRAFT EA

FRIENDS OF COBB MOUNTAIN

May 18, 2010

COMMENTS ON

CALPINE ENHANCED GEOTHERMAL SYSTEMS PROJECT, DRAFT EA, DOE/EA # 1733

In general terms, we find the EA to be well written with adequate coverage in all sections except one. This is the treatment of the matter of induced seismicity and its potential effects on the residential communities of Cobb and Anderson Springs, with regard both to the residents and their properties.

This particular project may be situated far enough away from these communities that seismic events caused by this project would be slight, but this cannot be guaranteed. Seismic events from M 2.0 upward are normally felt in both of these communities, no matter where they are centered in the Geysers field. One basic flaw in the analysis of induced seismicity in this document is that it is seemingly based solely on scientific data and theory — scientifically based predictions in the abstract with little regard for the verbal testimony of residents as to their effects on them and their properties, as well as considerable objective data on the impacts of microseismicity and associated ground motion. In the community of Anderson Springs there have been twenty cases of property damage acknowledged as having been caused by seismic events resulting from geothermal operations. The cumulative cost of repair for these damages has been \$72,380, paid by a fund to which one industrial company contributes. With regard to the human annoyance factor, this has caused the community of Anderson Sprigs to file a Public Nuisance complaint, which is still to be settled, but can be solved only by mitigation of the quakes. The point is that seismic predictions in an EA or other environmental document based on scientific data alone are inadequate to the purpose of the document. The experiential factor is vital, and with the reasonable assumption that what has happened once without corrective action will happen again.

Data collected since the strong motion machines were installed at Anderson Springs and Cobb gives evidence that some quakes in the M 2.0-2.9 range — the most characteristic range of felt quakes at The Geysers — are capable of generating intensities of MM VI amd MM VII, which are in the destructive category. The attached pages of graphs and charts show the relation of seismic events in intensities VI and VII within the date range of 7/11/03 and 11/2/09. It should be noted that five MM VII events are recorded, one by an M 4.3 quake, two by M 3s (3.02 and 3.03) and two by an M 2.89 and an M 2.98. Among the MM VIs, seven were caused by M 2s, the lowest of which was caused by an M 2.63. The collection and publication of this data was done by Jeffrey D. Gospe, President of the Anderson Springs Alliance, and has been presented to and discussed at length by the Lake County Seismic Monitoring Advisory Committee (SMAC) appointed by the Lake County Board of Supervisors.

The residents neighboring The Geysers field are not opposed to geothermal energy development in itself, but it can only be acceptably developed with adequate mitigation of its environmental effects. We, Friends of Cobb Mountain and the Anderson Springs Community Alliance as organizations, and other members of these communities worked hard in the early days of geothermal development in the region for the control of noise, air pollution from hydrogen sulfide, and water pollution in streams and we ultimately won with the imposition of adequate measures of prevention and mitigation. Now we are faced with an increasingly unacceptable level of seismic activity, and it can only be supposed that this will be true in other localities of geothermal activity, and especially so with the introduction of EGS projects which are partially dependent on earthquakes as a tool. It is clear that this will be a limiting factor in the geothermal future, and it needs to be faced as a primary problem. Regrettably, the International Geothermal Protocol does not adequately face this issue, nor does the EA under present discussion. Earthquakes can simply not be brought to a level of public acceptability, as the Protocol suggests they may be. Much more attention must be given to the mitigation of induced seismicity.

No cut-off magnitude or intensity levels have been specified as safety and nuisance mitigations for this project. We recognize that the geographical location of the project seems sufficiently remote from residential communities that destructive and heavy nuisance impacts would not be expected, but we believe that it is not unreasonable to request that if a project-related seismic event of M 4.0 or greater occurs, or a Mercalli Intensity VI (that is, 9.2%g to less than 18%g) is recorded at either the Cobb or Anderson Springs ground motion stations, a temporary shut-down be required pending study of the possible causes of the event, and that there be a complete shut-down of the project if higher Richter (above M 4.5) or Modified Mercalli readings of VII or higher (18%g+) occur.

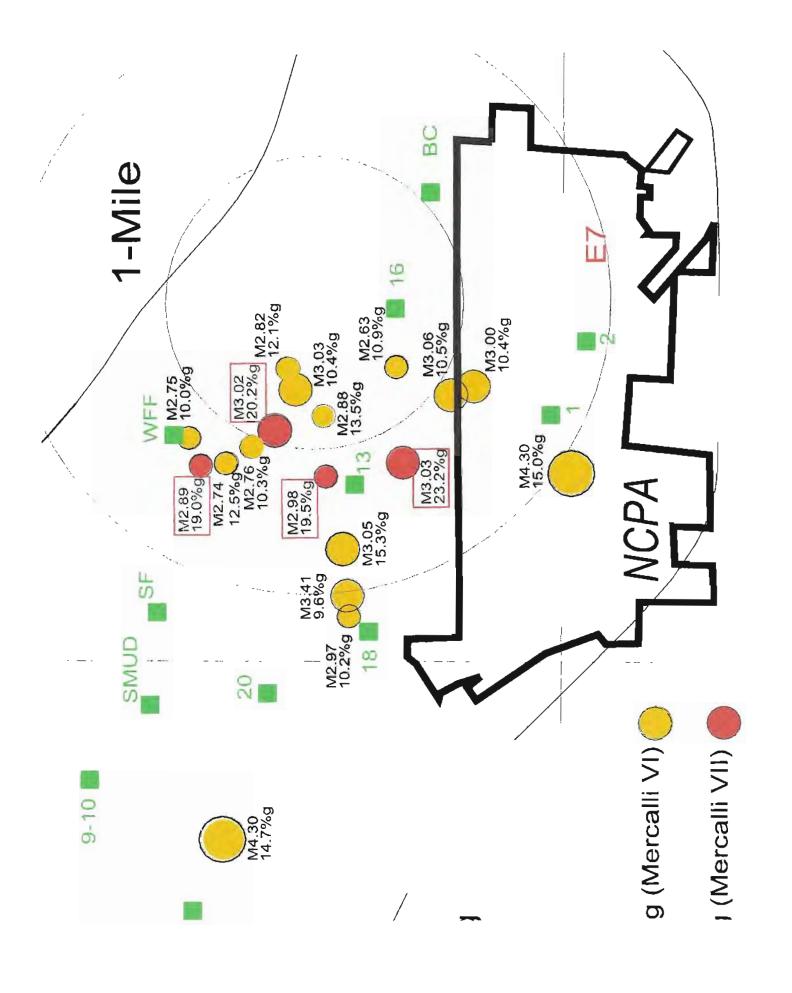
Respectfully submitted,

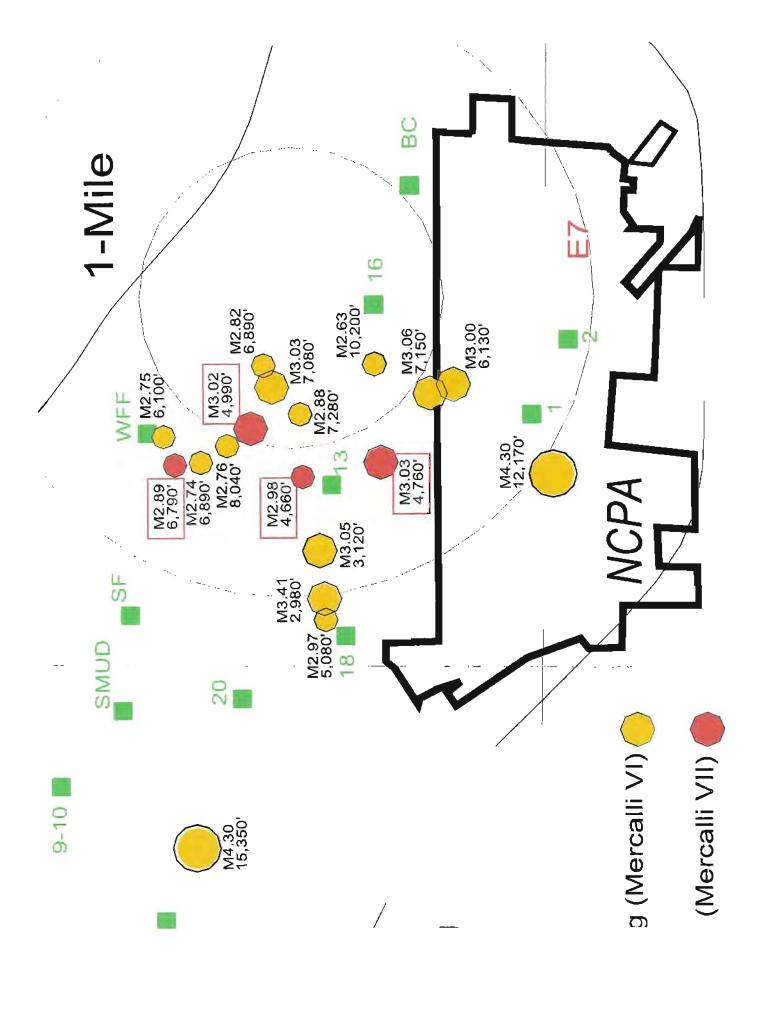
Hamilton Hess, Chair Friends of Cobb Mountain

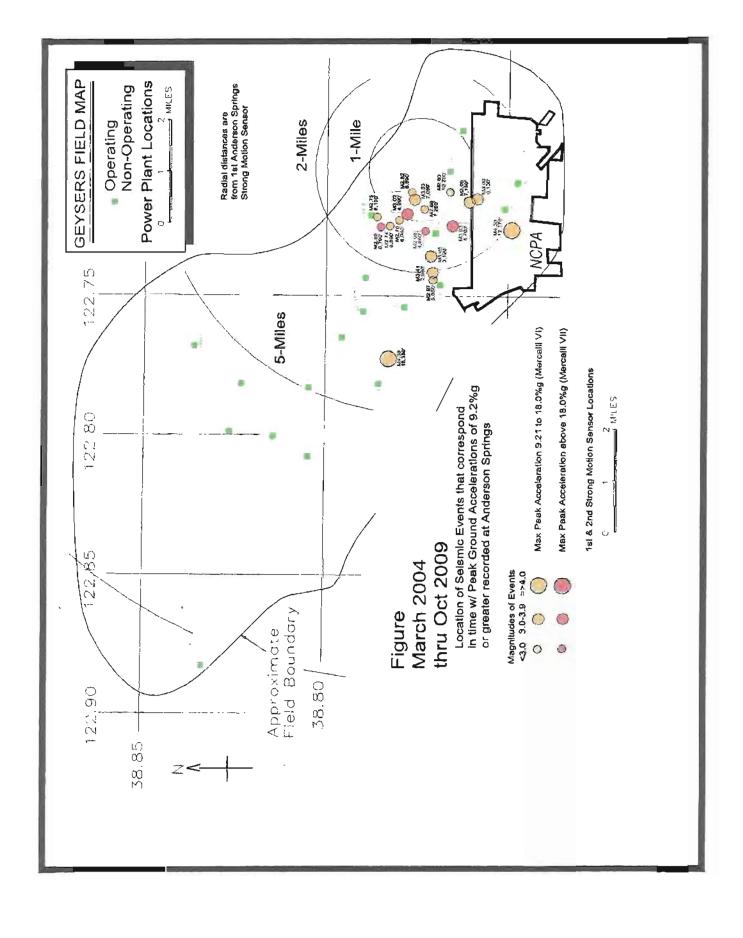
iends of Cobb Mountain See acompanying charts and graphs.

22 Geothermal Earthquakes YTD in 2009, Resulting in Modified Mercalli Intensities V or VI in Anderson Springs
Average of 2.2 Events per Month for 1/1/2009 through 10/31/2009 with PGA >=3.90%g

_	_	_					_	_	_																
Rec Center PGA +	Hot Springs PGA	N. O.	MA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V 7.	88%	67%	26%	¥?:	N/A	64%	32%	46%	85%	13.	21%	%09	32% to 88%
Recreation Center	PGA (%g)	143	M/A	N/A	N/A	N/A	N/A	N/A	٧ <u>/</u> ۷	N/A	N/A	∀ ?	4.8%	2.9%	2.5%	٩٠Ŋ	N/A	2.7%	1.5%	4.1%	6.1%	5.6%	2.4%	3.6%	1.8%g to 5.1%g
Hor Springs Road	PGA (%g)	14 7%	7.4%	4.2%	4.9%	2.0%	8.2%	4.2%	2.0%	6.9%	4.2%	۲۰ J	5.4%	4.3%	4.5%	12 1%	6.0%	4.3%	4.9%	8.2%	7.2%	12.5%	4.6%	6.8%	4.2%g to 14.7%g
	EQ Event ID	51214595	40231655	40232071	40232834	40234090	51220026	51220735	40237434	71241391	71241841	1249051	71271386	71271526	71271576	11271100	71280676	71286791	71295951	71298350	71302365	71302540	71302640		
	easehold	Calcone	Calpine	Calping	Calpine	Caiplne	Calpine	Calpine	Calpine	Calpine	Calpine	Campira	Calpina	NCPA	NCPA	Cargine	Calpine	Calpine	Calpine	Calpine	Calpine	Calpine	Calpine		
	Log	122 13	-122.716	-122.728	-122.741	122.732	122,718	-122.719	-122,713	-122,79	-122.795	122 123	-122.71	-122.715	-122.723	(22.717	-122.716	-122,711	122.801	122.755	.122.769	122 724	122.724		
	jū	38 7823	38,768	38.7857	38.7835	38.771	38.7785	38.7738	38,774	38.8083	38.8112	138 7802	38.778	38.756	38.7592	196, 86	38.7785	38.7673	38.7928	38.7925	38.7945	38 7837	38.7838		5
Ö	Depth (km)		2.4	2.1	1.7	2.8	2.3	2.0	2,5	4.1	3.9	4	2.6	2.0	1.5	11	2.5	2,1	3.8	4.0	4.8	5 2	2.1	2.8	5km to 4.8k
요	Magnetude	Dr. Dr	2.48	2.44	2.51	2.89	2.64	1.99	2.48	3.84	2.98	27.5	2.64	2.38	5.09	2.82	2.79	1.96	2.78	3.05	3.58	274	1.85	2.73	.85 to M4.3
	EQ Date	01:04:09	02/11/09	02/21/09	60/20/60	03/31/09	04/17/09	04/30/09	06/02/09	60/06/90	07/01/09	07/18/09	08/26/09	08/26/09	08/26/09	18/08/03	09/13/09	09/26/09	10/02/09	10/23/09	10/31/09	60/1E/01	10/31/09	Averages:	faximums:(1
	EQ TIME	527 10 PM	5:14:06 AM	11:58:44 AM	4:17:09 PM	521:55 PM	1:13:05 AM	1:11:15 AM	12:32:00 AM	5:27:28 PM	12:42:54 PM	9:35:50 AM	6:34:31 AM	1228:12 PM	2:08:08 PM	BABNE AM	10:32:47 PM	9:45:30 PM	8:03:46 PM	6:48:22 AM	6:52:24 AM	9-32:05 AM	12:20:36 PM	Α	Minimums & Maximums:11.85 to M4.;5km to 4,8km
	Shaking Time	527 12 PM	5:14:G7 AM	11:58:44 AM	4:17:10 PM	5:21:55 PM	1:13:06 AM	1:11:16 AM	12:32:00 AM	5:27:29 PM	12:42:55 PM	9.35.50 AM	8:34:31 AM	12:28:13 PM	2:08:08 PM	8.48.41 AM	10:32:47 PM	9:45:30 PM	8:03:48 PM	6:46:23 AM	6:52:25 AM	9-52:06 AM	12:20:36 PM		_
	Shaking Date Shaking Time	01 Dav09	02/11/09	02/21/09	03/07/08	03/31/09	04/17/09	04/30/09	06/02/09	60/06/90	02/01/09	3771508	08/26/09	08/26/09	08/26/09	1151/05/09	09/13/09	60/52/60	10/07/09	10/23/09	10/31/09	10/11/08	10/31/09	PGA >9.2%g)	
	# Strong Ground Motion Event ID	20090104 093358 ADSI/03431 EV1 DR1313	2 20090210_211726_ADSP-03433_EVT_DK1437	1 20090221 040148 ADSP-03433 EVT DK1483	4 20090307_061938_ADSP-03433_EVT_DK1541	E 20090331_102434_ADSP-03433_EVT_DK1623	6 20090416_181616_ADSP-03433_EVT_DK1686	20090429_181356_ADSP-03433_EVT_DK1739	8 20090601_173538_ADSP-03433_EVT_DK1828	9 20090630_104140_ADSP-03433_EVT_DK1936	10 20090701 054602 ADSP-03433 EVT DK1940	11 20090716 023918 ADSP-034(G EVT DK1987	12 20090826 063431 ADSP-03433 EW041	20090826_122813_ADSP-03433_EW044	14 20090826_140808_ADSP-03433_EW046	15 20090305 084141 AUSP 03433 EWO78	16 20030913_223247_ADSP-08433_EW112	17 20090926_214530_ADSP-03433_EW142	18 20091007_200348_ADSP-03433_EW178	79 20091023_064623_ADSP-03433_EW218	20 20091031_Cl65225_AUSP-03433_EW238	21 20091031 095206 ADSH-03433 EW240	22 20091031 122036 ALISP-03433 EW245	Modified Mercalli friensity VI Events in RED (i.e., PGA >9.2%g)	All dates & Ilmes in Universal Mean Time
																							_		







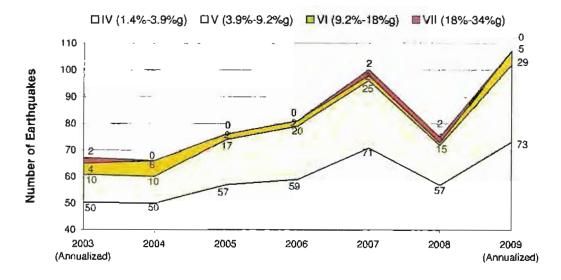
SUMMARY BY YEAR & MODIFIED MERCALLI INTENSITIES (%g Peak Ground Acceleration)

512 Earthquakes Generating Strong Peak Ground Accelerations (PGA ≥ 1.4%g or Modified Mercalli Intensities IV+)
Recorded in Anderson Springs over 76 Months (from July 11, 2003 through November 2, 2009)

	Modified M	ercalli Intensity ^f (%	6g Peak Ground Ad	cceleration)			
<u>Year</u>	(V (1.4%-3.9%g)	V (3.9%-9.2%g)	VI (9.2%-18%q)	VII (18%-34%a)	Grand Total		
2003 (Annualized)	50	10	4	2	67		
2004	50	10	6	٥	66		
2005	57	17	2	0	76		
2006	59	20	2	0	81		
2007	71	25	2	2	100		
2008	57	15	1	2	75		
2009 (Annualized)	73	29	5	0	107		
Grand Total	374	114	19	5	512		
	73%	22%	4%	1%	100%		

^{*} Actual data for partial years: 2003 based on 7/11/03 through 12/31/03; 2009 based on 1/1/09 through 7/19/09, and 8/16/09 through 11/2/09). For comparison purposes charts use annualized data for 2003 and 2009.

512 Earthquakes Generating Strong Peak Ground Accelerations (PGA ≥ 1.4%g or Modified Mercalli Intensities IV+)



[†] Definitions of Modified Mercalli Intensity Scale (per USGS website)

IV = Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. V = Felt by nearly everyone; many awakened. Some dishes, windows broken, unstable objects overturned. Pendulum clocks may stop.

VI = Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.

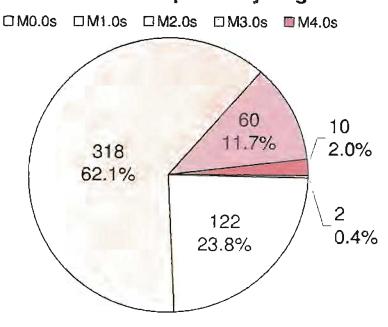
VII = Damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

SUMMARY BY YEAR & EARTHQUAKE MAGNITUDES

512 Earthquakes Generating Strong Peak Ground Accelerations (PGA ≥ 1.4%g or Modified Mercalli Intensities IV+)
Recorded in Anderson Springs over 76 Months (from July 11, 2003 through November 2, 2009)

YEAR	M0.0s	M1.0s	M2.0s	M3.0s	<u>M4.0s</u>	Grand Total
2003	1	9	17	4	1	32
Average PGA (%g)	3.5%	1.8%	3.5%	10.0%	7.4%	4.0%
Maximum PGA (%g)	3.5%	3.1%	9.3%	23.6%	7.4%	23.6%
2004	0	20	38	7	1	66
Average PGA (%g)	N/A	2.0%	3.3% -	7.0%	15.0%	3.5%
Maximum PGA (%g)	N/A	5.3%	13.5%	15.3%	15.0%	15.3%
2005	0	14	52	9	1	76
Average PGA (%g)	N/A	2.1%	3.1%	3.9%	13.2%	3.2%
Maximum PGA (%g)	N/A	3.5%	8.4%	10.4%	13.2%	13.2%
2006	0	17	44	18	2	81
Average PGA (%g)	N/A	2.5%	3.0%	5.4%	5.5%	3.5%
Maximum PGA (%g)	N/A	6.1%	6.9%	13.6%	9.1%	13.6%
2007	0	26	65	7	2	100
Average PGA (%g)	N/A	1.9%	3.7%	6.8%	4.5%	3.5%
Maximum PGA (%g)	N/A	3.9%	19.5%	20.2%	5.6%	20.2%
2008	0	16	51	6	2	75
Average PGA (%g)	N/A	2.1%	3.7%	7.0%	5.7%	3.7%
Maximum PGA (%g)	N/A	3.8%	19.0%	23.2%	7.8%	23.2%
2009	1	20	51	9	1	82
Average PGA (%g)	2.0%	2.4%	3.7%	4.2%	14.7%	3 5%
Maximum PGA (%g)	2.0%	5.6%	12.5%	8.2%	14.7%	14.7%
GRAND TOTAL	2	122	318	60	10	512
% Total	0.4%	23.8%	62.1%	11.7%	2.0%	100,0%
Average PGA (%g)	2.7%	2.1%	3.4%	5.8%	8.2%	3.5%
Maximum PGA (%g)	3.5%	6.1%	19.5%	23.6%	15.0%	23.6%

Distribution of Earthquakes by Magnitude



Courtesy of the Anderson Springs Community Alliance, November 9, 2009

Response to Friends of Cobb Mountain Comments on the Calpine EGS EA

2 June 2010

The thoughtful and well written comments from the Hamilton Hess and the Friends of Cobb Mountain are appreciated. The following are responses to the technical comments contained in the 18 May 2010 letter.

1. This particular project may be situated far enough away from these communities that seismic events caused by this project would be slight, but this cannot be guaranteed. Seismic events from M 2.0 upward are normally felt in both of these communities, no matter where they are centered in The Geysers field.

It is true that there are no "guarantees" involved in earthquake prediction; for this reason, scientists prefer to state observations in either relative or quantitative probabilistic terms.

Figure 1 shows the number of felt earthquakes based on the calls to the Calpine "hotline" telephone versus distance from the event to the Calpine strong motion instrument ADSP. Not all hotline calls from Anderson Springs are included but only those within 0.5 km of the ADSP strong motion instrument, which encompasses a large portion of the community. During the time period from January 1, 2004 to August 31, 2009, there were 2,020 earthquakes of **M** 2.0 and greater, of which 120 were reported as having been felt in Anderson Springs (or 6% of the total earthquakes over M 2.0). Of the 120 earthquakes reported as "felt" during this timeframe, the vast majority occurred within 10 km of the community.

2. One basic flaw in the analysis of induced seismicity in this document is that it is seemingly based solely on scientific data and theory – scientifically based predictions in the abstract with little regard for the verbal testimony of residents as to their effects on them and their properties, as well as considerable objective data on the impacts of microseismicity and associated ground motion.

Analyses based on communications from the community (including telephone calls to the Calpine hotline) have been performed to better understand the impacts of induced earthquakes at The Geysers (e.g., Figure 1). Thus "verbal testimony of the residents" both from the hotline and through community discussions are being considered in mitigation measures.

3. Data collected since the strong motion machines were installed at Anderson Springs and Cobb gives evidence that some quakes in the M 2.0-2.9 range – the most characteristic range of felt quakes at The Geysers – are capable of generating intensities of MM VI and MM VII, which are in the destructive category.

As stated on page 5-1 in the induced seismicity report included as Appendix I to the EA, correlations between any single ground motion parameter and intensity are highly uncertain. The correlations between peak horizontal ground acceleration and perceived shaking, as provided on page 5-1 (Wald *et al.*, 1999), is very approximate for The Geysers since it was developed based upon eight larger California earthquakes of $\mathbf{M} \ge 5.8$ (Wald *et al.*, 1999) that

6/8/2010

were tectonic events, which occur much deeper and have much longer durations than the shallow small magnitude Geysers earthquakes.

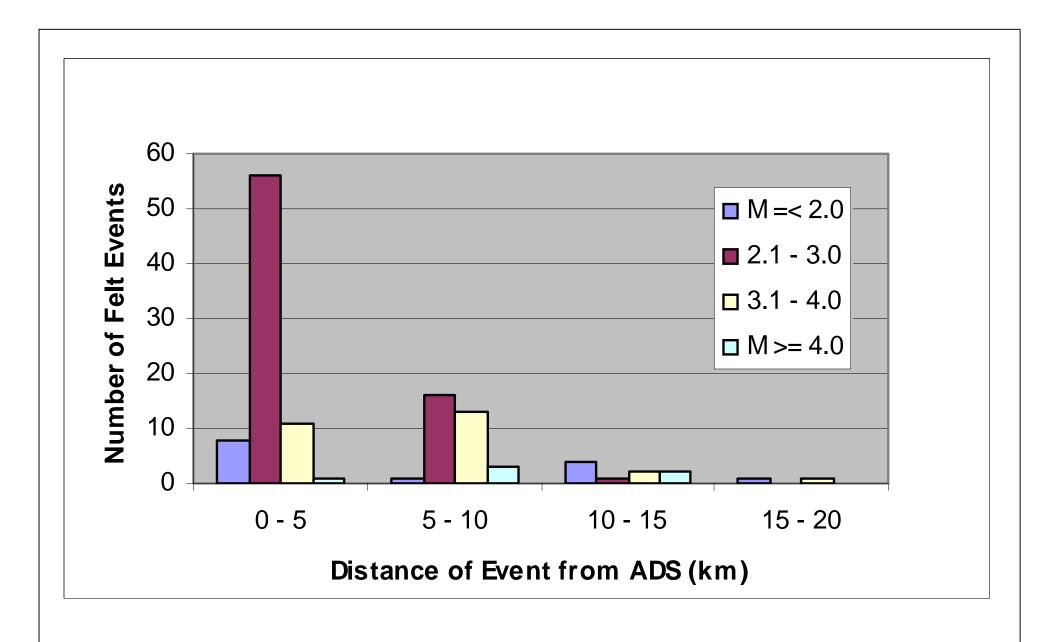
As stated on page 5-2 of the induced seismicity report included as Appendix I to the EA, the highest peak horizontal ground acceleration recorded to date on the Calpine strong motion instrument is 0.21 g at a distance of 2.0 km from ADSP. No damage was reported in that event according to the hotline calls and so no intensities in the "destructive" range have been observed to date.

4. No cut-off magnitude or intensity levels have been specified as safety and nuisance mitigations for this project. We recognize that the geographical location of the project seems sufficiently remote from residential communities that destructive and heavy nuisance impacts would not be expected, but we believe that it is not unreasonable to request that if a project-related seismic event of M 4.0 or greater occurs, or a Mercalli intensity VI (that is, 9.2% g to less than 18% g) is recorded at either the Cobb or Anderson Springs ground motion stations, a temporary shutdown be required pending study of the possible causes of the event, and that there be complete shutdown of the project if higher Richter (above M 4.5) or Modified Mercalli readings of higher (18% g+) occur.

Figures 2 and 3 show the PGA values recorded at ADSP and COB, respectively, from March 2003 through August 2008. Figure 2 shows that at distances beyond 10 km, only the larger events ($\mathbf{M} \geq 3.5$) record PGA values above 0.01 g (1% g) and no event had a PGA exceeding 0.10 g (10% g). Note that ADSP may have unusual site effects at the instrument site compared to the rest of the community, i.e., the ground motions are biased high. Anderson Springs is located about 14 km from the Prati State 31 and 32 wells. Figure 3 shows that no events have recorded a PGA higher than 0.03 g (3% g) at a distance greater than 8 km. Cobb is situated at about 10 km from the Prati State 31 and 32 wells. Although it is extremely difficult to estimate, it is not expected that earthquakes much larger than \mathbf{M} 3 will result from the EGS operations at Prati State 31 and 32 due to the low pumping rates and thus it is unlikely that a PGA, such as 0.18 g, will be observed in Cobb.

It is understood that there has been a general desire to put numerical limits on induced seismicity in terms of ground motions, magnitude (M) or Modified Mercalli intensity (MMI), however, the damage potential of The Geysers earthquake ground motions, if an earthquake occurs, is not well understood and so defining an absolute limit is difficult. As previously stated, no events have recorded a PGA higher than 0.03 g (3% g) at a distance greater than 8 km and no event at distances greater than 10 km had a PGA exceeding 0.10g (10% g). A comprehensive evaluation of the potential for induced seismicity is presented in the induced seismicity report included as Appendix I to the EA.

682010



URS

Project No. 26817267

Calpine

Number of Felt Events Within 500m of ADSP per Magnitude and Distance
1 Jan 2004 - 31 Aug 2009

