Engineered Geothermal Enhancement System Demonstration Project

Environmental Assessment and Initial Study/Proposed Mitigated Negative Declaration

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Prepared for
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List of Abbreviate Terms

1994 EIR/EIS	The Southeast Regional Wastewater Treatment Plan Facilities Improvements Project and Geysers Effluent Pipeline Project Draft EIR/EIS
2002 Supplemental EIR	Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Final Supplemental EIR
AB	Assembly Bill
AIRFA	American Indian Religious Freedom Act
AltaRock	AltaRock Energy Inc.
APD	Application of a Permit to Drill
ARB	Air Resources Board
ARPA	Archeological Resources Protection Act of 1979
BLM	Bureau of Land Management
BSCFZ	Big Sulphur Creek Fault Zone
CAA	Clean Air Act
CDFA	California Department of Food and Agriculture
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CNDDB	California Natural Diversity Data Base
CO	carbon monoxide
CO_2	carbon dioxide
CVRWQCB	Central Valley Regional Water Quality Control Board
dBA	A-weighted decibels
DFG	Department of Fish and Game
DOGGR	Department of Oil, Gas and Geothermal Resources
EA	Environmental Assessment
EGS	Engineered Geothermal System OR Enhanced Geothermal System
EIR	Environmental Impact Report
EIS	Environmental Impact Statement/
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRMs	Flood Insurance Rate Maps
FLPMA	Federal Land Policy and Management Act of 1976
FMMP	Farmland Mapping and Monitoring Program
FONSI	Finding of No Significant Impact
GAMP	Geysers Air Quality Monitoring Program

GGF	Geysers Geothermal Field
GHG	greenhouse gas
IDS	injection derived steam
IS	Initial Study
LACOSAN	Lake County Sanitation District
LCAQMD	Lake County Air Quality Management District
LCSDSRWS	Lake County Special District's Southeast Regional Wastewater System
LPA	Low Pressure Area
MW	megawatt
N_2O	nitrous oxide
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NAHC	Native American Heritage Commission
NCPA	Northern California Power Agency
NCRWQCB	North Coast Regional Water Quality Board
NEPA	National Environmental Policy Act
NHPC	National Historic Preservation Act
NO_2	nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
PM10	particulate matter 10 microns or less in diameter
PRC	Public Resource Code
RFD	reasonable foreseeable future development
RMP	Resource Management Plan
RWQCB	Regional Water Quality Control Board
SEIR	Supplemental Environmental Impact Report
SIPs	State Implementation Plans
SO_2	sulfur dioxide
TACs	Toxic Air Contaminants
TCPs	Traditional Cultural Properties
USC	United States Code
USFWS	U. S. Fish and Wildlife Service
VRM	Visual Resource Management
WDP	Waste Discharge Permit

Chapter 1 Introduction

1.1 Introduction

AltaRock Energy Inc. (AltaRock) and the Northern California Power Agency (NCPA) are proposing to undertake an Engineered Geothermal System (EGS) well stimulation project in the Geysers Geothermal Field (GGF). In essence, EGS is the process of the injection of water into wells to create an artificial reservoir and steam, which is harnessed to produce energy. The GGF consists of the entirety of The Geysers geothermal field, including areas beyond the NCPA leasehold. The "Geysers Management Area" defined in the Bureau of Land Management (BLM) Ukiah Field Office's Resource Management Plan (RMP) consists of all BLM managed lands in the Geysers area.

The BLM manages the federal lands that are underlain by the GGF. The Northern California Power Agency (NCPA) holds various geothermal leases from BLM in a portion of the GGF, and currently operates and maintains a number of geothermal producing wells in addition to a steam gathering system and a waste water pipeline supplying water for steam reservoir recharge. The wells and gathering system currently supply steam to two (2) NCPA 110 megawatt (MW) dry steam power plants. NCPA is interested in enhancing the production capability from its leases.

For purposes of the National Environmental Policy Act (NEPA), BLM is the lead agency by virtue of its management of geothermal lease operations on the land on which the proposed project is located, and the Department of Energy is a cooperating agency by virtue of its role in providing financing for the proposed EGS project. NCPA is the lead agency for purposes of the California Environmental Quality Act (CEQA).

NCPA's formal interest in developing geothermal power generation started in 1977 with a Shell Oil Co. contract for an exclusive right to purchase steam from BLM geothermal leases in the southeast GGF. NCPA Geothermal Plant No. 1 started operation in January 1983; Geothermal Plant No. 2 began operation in September 1985. In that same year, NCPA bought the steam wells, associated production facilities, and all rights for further development within the original Shell BLM leaseholds. As part of the geothermal power generation facilities, NCPA currently operates geothermal wells, two power plants, and associated steam pipelines, as well as part-ownership of the 26-mile Southeast Geysers Effluent Pipeline from nearby Lake County.

NCPA generally maintained 220-MW baseload electrical generation levels from its Geysers operations until 1988, when a fieldwide decline in steam reservoir pressure threatened future operations. At that time, an extensive reservoir performance analysis indicated that there was not enough steam available to operate NCPA's geothermal power plants at full load for their 30-year projected lives. In the early 1990s, NCPA, in conjunction with the Lake County Sanitation District and other geothermal power plant operators, began planning the Southeast Geysers Effluent Pipeline project (including a 26-mile long pipeline and set of pumping plants to deliver lake water and treated sewage effluent from Lake County to The Geysers). An Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was prepared for the project and considered by BLM, NCPA, and Lake County prior to their approvals of their respective parts of the overall project. The approved pipeline now provides water that is injected into the steam reservoir to reduce the decline noted above. Along with operational changes, this has extended the useful life of the geothermal resources. The Southeast Geysers Effluent Pipeline began delivering water to The Geysers steam field from Lake County on Sept. 25, 1997.

Well E-7 was drilled by NCPA on the E-Pad in 1988 under a Geothermal Drilling Permit granted by the BLM. It was deepened to its current 7,855-foot depth and converted to an injection well under Sundry Notice 340-08-01 issued by the BLM in late 2007. It is currently being used to inject water into the steam reservoir beneath the NCPA leasehold.

1.2 Project Location

The proposed project will take place in the southeastern portion of the GGF. The GGF is located west of Middletown on the border of Lake and Sonoma Counties. The general location of NCPA's facility is shown on Figure 1-1 (Regional Location). The project is proposed to be located at the "E-Pad" in the southern portion of NCPA's lease, in the northern portion of Section 1, T10N, R8W MDBM. That location is shown on Figure 1-2 (E-Pad Location).

The project site is a graded pad covered with gravel situated in the mountains at the eastern edge of Lake County in the Mayacmas Mountains, at an elevation of approximately 3,150 feet. The primary land uses surrounding the site are power generation and maintenance facilities associated with the GGF,, and undeveloped open space. The nearest residence lies 1.8 miles to the north, in the vicinity of the small unincorporated town of Castle Rock Springs. The project site is located on land managed by the BLM, and is part of the Geysers Management Area.

1.3 Purpose and Need

The project proposes to create additional sources of geothermal power within the NCPA leasehold. The project consists of deepening an existing NCPA injection well, then creating a new engineered steam reservoir system around this deepened well. A new production well (E-8) would be drilled from the "E-Pad" to intersect and utilize this new steam reservoir, and tests would be run to determine the wells' viability. A key concern of the testing would be to ensure that the new steam reservoir is geologically isolated from the existing reservoir. If the well produces sufficient steam from an independent reservoir, the steam may be supplied under a long-term contract to NCPA. NCPA would convert the steam into power for clients in its service area.

The GGF has experienced reduced steam capacity over the years, despite ongoing injection activities to regenerate the steam and careful management practices. Creating a new geothermal reservoir below the existing reservoir is needed in order to extend the lifetime of power production at the NCPA facility.

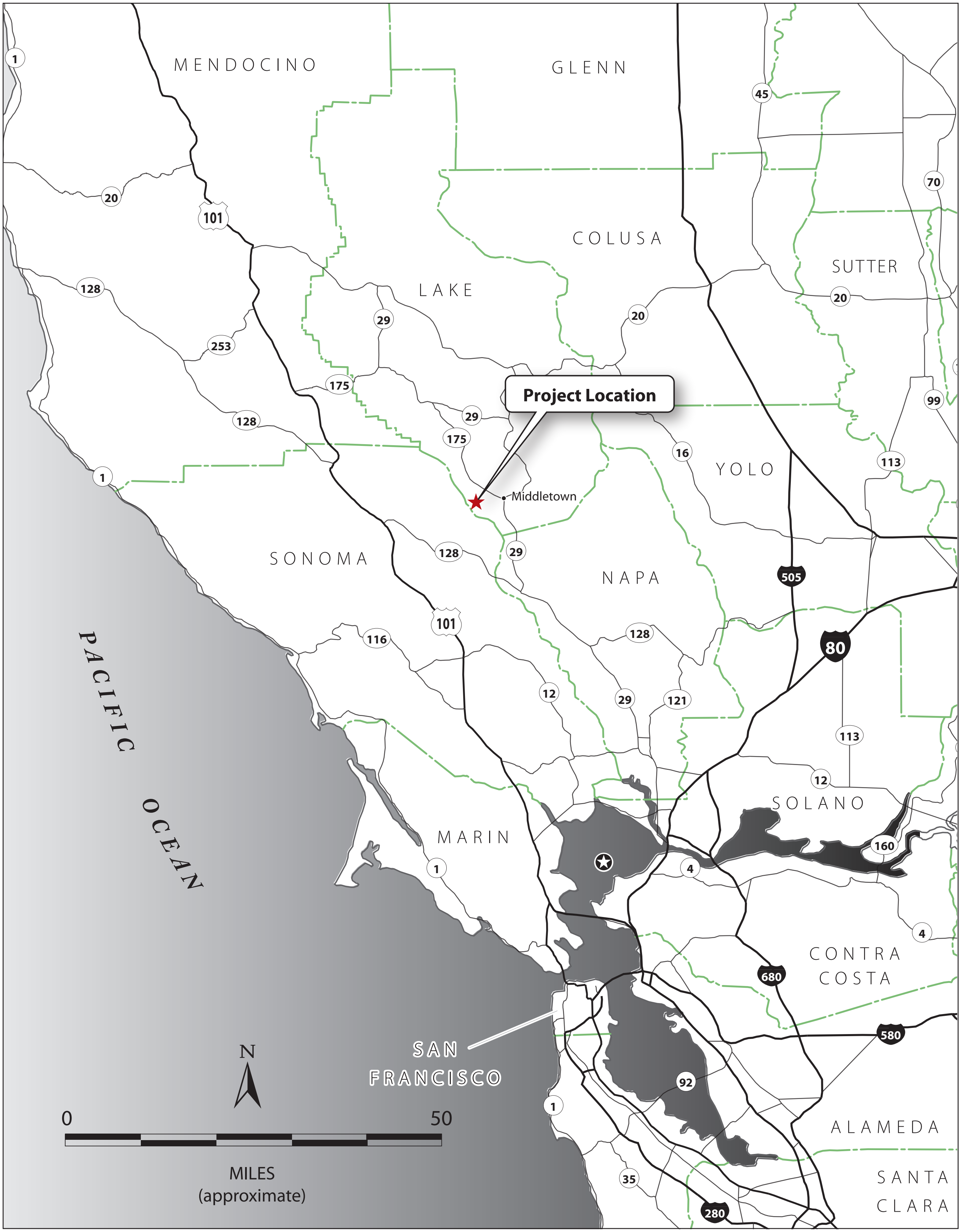

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Figure 1-1
Regional Location

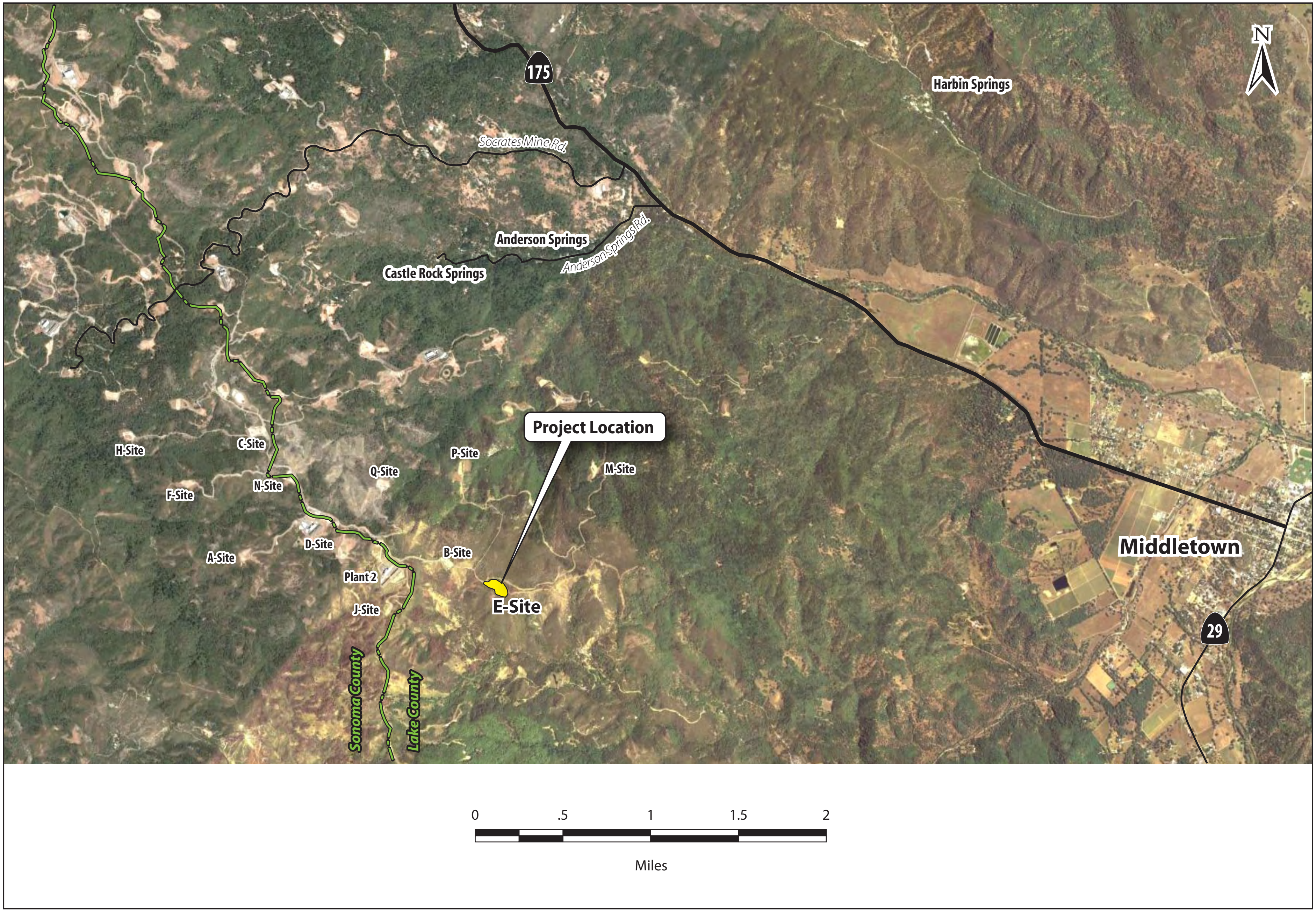

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Figure 1-2
E-Pad Location

1.4 Purpose of the Environmental Assessment/Initial Study

This Environmental Assessment/Initial Study (EA/IS): (1) describes the existing environmental resources in the project area, (2) evaluates the environmental effects of the project alternatives on those resources, and (3) determines the need for an EIS under NEPA or an EIR under CEQA if the effects are found to be significant. If an EIS and an EIR is not required, a Finding of No Significant Impact (FONSI) and Negative Declaration would fulfill the requirements of NEPA and CEQA, respectively.

1.4.1 Decisions to Be Made

The BLM will consider approval of either a Geothermal Sundry Notice or Geothermal Drilling Permit for the E-7 well deepening, depending upon the depth of the finished well. The new E-8 well would require approval of a Geothermal Drilling Permit. The hydroshearing/injection/production activity would require a Geothermal Sundry Notice.

NCPA proposes to enter into a contract with AltaRock for the proposed project.

1.5 Impact Evaluation

NEPA requires that effects be analyzed on the basis of their context and intensity. Generally, the more sensitive the context, the less intense an impact needs to be in order to be considered significant. “Context” refers to the affected environment (or environmental setting) in which the proposed action would take place. The analysis must consider the site location as well as the affected region and society as a whole. “Intensity” refers to the severity of the proposed action’s impact on the environment. The analysis must consider effects that are both beneficial and adverse, public health and safety; unique characteristics of the geographic area; the degree to which effects are likely to be highly controversial; degree to which effects are highly uncertain or involve unique or unknown risks; whether the action is may establish a precedent for future actions with significant impacts; action related to other actions with cumulatively significant impacts; scientific, cultural, or historical including those listed in or eligible for listing in the National Register of Historic Places; threatened or endangered species and their critical habitat; and violation of Federal, State or local law or requirements imposed for the protection of the environment.

CEQA provides that if there is a fair argument, based upon factual evidence in the record, that a project may have a significant effect, then an Environmental Impact Report must be prepared. “Significant” is defined as a substantial adverse change in the existing physical environment.

Both NEPA and CEQA allow the environmental analysis of a project or action to “tier” upon a prior NEPA (EA or EIS) or CEQA document previously prepared for that project. Where an analysis is tiered, it can focus on those aspects of the environmental impact that were not adequately analyzed in the prior document. For CEQA purposes, the EA/IS is considered a subsequent Mitigated Negative Declaration pursuant to CEQA Guidelines Section15162.

This EA/IS is tiered upon the following previously adopted NEPA and CEQA analyses:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan and Final Environmental Impact Statement, 2006. Bureau of Land Management and U.S. Department of the Interior.
- Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Supplemental EIR, 2002. Lake County Sanitation District and Northern California Power Agency.

The 1994 EIR/EIS examined the potential impacts of installation of the pipeline carrying lake water and treated sanitation plant effluent from Lake County to the Calpine and NCPA facilities at The Geysers. The EIR/EIS also examined the effects of the effluent injection program and concluded that the injection program "would result in increased microseismicity in the project area and vicinity, but probably would not induce larger earthquakes that pose a substantial threat to public safety and substantial damage to structures." It did conclude, however, that the injection program–related induced seismicity "potentially could contribute to minor local property damage." Neither of these effects were considered significant impacts.

The Ukiah Field Office's 2006 Resource Management Plan and EIS established policies for management of those portions of the Geysers Geothermal Field managed by the BLM and, in Appendix H of the EIS, examined the potential environmental impacts of a reasonable foreseeable future development (RFD) scenario within the geothermal field. The RFD included expansion of the existing facilities, deepening of existing wells, and EGS activities. No significant effects were identified as resulting from operations within the Geysers Geothermal Field. The BLM's policy is to review all EGS proposals to ensure that well design limits are not exceeded.

The 2002 Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Supplemental EIR (SEIR) analyzed the potential impacts arising from pump station upgrades along the existing Southeast Geysers effluent pipeline. The SEIR supplements the 1994 EIR/EIS relative to the pump station upgrades. Because the upgrade project would increase the capability to inject water into the NCPA steam field, this included an examination of geologic effects. The 2002 SEIR concluded that the upgrade project's potential to increase the annual number and frequency of earthquakes resulting from induced microseismic events was less than significant. Similarly, the upgrade project was found to have a less-than-significant potential to result in surface fault rupture from active faults.

Chapter 2 Alternatives

2.1 Actions/Alternatives Considered but Eliminated from Detailed Analysis

Two alternatives were analyzed for the purpose of this EA/IS; the Proposed Project and No Project alternatives. Other alternatives were not considered, as locating the project at a different location would not materially change the potential for effects or the nature of those effects. Further, placement of the Proposed Project on the E-pad would maximize its distance from sensitive receptors and residences.

2.2 Alternative 1: Proposed Project

The project consists of deepening the existing NCPA injection well E-7 into the high-temperature and low permeability felsite rock below the producing GGF steam reservoir. The location of the E-pad that hosts injection well E-7 is illustrated on Figure 2-1. AltaRock proposes to "hydroshear" this rock by injecting water using AltaRock's proprietary technology. The impacts related to this proprietary technology are analyzed throughout this document. Hydroshearing is a process in which hydraulic pressure is high enough to cause existing fractures to open slightly and slip, a process referred to as *shear dilation*. This process results in a network of small, interconnected fractures that act as underground heat exchangers and allow heat from the rock to be mined by circulating water through it repeatedly. The hydraulic pressure will not be high enough to exceed the tensile strength of the rock and create new fractures. Hydroshearing would expand existing fractures in the rock, in up to three individual zones from the well, creating an engineered steam reservoir system. In order to create the engineered geothermal reservoir, well E-7 would be deepened from its existing depth of 7,855 feet to a total depth of between 11,500 feet and 12,500 feet, depending on the results of initial tests of the direction of hydroshear dilation zone growth. If the hydroshear dilation zone grows upward, the well would be finished to the greater depth.

The hydrosheared zones would be flow tested and evaluated to determine whether they have sufficient newly created permeability to allow the circulation of injected water. Assuming that the tests prove positive, new production well E-8 would then be drilled from the same well pad to intersect the newly expanded fractures within the engineered reservoir. Well E-8 would be drilled from a point located approximately 50 feet southeast of the E-7 well head, on the same pad. A flow test of well E-8 would be conducted to evaluate whether sufficient permeability has been created between the two wells to allow the steam that results from the injection water into well E-7 to be accessed by well E-8.

If insufficient permeability is found, up to three hydrosheared zones would be created in well E-8 (again using AltaRock's proprietary techniques) and then well E-8 would be retested. Once it is determined that sufficient permeability exists between the two wells, a short-term flow test (7–10 days) would be run, and then the produced steam would be supplied to the existing NCPA power plant(s). After a sufficient period of long-term data collection and monitoring (approximately six months), the produced steam may be supplied under a long-term contract to NCPA.

The project would employ one drilling rig and would be in compliance with all applicable noise mitigation identified in the 1994 EIR/EIS for the Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project. These measures include the following:

> **Mitigation Measure 5.2.5.1.A: The construction contracts shall specify that noisy construction activities (including heavy truck trips on local roadways, but not including highways) are to be limited to 8:00 a.m, to 6:00 p.m., Monday through Saturday.**
>
> **Mitigation Measure 5.2.5.1.B: The construction contracts shall specify that construction equipment powered by internal combustion engines must be equipped with best available mufflers.**
>
> **Mitigation Measure 5.2.5.1.E: The construction plan shall identify all construction yards and staging areas.**
>
> **Mitigation Measure 5.2.5.1.F: All vehicles and heavy equipment used on-site shall be adequately muffled to comply with Motor Vehicle Code requirements.**
>
> **Mitigation Measure 5.2.5.1.G: Adjustable backup beepers (when required by law) shall be set to the lowest allowable levels.**
>
> **Mitigation Measure 5.2.5.1.H: In the event substantive noise complaints are received, the project sponsors shall submit a noise control plan for review and approval by the Lake County Noise Control officer.**

Any liquids produced would be reinjected into well E-7 and recirculated. No expansion of the E-pad would be required by the project, and drilling operations would be restricted to the area of the existing pad. Access to the E-pad would be provided by the existing paved roads, and existing pipelines would be used to bring water to the site for drilling and injection and to move produced steam to the existing NCPA power plants. Office/laboratory support would be housed in existing NCPA facilities, and in temporary trailers brought to the E-pad site for the drilling and testing operations. Existing storage at the E-pad would be relocated to a similar graveled area within NCPA's facilities at the GGF. Sumpless drilling rig operations would be employed during the deepening of well E-7 and drilling of well E-8. Cuttings from the drilling operations would be tested and sent to the Clover Flat landfill in Calistoga if non-hazardous. Any hazardous tailings would be transported to the Clean Harbors Buttonwillow Landfill in Kern County, California. All water necessary for the project would be supplied from the water capacity already permitted and supplied to NCPA. A fraction of the water currently being injected into the NCPA geothermal well field would be utilized for this project, and no new water over that currently injected would be required.

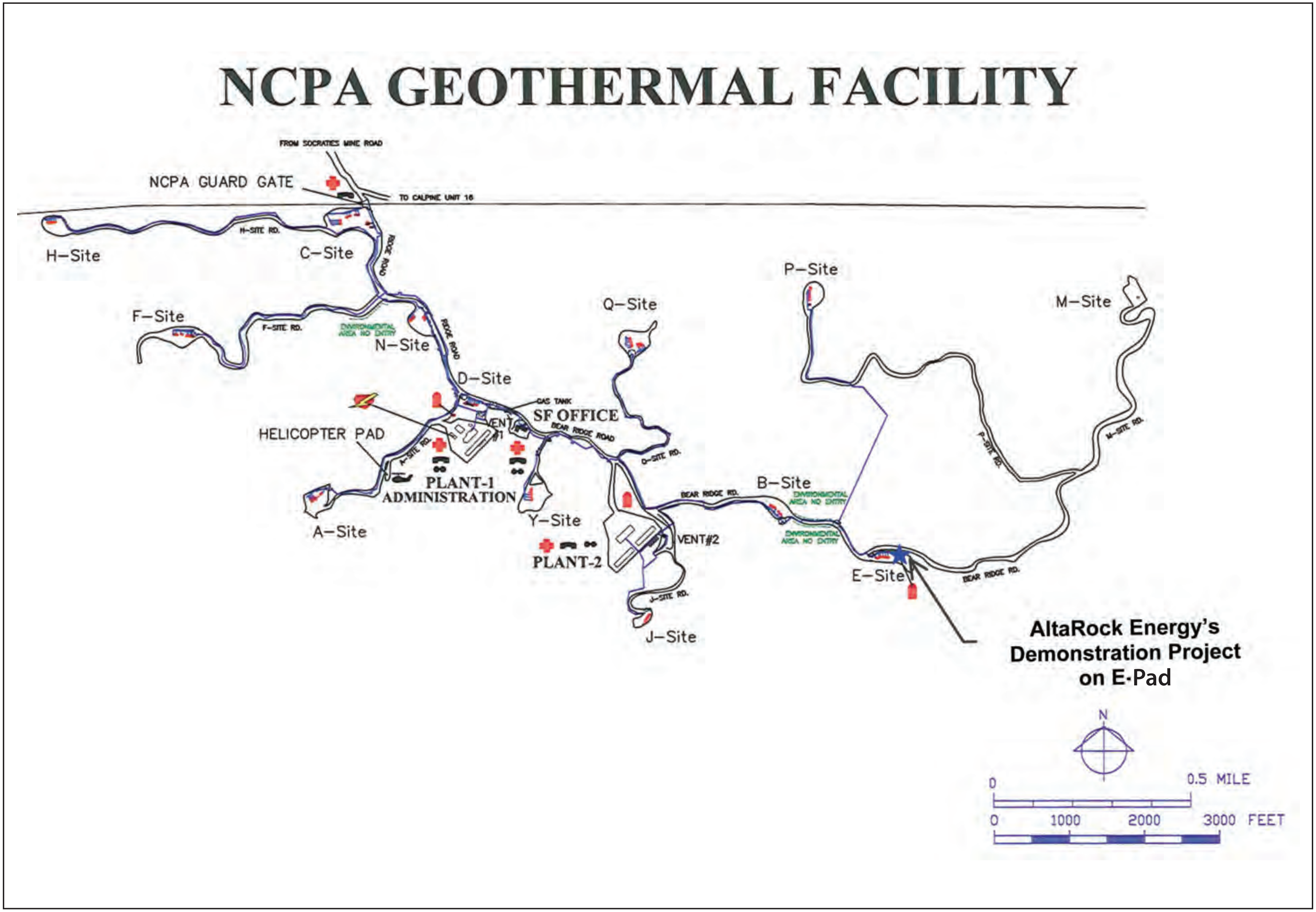

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Figure 2-1
E-Pad Location

Diesel engine exhaust, venting of steam and non-condensable gases, and dust are the primary impacts on air quality from well drilling operations. Vented steam can contain dust and hydrogen sulfide in the non-condensable gases. Hydrogen sulfide emissions would be abated through standard techniques that inject hydrogen peroxide and sodium hydroxide into the "blooie line" (a large diameter pipe that routes returning air and drill cuttings to a separator and muffler). Dust emissions from venting steam would be reduced by injecting water into the blooie line. Dust emissions from roads would be mitigated by periodic watering. The Project would comply with all applicable mitigation measures identified in the 1994 EIR/EIS for air quality control. These measures include the following:

> **Mitigation Measure 5.2.4.1.A: The project sponsors shall obtain an Authority to Construct permit prior to construction and Permit to Operate from the LCAQMD.**

> **Mitigation Measure 5.3.5.4: Viral and bacterial contamination of injection derived steam and/or effluent should be evaluated to assure absence or destruction of pathogens prior to atmospheric release.**

Permits to drill and operate wells E-7 and E-8 have been previously issued by the Lake County Air Quality Management District (LCAQMD).

An 8-station microseismic sensor array is in position in the area surrounding the E-pad to monitor existing microseismic activity and allow mapping of the engineered reservoir as hydroshearing proceeds. An approximately 1000' wide buffer zone would be maintained to prevent interaction between the zone of hydroshear-induced dilation and the Big Sulphur Creek Fault Zone (BSCFZ). If the hydroshear dilation zones do not grow in the desired direction or they approach the BSCFZ buffer zone, the hydraulic injection would be modified using AltaRock's proprietary technique to correct the growth direction.

2.3 Alternative 2: No Project

Under the No Project alternative, well E-7 would not be deepened, and well E-8 would not be drilled as part of the EGS Project. Current water injection operations at well E-7 would continue, and NCPA could still drill and complete well E-8 as part of its normal geothermal field operations. No new sources of geothermal steam would be created.

Chapter 3 Resources Eliminated from Detailed Analysis

The potential for significant effects was evaluated for each resource area and BLM supplemental authorities (Appendix A). Based on this evaluation, the following resource area and supplemental authorities were eliminated from detailed analysis and are not addressed in subsequent sections.

The following supplemental authorities/resources would not be impacted or are not affected by the proposed action or alternatives evaluated in this analysis, and therefore, will not be addressed: Livestock grazing, Areas of Critical Environmental Concern (ACEC), threatened or endangered species, wetlands/riparian areas, floodplains, farm lands, wilderness, wild and scenic rivers, invasive/non-native species, environmental justice, essential fish habitat, and healthy forests.

3.1 Agricultural Resources

The project site is located in a rural portion of Lake County in the Mayacmas Mountains. The site and project vicinity are used for energy production, and there are no agricultural uses. The site has a Farmland Mapping and Monitoring Program (FMMP) designation of “Other Land,” that is, land not included in any other mapping category. Examples of “Other Land” include low density rural developments, brush, timber, strip mines, and borrow pits.

The project site is not located on any land with the FMMP designation of Prime Farmland, Unique Farmland, or Farmland of Statewide Importance. Therefore, it would not convert any such land to a non-agricultural use. In addition, the project would not convert any currently existing land uses to alternative land uses. The project site is not located on land under a Williamson Act contract and is not zoned agricultural.

There are no adverse effects related to agricultural resources associated with the project. No mitigation measures are necessary.

3.2 Recreation

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population growth and consequent demand for recreational facilities. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA’s service area and consequent increased use of and demand for recreational facilities. However, it is uncertain if the proposed project will create a viable source of power and produce commercial amounts of steam. Even if a viable source of power is created, it remains uncertain how much power will be generated. Nonetheless, it can be reasonably assumed that if power is generated by the proposed project, it will not be enough to induce substantial population growth, and therefore would not result in a substantial increase in use of or demand for recreational facilities.

There are no recreational facilities in the project vicinity, and the project would not alter any recreational experiences.

There are no adverse effects related to recreational resources associated with the project. No mitigation measures are necessary.

Chapter 4 Resources Analyzed in Detail for Potential Effects

The following sections describe the environmental and resource effects for Alternatives 1 and 2 and, where appropriate, mitigation measures to avoid significant effects on the environment. NCPA is committed to implementing the mitigation measures.

4.1 Aesthetics/Visual Resources/Visual Resource Management

The term “aesthetics” typically refers to the perceived visual character of an area, such as of a scenic view, open space, or architectural facade. The aesthetic value of an area is a measure of its visual character and visual quality combined with viewer response (Federal Highway Administration 1988). This combination may be affected by the components of a project (e.g., buildings constructed at heights that obstruct views, hillsides cut and graded, open space changed to an urban setting), as well as variable elements such as light, weather, and the length and frequency of viewer exposure to the setting. Aesthetic impacts are changes in viewer response as a result of project construction and operation.

The existing conditions and environmental effects for aesthetics and visual resources were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management. (Section 5.2.7.1, page 5-75)
- Bureau of Land Management Ukiah Field Office ProposedResource Management Plan/Final Environmental Impact Statement (June 2006) and Record of Decision(September 2006, Section 3.8.2.1 Visual Resource Management, page 75 and figure 9). Existing Conditions

4.1.1.1 Environmental Conditions

The project site sits within the Geysers Geothermal Field (GGF), which is located in the Mayacmas Mountains viewshed. The predominant visual characteristics are rugged mountains. However, the visual landscape at the GGF is dominated by the power plants, steam collection lines, roads, cut and fill slopes, and other features of the human altered landscape, although there is some vegetation such as shrubs and scattered trees in the viewshed. The entire viewshed is either private land or areas under controlled access. Therefore, 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 site. The western side of the project site is seldom seen at all because public access is limited.

4.1.1.2 Regulatory Conditions

Federal

The Geysers area has received extensive alteration due to activities related to energy production. BLM lands in this area that have been altered, including at the project site, have been assigned to Visual Resource Management (VRM) Inventory Class IV. The objective of this class is to allow for management activities and uses requiring major modifications to the natural landscape. Therefore, the level of change to the characteristic landscape can be high. Management activities and uses may dominate the view and be a major focus of viewer attention. However, every attempt should be made to mitigate the impacts of activities through careful location and repeating the visual elements of the landscape.

State

There are no specific state or local aesthetics policies applicable to the Geysers area.

4.1.2 Environmental Effects

NEPA requires that effects be analyzed on the basis of their context and intensity. Generally, the more sensitive the context, the less intense an impact needs to be in order to be considered significant. "Context" refers to the affected environment (or environmental setting) in which the proposed action would take place. The analysis must consider the site location as well as the affected region and society as a whole. "Intensity" refers to the severity of the proposed action's impact on the environment. The analysis must consider effects that are both beneficial and adverse, public health and safety; unique characteristics of the geographic area; the degree to which effects are likely to be highly controversial; degree to which effects are highly uncertain or involve unique or unknown risks; whether the action may establish a precedent for future actions with significant impacts; action related to other actions with cumulatively significant impacts; scientific, cultural, or historical including those listed in or eligible for listing in the National Register of Historic Places; threatened or endangered species and their critical habitat; and violation of Federal, State or local law or requirements imposed for the protection of the environment.

For CEQA purposes, significance criteria were developed based on the State CEQA Guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if the project would:

- have a substantial adverse effect on a scenic vista;
- substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway;
- substantially degrade the existing visual character or quality of the site and its surroundings; or
- create a new source of light or glare which would adversely affect day or nighttime views in the area.

4.1.2.1 Alternative 1: Proposed Project

The Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS (1994 EIR/EIS) did not identify any visual impacts related to the proposed project site. The proposed project would not alter any scenic resources, including trees, rock outcroppings, or historic buildings. The proposed project is also not visible from any Caltrans-designated scenic highway.

The proposed project would occur on a graded site covered in gravel. The site would not be substantially altered or expanded, and no new structures would be constructed. Temporary structures and a drilling rig would be on site during construction, but would be removed upon completion of the project. The existing visual character and quality of the site and its surroundings would not be substantially altered.

No new structures would be constructed as part of the proposed project. Temporary structures would be on site during construction, but would be removed upon completion of the project. All construction equipment would be on the site temporarily, and no new sources of substantial light or glare that would adversely affect daytime or nighttime views in the area would be created.

There are no adverse effects related to aesthetics or visual resources associated with the project. Therefore, no mitigation measures are necessary.

4.1.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on aesthetic resources.

4.2 Air Quality

The environmental setting and impact analysis for air quality resources were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- California Air Resources Board. *Area Designation Maps – State and National*. Available at the following website: http://www.arb.ca.gov/desig/adm/adm.htm#state. Reviewed March 17, 2009.
- Lake County Air Quality Management District, Authority to Construct Permit # A/C 88-006, 2007. Lake County Air Quality Management District.

4.2.1 Existing Conditions

4.2.1.1 Environmental Conditions

The project is located within Lake County Air Basin, which lies entirely within the Coast Range mountains. The meteorological conditions in Lake County Air Basin are dominated by the semi-stationary Pacific high pressure system that is almost always present off the west coast of North America. This broad region of descending air is normally warm, dry, and stable. In winter, the Pacific high pressure system shifts southward, allowing a series of frontal systems to sweep across the area bringing rain for two to five days followed by one to two weeks of dry weather. Annual rainfall totals about 30 inches in Clear Lake Basin while more than double that amount occurs at the mountain ridges in the GGF. While the regional weather patterns have significant effects on the Lake County Air Basin wind, there are long periods when regional systems are weak; and locally generated, mountain-lake, wind systems predominate. Local wind patterns are determined by terrain characteristics, such as steep mountains and valleys that channel wind. The predominant regional northwest winds tend to flush out air pollutants from Lake County Air Basin. When local winds dominate, air pollutants tend to become entrained within the lake-mountain-valley circulations resulting in reduced air quality.

Geothermal air pollutants are generally emitted from steam wells, steam transmission lines and steam stacking, and non-condensable gas treatment facilities at power plants. Well bleeds and well maintenance steam releases are currently the largest steam field emissions sources. Geothermal air pollutants of concern consist mainly of hydrogen sulfide, ammonia, arsenic, boron, mercury, radon-222, silicon, sulfur dioxide, sulfates, and particulate matter. Operators of the geothermal facilities within the GGF run their facilities under permits issued by the LCAQMD, which are described below. The Geysers Air Quality Monitoring Program (GAMP) was established in 1983 to monitor air quality and meteorological data in order to track power plant emissions in the area.

Diesel engine exhaust, venting of steam, and dust are the primary sources of impacts on air quality from well drilling operations. Vented steam can contain significant amounts of dust, hydrogen sulfide, and other non-condensable gases.

4.2.1.2 Regulatory Conditions

Federal

The project site is located on public lands managed by the BLM, which has designated the site for production of geothermal power. new reservoirs and

The Clean Air Act (CAA), enacted in 1963 and amended several times thereafter (including the 1990 amendments), establishes the framework for modern air pollution control. The CAA directs the U.S. Environmental Protection Agency (EPA) to establish ambient air standards for six pollutants: carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter, ozone, and lead. The standards are divided into primary and secondary standards. Primary standards are designed to protect human health, including the health of “sensitive” populations such as asthmatics, children, and the elderly, with an adequate margin of safety.

Secondary standards are designed to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The primary legislation governing federal air quality regulations is the CAA Amendments of 1990, which delegate primary responsibility for clean air to the EPA. The EPA develops rules and regulations to preserve and improve air quality, as well as delegating specific responsibilities to state and local agencies.

Areas that do not meet federal ambient air quality standards are called *nonattainment* areas. For these nonattainment areas, the CAA requires states to develop and adopt State Implementation Plans (SIPs), which are air quality plans showing how air quality standards will be attained. The SIP, which is reviewed and approved by the EPA, must demonstrate how the federal standards will be achieved. Failing to submit a plan or secure approval could lead to the denial of federal funding and permits for such improvements as highway construction and sewage treatment plants.

In California, the EPA has delegated authority to prepare SIPs to the Air Resources Board (ARB), which, in turn, has delegated that authority to individual air districts. The individual air district with authority over the project site is LCAQMD. In cases where the SIP is submitted by the state but fails to demonstrate achievement of the standards, the EPA is directed to prepare a federal implementation plan.

State

Responsibility for achieving California's air quality standards, which are more stringent than federal standards, is placed on the ARB and local air districts and is to be achieved through district-level air quality management plans that will be incorporated into the SIP. In California, the EPA has delegated authority to prepare SIPs to the ARB, which in turn has delegated that authority to individual air districts.

The ARB traditionally has established state air quality standards, maintaining oversight authority in air quality planning, developing programs for reducing emissions from motor vehicles, developing air emission inventories, collecting air quality and meteorological data, and approving SIPs.

Responsibilities of air districts include overseeing stationary source emissions, approving permits, maintaining emissions inventories, maintaining air quality stations, overseeing agricultural burning permits, and reviewing air quality-related sections of environmental documents required by CEQA.

The Lake County Air Basin is in attainment for all state criteria pollutants. The air basin is either unclassified or in attainment for all federal criteria pollutants.

Greenhouse Gas Emissions

Global climate change is a problem caused by combined worldwide greenhouse gas (GHG) emissions. Greenhouse gases in the atmosphere trap infrared radiation emitted from the Earth's surface causing a "greenhouse effect." Emissions in excess of naturally occurring GHGs are thought to be responsible for the enhancement of the greenhouse effect and to contribute to what is termed "global warming," a trend of unnatural warming of the natural climate.

Carbon dioxide (CO_2) and nitrous oxide (N_2O) are the two GHGs released in the greatest quantities from mobile sources burning gasoline and diesel fuel. Because of the relatively long life of primary GHGs in the atmosphere, which results in their accumulation over time and well-mixing in the atmosphere, their impact on the atmosphere is mostly independent of their points of emission. Climate change is a global problem, and GHGs are global pollutants, unlike criteria air pollutants (such as ozone precursors) and Toxic Air Contaminants (TACs), which are pollutants of regional and local concern. Worldwide, California is the 12th to 16th largest emitter of CO_2 and is responsible for approximately 2% of the world's CO_2 emissions (California Energy Commission 2006).

Changes in California's climate and ecosystems are occurring at a time when California's population is expected to increase from 34 million to 59 million by the year 2040 (California Energy Commission 2005). Accordingly, the number of people potentially affected by climate change, as well as the amount of anthropogenic GHG emissions expected under a "business as usual" scenario, are expected to increase.

Assembly Bill (AB) 32 (Chapter 488, Statutes of 2006) was enacted for the purpose of reducing California's statewide GHG emissions to 1990 levels by 2020. This will require a reduction of about 30% from a business as usual projection of GHG emissions' increases without any action. ARB and other state agencies are in the process of enacting regulations to achieve this objective. The ARB scoping plan, adopted in December 2008, sets out over 70 measures that will be enacted—most by 2012. Under one of these measures, the California Public Utilities Commission and the California Energy Commission will require power providers by 2020 to obtain 33% of their power from renewable energy sources, such as geothermal.

4.2.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would:

- conflict with or obstruct implementation of the applicable air quality plan,
- violate applicable air quality standards,
- result in a cumulatively considerable net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard,
- expose sensitive receptors to substantial pollutant concentrations, or
- create objectionable odors affecting a substantial number of people.

4.2.2.1 Alternative 1: Proposed Project

A project is deemed inconsistent with air quality plans if it would result in population and/or employment growth that exceeds growth estimates included in the applicable air quality plan, which, in turn, would generate emissions not accounted for in the applicable air quality plan emissions budget. Therefore, proposed projects need to be evaluated to determine whether they would generate population and employment growth and, if so, whether that growth would exceed the growth rates included in the relevant air plans.

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population or employment growth. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA's service area. However, it is uncertain if the proposed project will create a viable source of power and produce commercial amounts of steam. Even if it did create a viable source of power, it remains uncertain how much power would be generated. It can also be reasonably assumed that if power is generated by the proposed project, it would not be enough to induce substantial population or employment growth. Therefore, the proposed project would not conflict with or obstruct implementation of the applicable air quality plan.

NCPA was issued an "Authority to Construct" by the LCAQMD for existing well E-7, and future wells E-8 and E-9 (this project does not propose to install well E-9). These permits were renewed in 2008. NCPA believes that a revised Authority to Construct may be needed from the LCAQMD for the deepening of E-7 and drilling of E-8, as the old one has outdated information about the "blooie line" (a large diameter pipe that routes returning air and drill cuttings to a separator and muffler), separator, and rig engines, which are now more efficient. These permits specify certain conditions that must be met, including emissions limits for certain pollutants. The proposed project would obtain and comply with this revised permit.

Diesel engine exhaust, venting of steam, and dust are the primary sources of impacts on air quality from well drilling operations. Vented steam can contain significant amounts of dust, hydrogen sulfide, and other non-condensable gases. As part of the proposed project, hydrogen sulfide emissions due to the project would be abated through the injection of hydrogen peroxide and sodium hydroxide into the blooie line. Also as part of the proposed project, dust emissions from venting steam would be reduced by injecting water into the blooie line. These would be considered adverse effects, but are mitigable.

The 1994 EIR/EIS determined that there would be less-than-significant adverse cumulative effects related to air quality. Those effects that the 1994 EIR/EIS did outline were due to the growth-inducing elements of the proposed project, which would cause increased vehicle miles traveled and consequent PM10 (particulate matter 10 microns or less in diameter) emissions. These effects are not relevant to the proposed project, as it does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population growth. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA's service area. However, it is uncertain if the proposed project will create a viable source of power and produce commercial amounts of steam. Even if it did create a viable source of power, it remains uncertain how much power would be generated. It can also be reasonably assumed that if power is generated by the proposed project, it would not be enough to induce substantial population growth, and therefore would not result in cumulative adverse effects to air quality.

There are no widely accepted published thresholds of significance for determining the impact of GHG emissions. However, the project would generate electrical power from a source of energy representing an alternative to carbon-emitting coal-based fuels (geothermal power). Accordingly, the project would produce a given amount of energy with fewer GHG emissions than would a fossil fuel burning power plant. This would help achieve the objectives of the AB 32 scoping plan to shift power production to renewable sources.

Therefore, the project would not result in a cumulatively considerable net increase of any criteria pollutant for which the project region is a nonattainment area for an applicable federal or state ambient air quality standard. There would not be an adverse effect.

Various construction activities are anticipated to involve the operation of diesel-powered equipment. In October 2000, ARB identified particulate emissions from diesel-fueled enginesas a TAC. Cancer health risks associated with exposures to diesel particulate emissions typically are associated with chronic exposure, in which a 70-year exposure period often is assumed. Although elevated cancer rates can result from exposure periods of less than 70 years, acute exposure (i.e., exposure periods of 2 to 3 years) to diesel particulate emissions typically are not anticipated to result in an increased health risk because it typically does not result in the exposure concentrations necessary to result in a health risk. Health impacts associated with exposure to diesel particulate emissions from project construction are not anticipated to be significant because construction activities would occur in phases at different locations throughout the site, rather than being concentrated in any one location for a long period. Therefore, the project would not result in long-term emissions of diesel particulate emissions at any one location on the project site, and there would be no adverse effects.

The 1994 EIR/EIS did not identify any impacts related to objectionable odors created by geothermal energy production. Although the operations would emit odiferous compounds, the site is distant from sensitive receptors. This analysis remains valid for the proposed project, as no significant changes to the method of energy production analyzed in the 1994 EIR/EIS would occur under the proposed project.

Impact AQ-1: Diesel engine exhaust, venting of steam, and dust associated with drilling operations will impact to air quality.

As stated above, vented steam can contain significant amounts of dust, hydrogen sulfide, and other non-condensable gases. As part of the proposed project, hydrogen sulfide emissions due to the project would be abated through the injection of hydrogen peroxide and sodium hydroxide into the blooie line. Also as part of the proposed project, dust emissions from venting steam would be reduced by injecting water into the blooie line. In addition, the project would comply with all applicable mitigation measures identified in the 1994 EIR/EIS/EIS for air quality control, as described below. With the obtainment of this revised Authority to Construct and compliance with applicable mitigation measures identified in the 1994 EIR/EIS detailed below, there would not be adverse effects associated with air quality.

Mitigation Measure 5.2.4.1.A: The project sponsors shall obtain an Authority to Construct permit prior to construction and Permit to Operate from the LCAQMD.

The project sponsors shall follow the conditions of this permit. The following is a dust control program that should be followed if one is not specified in the Authority to Construct permit:

- The area disturbed by clearing, earth moving, or excavation activities shall be minimized at all times. Construction of new dirt surface roads shall be minimized.
- All material excavated or graded shall be sufficiently watered to prevent excessive amounts of dust. Watering shall occur at least twice a day with complete coverage, carried out preferably in the late morning and after work is done for the day. Watering shall be more frequent on hot windy days (days where ground-level wind speeds exceed 13 mph). An effective watering program can reduce uncontrolled fugitive dust emissions from excavation and grading by up to 50%.
- All active construction areas shall be sufficiently watered to prevent excessive amounts of dust.
- All material transported off-site shall be either sufficiently watered or securely covered to prevent excessive amounts of dust and sediment deposition on roads.
- Vehicle speeds shall be limited to 15 mph or less on unpaved access roads.
- All areas with vehicle traffic shall be watered periodically or shall be treated with palliatives acceptable to LCAQMD or NSCAPCD (as appropriate) for stabilization of dust emissions.
- Disturbed areas (including temporary access roads and construction yards) shall be revegetated as soon as practicable once construction activities have been completed.

Mitigation Measure 5.3.5.4: Viral and bacterial contamination of injection derived steam and/or effluent should be evaluated to assure absence or destruction of pathogens prior to atmospheric release.

4.2.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on air quality resources.

4.3 Biological Resources

The existing conditions and environmental effects for biological resources were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan/ Final Environmental Impact Statement,(June 2006) and Record of Decision (September 2006, Sec. 2.2 Wildlife and Fish, 2.4 Riparian and Wetland Resources, and 3.8 Geysers). Bureau of Land Management and U.S. Department of the Interior.

4.3.1 Existing Conditions

4.3.1.1 Environmental Conditions

The project site is located on a disturbed grading pad covered with gravel. See Appendix C for a listing of species found in the project vicinity. The 1994 EIR/EIS determined that geothermal energy production, including water injection operations, would not disturb biological resources. There is no vegetation on the project site, and therefore limited habitat for any wildlife species.

4.3.1.2 Regulatory Conditions

Federal

The project site is located on public land managed by the BLM, which has designated the site for the production of geothermal power. In addition, the BLM's RMP outlines plans for the production of increased geothermal energy, including through the creation of EGS at the Geysers. The RMP provides goals and policies for the BLM's management at the Geysers Management Area, and states that the BLM's goals for the site include: ensuring that native wildlife and fish species are provided habitat of sufficient quantity and quality to enhance biological diversity and sustain their ecological, economic, and social values; improving habitats to support increased population levels; and rehabilitating, restoring, and maintaining riparian and wetland areas.

For the Geysers Management Area specifically, the RMP states that habitat management will primarily be passive and will focus on maintaining the current level of wildlife and fish populations by preventing adverse impacts from geothermal development. Regarding migratory birds, the RMP states that the BLM's goal is to ensure that any energy development has adequate measures to protect migratory bird habitat and flight routes.

State

As federally owned land, the site is not subject to local or state land use policies and regulations.

4.3.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would:

- have a substantial adverse effect on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by CDFG or USFWS;
- have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by CDFG or USFWS;
- have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act;
- interfere with the movement of any resident or migratory wildlife species;
- conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinances; or
- conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

4.3.2.1 Alternative 1: Proposed Project

The 1994 EIR/EIS determined that injection operations related to geothermal energy production would not disturb biological resources. This analysis remains accurate for the proposed project. No vegetation would be removed or disturbed, as the entire project site is a disturbed area, covered with gravel and containing no vegetation. Therefore, no habitat for wildlife would be destroyed or altered as a result of the project. As discussed in Section 4.10, "Noise," below, noise that would result from the proposed project that could affect wildlife would be essentially the same as currently results on a routine basis from well maintenance, and operation of the drilling rig would not result in a new or more severe impact than considered in the 1994 EIR/EIS. The proposed project would not adversely effect, either directly or through habitat modifications, any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service.

The 1994 EIR/EIS determined that injection operations related to geothermal energy production would not disturb biological resources. This analysis remains accurate for the proposed project. No riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service, exists on the project site.

The project site is a graded, drilling pad covered in gravel. There are no federally protected wetlands as defined by Section 404 of the Clean Water Act located on the site, and the proposed project would not affect any such wetlands. All fluids resulting from drilling operations would be retained on the site.

The 1994 EIR/EIS determined that regarding the Geysers Effluent Injection Program portion of the analyzed project, injection operations would not disturb biological resources. This analysis remains accurate for the proposed project. No vegetation would be removed or disturbed, as the entire project site is a disturbed area, covered with gravel and containing no vegetation. Therefore, no habitat for wildlife would be destroyed or altered as a result of the project. The project would not interfere with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.

No vegetation would be removed or disturbed, as the entire project site is a disturbed area, covered with gravel and containing no vegetation. Therefore, no habitat for wildlife would be destroyed or altered as a result of the project. The project would not conflict with any local policies or ordinances protecting biological resources. In addition, because it is located on federally owned land, the project site is not subject to local or state land use policies and regulations.

The project site is not located within the boundaries of any adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan.

4.3.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on biological resources.

4.4 Cultural Resources

The existing conditions and environmental effects for cultural resources were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan/Final Environmental Impact Statement, (June 2006) and Record of Decision (September 2006, Section 2.5 Cultural and Historic Resources). Bureau of Land Management and U.S. Department of the Interior.
- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.

4.4.1 Existing Conditions

4.4.1.1 Environmental Conditions

Archaeological resources in Lake County are extensive in occurrence and general richness. As early as 10,000 to 12,000 years ago, people occupied the area to take advantage of the abundant animal and plant resources. They exploited the local obsidian (volcanic glass) for tool material. Because of its unique cleavage, obsidian was highly valued for making sharp projectile points. The native peoples used obsidian as an important commodity for exchange with other aboriginal groups in California.

The archaeological record is contained in material culture, burials, occupation sites, and other evidence of past human activity that reveal the long period of human occupation in the region. Archaeological resources are found at depths up to several meters in the soil profile in some areas. Local sites excavated and dated using radiocarbon dates, obsidian hydration (weathering) readings, and artifact assemblages, reveal some of the earliest temporal sequences in northern California prehistory. They also reveal a wide diversity of peoples and cultural manifestations within the region; that is, multiple cultural sequences are recognized. The relationships of the cultures that lived in the region were diverse and cannot be simply ordered by an earliest to latest sequence of occupation. Additionally, the same cultural sequence cannot be overlain without reservation on every nearby area.

The Geysers region is divided into five archaeological cultures including: (1) Post Pattern; (2) Bald Mountain Aspect; (3) Mendocino Pattern; (4) Houx Aspect; and (5) Clear Lake Aspect. The archaeological record in the Geysers region is represented by a great variety of evidence that typically includes obsidian chert projectile points and chips, burials, bone tools, beads and ornaments, bedrock mortars and milling equipment, midden, housepits, stone alignments, petroglyphs, fire-affected rock, faunal remains, and other indicators of human use. The evidence is used to identify occupation sites of various sizes, probable importance, and frequency of use. There are abundant locations of possible large occupation sites as well as many sites of encampments, stone-working, and milling.

Native American populations present at the time when European peoples entered the area included three linguistically unrelated ethnographic groups. The Southeastern Pomo held lands including the eastern Clear Lake margin to Cache Creek. The Lake Miwok lived in the area between Cache Creek, south the Wappo boundary, east of Dry Creek, and south of Cobb Mountain. The Wappo occupied the southern part of the area including The Southeast Geysers. These were the latest of the ethnographic groups that came after thousands of years of continuous use and shifting cultural configurations. Several Native American villages in the project area continued to be occupied into the nineteenth and early twentieth centuries.

Until the 1840s the region remained fairly isolated from all but a few Spanish and American explorers. However, Spanish intrusion in the area occurred prior to 1816, and American trappers entered the area in 1832. In 1842, Salvador Vallejo led soldiers in an attack on the lake Indians. During the next several years, three tracts of land in the Clear Lake region were granted to Mexican citizens. By the mid-1840s, settlers began to come into the region; cabins and houses appeared as early as 1848.

Settlement increased to include a number of communities in the 1860s, in the Lower Lake and Burns Valley areas, and the Middletown area. Agriculture became firmly established in the 1860s through 1880s, and resorts were well established by the 1860s throughout the Geysers and Lake County regions. Mining was initiated in the mid-1800s. This included mercury which was mined for use in amalgam processing of gold and silver. Until the 1900s, mercury mining was Lake County's primary mineral output. Three abandoned mercury mines—the Chicago, Helen, and Research—are located in the Dry Creek drainage, approximately ¼ to ½ mile south of the project site.

In 1976, a portion of the area within the Whispering Pines and Mt. St. Helena topographic quadrangles was comprehensively and systematically surveyed for archeological resources. In reference to Section 1, T10N, R8W (where the proposed project is located), and Section 6, T10N, R7W (which adjoins this section to the east) MDBM, the 1976 survey report made the following conclusions:

> No archaeological resources of any kind were found within the study area. This finding is compatible with the results of archaeological surveys conducted in adjacent areas. The terrain was quite rugged and areas more favorable for habitation were located a short distance to the north in the Anderson Springs region and the west in the Putah Creek drainage. It is possible that archaeological resources may have been present at one time in the southern portion of the leasehold, but extensive mining operations have obscured any evidence that may once have existed. Judging from the nature of the terrain, however, it appears unlikely that extensive habitation sites were ever present within the study area. It is probable that the leasehold area was employed by pre-European inhabitants of the general region as a resource procurement zone with habitation situated in more favorable terrain to the north and east. (Fredrickson 1976:1–2)
>
> An intensive archaeological survey was conducted within a Shell Oil Company geothermal leasehold of approximately 800 acres that was located in Lake County, south of Anderson Springs. No materials of archaeological significance were discovered. The nature of the terrain made it unlikely that subsurface archaeological materials were present. Therefore, no recommendation concerning archaeological resources are required. (Fredrickson 1976:5)

The California Historic Resources Information Center at Sonoma State University was contacted during preparation of this EA/IS in search of current, recorded information about cultural resources that may exist on the site. No new resources have been reported since preparation of the 1994 EIR/EIS.

Besides tangible cultural resources, traditional cultural properties (TCPs) are considered important under the National Historic Preservation Act (NHPA 1966). Consultation with the affected Native American tribes is underway at this writing. As of this time, tribal consultation has not revealed any such properties.

4.4.1.2 Regulatory Conditions

Federal

The project site is located on public land managed by the BLM, which has permitted the site to allow for the production of geothermal power. In addition, the BLM's RMP outlines plans for the production of increased geothermal energy, including through the creation of EGS, in accordance with the proposed project.

The National Historic Preservation Act

The BLM has a programmatic agreement with the State Historic Preservation Officer that provides that if background research has determined the area is not sensitive, then either a "no sites affected determination" can be made or, if it falls under Class A/Class B, it is exempt (*Protocol 2007, Thresholds for SHPO Review VI:15*). In this case, exemption A27 best fits the project, although the project would also fall under exemption B16:

A27 Routine down-hole fracturing of rock formation to enhance production or injection.

B16 Approval of Application of a Permit to Drill (APD) or applications for rights-of-way for ancillary facilities within an established, utilized or developing oil and gas field for which Section 106 consultation has been completed or that does not involve historic properties.

Permits for the Project would be issued by the BLM once it has been determined that the project will not negatively impact resources deemed significant pursuant to the NHPA.

Other Federal Statutes, Policies, and Resources

- The Archeological Resources Protection Act of 1979 (ARPA).

  This statute (16 USC 470aa–470mm; Public Law 96-95 and amendments to it) was enacted

  > ...to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public lands and Indian lands, and to foster increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals. (Sec. 2(4)(b))

  As there are no archaeological resources currently in evidence at the project site, this statute would not apply unless a discovery is made.

- The Native American Graves Protection and Repatriation Act of 1990 (NAGPRA).

  NAGPRA is a federal law passed in 1990 that provides a process for museums and federal agencies to return certain Native American cultural items—human remains, funerary objects, sacred objects, and objects of cultural patrimony—to lineal descendants, culturally affiliated Indian tribes, and Native Hawaiian organizations.

  As there are no archaeological resources currently in evidence at the project site, this statute would not apply unless a discovery is made.

- The American Indian Religious Freedom Act (AIRFA).

  The American Indian Religious Freedom Act establishes a federal policy of respect for, and protection of Native American religious practices. It also has provisions for allowing some access to Native American religious sites.

  As there are no recorded traditional culture properties at the Project site, this statute would not apply.

- The BLM 8100 manual.

  This is a resource manual for cultural and public professionals.

- The Federal Land Policy and Management Act of 1976 (FLPMA).

  The FLPMA is an Act to establish public land policy; to establish guidelines for its administration; to provide for the management, protection, development, and enhancement of the public lands; and for other purposes. FLPMA requires the Field Office to consult with Native American tribes during the preparation of the RMP and to reflect tribal cultural concerns where possible.

State
As federally owned land, the site is not subject to local or state land use policies and regulations.

4.4.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would:

- cause a substantial adverse change in the significance of an historical resource,
- cause a substantial adverse change in the significance of an archaeological resource,
- directly or indirectly destroy a unique paleontological resource or site or unique geologic feature, or
- disturb any human remains, including those interred outside of formal cemeteries.

4.4.2.1 Alternative 1: Proposed Project

The proposed project would be built on a disturbed site already used for the production of geothermal energy. There are no known cultural resources located within the proposed project area. The existing pad is graded and graveled, and appears to be made up of several feet of fill material. However, it is possible that significant buried archaeological materials are present within the proposed project area. Disturbance or destruction of these resources may result from ground-disturbing activities associated with project-related construction. This would be an adverse effect, but is mitigable.

The underlying geology of the site is not supportive of paleontological resources. Underlying rock formations are greywacke and felsite. Neither generally contains fossils. Therefore, the project would not have an impact on such resources.

No known human remains are present within the proposed project area. While unlikely, it is possible that construction activities would result in the discovery of human remains. This would be an adverse effect, but is mitigable.

Impact CR-1: Disturbance or destruction of these resources may result from ground-disturbing activities associated with project-related construction.

With implementation of Mitigation Measure CR-1, there would be no adverse effects associated with this impact.

> **Mitigation Measure CR-1: Implement Plan to Address Discovery of Unanticipated Buried Cultural, Paleontological, or Geologic Resources.**
>
> If buried cultural resources such as chipped or ground stone, midden deposits, historic debris, building foundations, human bone, or paleontological resources are inadvertently discovered during ground-disturbing activities, work shall stop in that area and within

100 feet of the find until a qualified archaeologist or paleontologist can assess the significance of the find and, if necessary, develop appropriate treatment measures in consultation with Lake County and other appropriate agencies.

Impact CR-2: Possibility of construction activities resulting in the discovery of human remains.

With implementation of Mitigation Measure CR-2, there would be no adverse effects associated with this impact.

Mitigation Measure CR-2: Implement Plan to Address Discovery of Human Remains.

If remains of Native American origin are discovered during proposed project construction, it shall be necessary to comply with state laws concerning the disposition of Native American burials, which fall within the jurisdiction of the Native American Heritage Commission (NAHC). If any human remains are discovered or recognized in any location other than a dedicated cemetery, there shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until:

- the County coroner has been informed and has determined that no investigation of the cause of death is required; and
- if the remains are of Native American origin:
  - the most likely descendants of the deceased Native Americans have made a recommendation to the landowner or person responsible for the excavation work for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in Public Resource Code (PRC) 5097.98; or
  - the NAHC has been unable to identify a descendant or the descendant failed to make a recommendation within 24 hours after being notified.

According to the California Health and Safety Code, six or more human burials at one location constitute a cemetery (Section 8100) and disturbance of Native American cemeteries is a felony (Section 7052). Section 7050.5 requires that construction or excavation be stopped in the vicinity of discovered human remains until the coroner can determine whether the remains are those of a Native American. If the remains are determined to be Native American, the coroner must contact the NAHC.

The Native American Grave Protection and Repatriation Act (NAGPRA) provides for discoveries on federal or Indian land. If the discovery occurred in connection with an activity, including (but not limited to) construction, mining, logging, and agriculture, the person shall cease the activity in the area of the discovery, make a reasonable effort to protect the items discovered before resuming such activity, and provide notice under 43 CFR 10. Following the notification under this subsection, and upon certification by the Secretary of the department or the head of any agency or instrumentality of the United

States or the appropriate Indian tribe or Native Hawaiian organization that notification has been received, the activity may resume after 30 days of such certification.

4.4.2.2 Alternative 2: No Action

The No Action alternative would result in no impact on cultural resources.

4.5 Geology and Soils

This section provides a brief overview of the geology and soils of the project site and its surroundings. This includes a discussion of the potential for the project to induce seismic events. A detailed analysis of the potential for induced seismicity.

The environmental setting and impact analysis for geology and soils were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Final Supplemental EIR, 2002. Lake County Sanitation District and Northern California Power Agency.
- Induced Seismicity Report, Engineered Geothermal System Demonstration Project, Northern California Power Agency, the Geysers, CA. Greensfelder, Roger; Cladouhos, Trenton, and Jupe, Andy. November 17, 2008. (see Appendix B).

4.5.1 Existing Conditions

4.5.1.1 Environmental Conditions

The GGF is located in the Mayacmas Mountains within the Coast Ranges geomorphic province. As discussed in *Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Final Supplemental EIR*, 2002 (2002 Supplemental EIR), this province of geologic features of similar bedrock, structure, and age is characterized by northwest trending ridges and steep canyons. The GGF is located on the ridge that runs along the Lake County/Sonoma County line. The topography in the area is rugged, with elevations up to 3,600 feet.

The Mayacmas Mountains are composed primarily of marine sedimentary and volcanic rocks of the Franciscan Assemblage which are capped and intruded into by the volcanic Clear Lake Formation. The Franciscan Formation is composed primarily of greywacke, shale, and basalt, while the Clear Lake Formation includes basalt and rhyolite. The bedrock underlying the Geysers is intensely folded and faulted as a result of the forces of uplift that formed the Coast Range.

The existing GGF steam reservoir consists mainly of fractured greywacke (a hard, dark sandstone containing quartz, feldspar, and small rock fragments in a compact, clay-fine matrix), underlain by intrusive felsite (a fine-grained igneous rock containing quartz and feldspar). The existing GGF steam reservoir is presumed to be the result of heating of these rocks by deep magma chambers beneath the felsite. As discussed in the 2002 Supplemental EIR, the permeable fractures within the existing GGF reservoir are randomly oriented, and there are no preferential paths for fluid movement within the reservoir.

The E-pad is an engineered pad that has previously been graded level and covered with a layer of compacted fill material. No natural soil remains on the surface of the project site.

The 2002 Supplemental EIR describes the seismic setting of the GGF in some detail. Section 3.2 of that document, "Geology, Soils, and Seismicity," and the responses to the comments from the Anderson Springs Geothermal Monitoring Task Force are hereby incorporated by reference. Any inconsistencies between that section and responses to comments, and the Induced Seismicity report are to be resolved in favor of the latter. The Induced Seismicity report is more recent and site/project specific than the 2002 Supplemental EIR.

As explained in 2002 Supplemental EIR, the region is crossed by numerous active and potentially active faults (see Figure 4-1, Principal Active Faults in the Project Vicinity). "Active," as used by the California Geological Survey, means that the fault has shown movement during Quaternary time (i.e., the past 11,500 years). The primary active or potentially active faults in the region include the Anderson Springs Fault, the complex of faults in the vicinity of Mount Konocti, the Maacama Fault, the Barlett Springs Fault, and the Rodgers Creek Fault.

The active Maacama Fault is located approximately 4 miles southwest of the GGF, and the active Rodgers Creek Fault is approximately 12 miles south of the GGF. Both are capable of generating earthquakes of 6.6 and 7.0 Magnitudes on the Richter scale, respectively (ABAG 2009). The active Mount Konocti fault complex is approximately 6 miles from the GGF and was responsible for a 4.4 Magnitude earthquake in 1954 and two other quakes in 1955 with Magnitudes of 3.6 and 5.0. The Bartlett Springs Fault, approximately 24 miles east of the GGF, is considered active and was associated with an earthquake of approximate Magnitude 5.

Potentially active faults include the Collayami Fault, about 10 miles northwest of the Maacama Fault. The Big Valley Fault, located northeast of the GGF is considered to be a prominent minor fault at the extremity of the Collayami.

The GGF is located in a seismically active area, with numerous micro-earthquakes (i.e., those having Magnitudes of less than 3.0) occurring on a monthly basis. At the same time, relatively few earthquakes greater than a Magnitude of 4.0 have been generated here. Studies of seismicity at the GGF have generally concluded that seismicity has been induced by production of steam and injection of water related to the geothermal energy facilities.

The mechanism responsible for these micro-earthquakes is believed to be movement within the fractured rock that makes up the existing steam reservoir. The removal of steam and injection of water during facility operations creates an environment within the reservoir whereby the relief of stresses results in micro-earthquakes. This micro-earthquake activity is not a result of movement along the nearby faults, and there is no evidence that production and injection activities have any effect on the nearby faults. The 2002 Supplemental EIR concluded that "considering that the fluid does not preferentially enter faults at depth, neither the existing nor the proposed project [which included increased injection into the existing steamfield] can be considered to contribute to the risk of surface rupture along potentially active faults."

The induced seismicity report prepared for the project notes that the largest seismic events of the past 12 years in the NCPA area occurred within the Big Sulphur Creek Fault Zone (BSCFZ), which is not considered active at the surface but does form the southwestern boundary of the GGF steam reservoir. Because the BSCFZ is outside of the areas of water injection and steam production, the BSCFZ seismic events are also considered to be tectonic and unrelated to past injection activities.

4.5.1.2 Regulatory Conditions

Federal

The project site is located on public land managed by the BLM and administered under its Ukiah Field Office's Resource Management Plan. There are no federal regulations related to geology or seismicity that apply to this project.

State

The Alquist-Priolo Earthquake Fault Zone Act (PRC Section 2621, et seq.) was enacted to reduce the hazard of fault rupture to structures intended for human occupancy. It requires the State Geologist to identify active faults within California and establishes restrictions on development within zones along those faults. A geologic study must be prepared prior to development to specifically locate the fault or fault traces within a given fault zone. Any structure intended for human occupancy must be located so that it does not cross a mapped fault or fault trace. Because the project does not include structures intended for human occupancy, the Alquist-Priolo Act does not apply to this project.

The Seismic Hazards Mapping Act (PRC Section 2690, et seq.) is intended to reduce hazards from strong ground shaking, liquefaction, landslides, and other ground failures from earthquakes. The State Geologist is required to identify various hazard zones and requires cities and counties to restrict certain development within those zones. The area around the GGF has not been mapped in accordance with the Seismic Hazards Mapping Act. As with the Alquist-Priolo Act, the development being proposed by this project is not subject to the Act.

The California Building Code (Title 24, California Code of Regulations) regulates construction within the state. The Code does not apply to temporary drilling rigs or to office trailers. Because those are the only structures expected to be on the site, this Code is not applicable to the project.

4.5.2 Environmental Effects

For CEQA purposes, significance criteria were developed based on the State CEQA Guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects are considered significant if they would result in a new or

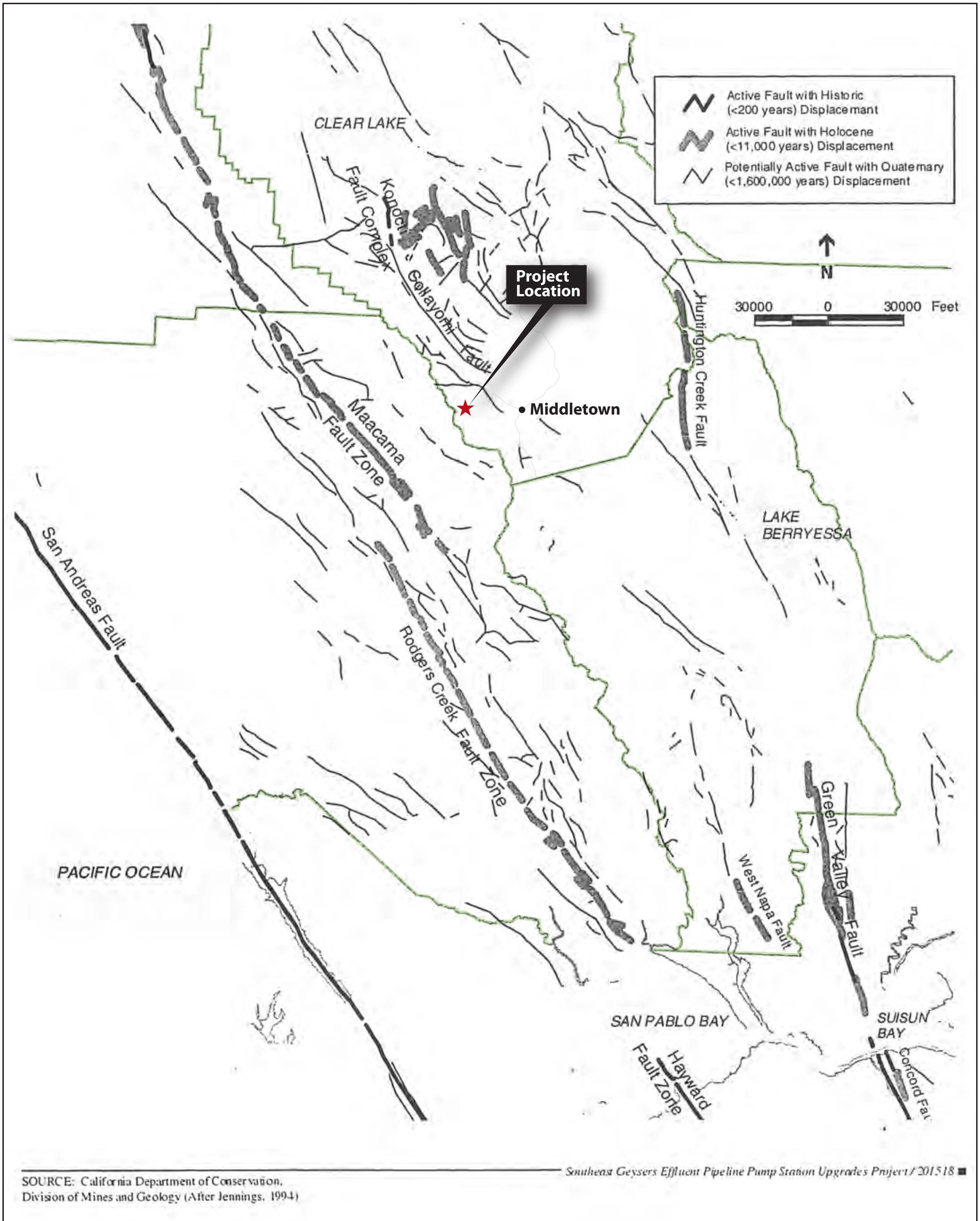

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Figure 4-1
Principal Active Faults in the Project Vicinity

more severe significant geologic effect that was not analyzed in the 1994 Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS nor the 2002 Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Final Supplemental EIR. The significance conclusions in those prior EIRs and EISs are shown in parentheses.

The Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS identified the following effects:

- **Impact 5.3.1.1**: The proposed injection of effluent could double the recovery rate of injection derived steam (IDS) within several years in Calpine, NCPA, and Unit 18&20 of Unocal leaseholds. (Significant Beneficial Impact)
- **Impact 5.3.1.2:** The proposed injection of effluent would slow the rate of decline in the Low Pressure Area (LPA) but would not change its special extent. (Significant Beneficial Impact)
- **Impact 5.3.1.3:** The proposed injection of effluent would be compatible with the chemistry of reservoir geothermal fluids and, therefore, would not have significant adverse impacts on geothermal field and power plant operations. (Less-than-Significant Impact)
- **Impact 5.3.2.1:** The project would result in increased microseismicity in the project area and vicinity, but probably would not induce larger earthquakes that pose a substantial threat to public safety and substantial damage to structures. (Less-than-Significant Impact)
- **Impact 5.3.2.2:** The project probably would not result in significantly increased hazards of major earthquakes, but project-related induced seismicity potentially could contribute to minor local property damage, e.g. cosmetic cracks in plaster and stucco. (Less-than-Significant Impact)

The Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Final Supplemental EIR identified the following effects:

- **Impact 3.2-1:** The proposed project could increase the annual number and frequency of earthquakes that result from induced microseismicity related to production and injection of water at The Geysers steamfield. (Less-than-Significant Impact)
- **Impact 3.2-2:** The project area is subject to surface fault rupture from active faults. (Less-than-Significant Impact)
- **Impact 3.2-3:** Proposed project facilities could be subject to slope failure. (Less than Significant with Mitigation)
- **Impact 3.2-4:** Construction activities involving soil disturbance, such as excavation, stockpiling and grading, could result in increased erosion and sedimentation to surface waters. Additionally, release of fuels or other hazardous materials associated with construction activities could degrade water quality. (Less than Significant with Mitigation)

4.5.2.1 Alternative 1: Proposed Project

The proposed project would deepen well E-7 to access the felsite formation below the existing steam reservoir and inject water through a proprietary process in an attempt to expand existing fractures in that formation. The hydraulic pressure will be high enough to cause existing fractures to open slightly and slip. This process is referred to as “shear dilation,” a combination of fracture-parallel shear movement and fracture-perpendicular opening. It would result in a network of small, interconnected fractures that will act as an underground heat exchanger and allow the heat to be removed from the rock by circulating water through it repeatedly. The hydraulic pressure will not be high enough to exceed the tensile strength of the rock and create new fractures. If successful, water injection would continue during a test period. If tests indicate that a new, geologically separate reservoir has been created, production well E-8 would be drilled elsewhere on the E-pad to intersect the fracture zones. Steam production from well E-8 would be monitored for the purpose of determining whether there is sufficient production to warrant supplying the existing NCPA power plants.

All work would occur on the existing E-pad. There would be no new slope cuts, excavation outside of the E-pad, or road construction undertaken as part of the project. All required permits would be obtained from the BLM and others prior to work.

Impacts 5.3.1.1, 5.3.1.2, and 5.3.1.3 are not applicable to the project. Its objective is to create a new steam reservoir at greater depth than the existing reservoir. If successful, that new reservoir would provide a new source of heat and steam for the NCPA power plants that would extend their productive lifespans. The project would not inject fluids into the existing reservoir and so the compatibility of fluids is not relevant.

Impacts 5.3.2.1, 5.3.2.2, and 3.2-1 relate to the proposed project in that, like current injection and production activities, the project is likely to result in micro-earthquake activity. As discussed in the induced seismicity report prepared for the project (see Appendix B), the objective of the project is to produce an engineered reservoir at depth by pumping water at a moderate pressure into a wellbore to create a system for fluid flow to pick up heat from the surrounding rock.

As discussed in the induced seismicity report in Appendix B, the level of microseismic activity would not be substantially greater than under current conditions. As a result, there would be no new or more severe significant effect:

> Using predicted injection rates for both phases of the EGS Demo Project (25 barrels/minute - 66 l/s [liters per second] for 21 days of hydroshearing in a single zone and 28 barrels/minute - 74 l/s for one month of circulation in three zones) gives 9 and 12 microseismic events per month with M>0.7 per year. As noted in section 3.1 [of the induced seismicity report], the ratio of normalized seismicity in the Calpine SE area and NCPA area is 0.29. Using that intensity correction predicts 3-3.6 microseismic events per month with M>0.7 for the hydroshearing and circulation phases of EGS, respectively. The applicability of the Parsons (2003a) equation to hydroshearing is in doubt, but it does provide one estimate of the numbers of microseismic events expected. Compared to the 1,000 microseismic events recorded in the GGF in 2007, 3 events during the hydroshearing month and 44 new microseismic events per year during the EGS production phase will have little discernible impact. (See page 39 of the report.)

The induced seismicity report in Appendix B goes on to state that it is also possible that there will be very little or no induced microseismic activity during the long-term production phase of the EGS Demo Project:

> The goal during the production phase will be to cause no additional shearing and the injection rate will be adjusted accordingly to ensure that no hydroshearing occurs. However, thermal contraction and some leak-off of fluid may cause some IS [induced seismicity] that can be estimated by the Parsons (2003a) equation reproduced in Section 4.1 above [of the induced seismicity report]. Using that statistically derived equation would predict 44 events per year in the magnitude range of 1.5 to 3.0 per hydrosheared interval. However, there will be no net increase in total injection across NCPA. When injection water is taken from wells that apply it to the Geysers-normal reservoir above the felsite, the seismicity at those depths will decrease. This was documented in the seismicity maps of Preiss et al. (2002). For example, in 1989, geothermal power plant Unit No. 15 in the southwest part of GGF was shut down and microseismicity abated soon after. Thus there may be an increase in IS of 44 events/year during the long-term data collection and monitoring of the EGS Demo Project, but that increase should be offset by a comparable decrease in IS in the Geysers-normal reservoir. It is also possible that there will be very little or no IS during the long-term production phase of the EGS Demo Project. However, long-term records of microseismicity are not available because few EGS projects have operated for periods longer than six months. (See page 41 of the report)

The Induced Seismicity report considered the possibility that injection resulting from the EGS activity would result in an increase in subsurface seismic hazard. It concluded that "[g]iven our understanding of the geology of the EGS Demo Project and the seismic hazards assessment conducted, it seems unlikely that a single EGS microseismic event could exceed M[agnitude]=2.3…."

The Induced Seismicity report also undertook a seismic hazards risk assessment for the community of Anderson Springs. It reached the following conclusion:

> The results indicate that the probable maximum annual seismic event shaking expected in Anderson Springs corresponds to [a Modified Mercali Intensity] MMI=III-IV due an EGS-induced event of M-3.0. In order for shaking to reach to the next intensity level, MMI=V, would require a seismic event with a M-4.0... Importantly, the numbers of seismic events and microseismicity from the EGS Demo Project is fully expected to be within the range of present levels experienced at Anderson Springs.

There is no evidence that Impact 3.2-2 would be more severe than under current activities. As discussed above, micro-earthquake activity is not a result of movement along the nearby faults, and there is no evidence that production and injection activities have any effect on the nearby faults. The induced seismicity report prepared for the project notes that the largest seismic events of the past 12 years in the NCPA area occurred within the BSCFZ, which is not considered active at the surface but does form the southwestern boundary of the GGF steam reservoir. An 8-station microseismic sensor array is in place to allow mapping of the engineered reservoir as hydroshearing proceeds. A buffer zone would be maintained to prevent interaction between the zone of hydroshear-induced dilation and the fault zone. If the hydroshear dilated fractures do not grow in the desired direction or the BSCFZ buffer is approached, the hydraulic injection would be modified to correct the growth direction. This would avoid the possibility of surface rupture from active faults. As a result, there would be no new or more severe significant effect.

The proposed Project would not alter any existing slopes and would take place on the existing, engineered E-pad. Therefore, Impact 3.2-3 is not relevant.

Impact 3.2-4 is relevant to the project in that it would utilize drilling fluids and other materials during drilling. It would not, however, result in grading or substantial surface disturbance beyond what already occurs during maintenance of NCPA injection and production facilities. Mitigation Measure 3.2-4 Storm Water Pollution Prevention Plan described in the 2002 Supplemental EIR, as modified below, would apply to this project. As a result, the impact would not be more severe than discussed in the prior EIS and EIRs.

Mitigation Measure 3.2-4: Storm Water Pollution Prevention Plan.

NCPA shall require contractors to develop a SWPPP for construction of proposed facilities (i.e., well drilling), as required by the RWQCB. The objectives of the SWPPP are to identify pollutant sources that may affect the quality of storm water discharge and implement Best Management Practices to reduce pollutants in storm water discharges. The SWPPP for this proposed action would include the implementation, at minimum of the following elements:

- Source identification;
- Preparation of a site map;
- Description of construction materials, practices, and equipment storage and maintenance;
- List of pollutants likely to contact storm water;
- Estimate of the construction site area and percent impervious area;
- Erosion and sediment control practices, including soils stabilization, revegetation, and runoff control to limit increases in sediment in storm water runoff, such as detention basins, straw bales, silt fences, check dams, geofabrics, drainage swales, and sandbag dikes;
- Proposed construction dewatering plans;
- List of provisions to eliminate or reduce discharge of materials to storm water;
- Description of waste management practices;
- Maintenance and training practices; and
- Sampling and analysis strategy and sampling schedule for discharges from construction activities.

4.5.2.2 Alternative 2: No Action

The No Action alternative would result in no change in existing conditions and therefore no adverse effects related to geology and soils.

4.6 Hazards and 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.

The environmental setting and impact analysis for hazards and hazardous materials were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.
- U.S. Department of the Interior, Geological Survey Conservation Division, Geothermal Resources Operational Order Number 2, 1975.
- California Department of Toxic Substances Control, EnviroStor Hazardous Waste and Substances Site List, 2008.

4.6.1 Existing Conditions

4.6.1.1 Environmental Conditions

The proposed project would occur in an area that contains naturally occurring asbestos and mercury. Ongoing operations and maintenance of the steam collection and power generation equipment associated with the project require the use of various industrial hazardous substances and fuel. Improper storage, use, or disposal of these substances would cause environmental contamination.

4.6.1.2 Regulatory Conditions

Federal

The project site is located on public land managed by the BLM, which has designated the site for the production of geothermal power.

State and Local

Cuttings and other wastes produced from geothermal drilling activities are required by the Regional Water Quality Control Board (RWQCB) to be disposed of in approved sites, as the wastes often contain elevated levels of heavy metals, petroleum products, and chemicals used to thicken drilling mud.

LCAQMD also has a variety of regulations related to drilling where naturally occurring asbestos may occur, as well as the production of dust.

4.6.2 Environmental Effects

For CEQA purposes, significance criteria were developed based on the State CEQA Guidelines as well as professional standards and practices. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would:

- create a hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials;
- create a hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials to the environment;
- emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school;
- be located on a site that is on a list of hazardous materials sites compiled pursuant to California Government Code 65962.5, and as a result would create a significant hazard to the public or the environment;
- be located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport, and result in a safety hazard for people residing or working in the project area;
- be located within the vicinity of a private airstrip and result in a safety hazard for people residing or working in the project area;
- impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan; or
- expose people to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands.

4.6.2.1 Alternative 1: Proposed Project

The deepening of well E-7 and the drilling well E-8 will employ sumpless drilling rig operations. Thus, no excavation of asbestos-containing serpentine rock (at least as contemplated by the LACQMD regulations) is proposed. The drilling process may encounter serpentine-containing rocks, but the control of any potential emissions are handled in the site-specific permits issued by the LACQMD pursuant to Mitigation Measure 5.2.10.1.A, below.

Improper use, storage, or disposal of hazardous substances used in project construction and long-term operation, such as fuel, oil, solvents, motor oil and hydraulic fluids, could expose workers to hazardous substances and cause environmental contamination. If improperly used or stored, these materials can cause environmental contamination and expose workers to health hazards. This would be an adverse impact, but is mitigable.

The proposed project has the potential to create a hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. This is an adverse effect, but is mitigable.

The project site is several miles from the nearest school. It is not located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5. It is not located within any airport land use plan area or within two miles of a public airport or public use airport, nor is it located within the vicinity of a private airstrip.

As part of its RPM, the BLM's Ukiah office has developed a fire prevention and management plan for its resource areas, including the Geysers Management Area. The proposed project would not introduce residences to the project area, and existing or temporary facilities would be used for operation of the new geothermal energy drilling equipment. No people would be exposed to wildfire, and a minimal number of structures would be exposed to a risk of loss, injury, or death involving wildland fires. With the implementation of the BLM's fire management plan, there would be no adverse effect.

Solid waste generated by the proposed project would occur during the deepening of well E-7 and the creation of well E-8. If discharged to the ground, cuttings and other wastes produced from geothermal drilling activities are required by the RWQCB to be disposed of in a clay-lined sump which is usually constructed adjacent to the drilling pad. The wastes in the sump often contain elevated levels of heavy metals, petroleum products, and chemicals used to thicken drilling mud. Once drilling is complete, the sump is capped and the wastes inside are isolated from the environment as long as they are tested and determined to not be characteristically hazardous and the clay liner is intact. However, drilling conducted as part of the proposed project would utilize "sumpless" drilling techniques, in which dewatered cuttings are discharged into metal tanks and disposed of offsite in approved waste disposal sites. The 1994 EIR/EIS analysis found that by disposing of such waste in approved sites, there would be no adverse effects related to solid waste disposal. This analysis remains accurate.

Impact HAZ-1: Excavation without the proper dust control and work safety measures would result in the release of asbestos fibers and possibly heavy metal–containing dust into the air and expose workers to a health hazard.

Compliance with applicable mitigation measures from the 1994 EIR listed below when excavating serpentine material containing more than state Title 22, Section 66261 limits (even if the level of asbestos is below 1%), combined with additional worker safety training on the hazards of mercury-containing material, would provide adequate worker protection, and there would be no adverse effect related to excavation of hazardous materials.

> **Mitigation Measure 5.2.10.1.A: The construction contractors shall comply with LCAQMD regulations for the excavation of serpentine rock in Lake County and meet the LCAQMD performance goals.**
>
> LCAQMD regulations for the excavation of serpentine material are contained in LCAQMD Regulations Section 467. The regulations require that serpentine material be analyzed for asbestos and that dust mitigation and construction management plans be

developed and approved by the LCAQMD prior to excavation. There is a performance goal of "no visible emissions" and requirement of not exceeding a visible opacity of greater than 5%. Water or other control measures may be used to meet the dust mitigation requirements.

Mitigation Measure 5.2.10.1.B: The construction contractors shall 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 personal protective equipment by workers when asbestos levels exceed 0.2 asbestos fibers per cubic centimeter of ambient air.

Mitigation Measure 5.2.10.1.C: Any serpentine material encountered in disturbance areas prior to or during construction shall be analyzed for heavy metals.

If the levels of the metals exceed the state CCR Title 22, Section 66261 limits, the construction contractor shall comply with the hazardous waste worker safety requirements. Any serpentine soil excavated that contains both asbestos and heavy metals in excess to the state Title 22, Section 66261 limits shall not be disposed as side cast. The material should be handled and disposed of in a manner to minimize to potential for short-term and long-term dust generation. LCAQMD and the Lake County Department of Environmental Health shall approve the method of disposal. Hazardous substance worker safety regulations are found in 40 CFR 262,29 CPR 1910, and other federal and state Title 22 regulations. In general, the regulations require safety training for workers, the use of engineering controls to reduce worker exposure to hazardous materials, and the use of appropriate personal protective equipment to reduce worker exposure.

Impact HAZ-2: Improper use, storage, or disposal of hazardous substances used in project construction and long-term operation, such as fuel, oil, solvents, motor oil and hydraulic fluids, could expose workers to hazardous substances and cause environmental contamination.

If improperly used or stored, hazardous substances used in project construction and long-term operation can cause environmental contamination and expose workers to health hazards. By complying with applicable mitigation measures from the 1994 EIR, listed below, there would be no adverse effects associated with this impact.

Mitigation Measure 5.2.10.4.A: The construction contractors, Lake County Sanitation District (LACOSAN) and the geothermal operators must comply with all federal, state, and local hazardous substance regulations.

Mitigation Measure 5.2.10.4.B: The construction contractors, LACOSAN and geothermal operators shall service construction equipment only on impermeable surface with spill containment features.

Motor oil and hydraulic fluid are commonly spilled when heavy equipment is serviced. If the equipment is serviced in the field, spills would contaminate the soil. If the equipment is serviced on an impermeable surface, spilled substances could be cleaned up using acceptable practices without causing environmental contamination.

Mitigation Measure 5.2.10.4.C: Any fuel wagon or temporary fuel storage structure used by the construction contractor in the field shall not leak and shall not release large amounts of fuel in case of a fuel hose rupture.

Fuel wagons are not regulated as strictly as permanent fuel storage tanks. Small leaks in the tanks on a fuel wagon are common in many areas. The release of just a few gallons per day of fuel can cause environmental contamination. Fuel wagons often are tempting targets for fuel thieves and vandals. Fuel hoses can be cut by thieves. Depending on design, unless the check valve is closed and secured, the contents of the wagon can drain through the cut hose and cause environmental contamination. A secure fuel wagon would discourage thieves and would prevent potential large fuel spills.

Mitigation Measure 5.2.10.4.D: The construction contractor and the geothermal operators shall instruct workers on the proper and safe procedures for disposal of hazardous wastes generated during project construction and long-term operation.

Documentation of the worker instruction shall be placed in the administrative file.

4.6.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects related to hazards and hazardous materials.

4.7 Hydrology and Water Quality

The existing conditions and environmental effects analysis for hydrology and water quality resources were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan/ Final Environmental Impact Statement,(June 2006) and Record of Decision (September

2006, Section 2.17 Water Resources). Bureau of Land Management and U.S. Department of the Interior.

- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.
- U.S. Department of the Interior, Geological Survey Conservation Division, Geothermal Resources Operational Order Number 2, 1975.
- Southeast Geysers Effluent Pipeline Pump Station Upgrade Project Supplemental EIR, 2002. Lake County Sanitation District and Northern California Power Agency.

4.7.1 Existing Conditions

4.7.1.1 Environmental Conditions

The project area is located in the high-lying portions of the Mayacmas Mountains. This area receives up to 80 inches of precipitation annually. The topography is rugged and runoff is quickly directed into stream channels. There is no snow pack during winter; intermittent snows melt off after a few days. Much of NCPA leasehold comprises headwaters of stream courses (Anderson, Bear Canyon, and Cub Canyon Creeks), and there are few large permanent streams. The streams are located at the bottoms of deep ravines.

Winter rainstorms result in rapid runoff in the area. The high flows flush sediments and debris from the watercourses. In summer, the flows are reduced. Most of the tributary water courses dry up within the area.

The Federal Emergency Management Agency (FEMA) delineates 100-year floodplains and publishes the information on Flood Insurance Rate Maps (FIRMs). According to the FIRM, the proposed project is not located within any special flood hazard areas.

Geothermal operations conducted at the NCPA portion of the GGF include the injection of geothermal condensate, onsite domestic wastewaters, collected rain waters, surface waters from Clear Lake, and advanced secondary treated wastewater effluent from the Lake County Special District's Southeast Regional Wastewater System (LCSDSRWS), in Lake County. Wastewater contributions from the LCSDSRWS are derived from the Southeast Regional and Middletown Treatment Plants, and from the Clear Lake Oaks County Water District.

4.7.1.2 Regulatory Conditions

Federal, State, and Local

The project site is located on public land managed by the BLM, which has designated the site for the production of geothermal power.

NCPA has a general Waste Discharge Permit (WDP), last revised and approved in 1998, addressing injection of effluent and condensate. NCPA reports periodically to the BLM, to the North Coast Regional Water Quality Board (NCRWQCB) and to the Central Valley Regional

Water Quality Control Board (CVRWQCB) on injection volumes. The BLM transfers the injection reports to the California Department of Oil, Gas and Geothermal Resources (DOGGR). The proposed project would operate under the existing NCPA WDP.

Clean Water Act

Important applicable sections of the federal CWA (United States Code (USC), title 33, sections 1251–1376) 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 United States to obtain certification from the state that the discharge will comply with other provisions of CWA. Certification is provided by the 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 U.S. Army Corps of Engineers.

4.7.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would cause:

- alteration in the quantity and quality of surface runoff;
- degradation of water quality;
- violation of any water quality standards or waste discharge requirements;
- substantial alteration of the existing drainage pattern of the site or area, such that flood risk and/or erosion and siltation potential would increase;
- placement of structures that would impede or redirect flood flows within a 100-year flood plain;
- exposure of people, structures, or facilities to significant risk from flooding, including flooding as a result of the failure of a levee or dam;
- creation of or contribution to runoff that would exceed the capacity of an existing or planned stormwater management system; or
- reduction in groundwater quantity or quality.

4.7.2.1 Alternative 1: Proposed Project

NCPA has a general WDP, last revised and approved in 1998, addressing injection of effluent and condensate. NCPA reports periodically to the BLM, to the NCRWQCB, and to the CVRWQCB on injection volumes. The BLM transfers the injection reports to the DOGGR. The proposed project would operate under the existing NCPA WDP.

Injection of water and disposal of waste discharge due to drilling would comply with all requirements outlined in the permit.

Injection into well E-7 and E-8 would be similar to the injection process analyzed in both the1994 EIR/EIS and the 2002 Supplemental EIR, and would not produce any new hydrology or water quality impacts. Any liquids produced by the production of geothermal power would be reinjected into well E-7 and recirculated. The proposed project would not violate any water quality standards or waste discharge requirements.

All water necessary for the proposed project would be supplied from the water capacity already permitted and supplied to NCPA, and no new water is required. Injection water for wells E-7 and E-8 would come from geothermal condensate, onsite domestic wastewaters, collected rain waters, surface waters from Clear Lake, and advanced secondary treated wastewater effluent from the LCSDSRWS. Wastewater contributions from the LCSDSRWS are derived from the Southeast Regional and Middletown Treatment Plants, and from the Clear Lake Oaks County Water District. No groundwater would be used for the proposed project, and therefore it would not substantially deplete groundwater supplies or interfere substantially with groundwater recharge, resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level.

The proposed project would not substantially alter the existing drainage pattern of the site, either through the alteration of the course of a stream or river. No streams or rivers exist on the project site. Therefore, the proposed project would not result in substantial erosion or siltation on- or off site.

The proposed project would not substantially alter the existing drainage pattern of the site or area either through the alteration of the course of a stream or river. No streams or rivers exist on the site. The proposed project would not include substantial additions of impermeable surfaces to the project site, and would therefore not substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off site.

All stormwater would run off into existing natural drainage systems, and therefore would not contribute to or exceed the capacity of existing or planned stormwater drainage systems.

Drilling activities that would occur during construction of the proposed project would result in soil disturbance that could temporarily increase erosion and sedimentation. Maintenance of equipment would require the use of hazardous materials such as gasoline, engine oil, and concrete, which could contaminate runoff and surface waters in the project area. Additionally, operational impacts of automobiles and other post-construction activities could potentially impact the beneficial uses of the receiving waterways. As discussed in Section 4.6, “Hazards and Hazardous Materials," this has the potential to result in an adverse effect, but is mitigable. With implementation of Mitigation Measures 5.2.10.4.A, 5.2.10.4.B, 5.2.10.4.C, and5.2.10.4.D, there would be no adverse effect.

As stated above, the NCPA currently has a WDP addressing injection of effluent and condensate. Injection of water and disposal of waste discharge would comply with all requirements outlined in this permit.

Injection into well E-7 and E-8 would be similar to the injection process analyzed in both the1994 EIR/EIS and the 2002 Supplemental EIR, and would not produce any new impacts. Any liquids produced by the production of geothermal power would be reinjected into well E-7 and recirculated. The proposed project would not violate any water quality standards or waste discharge requirements.

The proposed project does not include any housing units, and is not mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map.

The proposed project site is outside of any 100-year flood hazard area, and is not downstream of a major dam or levee. Therefore, the proposed project would not expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam.

Due to the lack of proximity of the project to the ocean or a large lake, and the project being located on crest of a mountain, the risk of exposing people or structures to a tsunami, seiche, and mudflow is very low.

Impact HYD-1: Drilling activities that would occur during construction of the proposed project would result in soil disturbance that could temporarily increase erosion and sedimentation.

Maintenance of equipment would require the use of hazardous materials such as gasoline, engine oil, and concrete, which could contaminate runoff and surface waters in the project area. Additionally, operational impacts of automobiles and other post-construction activities could potentially impact the beneficial uses of the receiving waterways.

With implementation of Mitigation Measures 5.2.10.4.A, 5.2.10.4.B, 5.2.10.4.C, and5.2.10.4.D, there would be no adverse effect.

4.7.2.2 Alternative 2: Proposed Project

The No Action alternative would result in no adverse effects on hydrology and water resources.

4.8 Land Use and Planning

The environmental setting and impact analysis for land use and planning resources was developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan/ Final Environmental Impact Statement, (June 2006) and Record of Decision (September 2006, . Bureau of Land Management and U.S. Department of the Interior.
- Lake County General Plan Land Use Designation Map, 2008.
- Lake County Zoning Designation Map, 2008.
- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.
- U.S. Department of the Interior, Geological Survey Conservation Division, Geothermal Resources Operational Order Number 2, 1975.

4.8.1 Existing Conditions

4.8.1.1 Environmental Conditions

The site is located on land with a Lake County General Plan designation of Public Lands, and a zoning designation of Open Space. However, the site is located on public land managed by the BLM, and is therefore not required to comply with local and state land use regulations. The BLM has designated the site as an area for the production of geothermal energy, and has issued permits for this activity to occur. The primary land uses in the project vicinity are geothermal mining uses and open space.

4.8.1.2 Regulatory Conditions

Federal

The RMP is the federal land use planning document that provides guidance of BLM activities to achieve the mission and goals outlined in the Department of Interior (DOI) Strategic Plan. In the planning processes, BLM utilizes the best information available in this decision making process.

State

As federally owned land, the site is not subject to local or state land use policies and regulations.

4.8.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would cause:

- physical division of an established community;

- conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction of the project adopted for the purpose of avoiding or mitigation an environmental effect; or
- conflict with any applicable habitat conservation plan or natural community conservation plan.

4.8.2.1 Alternative 1: Proposed Project

The proposed project would continue an existing land use. The project site is located in a rural area, dominated by open space and uses related to the production of geothermal energy. The nearest residence lies 1.8 miles to the north, in the vicinity of the small unincorporated community of Castle Rock Springs. The project would not affect or divide any established community.

The proposed project would not significantly alter the current use of the project site. The project site and other NCPA development activities have been granted permits by the BLM for the production of geothermal power, and is compatible with the BLM RMP for the Geysers Management Area. The project site is not subject to state and local land use policies. Therefore, the project would not conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project adopted for the purpose of avoiding or mitigating an environmental effect.

The project site is not located within the boundaries of any habitat conservation plan or natural community conservation plan.

There are no adverse effects related to land use associated with the project. No mitigation measures are necessary.

4.8.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on land use or planning.

4.9 Mineral Resources

The environmental setting and impact analysis for mineral resources were developed through a review of the following documents:

- Publications of the SMARA Mineral Classification Project Dealing with Mineral Resources in California, California Department of Conservation, 2001.
- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan/ Final Environmental Impact Statement, (June 2006) and Record of Decision (September 2006, . Bureau of Land Management and U.S. Department of the Interior.
- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.

- U.S. Department of the Interior, Geological Survey Conservation Division, Geothermal Resources Operational Order Number 2, 1975.

4.9.1 Existing Conditions

4.9.1.1 Environmental Conditions

The GGF, including the project site, is currently used for the production of geothermal power. The project site is located on public land managed by the BLM, and is not subject to local general plans, specific plans, or other local or state land use plans. The BLM has designated the use of this project site for the production of geothermal energy in its Ukiah Field Office's RMP.

4.9.1.2 Regulatory Conditions

Federal

The GGF and the project site are located on public land managed by the BLM, which has permitted the site to allow for the production of geothermal power. The Ukiah Office BLM's RMP states that BLM's goals for the Geysers Management Area are as follows:

- Provide necessary access to federal mineral resources for energy development (oil, gas, and geothermal) to meet public demand, while protecting the natural resources in the planning area.

In addition, the RMP addresses the larger Geysers Management Area, which encompasses the existing geothermal development and additional areas that may have potential for large-scale development. The RMP states that additional geothermal development within "the Geysers" area is anticipated to be fairly consistent with the current development seen in the rest of the existing field. The RMP also states that "development within this region is expected to be the most intense, with drilling of deep geothermal production and injection wells and the construction of four new power plants. Development will also include Enhanced Geothermal Systems (EGS), ancillary facilities such as pipelines, access roads, transmission intertie lines, and various minor structures to support operation and maintenance of the existing and new development." It also states that projects classified as EGS are very likely to happen at the Geysers over the next 20 years. These projects will occur on new lease areas as well as existing lease areas. Examples of EGS projects include, but are not limited to:

- Hydro-fracturing reservoir rock to increase permeability
- Acidizing to increase reservoir permeability
- Increase and improve injection to help sustain reservoir pressure

State

As federally owned land, the project site is not subject to local or state land use policies and regulations.

4.9.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would result in:

- the loss of availability of a known mineral resource that would be of value to the region and the residents of the state; or
- the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan.

4.9.2.1 Alternative 1: Proposed Project

The California Department of Conservation's California Geologic Survey has not produced a Surface Mining and Reclamation Act of 1975 Mineral Land Classification Report that documents the mineral resources in the project area. However, geothermal resources of value to the region and the residents of the state have been identified at the project site by the U.S. Department of the Interior. As discussed above, the project site is within the Geysers Management Area identified in the RMP adopted by the BLM Ukiah Field Office. As such, it is subject to BLM policies favoring the continued production of geothermal resources. These resources would be utilized as a result of the proposed project, which would create more access and greater use of the identified resource. Therefore, the proposed project would not result in the loss of availability of this resource, but greater utilization of it.

Geothermal mineral resources of local importance have also been delineated in Sonoma County's and Lake County's general plans. While the project site is not subject to local plans or policies, the project would result in the increased utilization of this designated mineral resource, not its loss of availability.

There are no adverse effects related to mineral resources associated with the project. No mitigation measures are necessary.

4.9.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on mineral resources.

4.10 Noise

The environmental setting and impact analysis for noise was developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.

- U.S. Department of the Interior, Geological Survey Conservation Division, Geothermal Resources Operational Order Number 2, 1975.
- Lake County General Plan, 1981. Lake County.
- Lake County Zoning Ordinance, Article 41: General Performance Standards, 2008. Lake County.

4.10.1 Existing Conditions

4.10.1.1 Environmental Conditions

Noise-sensitive land uses are defined as uses that can be adversely affected by high levels of noise (e.g., sleep disturbance, annoyance). Residences, schools, hospitals and nursing homes, and other areas of similar use are often considered to be sensitive to noise. There are no noise sensitive land uses in the project area. The nearest residence to the project site is approximately 1.8 miles to the north, in the unincorporated communities of Castle Rock Springs and Anderson Springs. The next nearest town, Middleton, is located 4 miles to the east.

Geothermal development in the southern portion of the County includes a wide variety of intrusive noise sources, some relatively constant and others intermittent. In the GGF, the noise environment is affected by geothermal resource operations. 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).

The major sources of noise at the power plants are cooling towers, turbine generators, steam jet ejectors, and pumping gear. The movement of steam through the steam lines and venting of steam lines also generates considerable noise. Noise associated with bleed line discharges is about 85 dBA (A-weighted decibels) but can be lowered to about 65 dBA by venting the line into a rock-filled concrete structure (muffler).

Typically, the loudest noise source while drilling a well is the air compressors (used while drilling with air), which can generate noise levels up to 91 dBA at 50 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 of this magnitude. Both of these events are very rare, especially the well blowout, which is an uncontrolled flow event. The project would employ one drilling rig.

4.10.1.2 Regulatory Conditions

Federal

. The RMP does not specifically address noise impacts and issues.

Local

As noted elsewhere, the project is not subject to local land use regulations. However, these local standards can provide an indicator of a project's potential for significant impact. The Lake County Zoning Ordinance (Section 41.11) states that from 7 a.m. to 10 p.m., the maximum 1-hour equivalent sound pressure levels are 55 dBA if the receiving site is zoned residential; 60 dBA if the receiving site is zoned commercial, and 60 dBA if the receiving site is zoned industrial. From 10 p.m. to 7 a.m., the maximum 1-hour equivalent sound pressure levels are 45 dBA if the receiving site is zoned residential; 55 dBA if the receiving site is zoned commercial, and 60 dBA if the receiving site is zoned industrial. Noise levels due to construction site sounds from 7 a.m. to 7 p.m. are not regulated.

4.10.2 Environmental Effects

For CEQA purposes, significance criteria are based upon the State's CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were considered significant if they would:

- expose persons to or generates noise levels in excess of standards established in the local general plan, noise ordinance, or applicable standards of other agencies;
- expose persons to or generate excessive ground-borne vibration or ground-borne noise levels;
- create substantial permanent increase in ambient noise levels in the project vicinity above noise levels existing without the project;
- create a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project;
- be located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, and expose people residing or working in the project area to excessive noise levels; or
- be located within the vicinity of a private airstrip, and expose people residing or working in the project area to excessive noise levels.

4.10.2.1 Alternative 1: Proposed Project

Project construction would include the operation of one drilling rig, which would generate noise. Use of the drilling rig to deepen and complete well E-7 and to drill and complete well E-8 would be essentially the same as is currently done on a routine basis at the GGF for well drilling and maintenance. Operation of the drilling rig would not result in new or more severe adverse effects than considered in the 1994 EIR/EIS. Noise levels of 91 dBA generated by drilling of the wells would be expected to attenuate to 55 dBA at 3,200 feet (1.25 miles), and would likely attenuate down to less than 46 dBA at the nearest residence (1.8 miles away). Thus, the project would not have the potential to expose persons to noise levels in excess of standards established in the local general plan, noise ordinance, or applicable standards of other agencies.

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 site would be relatively small, and the duration that any one road would be used for construction purposes would be brief.

As described above, the operation of wells E-7 and E-8 would not permanently increase ambient noise levels in the project vicinity above existing levels. The operation of well E-7 already produces a certain level of noise, and the operation of well E-8 would not substantially increase this level.

The proposed project is not located within an airport land use plan area, or within 2 miles of a public airport or public use.

The proposed project is not located in the vicinity of a private airstrip. There would be no impact.

Impact NOI-1: Project construction and operation of the drilling rig used to deepen and complete well E-7 and to drill and complete well E-8 generate noise levels in excess of local standards.

This effect would not have the potential to expose persons to or generate noise levels in excess of standards established in the local zoning ordinance. As noted above, the closest sensitive receptor is approximately 1.8 miles from the site and would not be exposed to noise in excess of the adopted County zoning standard as a result of the project. Operation of the drilling rig would not result in new or more severe adverse effects than considered in the 1994 EIR/EIS.

The applicable noise mitigation measures from the 1994 EIR/EIS, outlined below, would be applied to the project.

> **Mitigation Measure 5.2.5.1.A: The construction contracts shall specify that noisy construction activities (including heavy truck trips on local roadways, but not including highways) are to be limited to 8:00 a.m, to 6:00 p.m., Monday through Saturday.**
>
> **Mitigation Measure 5.2.5.1.B: The construction contracts shall specify that construction equipment powered by internal combustion engines must be equipped with best available mufflers.**
>
> **Mitigation Measure 5.2.5.1.E: The construction plan shall identify all construction yards and staging areas. The construction yards/staging areas shall be located as far as practicable away from existing residences and schools. Other construction yards/staging areas shall not be permitted.**
>
> The construction yards/staging areas shall be located as far as practicable away from existing residences and schools. Other construction yards/staging areas shall not be permitted. With a substantial buffer distance between the construction yard or staging area and residences and schools, nuisance impacts would be less likely.

Mitigation Measure 5.2.5.1.F: All vehicles and heavy equipment used on-site shall be adequately muffled to comply with Motor Vehicle Code requirements.

Mitigation Measure 5.2.5.1.G: Adjustable backup beepers (when required by law) shall be set to the lowest allowable levels.

Mitigation Measure 5.2.5.1.H: In the event substantive noise complaints are received, the project sponsors shall submit a noise control plan for review and approval by the Lake County Noise Control officer.

This noise control plan may require reduced hours of construction or other noise mitigation measures.

4.10.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects related to noise.

4.11 Population and Housing

The existing conditions and environmental effects analysis for population and housing resources were developed through a review of the following documents:

4.11.1 Existing Conditions

4.11.1.1 Environmental Conditions

The GGF and the project site are located in a rural, mountainous area dominated by geothermal energy production facilities and open space. The nearest residence lies 1.8 miles to the north, in the vicinity of the small unincorporated communities of Castle Rock Springs and Anderson Springs. The closest town is Middleton, located approximately 4 miles to the east.

4.11.1.2 Regulatory Conditions

Federal

State

As federally owned land, the site is not subject to local or state land use policies and regulations.

4.11.2 Environmental Effects

For CEQA purposes, the effects on population and housing as a result of implementing the proposed project were analyzed based on the significance criteria set forth in the State CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were found to be significant if the project would:

- induce substantial population growth in an area, either directly or indirectly;
- displace substantial numbers of existing homes, necessitating the construction of replacement housing elsewhere;
- disrupt or divide an established low-income or minority community; or
- displace substantial numbers of people, necessitating the construction of replacement housing elsewhere.

4.11.2.1 Alternative 1: Proposed Project

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA's service area. However, it is uncertain if the proposed project will create a viable source of power and produce commercial amounts of steam. Even if it does create a viable source of power, it remains uncertain how much power would be generated. It can also be reasonably assumed that if power is generated by the proposed project, it would not be enough to induce substantial population growth.

No housing units exist on the project site, and the project would not require the demolition or displacement of any housing units. The nearest residence is 1.8 miles to the north.

There are no adverse effects related to population and housing associated with the project. No mitigation measures are necessary.

4.11.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects related to population and housing.

4.12 Public Services

The existing conditions and environmental effects analysis for public services resources were developed through a review of the following documents:

- Bureau of Land Management Ukiah Field Office Proposed Resource Management Plan and Final Environmental Impact Statement, 2006. Bureau of Land Management and U.S. Department of the Interior. (Section 4.5.11, page 4-46)

4.12.1 Existing Conditions

4.12.1.1 Environmental Conditions

The GGF and the project site are located in a rural, mountainous area dominated by geothermal energy production facilities and open space. The nearest residence lies 1.8 miles to the north, in the vicinity of the small unincorporated communities of Castle Rock Springs and Anderson Springs. The closest town is Middleton, located approximately 4 miles to the east.

4.12.1.2 Regulatory Conditions

Federal

The RMS does not address public services. The EIS prepared for the RMS indicates that geothermal development would result in negative impacts on such social and economic conditions as traffic, noise and induced seismicity. Those impacts are discussed elsewhere in the EA/IS.

State

As federally owned land, the site is not subject to local or state land use policies and regulations.

4.12.2 Environmental Effects

For CEQA purposes, effects on public services as a result of implementing the Proposed Project were analyzed based on the significance criteria set forth in the State CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were found to be significant if the project would:

- Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities or a need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the following public services:
  - Fire protection,
  - Police protection,
  - Schools,
  - Parks, or
  - Other public facilities.

4.12.2.1 Alternative 1: Proposed Project

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population growth and consequent demand for public services. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA’s service area and consequent increased demand for public services. However, it is uncertain whether the proposed project will create a viable source of power and produce commercial amounts of steam. If it did create a viable source of power, it remains uncertain how much power would be generated. It can also be reasonably assumed that if power is generated by the proposed project, it would be sold over a large market area. By itself, this additional power would not be enough to induce substantial population growth, and therefore would not result in a substantial increase in demand for public services. The project would therefore not cause substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities or a need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts.

There are no adverse effects related to public services associated with the project. No mitigation measures are necessary.

4.12.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on public services resources.

4.13 Traffic and Transportation

4.13.1 Existing Conditions

4.13.1.1 Environmental Conditions

Access to the project site is by private roads operated by the GGF. No private access is allowed. The operators of the GGF, including NCPA, coordinate with local emergency service providers to ensure emergency access to the site if it is needed. Roads used to access the GGF and the project site are used entirely for maintenance of, operation of, and improvements to geothermal energy production facilities. Access to the site is by way of Highway 175, a state highway, and Socrates Mine Road. Both of these facilities have low traffic volumes. In addition to providing access to the NCPA facility, Socrates Mine Road serves a number of single-family homes and other facilities at the GGF. Lake County has not established Level of Service Standards for either Highway 175 or Socrates Mine Road.

4.13.1.2 Regulatory Conditions

Federal

The RMP does not address transportation. State

As federally owned land, the site is not subject to local or state land use policies or regulations.

4.13.2 Environmental Effects

For CEQA purposes effects on traffic and transportation as a result of implementing the proposed project were analyzed based on the significance criteria set forth in the State CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were found to be significant if the project would:

- cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system;

- exceed either individually or cumulatively, a level of service standard established by the by the county congestion management agency for designated roads and highways;
- result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks;
- substantially increase hazards due to a design feature or incompatible uses;
- result in inadequate emergency access;
- result in inadequate parking capacity; or
- conflict with adopted policies, plans, or programs supporting alternative transportation.

4.13.2.1 Alternative 1: Proposed Project

The proposed project would be accessed on existing private roads. These roads are inaccessible to the public, and used entirely for maintenance, operation, and improvements to existing geothermal energy production facilities. Construction vehicle access to the site would have no effect on surrounding traffic patterns, and would be temporary. The operation of the project would not cause an increase in traffic that is substantial in relation to the existing traffic load and capacity of the street system.

Traffic on public roads leading to the project site and the GGF would increase marginally during the well drilling as workers commute to the site. There would also be a limited number of trucks delivering material associated with the drilling. The operation of the project would not result in a substantial increase in traffic over existing conditions, nor cause congestion on nearby roads or highways.

The proposed project would not alter air traffic patterns. Ground transportation would be used for all tasks related to construction and operation of the proposed project.

The proposed project does not include the construction of any roadways, and therefore would not increase hazards because of any road-related design features. The type of transportation vehicles currently used at the site would not change, and therefore the proposed project would not introduce any incompatible uses with the current transportation infrastructure.

The operators of the GGF, including NCPA, coordinate with local emergency service providers to ensure adequate access to the project site. Access to the proposed project would be on existing roads, and would not block these roads or prevent access by emergency vehicles.

Sufficient parking exists in the GGF facilities to accommodate current employee parking and any parking needed for employees operating the new mines. Construction equipment would be parked on E-pad, which consists of a large, graded area covered with gravel. Sufficient parking space exists for these construction vehicles.

There are no relevant adopted policies, plans, or programs supporting alternative transportation specific to the Geysers Management Area.

There are no adverse effects related to traffic and transportation associated with the project. No mitigation measures are necessary.

4.13.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on traffic and transportation.

4.14 Utilities and Service Systems

The existing conditions and environmental effects analysis for utilities and service systems were developed through a review of the following documents:

- Southeast Regional Wastewater Treatment Plant Facilities Improvements Project and Geysers Effluent Pipeline Project Final EIR/EIS, 1994. Lake County Sanitation District and U.S. Bureau of Land Management.
- U.S. Department of the Interior, Bureau of Land Management, Geothermal Sundry Notice, Well E-7, Permit Number 340-08-01.
- U.S. Department of the Interior, Geological Survey Conservation Division, Geothermal Resources Operational Order Number 2, 1975.

4.14.1 Existing Conditions

4.14.1.1 Environmental Conditions

The existing well E-7 is an injection well, injecting water at low pressure into the existing GGF geothermal steam reservoir. The injection wells on E-pad receive injection water from the existing Southeast Geysers Effluent Pipeline that was constructed for the purpose of delivering wastewater and fresh makeup water from Clear Lake for injection at the Geysers. The new well, E-8, would receive water from the same source during the hydroshearing process. The purpose and need for the wastewater injection project was to use effluent as injection fluid in the Southeast Geysers geothermal steam field in order to increase the current steam mass and thereby bring power production at existing power plants to a level closer to their installed plant capacity.

Any liquids produced by the project would be reinjected into well E-7 and recirculated. All water necessary for the project would be supplied from the water capacity already permitted and supplied to NCPA, and no new water is required.

The project site is a graded pad covered in gravel containing no vegetation. There are no stormwater facilities currently on the site, as stormwater drains directly into the ground or the surrounding natural watersheds.

4.14.1.2 Regulatory Conditions

Federal

The RMP does not address Utilities and Service system effects. State
As federally owned land, the site is not subject to local or state land use policies and regulations.

4.14.2 Environmental Effects

For CEQA purposes, effects on utilities and service systems as a result of implementing the proposed project were analyzed based on the significance criteria set forth in the State CEQA guidelines. For NEPA purposes, the Finding of No Significant Impacts (FONSI) explains why an action will not have significant effects. Effects were found to be significant if the project would:

- exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board;
- require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects;
- require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects;
- have insufficient water supplies available to serve the project from existing entitlements and resources;
- result in a determination by the wastewater treatment provider that serves or may serve the project that it has inadequate capacity to serve the project's projected demand in addition to the provider's existing commitments; or
- be served by a landfill with insufficient permitted capacity to accommodate the project's solid waste disposal needs or fail to comply with federal, state, and local statutes and regulations related to solid waste.

4.14.2.1 Alternative 1: Proposed Project

Any liquids produced in the deepening and testing of well E-7, drilling and testing of well E-8, and operation of both wells would be reinjected into well E-7 and recirculated. The proposed project would not produce significant amounts of wastewater, and therefore would not exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board.

All water necessary for the project would be supplied from the water capacity already permitted and supplied to NCPA, and no new water would be required. In addition, the proposed project would not produce significant amounts of wastewater. The proposed project would not require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects.

There are no stormwater drainage facilities currently on the site, and the proposed project would not require the construction of new stormwater drainage facilities. Stormwater would enter the ground through the gravel surface of the project site, or flow off the project site and enter the natural drainages surrounding the project site. There would be no impact.

All water necessary for the project would be supplied from the water capacity already permitted and supplied to NCPA. Sufficient water supplies are available to serve the project from existing entitlements and resources, and no new or expanded entitlements would be needed.

As stated above, any liquids produced in the deepening and testing of well E-7, drilling and testing of well E-8, and operation of both wells would be reinjected into well E-7 and recirculated. The proposed project would not produce significant amounts of wastewater, and therefore would not result in a determination by the wastewater treatment provider that serves or may serve the project that it has inadequate capacity to serve the project's projected demand in addition to the provider's existing commitments.

The deepening of well E-7 and the drilling of well E-8 would generate solid waste, the disposal of which is discussed in Section 4.6, "Hazards and Hazardous Materials," above. Drilling conducted as part of the proposed project would utilize "sumpless" drilling techniques, in which dewatered cuttings are discharged into metal containers and disposed of offsite in approved sites. Cuttings from the drilling operation would be tested and sent to the Clover Flat landfill in Calistoga if non-hazardous. Any hazardous drill cuttings would be transported to the Clean Harbors Buttonwillow Landfill in Kern County, west of Bakersfield. According to California Solid Waste Information System, the Clover Flat Landfill is a Class III facility with a maximum permitted throughput of 600 tons per day, a remaining capacity of approximately 2.6 million cubic yards, and is expected to remain active until 2021 (California Integrated Waste Management Board 2009). Class III facilities accept municipal, agricultural, and construction/demolition wastes. The Clean Harbors Buttonwillow Landfill is a Class I facility permitted to accept contaminated soil and industrial wastes. It has a maximum permitted throughput of 10,480 tons per day and is expected to remain active until 2040 (California Integrated Waste Management Board 2009).

The 1994 EIR/EIS analysis found that by disposing of such waste in approved sites, there would no adverse effects related to solid waste disposal. This analysis remains accurate. Other than drilling waste, there would not be substantial solid waste generated by the proposed project, and it would not substantially add to the amount of waste entering the landfills serving the GGF.

The proposed project would comply with all federal statutes and regulations related to solid waste. The proposed project is located on federally owned land, and is not subject to local land use policies and regulations.

There are no adverse effects related to utilities or service systems associated with the project. No mitigation measures are necessary.

4.14.2.2 Alternative 2: No Action

The No Action alternative would result in no adverse effects on utilities or services systems.

Chapter 5 Cumulative and Growth-Inducing Effects

Cumulative impacts are those that result from the incremental impacts of a proposed action when added to other past, present, and reasonably foreseeable future actions (CEQA Guidelines Section 15355[b], 40 CFR 1508.24[a][2]). Other relevant projects that could be cumulatively considerable in combination with the effects of the proposed project are discussed below.

5.1 Other Local Projects

5.1.1 Calpine Expansion

Calpine Corporation, a power company also operating at the GGF, has announced a planned five-year expansion program. The Calpine project would include drilling as many as 80 new wells, adding more water-injection systems to rejuvenate existing wells, and replacing or rebuilding steam turbines, cooling towers, and generators at some of their existing power plants. The project would add as many as 80 megawatts to the current output of 725 megawatts and would increase the output of Calpine's existing power plants.

5.2 Cumulative Effects of the Proposed Project

5.2.1 Aesthetics/Visual Resources

The proposed project would occur in a rural area, with the nearest residence 1.8 miles away. The proposed project would have no adverse effects on aesthetic/visual resources. Therefore, effects on aesthetics and visual resources would not be cumulatively considerable.

5.2.2 Air Quality

The proposed project would result in construction and drilling-related effects on air quality. These effects are cumulative with those of other projects in the air basin. Because the air basin is in attainment for all pollutants, additional contributions could have an adverse effect. With incorporation of the mitigation measures related to air quality outlined in Chapter 3, *Resources Analyzed in Detail for Potential Effects*, and by obtaining the appropriate required permits from the LCAQMD, the project's incremental contribution would not be cumulatively considerable.

5.2.3 Biological Resources

The proposed project is located on a graded, gravel pad; has no vegetation; and has very limited habitat for wildlife species. The proposed project would have no adverse effects on biological resources, and, therefore, effects would not be cumulatively considerable.

5.2.4 Cultural Resources

Records of historical or archaeological resources were not found for the project area where construction would occur, and no culturally significant resources were identified during a literature review of the project area. As discussed in Chapter 4, *Resources Analyzed in Detail for Potential Effects*, the 1976 archeological survey of the area did not locate any cultural resources in the project area. Therefore, the project is not expected to contribute to cumulative effects on cultural resources.

5.2.5 Geology and Soils

The proposed project is located on an existing, graded, gravel pad; and there would be no new slope cuts, excavation outside of the E-pad, or road construction undertaken as part of the project. Therefore, there would be no cumulatively considerable effect on soils.

The proposed project, like current injection and production activities in the GGF, is likely to result in induced microseismic activity. However, as discussed in the Induced Seismicity Report and addendum prepared for the project (see Appendix B), the level of microseismic activity would not be substantially greater than under current conditions, nor would the magnitude of seismic events be more severe than under current activities. Thus, the project would not make a cumulatively considerable contribution to existing conditions.

5.2.6 Hazards and Hazardous Materials

The project is using an existing well pad for drilling the wells, and will use sumpless drilling. No excavation of asbestos-containing serpentine rock (at least as contemplated by the LACQMD regulations) is proposed. The drilling process may encounter serpentine-containing rocks, but the control of any potential emissions are handled in the site-specific permits issued by the LACQMD, not the general regulations. Cuttings from the drilling operation would be tested and sent to the Class III Clover Flat landfill in Calistoga if non-hazardous. Any hazardous cuttings would be transported to the Class I Clean Harbors Buttonwillow Landfill west of Bakersfield.

The applicable air quality mitigation measures identified in the 1994 EIR/EIS would be applied to this project, thus avoiding the possibility of the release of asbestos resulting from the drilling process. With implementation of the mitigation measures related to Hazards and Hazardous Materials outlined in Chapter 4, *Resources Analyzed in Detail for Potential Effects*, the proposed project would not have any adverse effects, and would not contribute to cumulative effects on hazards and hazardous materials.

5.2.7 Hydrology and Water Quality

The proposed project would not affect hydrology or water quality. Therefore, it would not contribute to any cumulative effects on these resources.

5.2.8 Land Use and Planning

The proposed project will continue an existing land use. The proposed project would not significantly alter the current use of the project site. The project site and GGF have been granted permits by BLM for the production of geothermal steam and electrical power, and is compatible with the BLM Resource Management Plan for the Geysers Management Area. Therefore, the proposed project would not affect land use and planning, and would not contribute to any cumulative effects on these resources.

5.2.9 Mineral Resources

Geothermal resources of value to the region and the residents of the state have been identified at the project site by the U.S. Department of the Interior. These resources would be utilized as a result of the proposed project, which would create more access and greater use of the identified resource. Therefore, the proposed project would not result in the loss of availability of this resource, but greater utilization of it. The proposed project would not affect mineral resources and would not contribute to any cumulative effects on these resources.

5.2.10 Noise

Due to its distance from sensitive receptors, the proposed project would not have the potential to expose sensitive receptors to noise levels exceeding the standards established in the local general plan, noise ordinance, or applicable standards of other agencies. The closest sensitive receptor is approximately 1.8 miles from the site.

Noise levels will be essentially the same as is currently experienced on a routine basis at the project site during well maintenance. Operation of the drilling rig would not result in a new or more severe adverse effect than considered in the 1994 EIR/EIS, and with implementation of applicable mitigation measures from the 1994 EIR/EIS, there would be no adverse effects due to the project. The proposed project would not have any adverse effects related to noise resources and would not contribute to any cumulative effects on this resource.

5.2.11 Population and Housing

The Proposed Project would not have any effect on population and housing, and therefore would not contribute to any cumulative effect on these resources.

5.2.12 Public Services

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population growth and consequent demand for public services. The project could potentially create a new source of power, which could in turn potentially induce population growth in

NPCA's service area and consequent increased demand for public services. However, it is uncertain whether the proposed project will create a viable source of power and produce commercial amounts of steam. Even if the project did create a viable source of power, it remains uncertain how much power would be generated. It can be reasonably assumed that if power is generated by the proposed project, it will be sold over a large market area. By itself, this additional power would not be enough to induce substantial population growth, and therefore would not result in a substantial increase in demand for public services. The project would therefore not have any effect on public services and would not contribute to any cumulative effect on these resources.

5.2.13 Traffic and Transportation

The proposed project would be accessed from Highway 175 from Socrates Mine Road. Roads within the NCPA facility are inaccessible to the public, and used entirely for maintenance, operation, and improvements to existing geothermal energy production facilities. The operation of the project would not result in a substantial increase in traffic over existing conditions, nor cause congestion on nearby roads or highways. The proposed project would not have any effect on traffic and transportation, and therefore would not contribute to any cumulative effect on these resources.

5.2.14 Utilities and Services

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population growth and consequent demand for utilities and services. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA's service area and consequent increased demand for utilities and services. However, it is uncertain whether the proposed project will create a viable source of power and produce commercial amounts of steam. Even if it did create a viable source of power, it remains uncertain how much power would be generated. It can also be reasonably assumed that if power is generated by the proposed project, it would be sold over a large market area. By itself, this additional power would not be enough to induce substantial population growth, and therefore would not result in a substantial increase in demand for utilities and services. The project would therefore not have any effect on utilities and services, and would not contribute to any cumulative effect on these resources.

5.3 Cumulative Effects of Alternative 2: No Project

The No Action alternative, when considered with other past, present, and reasonably foreseeable projects, would not contribute to a significant cumulative effect on any resources within the project site. Therefore, the incremental contribution of the No Action alternative is not cumulatively considerable.

5.4 Growth-Inducing Effects

The proposed project does not include the construction of any new homes or businesses, and would not extend any roads or other significant public infrastructure that could induce significant population growth and consequent demand for public services. The project could potentially create a new source of power, which could in turn potentially induce population growth in NPCA's service area and growth-inducing effects. However, it is uncertain whether the proposed project will create a viable source of power and produce commercial amounts of steam. Even if it does create a viable source of power, it remains uncertain how great a net increase it would represent in the level of power currently being generated at the NCPA facility. It can also be reasonably assumed that if power is generated by the proposed project, it would be sold over a large market area. By itself, this additional power would not be enough to induce substantial population growth, and therefore would not result in growth-inducing effects.

Chapter 6 Compliance with Environmental Laws and Regulations

6.1 Federal Regulations

An overview of laws, regulations, and executive orders, defining the BLM's responsibilities when analyzing environmental impacts are listed below. Although many of these regulations may not apply to the project due to lack of jurisdiction or because the resources in question are avoided, they are discussed here to provide context for determining which resources are considered *sensitive* for the purposes of this document and to discuss the effects the project may have on these resources.

6.1.1 The Clean Air Act

The Clean Air Act of 1972 (as amended in 1990; 42 USC 7401, et seq. Section 176[c]) prohibits federal action or support of activities that do not conform to a state implementation plan. The proposed project would implement the mitigation measures outlined in Chapter 4, *Resources Analyzed in Detail for Potential Effects,* and obtain all necessary permits from the Lake County Air Pollution Control District in order to avoid violating any applicable standard; therefore, the project would not increase violations in the project area, exceed the Environmental Protection Agency's general conformity *de minimis* threshold, or hinder the attainment of air quality objectives in the local air basin. The proposed project would have no adverse effect on the future air quality of the project area and would be in compliance with the Clear Air Act.

6.1.2 The Endangered Species Act

The project would be located on a graded and leveled engineered pad. The 1994 EIR/EIS for the original well site determined that injection operations related to geothermal energy production would not disturb biological resources. This analysis remains accurate for the proposed project. A list of federally threatened, endangered, proposed, or candidate plant and wildlife species that have potential to occur in the vicinity of the project area was obtained from the U. S. Fish and Wildlife Service (USFWS) Sacramento Field Office website and from the California Department of Fish and Game's (DFG's) California Natural Diversity Data Base (CNDDB). After a review of the USFWS list and CNDDB, it was determined that the proposed project would not adversely affect—either directly or through habitat modifications—any of the federally listed species and, therefore, consultation with the USFWS is not necessary.

6.1.3 National Environmental Policy Act

The National Environmental Policy Act (42 USC 4321 et seq.) requires federal agencies to consider the environmental impacts of their proposed actions and alternatives to those actions.

This Draft EA/IS serves as public notification of the proposed project. The public comment period is 30 days following the issuance of this document. Therefore, the project would be in compliance with this Act.

6.1.4 National Historic Preservation Act

The National Historic Preservation Act of 1966 (amended through 2000; 16 USC et seq.) requires agencies to take into account the effects of their actions on properties listed in or eligible for listing in the National Register of Historic Places (NRHP). The Advisory Council on Historic Preservation has developed implantation regulations (Code of Federal Regulations (CFR), title 36, section 800), which allow agencies to develop agreements for consideration of these historic properties. The proposed project was reviewed in compliance with a National Programmatic Agreement and a California Statewide Protocol Agreement between BLM and the State Historic Preservation Officer. A site-specific inquiry was made to the California Historic Resources Information Center at Sonoma State University. A search of the database revealed no NRHP listed properties or other cultural resources within the project area. Therefore, the proposed project is in compliance with Section 106 of the Act.

6.1.5 Executive Order 1289—Environmental Justice

Environmental justice refers to “non-discrimination in federal programs substantially affecting human health and the environment” and “providing minority communities and low-income communities’ access to public information on, and an opportunity for public participation in, matters relating to human health or the environment.” In particular, it involves preventing minority and low income communities from being subjected to disproportionately high and adverse environmental effects of federal actions.

The proposed project would be in compliance with this Executive Order. The project site is isolated from existing residential communities and would not result in any significant effects. Therefore, project construction would not have a disproportionate adverse effect on any minority or low-income communities.

6.1.6 Archaeological Resources Protection Act

The Archaeological Resources Protection Act (16 USC 470aa–470mm; Public Law 96-95 and amendments to it) was enacted to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public lands and Indian lands, and to foster increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals (Sec. 2(4)(b)).

No known cultural resources and/or human remains are present within the proposed project area. While unlikely, it is possible that construction activities would result in the discovery of cultural resources and/or human remains. However, with implementation of Mitigation Measures CR-1 and CR-2 there would be no adverse effects associated with these impacts, and the project would be in compliance with the Archaeological Resources Protection Act.

6.1.7 Native American Graves Repatriation Act

The Native American Graves Protection and Repatriation Act (Public Law 101-601; 25 USC 3001–3013) describes the rights of Native American lineal descendants, Indian tribes, and Native Hawaiian organizations with respect to the treatment, repatriation, and disposition of Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony, referred to collectively in the statute as cultural items, with which they can show a relationship of lineal descent or cultural affiliation. One major purpose of this statute (Sections 5–7) is to require that federal agencies and museums receiving federal funds inventory holdings of Native American human remains and funerary objects and provide written summaries of other cultural items. The agencies and museums must consult with Indian tribes and Native Hawaiian organizations to attempt to reach agreements on the repatriation or other disposition of these remains and objects. Once lineal descent or cultural affiliation has been established, and in some cases the right of possession also has been demonstrated, lineal descendants, affiliated Indian tribes, or affiliated Native Hawaiian organizations normally make the final determination about the disposition of cultural items. Disposition may take many forms, from reburial to long-term curation, according to the wishes of the lineal descendent(s) or culturally affiliated tribe(s).

No known cultural resources and/or human remains are present within the proposed project area. While unlikely, it is possible that construction activities would result in the discovery of cultural resources and/or human remains. With implementation of Mitigation Measures CR-1 and CR-2 there would be no adverse effects associated with these impacts, and the proposed project would be in compliance with the Native American Graves Repatriation Act.

6.1.8 American Indian Religious Freedom Act

The American Indian Religious Freedom Act is a 1978 federal law and a joint resolution of Congress that pledged to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. The proposed project is not located within any tribal territories or sites of cultural significance. Therefore, the American Indian Religious Freedom Act is not applicable to the project.

6.1.9 The Federal Land Policy and Management Act

The proposed project would not significantly alter the current use of the project site. Geothermal power production within the GGF has been granted permits by BLM, and is consistent with the BLM Resource Management Plan for the Geysers Management Area. The project site is not subject to state and local land use policies. Therefore, the project would not conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project adopted for the purpose of avoiding or mitigating an environmental effect, and would be in compliance with the Federal Land Policy and Management Act.

6.1.10 Federal Water Pollution Control Act

The Federal Water Pollution Control Act, popularly known as the Clean Water Act, is a comprehensive statute aimed at restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Enacted originally in 1948, the Act was amended numerous times until it was reorganized and expanded in 1972. It continues to be amended almost every year.

The project site is a graded, drilling pad covered in gravel. There are no federally protected wetlands as defined by Section 404 of the Clean Water Act located on the site, and the proposed project would not affect any such wetlands. All fluids resulting from drilling operations would be retained on the site and operations would be required to conform to a Storm Water Pollution Prevention Plan, as provided in Mitigation Measure 3.2-4. Therefore, the project would be in compliance with the Federal Water Pollution Control Act.

6.1.11 Lacey Act—Federal Noxious Weed Act of 1974

The 1994 EIR/EIS determined that injection operations related to geothermal energy production would not disturb biological resources. The project site (i.e., the E-pad) is maintained in a weed free state by NCPA as part of its standard operations. As a result, noxious weeds are unlikely to be able to become established. This analysis remains accurate for the proposed project. Therefore, the Lacey Act would not apply to the proposed project.

6.1.12 Executive Order 11987—Exotic Species

The 1994 EIR/EIS determined that injection operations related to geothermal energy production would not disturb biological resources. This analysis remains accurate for the proposed project. Therefore, no exotic species would be destroyed or altered as a result of the project, and Executive Order 11987 would not apply to the proposed project.

6.1.13 Executive Order 13112 (1999)—National Invasive Species Council

Executive Order 13112 (February 3, 1999) charges that each federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law: (1) identify such actions; and (2) subject to the availability of appropriations, and within Administration budgetary limits, use relevant programs and authorities to: (i) prevent the introduction of invasive species, (ii) detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner, (iii) monitor invasive species populations accurately and reliably, (iv) provide for restoration of native species and habitat conditions in ecosystems that have been invaded, (v) conduct research on invasive species and develop technologies to prevent introduction and provide for environmentally sound control of invasive species, and (vi) promote public education on invasive species and the means to address them. An *invasive species* is defined as a species that is (1) nonnative (or alien) to the ecosystem under consideration, and (2) whose introduction causes or is likely to cause economic or environmental harm to human health.

The California Department of Food and Agriculture (CDFA) maintains a list of noxious weeds and advises the County Agricultural Commissioner as to the action to take regarding each noxious weed species. A-rated weeds are subject to eradication, containment, rejection, or other holding action at the state/county level. B-rated weeds are subject to eradication, containment, control, or other holding action at the discretion of the County Agricultural Commissioner. C-rated weeds are subject to action to retard their spread outside of nurseries at the discretion of the County Agricultural Commissioner.

The 1994 EIR/EIS determined that injection operations related to geothermal energy production would not disturb biological resources. This analysis remains accurate for the proposed project. No vegetation will be removed or disturbed, as the entire project site is a disturbed area, covered with gravel and contains no vegetation. Therefore, no habitat for wildlife would be destroyed or altered as a result of the project, and Executive Order 13112 would not apply to the proposed project.

6.1.14 Executive Order 12580—Clean Water

The federal Clean Water Act was enacted as an amendment to the federal Water Pollution Control Act of 1972, which outlined the basic structure for regulating discharges of pollutants to waters of the United States. The CWA serves as the primary federal law protecting the quality of the nation’s surface waters, including lakes, rivers, and coastal wetlands.

Important applicable sections of the federal CWA (33 USC 1251–1376) include:

- 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 United States to obtain certification from the state that the discharge will comply with other provisions of 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 US Army Corps of Engineers.

The proposed project would not substantially alter the existing drainage pattern of the site through the alteration of the course of a stream or river. No streams or rivers exist on the project site. Therefore, the proposed project would not result in substantial erosion or siltation on- or off site. The proposed project would not include substantial additions of impermeable surfaces to the project site, and would therefore not substantially increase the rate or amount of surface runoff in a manner that would result in flooding on or off site. Therefore, the proposed project would be in compliance with Executive Order 12580.

6.1.15 Executive Order 13186—Responsibilities of Federal Agencies to Protect Migratory Birds

The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. Such conventions include the Convention for the Protection of Migratory Birds with Great Britain on behalf of Canada 1916, the Convention for the Protection of Migratory Birds and Game Mammals—Mexico 1936, the Convention for the Protection of Birds and their Environment—Japan 1972, and the Convention for the Conservation of Migratory Birds and their Environment—Union of Soviet Socialist Republics 1978.

These migratory bird conventions impose substantive obligations on the United States for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act; the United States has implemented these migratory bird conventions with respect to the United States.

Executive Order 13186 directs executive departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act and requires that each federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations be directed to develop and implement, within 2 years, a Memorandum of Understanding with the U.S. Fish and Wildlife Service that will promote the conservation of migratory bird populations.

The project would not interfere with the movement of any native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites. Therefore, the proposed project is in compliance with Executive Order 13186.

6.1.16 BLM Section 6840—Special Status Plants and Animals

The purpose of this BLM Manual Section is to provide policy and guidance, consistent with appropriate laws, for the conservation of special status species of plants and animals, and the ecosystems upon which they depend. These are species which are (1) proposed for listing, officially listed as threatened or endangered, or are candidates for listing as threatened or endangered under the provisions of the Endangered Species Act (ESA); (2) those listed by a state in a category such as threatened or endangered implying potential endangerment or extinction; and (3) those designated by each State Director as sensitive. “Conservation” in this section and pursuant to the ESA means the use of all methods and procedures that are necessary to improve the status of federally listed species and their habitats to a point where the provisions of the ESA are no longer necessary. Conservation of special status species means the use of all methods and procedures that are necessary to improve the condition of special status species and their habitats to a point where their special status recognition is no longer warranted.

The objectives of the special status species policy are:

A. to conserve listed species and the ecosystems on which they depend; and

B. to ensure that actions requiring authorization or approval by the BLM are consistent with the conservation needs of special status species and do not contribute to the need to list any special status species, either under provisions of the ESA or other provisions of this policy.

The 1994 EIR/EIS determined that injection operations related to geothermal energy production would not disturb biological resources. This analysis remains accurate for the proposed project. No vegetation will be removed or disturbed, as the entire project site is a disturbed area, covered with gravel, and contains no vegetation. The proposed project would not adversely effect, either directly or through habitat modifications, any federally listed species identified on the USFWS list or from the CNDDB. Therefore, the proposed project is in compliance with BLM Section 6480.

6.1.17 Executive Order 13084—Consultation and Coordination with Indian Tribal Government

Consultation and coordination with Indian tribal governments has occurred. The proposed project is in compliance with Executive Order 13084.

6.1.18 16 USC 431-433—American Antiquities Act of 1906

The Antiquities Act of 1906 resulted from concerns about protecting mostly prehistoric Indian ruins and artifacts—collectively termed "antiquities "—on federal lands in the West. It authorized permits for legitimate archeological investigations and penalties for persons taking or destroying antiquities without permission. The Act also authorized presidents to proclaim "historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest" as national monuments "….the limits of which in all cases shall be confined to the smallest area compatible with the proper care and management of the objects to be protected."

6.1.19 16 USC 461 to 467—Historic Sites Act of 1935

The Historic Sites Act establishes a national policy to preserve for public use, historic sites, buildings, and objects of national significance for the inspiration and benefit of the American people. The Act authorizes the designation of national historic sites and landmarks, authorizes interagency efforts to preserve historic resources, and establishes a maximum fine of $500 for violations of the Act. The Act authorizes surveys of historic and archeological sites, buildings, and objects to determine which are significant, and provides for the restoration, reconstruction, rehabilitation, preservation, and maintenance of historic or prehistoric properties of national significance. The Secretary of the Interior, through the National Park Service, is authorized to conduct surveys and studies, collect information, and purchase significant historic properties. The Secretary is also authorized to restore, preserve, maintain, and rehabilitate structures and sites. Museums may be established, and the National Park Service may operate and manage historic sites and develop educational programs.

Chapter 7 Coordination and Review of the EA/IS

This EA/IS has been prepared to comply with the requirements of both CEQA and NEPA. For purposes of CEQA, the EA/IS will be sent to the State Clearinghouse for transmittal to State agencies. Notice will be provided at the office of the County Clerk and will be published in the local newspaper. The agency and public review period will be 30 days.

For purposes of NEPA, the EA/IS will be circulated for 30 days to agencies, organizations, and individuals known to have a special interest in the proposed project. A copy of the document will also be available on the BLM's website (www.blm.gov/ca/st/en/fo/ukiah.html). Comments will be received and addressed or incorporated into the project as appropriate. The NCPA will consider the EA/IS, a Mitigated Negative Declaration, and the comments received on the documents prior to acting on the proposed project. The BLM will also consider the EA/IS and the comments received on the EA/IS and issue a Finding of No Significant Impact describing its findings when taking action on the proposed project.

All those responding to the EA/IS are asked to submit their comments in writing during the 30-day review period. Comments should be submitted to either of the two following contacts:

Mr. Hari Modi
Northern California Power Agency
651 Commerce Drive
Roseville, CA 95678-6411
E-mail: hari.modi@ncpagen.com

Ms. Jonna Hildenbrand
BLM Ukiah Field Office
2550 North State Street
Ukiah, CA 95482
E-mail: Jonna_Hildenbrand@blm.gov

Comments may also be submitted by e-mail to the e-mail addresses listed above. Please indicate that you are commenting on the AltaRock project.

Individual respondents may request confidentiality. Those choosing to withhold their name or address from public review or from disclosure under the Freedom of Information Act must state this prominently at the beginning of a written comment. Such requests will be honored to the extent allowed by law. All submissions from organizations and businesses, and from individuals identifying themselves as representatives or officials of organizations or businesses, will be available for public inspection in their entirety.

Chapter 8 List of Preparers

ICF Jones & Stokes

- Ken Bogdan—Project Director
- Terry Rivasplata—Project Manager
- Casey Mills—Project Coordinator, Environmental Evaluation
- Amy Fransen—Cultural Resources
- Will Kohn—Biologist
- Andrea Nardin—Archaeologist
- Ken Cherry—Technical Editor
- Ryan Patterson—Publications Specialist

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Appendix A CEQA Checklist

Appendix A CEQA Checklist

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
I.	**AESTHETICS.** Would the project:				
a.	Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
b.	Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings along a scenic highway?	☐	☐	☐	☒
c.	Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☐	☒
d.	Create a new source of substantial light or glare that would adversely affect daytime or nighttime views in the area?	☐	☐	☐	☒
II.	**AGRICULTURAL RESOURCES.** In determining whether impacts on agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Department of Conservation. Would the project:				
a.	Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
b.	Conflict with existing zoning for agricultural use or conflict with a Williamson Act contract?	☐	☐	☐	☒
c.	Involve other changes in the existing environment that, due to their location or nature, could result in conversion of Farmland to non-agricultural use?	☐	☐	☐	☒

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
III.	**AIR QUALITY.** When available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:				
a.	Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☒
b.	Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☒	☐	☐
c.	Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is a nonattainment area for an applicable federal or state ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)?	☐	☒	☐	☐
d.	Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☒	☐
e.	Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☒
IV.	**BIOLOGICAL RESOURCES.** Would the project:				
a.	Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☐	☒
b.	Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☐	☒
c.	Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marshes, vernal pools, coastal wetlands, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☐	☒

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
d.	Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☒
e.	Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
f.	Conflict with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒
V.	**CULTURAL RESOURCES.** Would the project:				
a.	Cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5?	☐	☐	☐	☒
b.	Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5?	☐	☒	☐	☐
c.	Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☒	☐	☐
d.	Disturb any human remains, including those interred outside of formal cemeteries?	☐	☒	☐	☐
VI.	**GEOLOGY AND SOILS.** Would the project:				
a.	Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
	1. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
	2. Strong seismic groundshaking?	☐	☐	☒	☐
	3. Seismic-related ground failure, including	☐	☐	☐	☒

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
	liquefaction?				
	4. Landslides?	☐	☐	☐	☒
b.	Result in substantial soil erosion or the loss of topsoil?	☐	☐	☐	☒
c.	Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the project and potentially result in an onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☐	☒
d.	Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☒
e.	Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems in areas where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒
VII.	**HAZARDS AND HAZARDOUS MATERIALS.** Would the project:				
a.	Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☒	☐	☐
b.	Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☒	☐	☐
c.	Emit hazardous emissions or involve handling hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d.	Be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☒
e.	Be located within an airport land use plan area or, where such a plan has not been adopted, be within two miles of a public airport or public use airport, and result in a safety hazard for people residing or	☐	☐	☐	☒

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
	working in the project area?				
f.	Be located within the vicinity of a private airstrip and result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
g.	Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
h.	Expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☒	☐
VIII.	**HYDROLOGY AND WATER QUALITY.** Would the project:				
a.	Violate any water quality standards or waste discharge requirements?	☐	☐	☐	☒
b.	Substantially deplete groundwater supplies or interfere substantially with groundwater recharge, resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☐	☒
c.	Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation onsite or offsite?	☐	☐	☐	☒
d.	Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding onsite or offsite?	☐	☐	☐	☒
e.	Create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional	☐	☒	☐	☐

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
	sources of polluted runoff?				
f.	Otherwise substantially degrade water quality?	☐	☐	☐	☒
g.	Place housing within a 100-year flood hazard area, as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
h.	Place within a 100-year flood hazard area structures that would impede or redirect floodflows?	☐	☐	☐	☒
i.	Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☐	☒
j.	Contribute to inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☒
IX.	**LAND USE AND PLANNING.** Would the project:				
a.	Physically divide an established community?	☐	☐	☐	☒
b.	Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to, a general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☒
c.	Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☒
X.	**MINERAL RESOURCES.** Would the project:				
a.	Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
b.	Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	☐	☐	☐	☒
XI.	**NOISE.** Would the project:				
a.	Expose persons to or generate noise levels in excess of standards established in a local general	☐	☒	☐	☐

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
	plan or noise ordinance or applicable standards of other agencies?				
b.	Expose persons to or generate excessive groundborne vibration or groundborne noise levels?	☐	☐	☐	☒
c.	Result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☒
d.	Result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☒	☐	☐
e.	Be located within an airport land use plan area, or, where such a plan has not been adopted, within two miles of a public airport or public use airport and expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
f.	Be located in the vicinity of a private airstrip and expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
XII.	**POPULATION AND HOUSING.** Would the project:				
a.	Induce substantial population growth in an area, either directly (e.g., by proposing new homes and businesses) or indirectly (e.g., through extension of roads or other infrastructure)?	☐	☐	☒	☐
b.	Displace a substantial number of existing housing units, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
c.	Displace a substantial number of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
XIII.	**PUBLIC SERVICES.** Would the project:				
a.	Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities or a need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain				

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
	acceptable service ratios, response times, or other performance objectives for any of the following public services:				
	Fire protection?	☐	☐	☒	☐
	Police protection?	☐	☐	☒	☐
	Schools?	☐	☐	☒	☐
	Parks?	☐	☐	☒	☐
	Other public facilities?	☐	☐	☒	☐
XIV.	**RECREATION.** Would the project:				
a.	Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☒	☐
b.	Include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	☐	☐	☒	☐
XV.	**TRANSPORTATION/TRAFFIC.** Would the project:				
a.	Cause an increase in traffic that is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in the number of vehicle trips, the volume-to-capacity ratio on roads, or congestion at intersections)?	☐	☐	☐	☒
b.	Cause, either individually or cumulatively, exceedance of a level-of-service standard established by the county congestion management agency for designated roads or highways?	☐	☐	☐	☒
c.	Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☒
d.	Substantially increase hazards because of a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☒

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
e.	Result in inadequate emergency access?	☐	☐	☐	☒
f.	Result in inadequate parking capacity?	☐	☐	☐	☒
g.	Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☒
XVI.	**UTILITIES AND SERVICE SYSTEMS.** Would the project:				
a.	Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☒
b.	Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
c.	Require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
d.	Have sufficient water supplies available to serve the project from existing entitlements and resources, or would new or expanded entitlements be needed?	☐	☐	☐	☒
e.	Result in a determination by the wastewater treatment provider that serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☒
f.	Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☒
g.	Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒

		Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
XVII.	**MANDATORY FINDINGS OF SIGNIFICANCE.**				
a.	Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?	☐	☒	☐	☐
b.	Does the project have impacts that are individually limited but cumulatively considerable? (“Cumulatively considerable” means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.)	☐	☐	☒	☐
c.	Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☒	☐	☐

Appendix B Induced Seismicity Report, Engineered Geothermal System Demonstration Project

Induced Seismicity Report, Engineered Geothermal System Demonstration Project

Northern California Power Agency, The Geysers, CA©

prepared by

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17 November 2008

prepared for

U.S. Bureau of Land Management
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GLOSSARY OF TERMS

AltaRock	AltaRock
BSCFZ	Big Sulphur Creek Fault Zone
EGS	Engineered geothermal systems
EGS Demo Project	Proposed AltaRock EGS Demonstration Project (on NCPA lease below The Geysers Geothermal Field)
EFM	Earthquake focal mechanism
EIR	Environmental Impact Report (state)
EIS	Environmental Impact Statement (federal)
Fracture stimulation or hydraulic fracturing	Used in oil and gas reservoirs where the *in situ* tensile strength of the reservoir rock is usually exceeded to create new tensional fractures.
GGF	The Geysers Geothermal Field
Hydroshearing or hydroshear dilation	Used in EGS where pumping water into a well at selected pressues to cause the existing fractures to open slightly and slip
IS	Induced seismicity
LACOSAN	Lake County Sanitation District
LBNL	Lawrence Berkeley National Laboratory
M	Earthquake Magnitude
Mg	Millions of gallons
MMI	Modified Mercalli Intensity (MMI) Scale
M_W	Moment magnitude; used for theoretical calculations herein, but not used observationally by USGS for M<3.5; equivalent to M when M<3.5
Microseismic event	M less than 3.0
MSA	Microseismic Array
NCEDC	Northern California Earthquake Data Center (NCEDC) website, maintained by the Seismographic Station of the University of California, Berkeley
NCPA	Northern California Power Agency
NCSN	Northern California Seismic Network operated by the USGS
PGA	Peak ground acceleration
SEGEP	Southeast Geysers Effluent Pipeline
USGS	U.S. Geological Survey

Executive Summary

AltaRock Energy Inc. will be testing a number of its proprietary technologies for Engineered Geothermal System (EGS) in the Northern California Power Agency (NCPA) leasehold, located in the Southeast Geysers Geothermal Field (GGF). Induced seismicity (**IS**) has been occurring at the GGF for more than 40 years and previous studies have related **IS** to both steam production and fluid injection. This study analyzes the possibility that AltaRock's planned EGS demonstration project (EGS Demo Project)may cause changes in the GGF IS.

Previous studies of GGF seismicity, in particular the NCPA leasehold, concluded that deep-well injection in the GGF produces mostly microseismic events, defined here as having magnitudes (M) less than (<) 3. Also, when the total volume of water injected in the NCPA lease roughly doubled in 1998, the rate of microseismic events also doubled. However, it is difficult to directly relate the observed microseismicity in the NCPA area to any specific single NCPA injection well due to the relatively low injection rates, even though there are up to a dozen or so relatively closely spaced NCPA injection wells that are continuously active at any time.

The largest seismic events of the past 12 years in the NCPA area occurred within the Big Sulphur Creek Fault Zone (BSCFZ), which is not considered active at the surface but does form the southwestern boundary of the steam reservoir. Because the BSCFZ is outside of the areas of water injection and steam production, the BSCFZ seismic events are considered to be tectonic and unrelated to past injection activities. Nevertheless, the EGS Demo Project activities have been designed to avoid this zone and the uncertain engineering conditions it might present.

The EGS Demo Project will monitor four very different categories of **IS**: (1) background microseismicity, (2)°microseismicity due to the creation of the engineered reservoir, (3) microseismicity, if any, related to ~2 years of circulation testing (referred to as long-term data collection and monitoring), and (4) microseismicity, if any, during operation of the geothermal resource for power generation. While the past history at the GGF may help predict microseismicity in Phases 3 and 4, to predict Phase 2 microseismicity requires review of past EGS experience and application of geomechanical models with inputs specific to this EGS Demo Project.

Worldwide EGS **IS** data indicate that the largest **IS** event linked to EGS activities was a M=3.7 in the Cooper Basin of Australia. The best analog for the EGS Demo Project is the Soultz-sous-Forêts, France, EGS project, which had similar rock type (granitic), stress regime (transitional normal faulting to strike-slip), injection rates (15-18 gallons/s), and injection duration (1-2 weeks) as are planned for the EGS Demo Project. At Soultz, the maximum IS event had M2.9. Application of three different geomechanical models for the specific engineering parameters of the EGS Demo Project provide similar results, and indicate that the maximum expected **IS** event will have a M<~2.3.

The EGS Demo Project is not expected to cause significant changes in the rates or maximum magnitude of GGF **IS** because the water injected during the project would otherwise have been

injected into the NCPA wells/reservoir at the same rates and volumes. Also, a seismic hazards risk analysis predicts no significant changes in the number of events felt by the residents of Anderson Springs, the community nearest the project site, and this analysis indicates that the probable maximum annual seismic event shaking expected in Anderson Springs corresponds to MMI=III-IV, due an EGS-induced event of M<3.0. This is based on historic seismicity and on the expected EGS **IS** rates and maximum event size.

1. Introduction

1.1 Objective

The objective of this study is to analyze the likelihood of possible changes in induced seismicity (**IS**) caused by the planned AltaRock Energy Inc (AltaRock) Engineered Geothermal System (EGS) demonstration project (EGS Demo Project) in the Northern California Power Agency (NCPA) leasehold, which is located in the southeastern Geysers Geothermal Field (GGF). The relationship between water injection and **IS** in the southeastern GGF was last analyzed in 2002 and 2003, when increased wastewater injection Lake County Sanitary District (LACOSAN) was proposed for the NCPA and the southernmost portion of the Calpine leasehold (GeothermEx, 2002; Parsons, 2003a) and presented in Environmental Impact Reports (EIR) prepared by Criterion Planners/Engineers et al. (2002) and Parsons (2003b). This report updates the **IS** analysis presented in the aforementioned EIR along with other EIRs/Environmental Impact Statements (EISs), and adds new analysis specific to the EGS Demo Project. It is being submitted to the U.S. Bureau of Land Management (BLM), which is the regulatory agency for federal land in the GGF. Courtesy copies will be provided to NCPAand the Anderson Springs Geothermal Impact Mitigation and Community Investment Funds. .

A microseismic event is defined here as having magnitude (M) less than (<) 3.0 (Parsons, 2003a), and can be of either natural or manmade (production/injection operations) origin. Seismic events, on the other hand, have a M greater than or equal to (≥) 3.0.

During the creation of the EGS engineered reservoir, the growth of the reservoir can be monitored with very sensitive seismic instruments that can detect the elastic energy radiated from seismic events generated when the fractures shear. Mapping event locations—which are inferred from the arrival times of the energy at the instruments—allows the engineered reservoir to be targeted by a production well drilled later. Several experimental and early stage commercial EGS projects have used this method for mapping the created, engineered reservoir. This EGS Demo Project will be using the same methodology.

The largest seismic event that can be attributed to the activities of creating or operating an EGS reservoir occurred in Cooper Basin, Australia, and had a magnitude (M) of 3.7. A M=4.4 that occurred after a EGS project at the Berlin geothermal field in El Salvador is reported by Bromley and Mongillo (2008) to be tectonic in origin. In the EGS project at Soultz-sous-Forêts, France (Soultz), which appears to be the best analog for the EGS Demo Project, the maximum induced seismic event had M=2.9. A seismic hazards assessment based on geomechanical considerations of the EGS Demo Project indicates M=2.3 is the potential maximum induced-event size (Appendix A). Parsons (2003) calculated a potential maximum induced-event size of M=5.0 for the upper limit in the Geysers-normal reservoir. To date, the largest actual induced-event size has been M=4.6. Thus, M=5.0 appears very conservative. For the EGS Demo Project, we expect the **IS** will be significantly less than M=3.

1.2 Description of the EGS Demonstration Project

To demonstrate the commercial viability of a separate EGS development in the underlying felsite beneath The Geysers "normal" production zone, AltaRockwill be testing and evaluating a number of its proprietary technologies. AltaRock has a portfolio of over 25 United States patent filings related to these proprietary EGS techniques. As detailed in the discussion below, the application of these technologies is not expected to change the rate or maximum magnitude of **IS** in the GGF.

For the EGS Demo Project, an engineered reservoir will be produced at depth by pumping water at a moderate pressure into a wellbore to create a system for fluid flow to pick up heat from the surrounding rock. The pumped water will be directed to an isolated interval within the wellbore using a combination of commercial and proprietary techniques. The hydraulic pressure will be high enough to cause existing fractures to open slightly and slip. This process is referred to as *shear dilation*, a combination of fracture-parallel shear movement and fracture-perpendicular opening. It results in a network of small, interconnected fractures which will act as an underground heat exchanger and allow mining the heat from the rock by circulating the same water through it repeatedly. The hydraulic pressure will not be high enough to exceed the tensile strength of the rock and create new fractures. This process is analogous to what is currently occurring at the GGF, except for the moderate pressure being applied to generate the shear dilation.

In the petroleum industry, reservoir rocks are fractured or stimulated by increasing the pumping pressure until the rock strength is exceeded and the rock fails in tension. This process, termed hydraulic fracturing or fracture stimulation, results in large open fractures that can drain the hydrocarbons from porous reservoir rocks. For AltaRock's EGS projects, we will use techniques specifically designed for geothermal applications to engineer the reservoir through shear dilation, which will also be referred to as *hydroshear dilation or hydroshearing*.

AltaRock will use the NCPA well E-7 (E-7) located on a large pad at the southeastern portion of NCPA's lease as the EGS injection well. Water from the Southeast Geysers Effluent Pipeline (SEGEP) enters the NCPA project on this well pad. This water will be available for the proprietary hydroshear dilation operation, and for make-up water during long-term data collection and monitoring. Prior to hydroshearing in E-7, a microseismic array (MSA) will be installed around E-7 for seismic monitoring during (1) the pre-EGS operations for background data, (2) the drilling and hydroshearing operations to map the shear fracture(s) growth in the engineered geothermal reservoir, (3) the long-term data collection and monitoring, if any, and (4) potential long-term production, if any. Most of the **IS** activity is expected during hydroshearing; little or no microseismicity is expected during the long-term data collection and monitoring, or during the long-term production phase, if there is one.

In order to create the engineered geothermal reservoir, E-7 will be deepened to a total depth of between 11,500 feet (ft.) and 12,500 ft., depending on the results of initial tests of the direction of hydroshear dilation zone growth. Upward zone growth would require a greater total depth.

In the open part of the wellbore, up to three zones will be hydrosheared using AltaRock's proprietary methods. The hydroshear dilation will be monitored using the MSA and mapped with methods used at other EGS projects. The newly created reservoir will be tested using single well methods.

Following the creation of multiple hydroshear dilation zones and mapping of the newly created reservoir, the production well course will be planned. This new well will be drilled into the mapped fractures and the degree of connectivity between the two wells tested. An assessment of the reservoir connectivity will be made, and if additional fracture permeability is required, the production well, or both wells, will be hydrosheared.

Once sufficient permeability has been created between the injection and production wells, long-term data collection and monitoring will occur.

1.3 Methods of Investigation

For seismicity data, including **IS**, we have used location and magnitude information provided by the Northern California Seismic Network (NCSN) operated by the United States Geological Survey (USGS). These data are available on the Web site of the Northern California Earthquake Data Center (NCEDC) maintained by the Seismographic Station of the University of California, Berkeley. Figure 1.1a is a map of the region around the GGF showing locations of NCSN seismograph stations of the regional network.

Additionally, NCPA seismicity characterizations referenced in this report were derived from observations made with a denser array of 22 stations operated in the southern GGF by Lawrence Berkeley National Laboratory (LBNL). Their data are utilized with that from the NCSN network in order to determine seismographic parameters with the best possible precision in the southern GGF. Figure 1.1b is a map of this array. Parsons (2003a) and Smith et al. (2000) analyzed digital seismic data from this array. However, these data have not been updated in about a decade (NCEDC, 2008).

Since 1967, the USGS has operated the NCSN to provide regional earthquake data for a wide range of research topics and hazard-reduction activities. The network design was motivated by the need to monitor active faults and volcanoes with a station density sufficient to determine the focal depth of shallow (0-15 km) earthquakes. The detection threshold of a seismic network—the smallest event it can detect—depends on the concentration of stations in a region, seismometer sensitivity, and levels of ambient seismic noise. For the NCSN, the minimum M for which seismic event detection is complete—that is, all events of that M and larger are detected—varies from about M=1.4 in parts of the central Coast Ranges, down to M=1.0 in the GGF.

Since 1976, the accuracy of NCSN hypocenter locations has improved. According to David Oppenheimer, seismologist with the USGS, knowledgeable about the NCSN and GGF seismicity (personal communication November 10, 2003), since April 2003 the accuracy of hypocentral coordinates (x, y, z) in the southern GGF has been within a approximately 150 ft but prior to that date, accuracy was poorer, being only within around 1,700 ft. In this report, we use only the more accurate Geysers locations—those determined using data from April 2003 and later—in correlating **IS** with wellbores and geologic structures.

Pre-geothermal production (up to early 1960s) seismicity at the GGF is not well documented. It appears that the currently high rate of seismicity within the GGF began in the early 1960s, shortly after initiation of commercial steam power generation. Studies of **IS** in the GGF began in 1971, and by 1972 regional seismographic monitoring capabilities were established. At that time, numerous **IS** with epicenters in the GGF began to be routinely reported. Since 1975, more than 20,000 microseismic events—those with M<3 and a minimum M=0.7 due to the seismographic equipment sensitivity and about 300 seismic events with M=3.0-4.6 have been reported to originate within the GGF (Preiss et al., 2002). Figures 1.2, 1.3, and 1.4 show epicenters for events from three different time periods (1991-1995, 1996-2002, and 2003-2008, respectively). These three time spans show the marked increase in seismicity in the southeast GGF after 1995, due to a doubling of total injection rates in that area in 1998.

A number of studies, including those for various EIRs/EISs dealing with wastewater injection (e.g., GeothermEx, 2002; Parsons, 2003a), have analyzed relationships between **IS** and deep well injection and/or production (Majer and McEvilly 1979; Eberhart-Phillips and Oppenheimer 1984; Oppenheimer 1986, Enedy et al. 1992; Stark 1990; Kirkpatrick et al. 1999; Smith et al. 2000). In this investigation, **IS** used for analysis was selected on the basis of spatial correlation of epicenters or hypocenters with well courses. Temporal analysis employed monthly intervals for counting microseismic events and volume of injected water. Also, the baseline microseismicity was divided into three separate populations analyzed for spatial patterns on maps and cross-sections—above the felsite, within the felsite and within the BSCFZ.

In addition to the analysis of the past history of injection, production, and microseismicity, several other investigatory methods were used to better understand the ongoing and future seismicity at GGF. Magnitude-frequency plots of seismic events—which show the cumulative numbers of events of a given magnitude or higher—provided b-values (slopes on the magnitude-frequency plot) for different time spans and areas of the Geysers. This statistical technique compares different populations of seismicity and, because **IS** has distinctive b-values, look for **IS** dominated populations (e.g., natural seismicity and **IS**).

Microseismicity related to the EGS Demo Project will be similar to the current **IS** caused by water injection in the GGF. To characterize EGS-specific seismicity, the history of seismicity and microseismicity of EGS projects worldwide were used to help develop geomechanical models for parameters specific to the EGS Demo Project. These two analyses provide a maximum probable seismic event due to the EGS Demo Project. In addition, the geometry of the EGS Demo Project well and hydroshear zone was examined relative to the geometry of the BSCFZ. Calculations of the growth rate of the hydroshear zone as a function of time and distance were compared to the distance to the BSCFZ.

In order to assess the seismic hazard risk to local communities of Cobb and Anderson Springs by the EGS Demo Project, the record of historic and felt earthquakes in the local area were reviewed, and calculations made relating seismic event ground shaking intensity based on the Modified Mercalli Intensity (MMI) scale , event magnitude, and epicentral distance. Combining these with the maximum probable magnitude of a seismic event at the EGS Demo Project allows prediction of seismic events likely to be experienced in Anderson Spring, the community most likely to be potentially affected

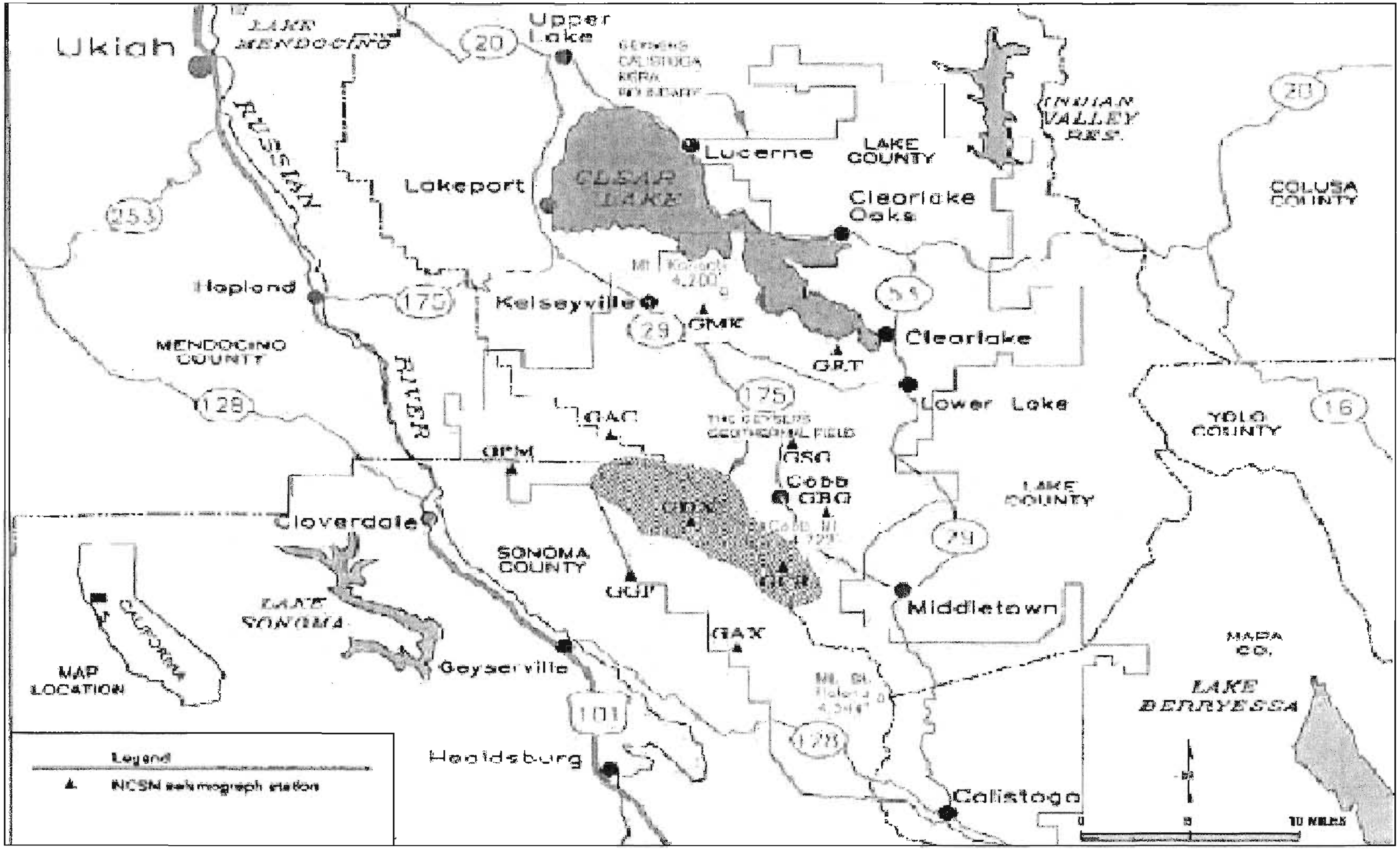


Figure 1.1a: Seismograph Station Locations in Geysers Region, NCSN (USGS) Network (GeothermEx,2002)

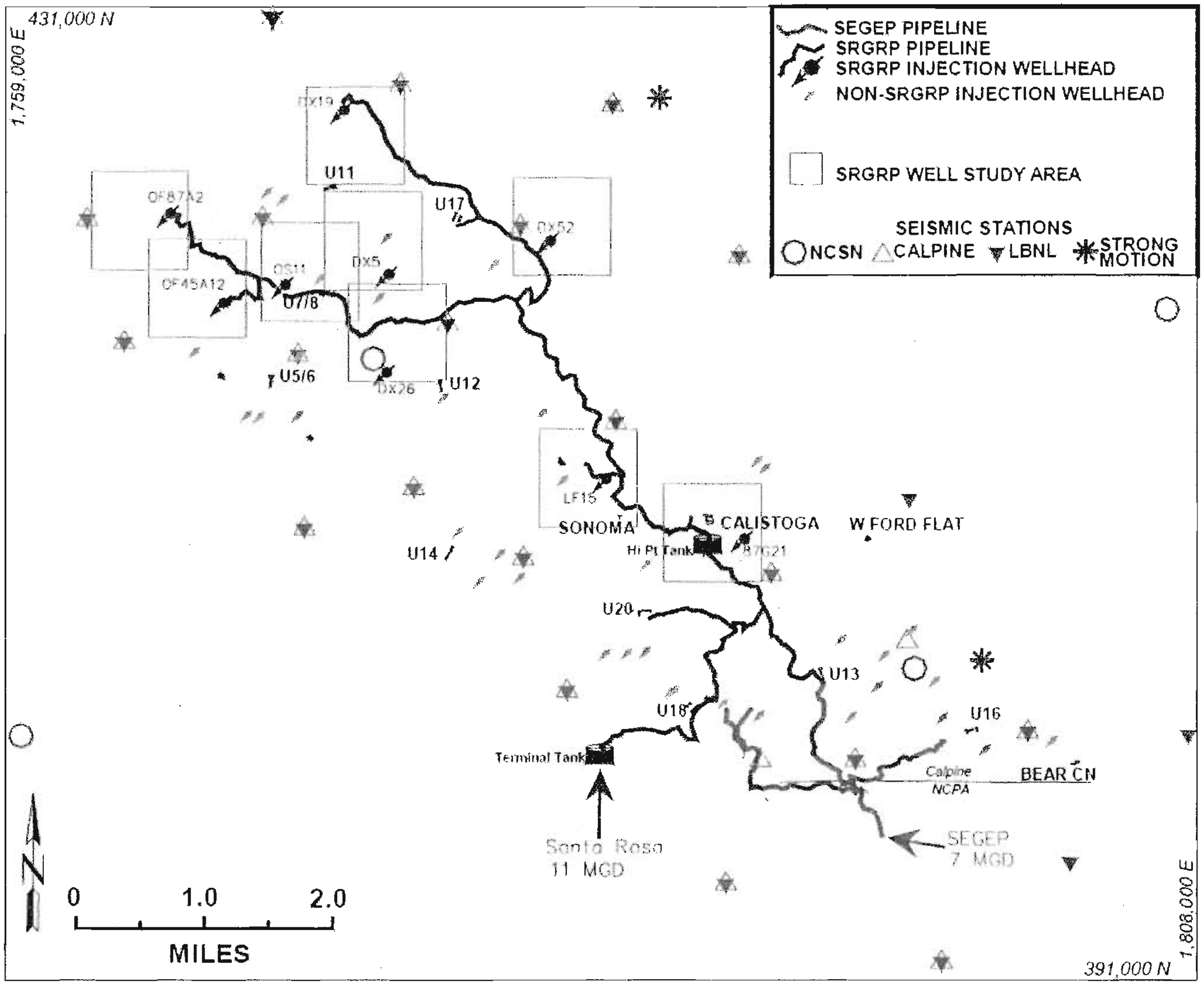


Figure 1.1b: Seismograph Station Locations at The Geysers relative to the Southeast Geysers Geothermal Field (SEGEP) and Santa Rosa Geothermal Recharge Project (SRGRP), from Majer et al. (2004)

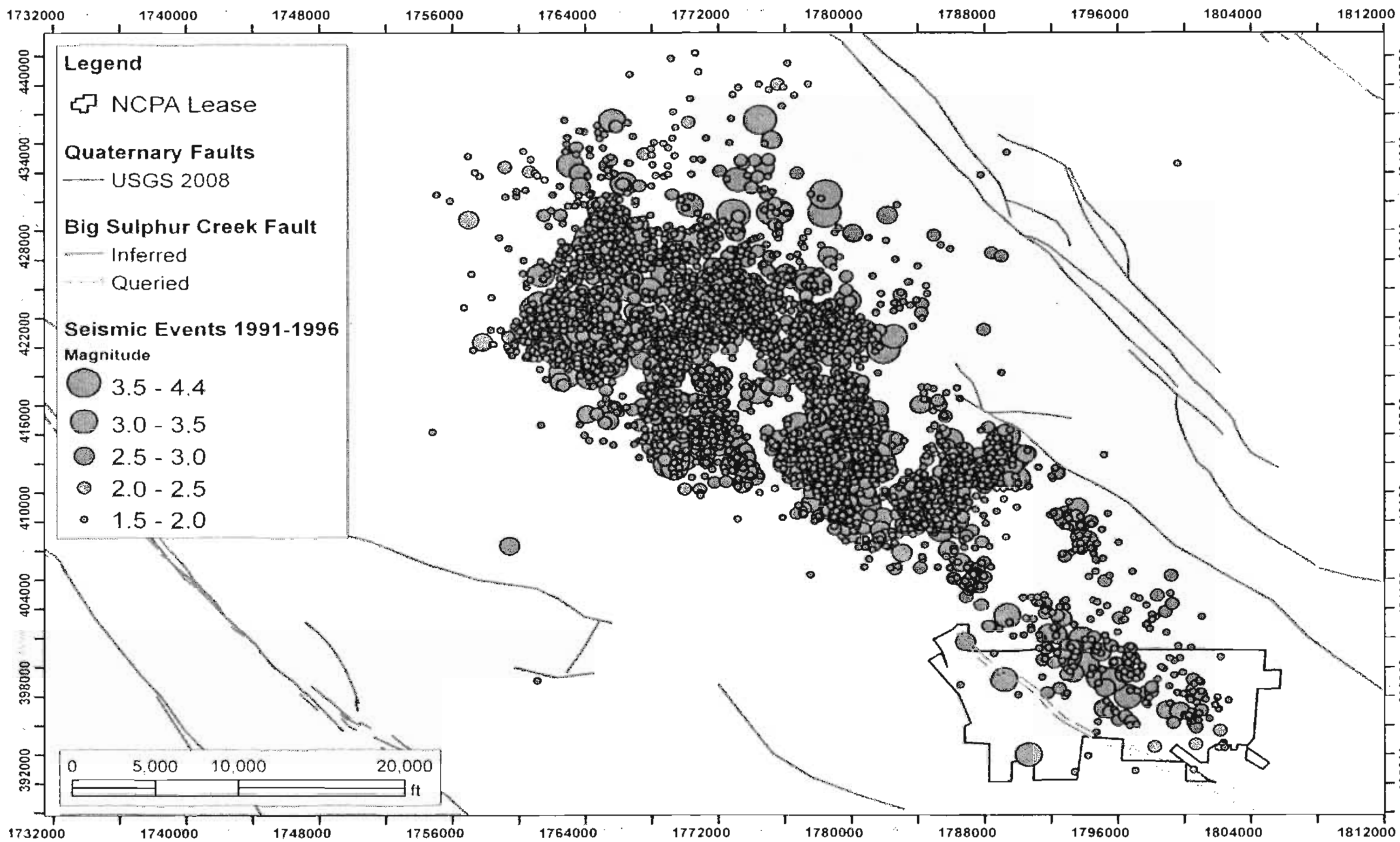


Figure 1.2: Seismic Event Epicenters for the GGF, 1991-1995 (NCEDC, 2008)

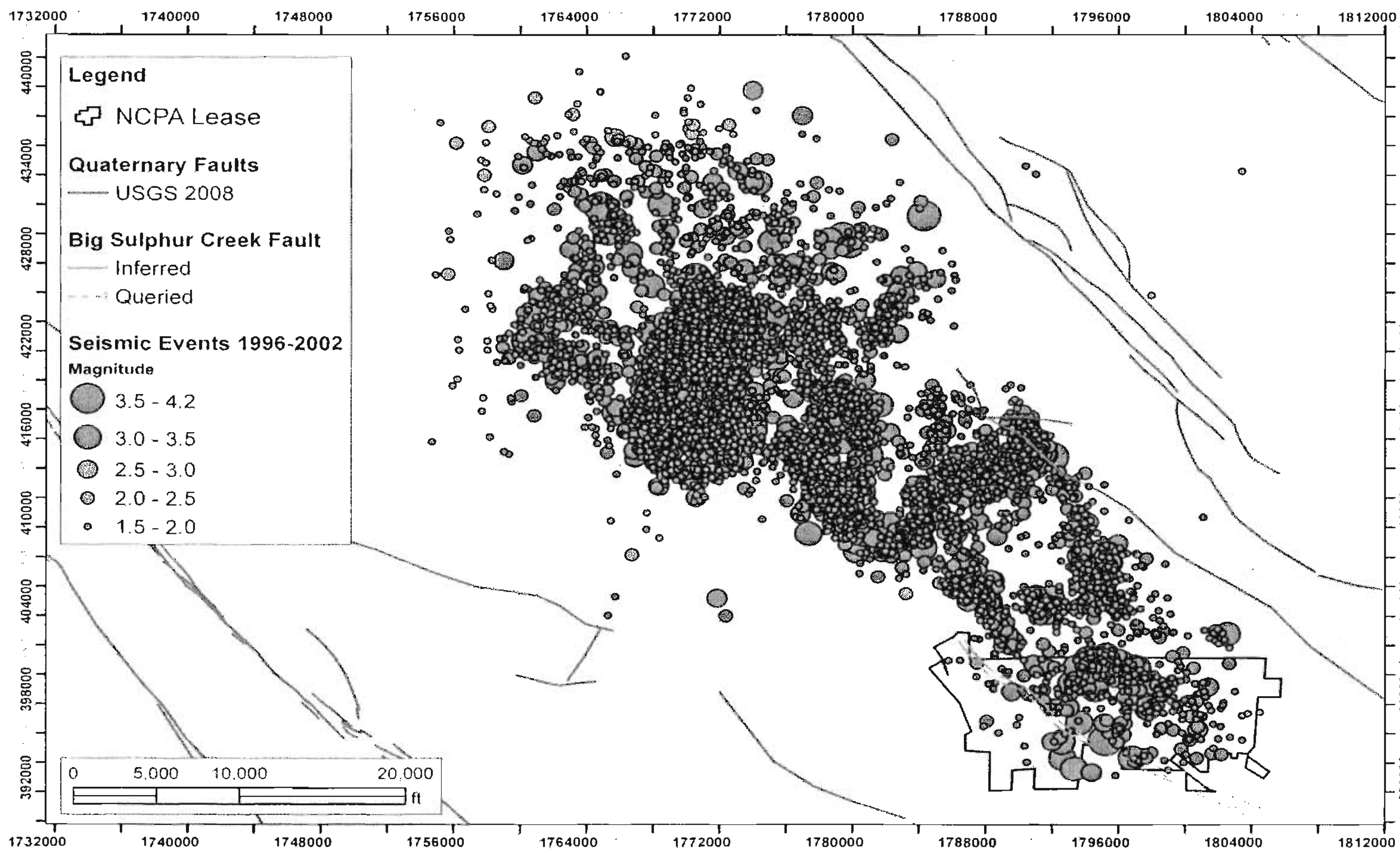


Figure 1.3: Seismic Event Epicenters for the GGF, 1996-2002 (NCEDC, 2008)

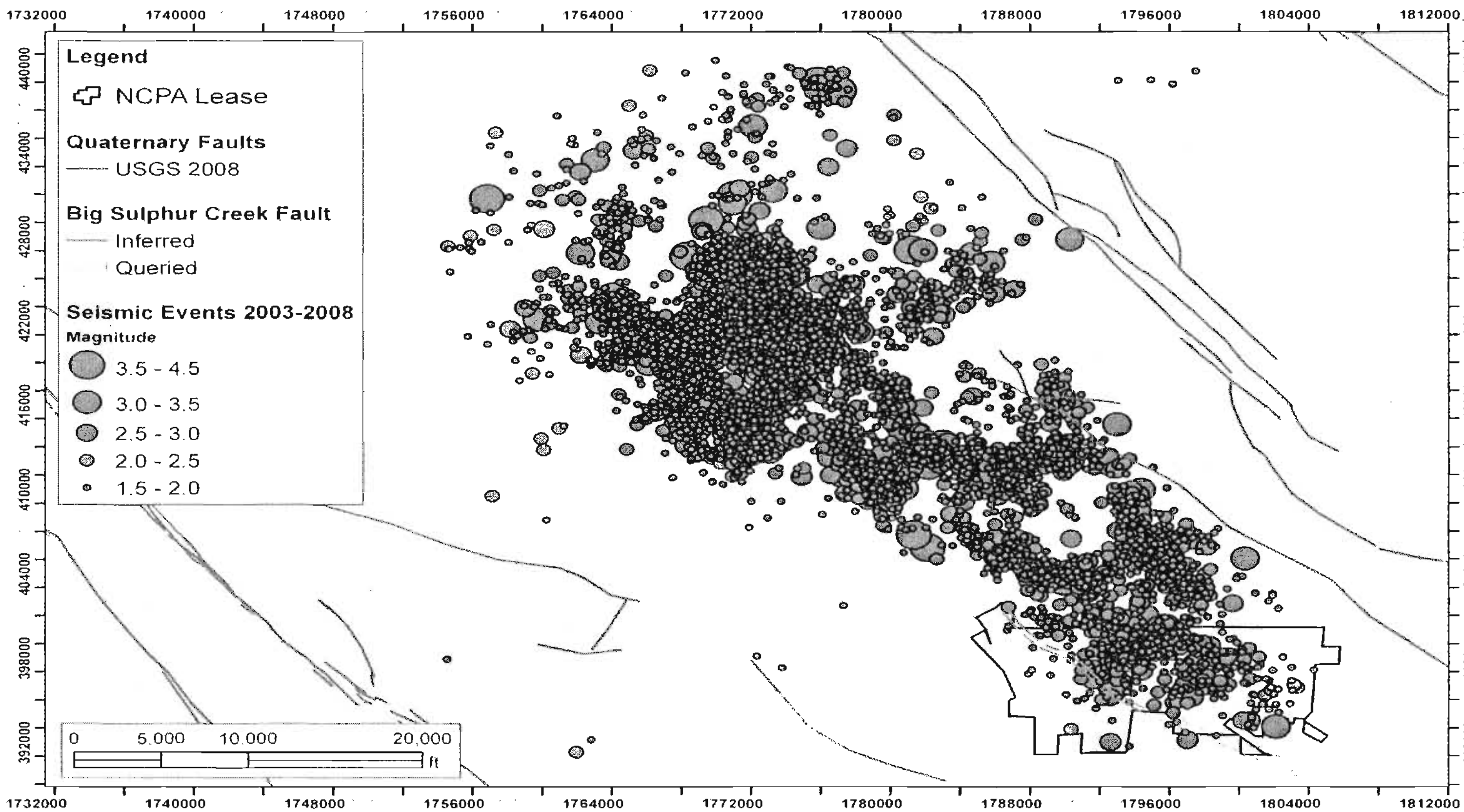


Figure 1.4: Seismic Event Epicenters for the GGF, 2003-2008 (NCEDC, 2008)

1. Findings of Relevant Prior IS and EGS Investigations

*2.1 Summary of Results of Past Studies of **IS***

Overview of the Entire GGF. Based on the documented parallel increase of seismicity rates and geothermal steam production and water/steam condensate injection, a general causal relationship has been established between these activities and **IS** (Greensfelder, 1993; Greensfelder and Parsons, 1996; GeothermEx, 2002; Stark, 1990), although as discussed below, the exact relationship between these activities is variable and not fully understood. It is generally accepted that **IS** may increase in the vicinity of an injection well by increasing water pressure within pre-existing fractures in the reservoir rock. Additionally, it has been suggested that localized cooling and resulting rock shrinkage around the wellbore can change the local stress conditions, which reduces resistance to shearing and permits the release of natural tectonic stress and strain, resulting in **IS**. However, the detailed mechanism of the release of natural elastic energy is not completely understood nor easily predicted. Static-stress modeling calculations indicate that microseismic events induced at the GGF do not contribute to the risk of a larger seismic event on nearby faults (Greensfelder and Parsons, 1996).

Several mechanisms and physical models have been proposed to explain the generation of seismic events by fluid injection or withdrawal, but none has been generally accepted as proven for The Geysers. On balance, previous studies of **IS** in the GGF indicate that injection and increased **IS** are often correlated phenomena, although the relationship appears to be highly variable and poorly understood. The relationship is more evident for some wells, or portions of the GGF, than for others, and it appears to vary with time, as well as with detailed temporal variation of injectate flow. **IS** is also related to production, although the correlation is not well resolved. Some of this apparent variability may be the result of imprecision in hypocentral determinations or in analytical procedures, resulting in inadequate resolution of induced seismicity characteristics.

The largest event recorded to date at the GGF had a M=4.6 and occurred five years before the peak of production in 1987. Since 1997, water injection to recharge the steam reservoir has grown considerably. In 2007, about 100 billion pounds (12.5 million gallons) of water was injected in the GGF (Figure 2.1). The number of microseismic events with M≥ 1.5, averaging about 1,000 per year over the last decade, has clearly increased with injection. However, the rates of seismic events that are likely to be felt has remained constant over the last decade of higher injection rates. Seismic events with M≥4.0 have occurred at a rate of about one per year, and those with M≥3.0 have occurred at a rate of 16 to 29 per year, or an average of about 20 per year (Figure 2.1).

It has been inferred that the largest possible seismic event at the GGF, induced or tectonic, would be a magnitude 5.0 (Majer et al., 2007) based on the lack of continuous long faults, the lack of alignment of event epicenters, the abundance of microseismicity to relieve any stress before it builds, and historical analysis of seismicity by Greensfelder and Parsons (1996). For the EGS Demo Project, we calculated that the maximum realistic **IS** could be M=2.3 (see Appendix A for a detailed discussion).

Although the deep well injection of steam condensate has taken place for at least 40 years, injection of large amounts of municipal wastewater from Lake County only began in September 1997. Over the last 11 years, NCPA has received about 40% of the pipeline water. Between June 1, 1997, and November 30, 2002, the NCSN annually detected and located 877 seismic events with M≥1.5, 210 with M ≥2.0, and 3 with M ≥3.5. This overall level of **IS** at the GGF is approximately 14% higher than during the preceding period January 1, 1980 to August 31, 1997. In the southeast portion of The Geysers (within both the NCPA and southernmost Calpine leasehold), the rate of microseismic events approximately doubled during the period 1997-2002 (GeothermEx, 2002), apparently related to increased injection (also compare Figure 1.2 and 1.3).

A standard procedure in the analysis of seismicity is to make a graph of magnitude-vs-frequency of occurrence, which exhibits a log-linear empirical relationship. The frequency data are the cumulative numbers of events with M>M' (M' is any chosen magnitude of interest) of seismic events per unit time (N/T, just named "N" on the chart where T is usually a period of one year). The logarithm of N bears a linear relationship to the cumulative magnitude, as expressed in the equation

$$\log N (\geq M) = a + bM,$$

and this is termed the "magnitude-frequency" relationship for the area under analysis. These data normally can be fit well with a straight line of negative slope (-b), termed "the b-slope," over a range of magnitudes where the seismic events are completely recorded. Note that when we describe the value of a b-slope, we are discussing its absolute value, which is always positive.) For example, in Figure 2.2, the seismic events plotted range from M=1.04.0. At lower magnitudes, magnitude-frequency curves usually flatten because not all small seismic events are detected and/or recorded as the sensitivity of the current seismic network (M~0.7) is approached. The lower bound of this range of M is determined by the sensitivity of the seismographs used and background noise, either natural or man-made. The upper bound of M is usually determined by the time span of the seismicity record under analysis because large-magnitude events are infrequent. For example, we cannot determine the annual frequency of occurrence of M≥5 if none, or only one, has occurred (this is a matter of sampling statistics) within a given study area and time. Changes in the b-slope may indicate a magnitude above which most events are natural and below which events are due to both natural seismicity and **IS**. Presented below is the significance of the b-slope measurement for the Calpine and NCPA areas.

Figure 2.1 presents magnitude-frequency curves for the entire GGF for the period 1980 to 2002. In addition, two curves for the Calpine-SE area as well as two for the NCPA are shown. These are discussed at detail below. Note that all curves on Figure 2.2 remain linear down to M=1. This indicates that the flattening of the curves below M=1 and that networks are likely detecting all events with M>1.0, which is consistent with the known sensitivity of the current seismic network of M~0.7.

Locally felt seismic events centered in the GGF have been continually reported in the towns of Cobb and Anderson Springs. During the period from 1975 to 1985, 21 seismic events with magnitudes from 2.3 to 4.2 were reported felt there (Greensfelder and Parsons, 1996). See Section 5 for additional details on the history of locally felt and regionally damaging seismic events.

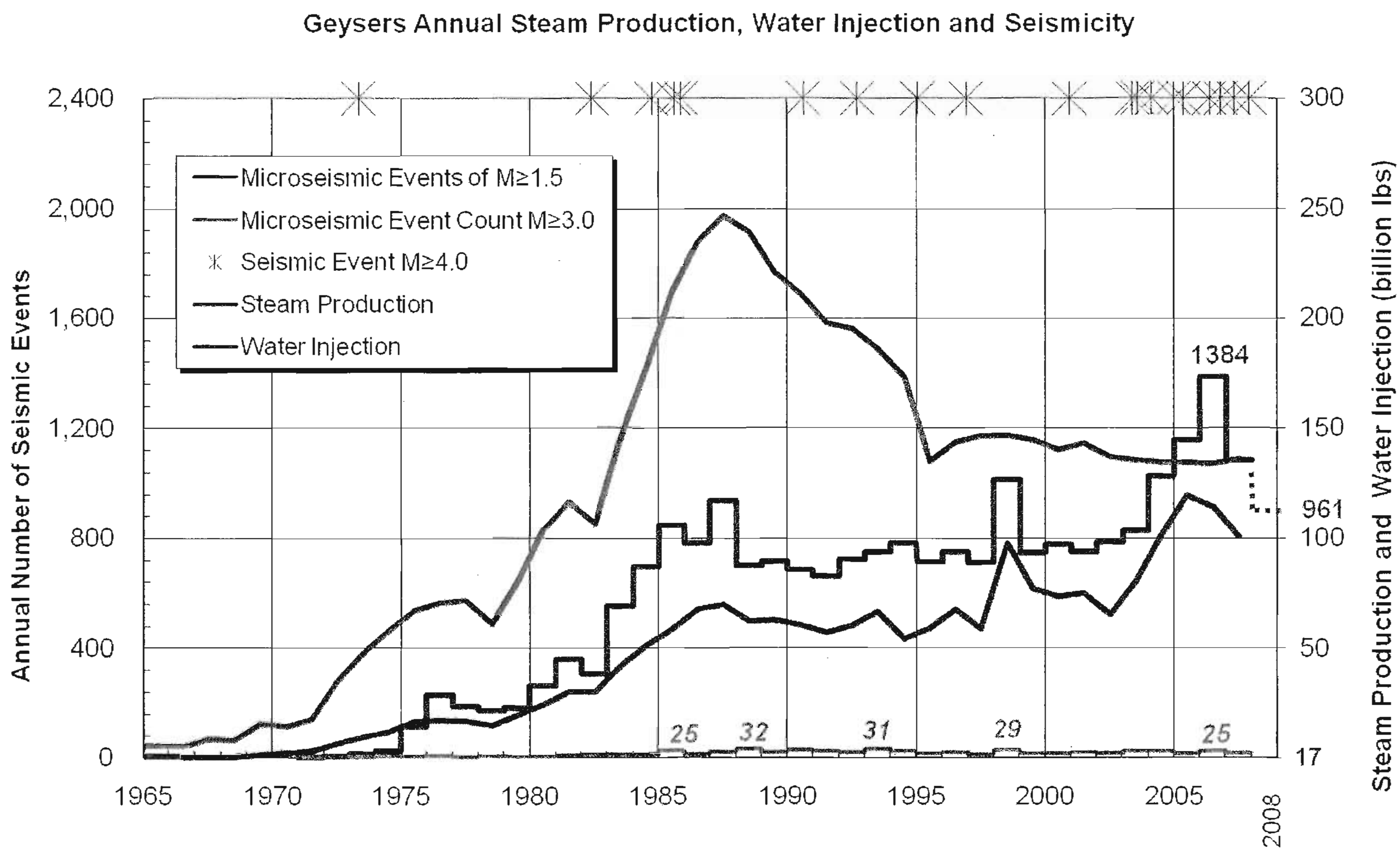


Figure 2.1: GGF Annual Steam Production, Water Injection and Seismicity (NCPA, 2008)

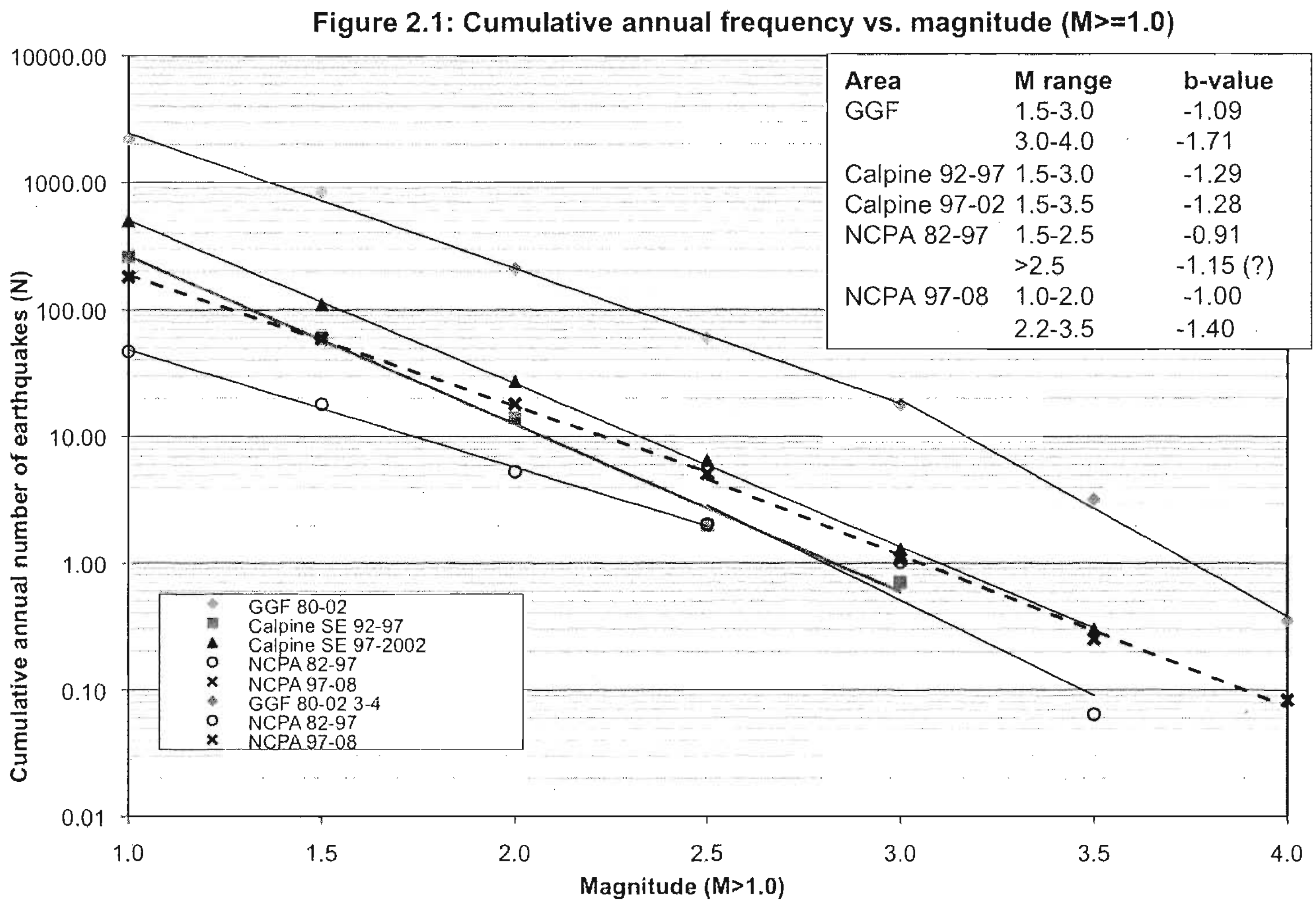


Figure 2.2: Cumulative Annual Frequency vs. Magnitude (M≥1.0)

2.1.2 Calpine Leasehold

The northern and central portions of the GGF are seismically very active (Figure 1.4). Seismic events occur at apparently random intervals rather than in related groups or swarms. They generally have depths less than 20,000 ft. Seismographic data has demonstrated that **IS** has increased as steam production and water injection increased from the 1960s to the 1970s and to the present time. Studies have also revealed an irregular correlation between **IS** and steam production, and episodes of water injection (Stark, 1990; Greensfelder, 1993; Greensfelder and Parsons, 1996; GeothermEx, 2002). While a majority of wells do not seem to exhibit correlation between **IS** and changes of injection flow rate, many do, and a few strikingly so.

The current **IS** investigation is, in essence, a continuation and update of previous comprehensive studies (Greensfelder and Parsons, 1996; GeothermEx, 2002; Parsons, 2003a; Parsons, 2003b). These studies confirmed the occurrence of **IS** (as reported by the NCSN) in the central and southern parts of the Calpine leasehold as a result of ongoing fluid injection in deep wells. Seismicity variations in the immediate vicinities of five injection wells were analyzed for their correlation in time with variations in the rate of injection. For three wells, such correlation was observed and was roughly quantified. Important conclusions were as follows:

1) injection at rates over 1.38 million gallons per day (Mg/d), which is about one million barrels of water (bbls) per month, in a given well is virtually certain to induce microseismic events; injection at rates of 0.69 to 1.38 Mg/d has a good chance of causing **IS**;
2) for injection rates over 1.38 Mg/d, one may expect induced microseismicity ($3>M\geq0.7$) at rates of about 10 to 30 per month;
3) the incremental (over background) rate is about 10 microseismic events per month ($M\geq0.7$) for injection of 1.38 Mg/d , increasing roughly proportionately with greater injection.

For the purpose of objectively predicting rates of **IS** due to injection, data from all Calpine study areas were plotted with millions of barrels injected per month (V) on the x-axis and count of earthquakes per month (N) on the y-axis (Figure 4.22 of Greensfelder and Parsons, 1996). A linear regression analysis was performed on the points where the rate of injection exceeded 1 million barrels/month. The simplest mathematical function that could reasonably represent the data was chosen as a model equation, namely, a third-order polynomial. Given a rate of injection that exceeds one million bbl/month, this equation is

$$N = 5.01 + 1.86\ V + 4.75\ V^2 - 1.15\ V^3 \pm 4.75$$

where N is the monthly number of events with $M\geq0.7$ and V is injection rate in *millions of bbl/month*. The standard error of this estimate is 4.75. See discussion of b-slope data in the Calpine area presented below.

2.1.2 NCPA Leasehold

Steam production in the NCPA leasehold began in 1983, about 20 years after its beginning in other parts of the GGF. A detailed examination was made of natural and **IS** in this area, and the possible increase of **IS** caused by an increase of injected water (GeothermEx, 2002). The additional water was to come as a result of a new pump station on the pipeline that carries municipal wastewater from the LACOSAN, dedicated to deep well injection. A detailed map of epicenters for the period April 2003 through August 2008 is presented in Figure 2.2, and a chart of magnitude-frequency data and curves is shown in Figure 2.1. The map reveals a high density of **IS** in the north-central part of the leasehold, in rough correspondence with the area containing most of the wells.

Figure 2.1 shows magnitude-frequency relationships for the whole GGF from 1980 to 2002, the Calpine Leasehold before and after increased injection in 1998 and the NCPA Leasehold before and after 1998. The curves exhibit a range of b-slopes, from a magnitude maximum of 1.46 to a minimum of 1.00. The curve for the entire GGF (1980-2002) has a slope of 1.09, which is close to values calculated for the Calpine area. It is well to note here that b-slopes for *natural* seismicity are nearly always smaller – generally in the range 0.9 to 1.0 – than for **IS** anywhere and certainly are smaller than b-slopes at the GGF. Previous work has indicated that subregions of the GGF usually have b-slopes ranging from 1.10 to 1.40, varying by locale and magnitude interval, with events of M>3 having a b-slope greater than those with M<3. Except for one (NCPA: 1982-1997), the curves steepen somewhat or greatly for M≥ 2.5 or 3.0. A larger b-value, or steeper slope, for **IS** compared to natural seismicity means that smaller events are relatively more common and larger events less common for **IS** compared to natural seismicity.

The NCPA seismicity map is divided into three groups (Table 2.1 and Figures 2.3 and 2.4) by two structural features in the area: the top surface of the felsite and the Big Sulphur Creek Fault Zone (BSCFZ). The felsite surface, as contoured by NCPA (2008), slopes upward toward a highpoint in the north-central part of the lease area (contour in Figures 2.3 and 2.4) and continues to its high point in the GGF of slightly above sea level just 2,000 ft. north of the NCPA lease area (Hulen and Nielson, 1996). The Geysers-normal steam reservoir is contained in the metasediments above the felsite. Seismicity in the felsite itself appears to be less directly related to injection. The BSCFZ is the southwestern boundary of the steam reservoir (Enedy et al., 1990). The felsite has not been found on the south side of this zone either because it is displaced downward or horizontally by the fault and/or the fault controlled the edge of the intrusion (Hulen and Nielson, 1996). Therefore the events within and southwest of the BSCFZ are not considered as either above or below the felsite.

Histograms of seismic event magnitudes are shown for three groups in Figure 2.5: above the felsite, below the felsite, and in the BSCFZ. Table 2.1 presents the event magnitude data by magnitude and group defined above. These data show that most (60%) of the seismic events under NCPA have occurred in the Geysers-normal steam reservoir, above the felsite. Those events are all smaller than M=3.06 and are mostly smaller than M=1.5.

The largest events of the past 12 years occurred in the BSCFZ. On 10/12/1996, an M=3.7 event occurred. Based on proximity in both time and space, that event was accompanied by two apparent aftershocks (an M=3.02, 4 minutes after the main shock and an M=3.11, 8 hours after the main shock). The 12/27/2004 seismic event (M= 4.32) is the largest in the NCPA data set. All three of these events occur along a N50°W trend along the BSCFZ at the southeastern edge of the NCPA area. The nodal planes as determined by automated routines run at the Berkeley Seismological lab (NCEDC, 2008) for the two main events have strikes roughly parallel to the BSCFZ trend. However the dip (50°) and sense of movement (normal slip) indicated by the nodal plane is not consistent with an 85° dip to the northeast and an inferred movement of thrust (McLaughlin, 1977) or strike-slip (NCPA, 2008), as described for the BSCFZ. Because this fault zone is outside of the areas of water injection and steam production, the BSCFZ seismic events are considered to be tectonic, not induced, and unrelated to the injection activities.

Table 2.1: NCPA Seismicity by Magnitude and Group for Past 5 years (4/2003-8/2008)

Magnitude Range	Above Felsite	Below Felsite	BSCFZ[1]	All
1-1.5	516	209	117	842
1.5-2.0	130	65	37	232
2.0-2.5	48	14	11	73
2.5-3.0	17	2	5	24
3.0-3.5	2	1	0	4
3.5-4.0	0	1	0	1
4.0-4.5	0	0	1	1
Total	712	292	171	1177
Percent of total	**60%**	**25%**	**15%**	**100%**

[1]Big Sulfur Creek Fault Zone

Five cross-sections were prepared to look for lineations of seismic events and clustering of events around injection wells (Figures 2.6 through 2.10). The locations of the cross-sections (AA' through EE') are shown on Figures 2.3 and 2.4. On all the maps and cross-sections showing the injection wells in this report, the injection wells are represented by three points: the surface location, the mean steam entry determined during drilling, and the bottom of the hole. These three points are joined by lines to represent the generalized well path, although the actual well courses may be more complex.

In general, the cross sections show that seismicity does not cluster around the mean steam entry points or anywhere along the injection wells. In fact, it is not possible to identify spatial patterns to the seismicity. As discussed above, seismicity is more frequent in the reservoir (above the felsite); however, significant activity also occurs in the felsite in which minimal drilling and/or injection has historically been conducted. Cross-sections AA' and CC' pass through the E-7 well and show the proposed deepening of that well. The total vertical depth is projected to be 12,247 ft. is shown, which is consistent with a scenario where the hydroshear dilation zone grows upward away from the isolation zone in the borehole (more details in section 4.3).

Smith et al. (2000) observed a similar pattern as illustrated using data obtained from the more densely spaced Calpine seismic array. These data show that within the northern part of the southeastern GGF there are distinct clusters of **IS** around injection wells and extending to depths below them, as shown in cross sections presented in Smith et al. (2000) of one year of seismicity both before and after the startup of the SEGEP pipeline in late in 1997. Smith et al. (2000; Rutqvist and Oldenburg, 2007) attributed this distribution of events to the depth to which injected water penetrates before boiling. This cools the reservoir rock, causing contractional-induced fracturing as well as shear slip. It would appear that given the continued pattern of seismicity, the mechanism for microseismicity has not changed after continued and increased seismicity over the last decade.

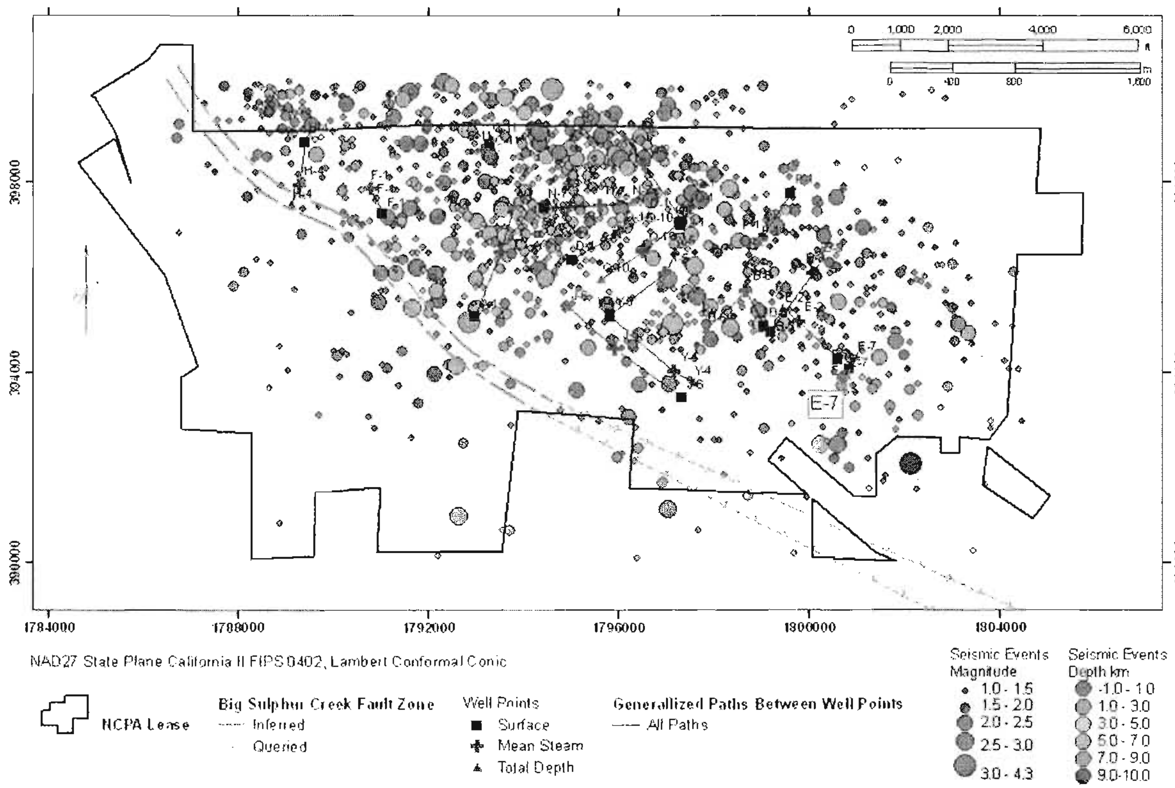


Figure 2.3: All Seismic Events in NCPA Area, 4/1/2003 – 8/31/2008, M = 1.0 – 4.3 (NCEDC, 2008)

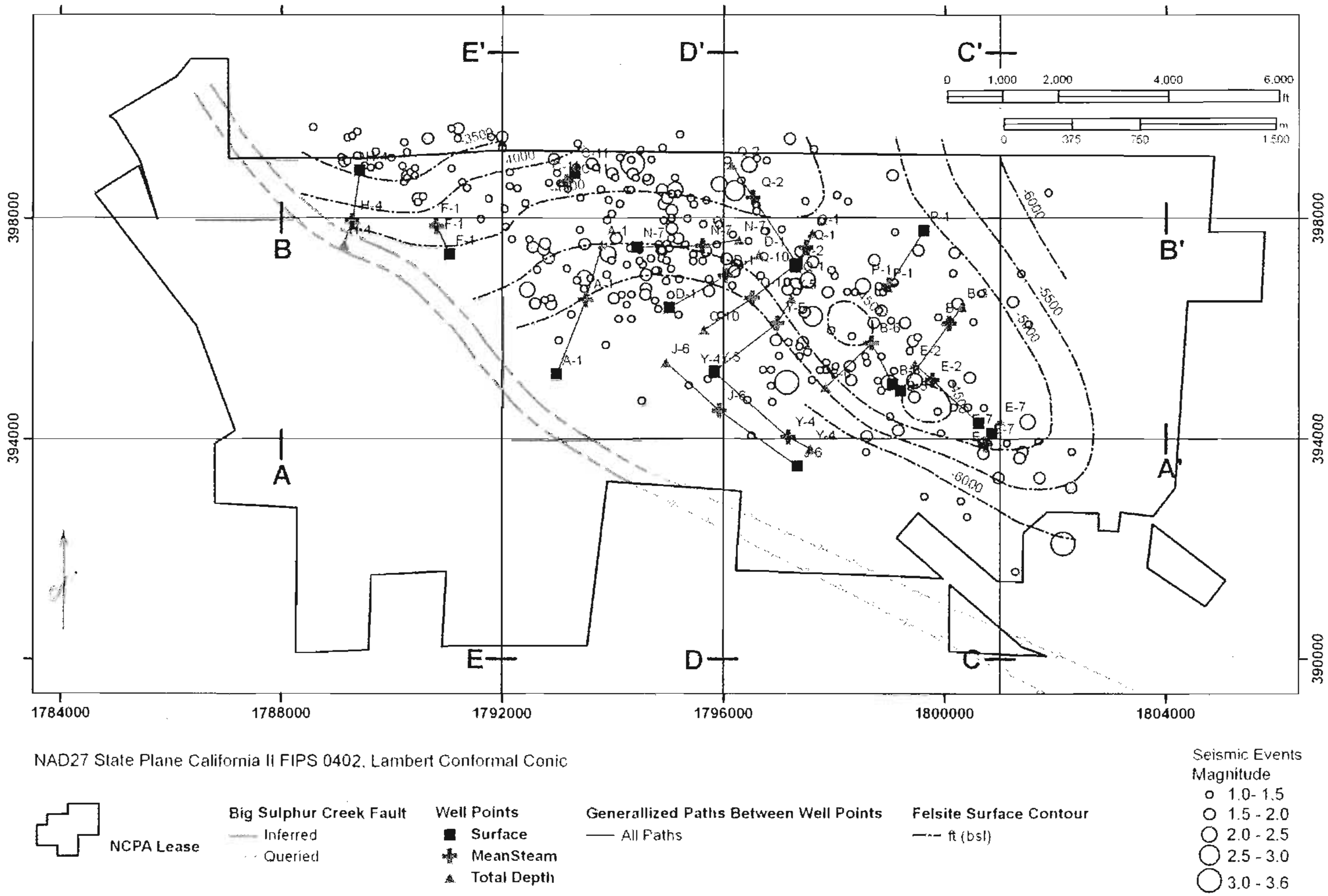


Figure 2.4: Microseismic and Seismic Events in NCPA Area below Felsite Surface Shown in Contours, 4/1/2003 – 8/31/2008, M = 1.0 – 3.6 (NCEDC, 2008)

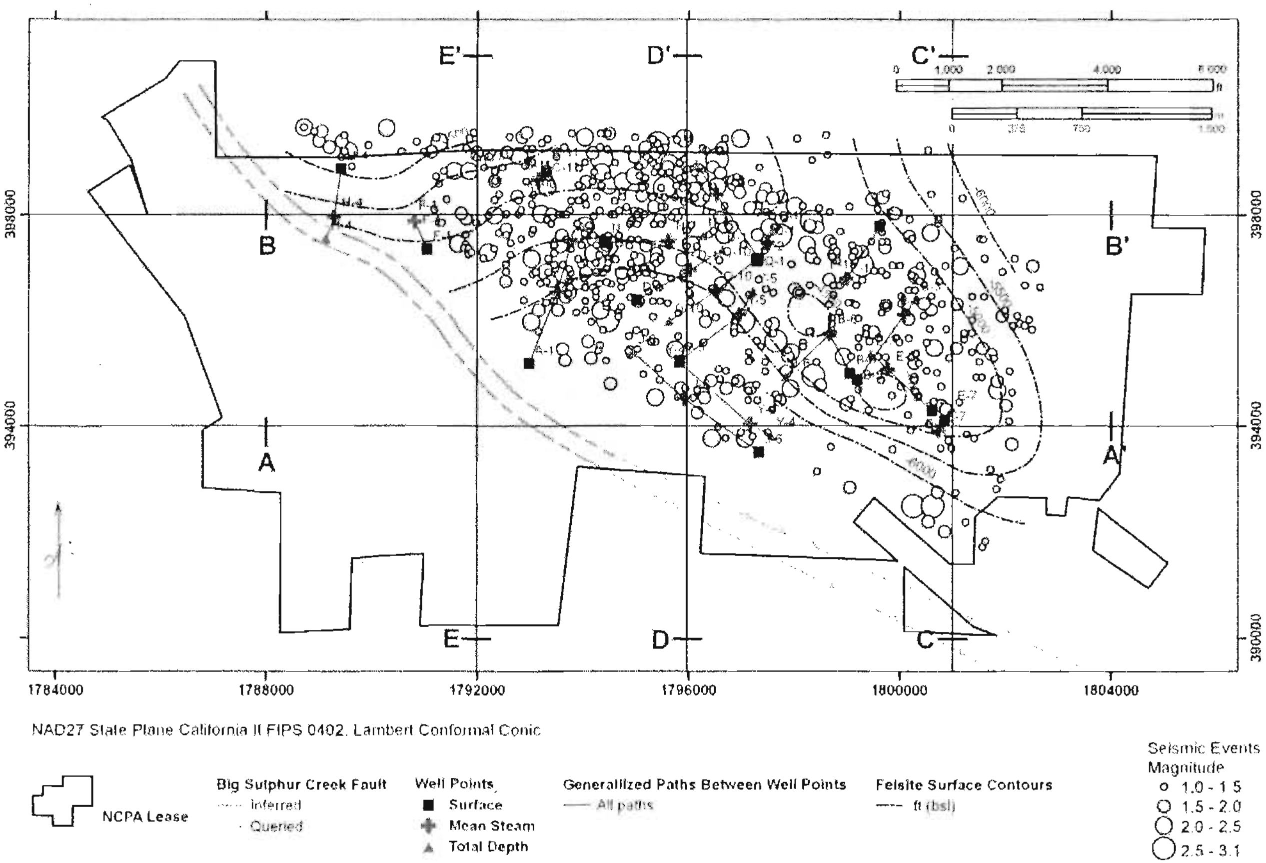


Figure 2.5: Microseismic and Seismic Events in NCPA Area above Felsite Surface Shown in Contours, 4/1/2003 – 8/31/2008, M = 1.0 – 3.1 (NCEDC, 2008)

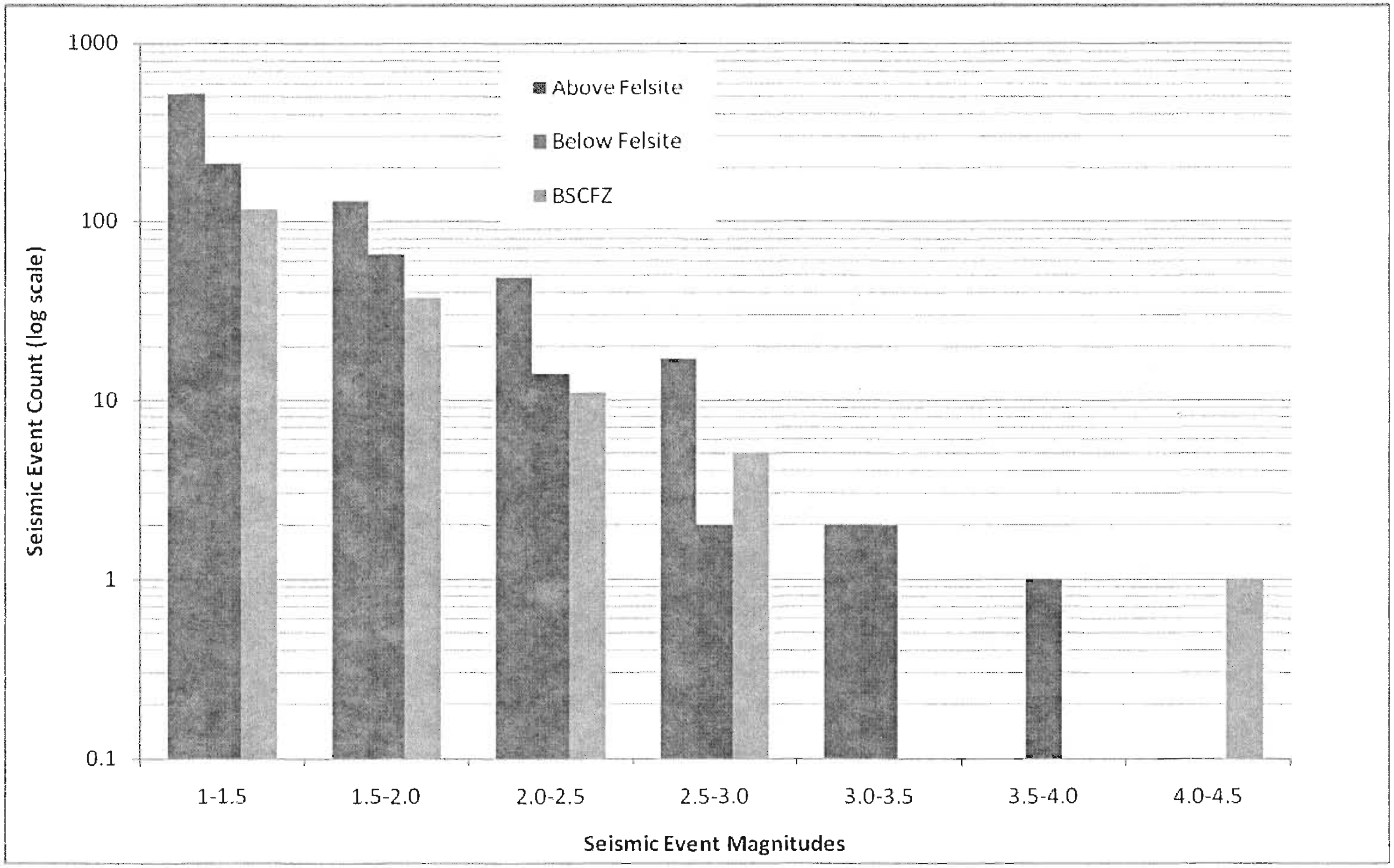


Figure 2.6: Histogram of Seismic Event Magnitudes for Three Distinct Geologic Domains at the GGF, 4/1/2003 – 8/31/2008

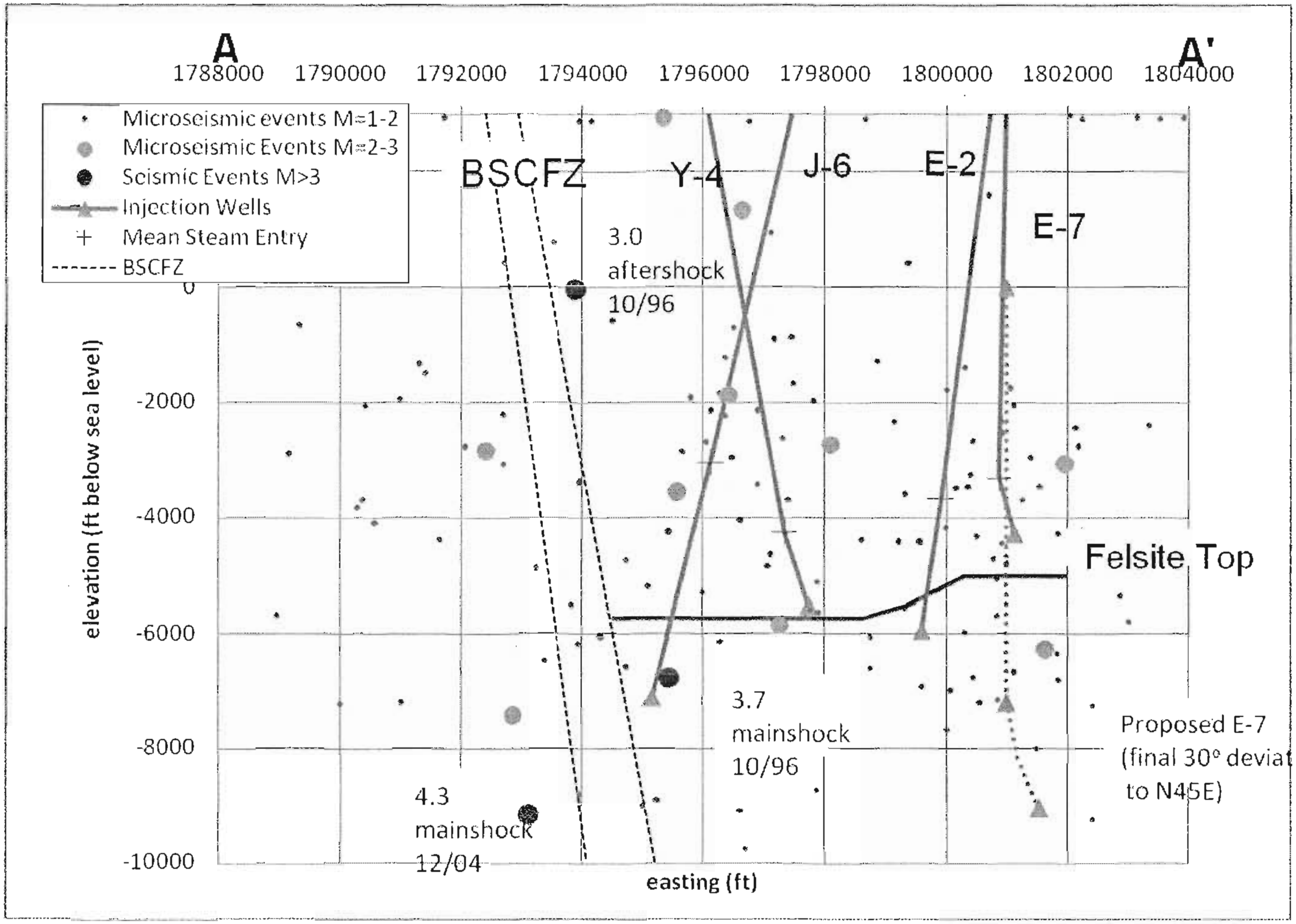


Figure 2.7: Cross-section AA' (section line shown in Figure 2.5)

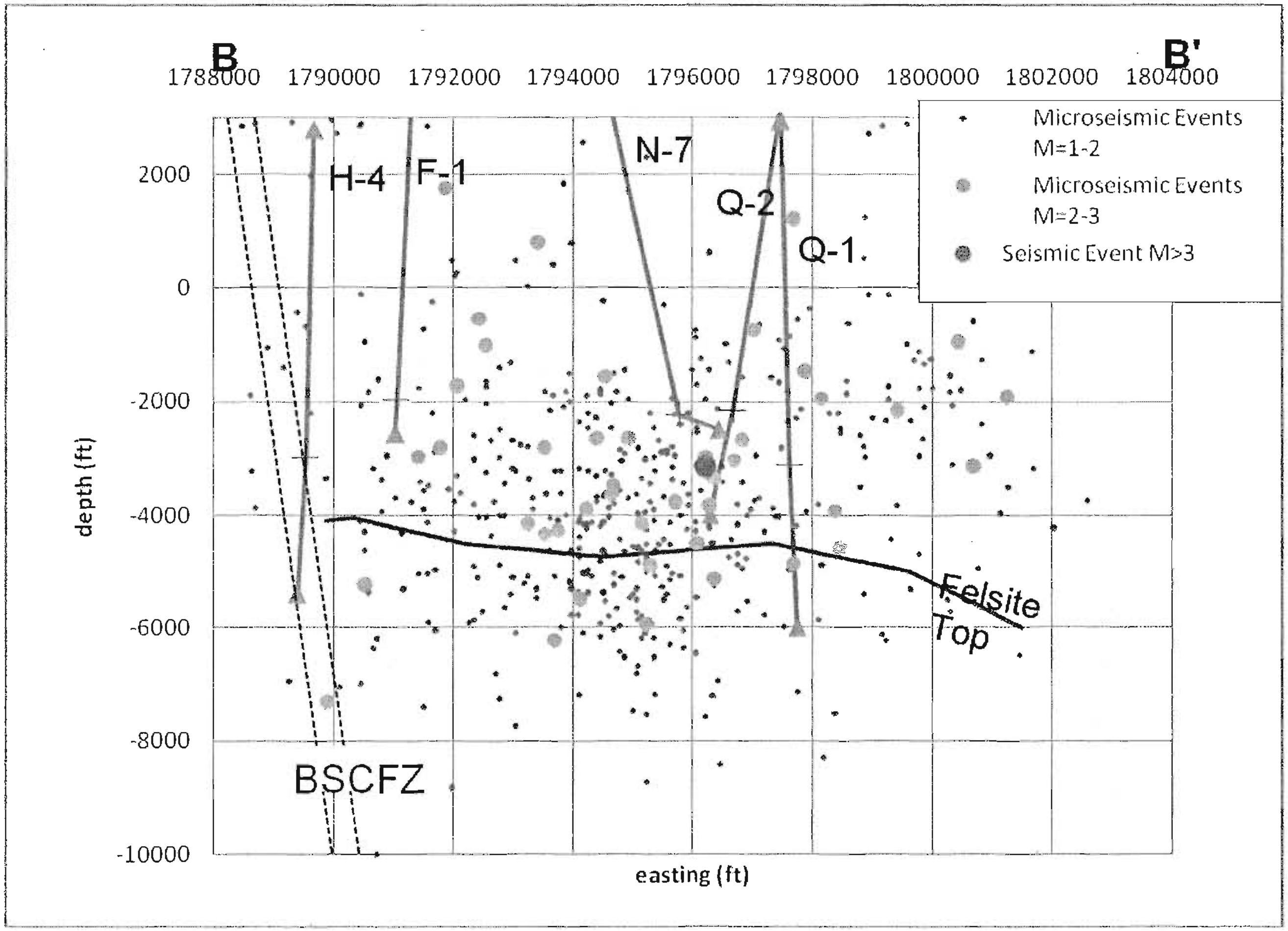


Figure 2.8: Cross-section BB' (section line shown in Figure 2.5)

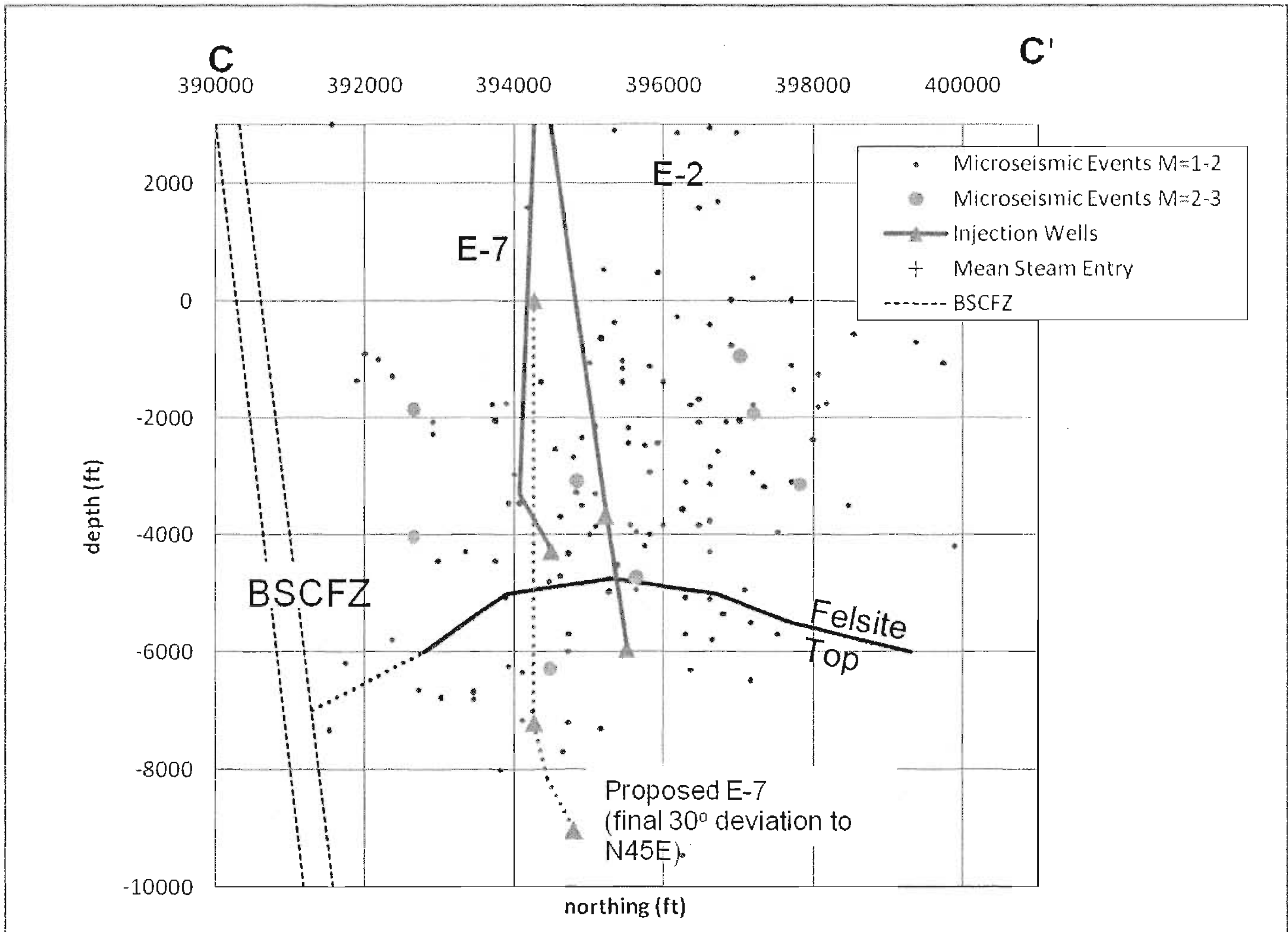


Figure 2.9: Cross-section CC' (section line shown in Figure 2.5)

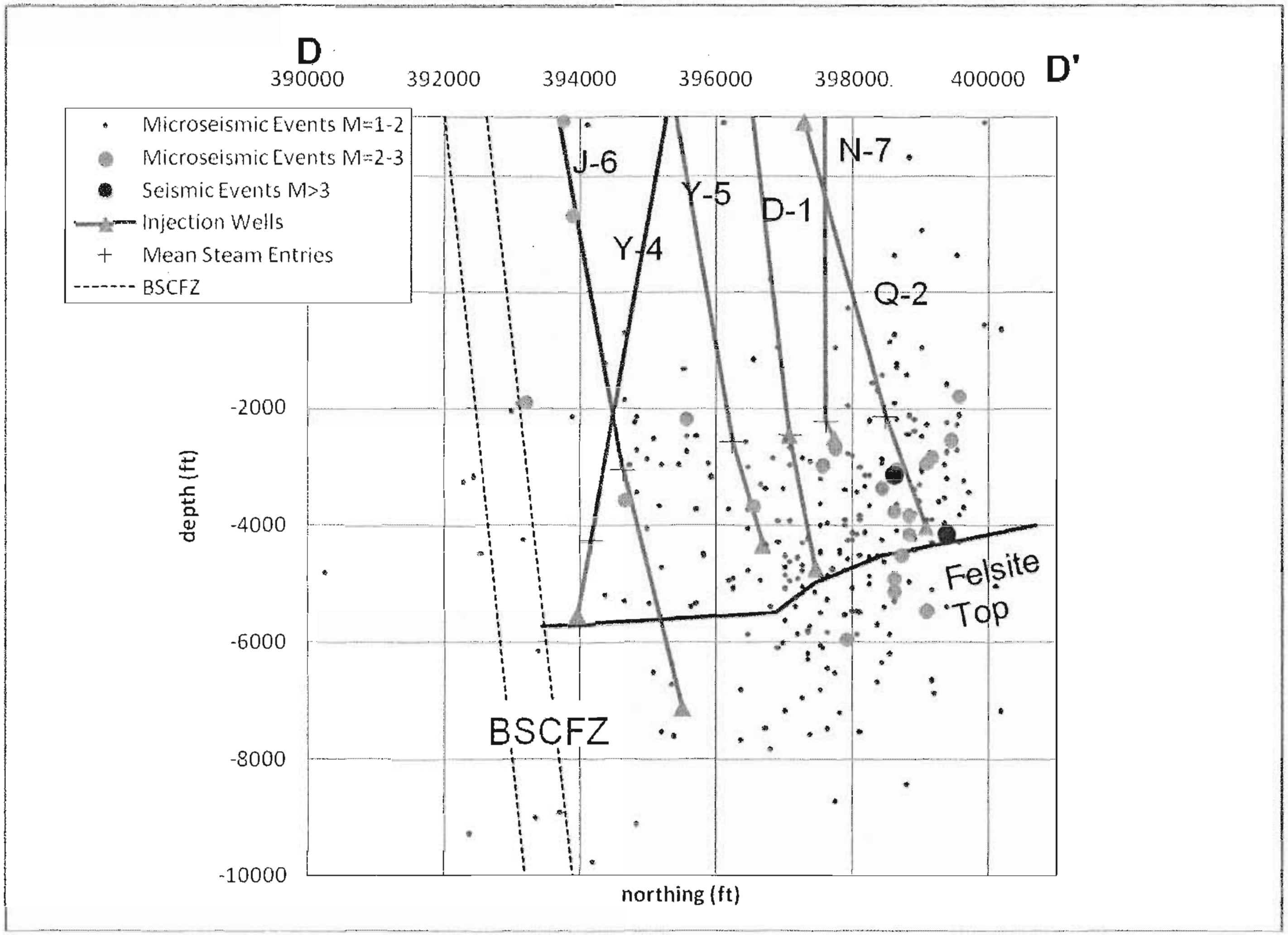


Figure 2.10: Cross-section DD' (section line shown in Figure 2.5)

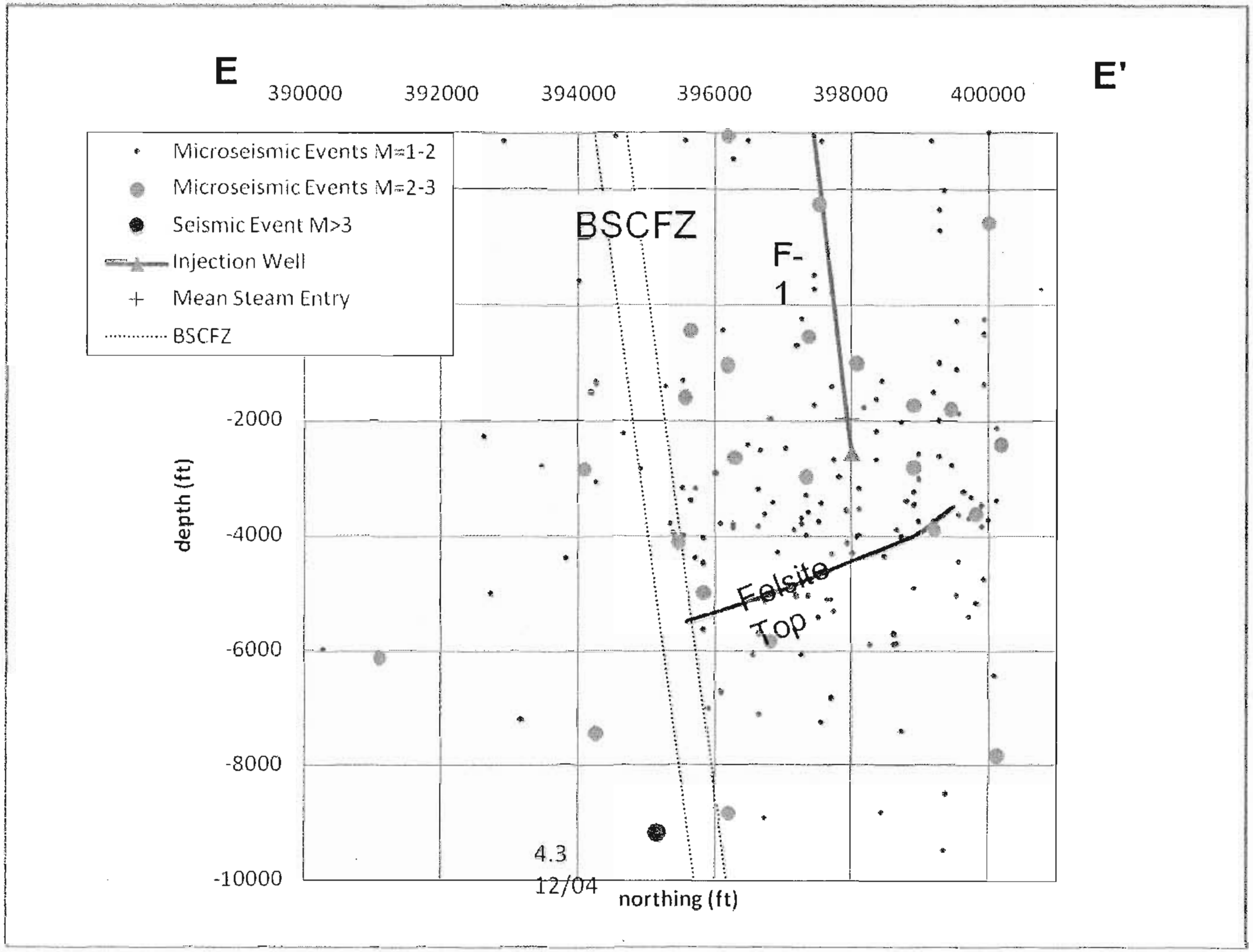


Figure 2.11: Cross-Section EE' (section line shown in Figure 2.5)

2.2 Summary of Results of Past Studies of EGS

An important issue related to any geothermal project involving injection, including EGS, is the generation of **IS** and its impact on local communities. An EGS project will involve four very different categories of **IS** (1) background microseismicity, (2) microseismicity due to the creation of the engineered reservoir and (3) microseismicity, if any, related to the long-term data gathering and monitoring, and (4) microseismicity, if any, during operation of the geothermal resource for power generation. The EGS Demo Project plan calls for a 21-day period for reservoir creation. The long-term data gathering and monitoring is planned for a two year period, but the actual duration will be dictated by the behavior of the engineered geothermal reservoir. The engineered reservoir will be used for power generation if the long-term data gathering and monitoring is successful.

To create the reservoir, water will be injected at pressures sufficient to cause shear-slip of existing fractures (hydroshearing) but not enough to cause a tension fracture in the rock. During this period, microseismicity is an expected and necessary aspect of EGS because hydroshear dilation will create thousands of very small (M<<1) microseismic events that will be recorded by the EGS Demo Project MSA but for the most part, will not recorded by the NCSN because it is not sensitive enough and not felt at the surface. Section 4.4 and Appendix A, provide models specific to the hydroshear dilation that will be performed at E-7.

Two recent technical papers, Majer et al., (2007) and Bromley and Mongillo (2008) provide excellent, up-to-date reviews of what has been learned about **IS** at other EGS projects that have been conducted around the world. Soultz is one of the best studied and documented EGS sites in the world. The stimulation of a 15,000 foot deep well at Soultz, GPK3, in 2003 provides an example of expected **IS** for the EGS Demo Project. Majer et al. (2007) describes the activities at Soultz and the associated **IS**. During the hydroshear dilation of GPK3, about 10.6 million gallons (40,000 m^3) of water were injected at a rate of 5 to 21 gallons/s (20-80 L/s) over about 11 days. More than 400 events above magnitude 1.0 were generated, and about 30 were above 2.0 (Figure 2.12). Approximately 6000 microseismic events between -1.0<M<1.0 were detected. Below M=-1.0 the drop-off in the number of events likely indicates that the detection was incomplete. The largest event was M=2.9. Although local residents did feel some of these microseismic events, no damage was documented. AltaRock's MSA that will be installed for the EGS Demo Project will have a sensitivity similar to the Soultz array, and is expected to detect events down to M=-1.0, with a strong drop-off in detection below that level. Also the injection volumes and rates of the EGS Demo Project will be similar to those used at Soultz. Therefore, we expect that Figure 2.12 provides a good prediction of the size distribution of **IS** expected at the EGS Demo Project.

Structural damage from EGS activities as summarized by Bromely and Mongillo (2008) is not expected:

> With regard to vibration hazard, EGS is similar to other activities such as mining, hydrocarbon production, waste disposal or dam filling operations, where the possibility always exists for higher stress release when a load changes. In these

cases, the frequencies generated are generally too high to cause significant structural damage. The defining criteria used for assessing the magnitude of induced seismicity should be ground acceleration and frequency content. For structural damage to occur, frequencies of less than about 10 Hz are normally required. Generally frequencies associated with induced seismicity are much higher, between 100Hz and 300Hz, and are consequently less likely to cause structural damage.

Seismic data from downhole sensors at Soultz indicated that the predominant frequency was 90 Hz, which is very unlikely to cause any structural damage.

The maximum magnitude of seismic events at EGS sites worldwide have been in the range of 2.9 to 3.7 (Table 2.2) and it is not certain whether the events over 3.0 are related to **IS** or are of tectonic origin. There is an important difference between the geologic and tectonic settings of the EGS projects shown in Table 2.2 and the proposed EGS project at GGF that may further mitigate the risk of this project. The European and Australian sites are in areas with no prior geothermal activities far from active tectonic boundaries with low seismicity rates prior to EGS activities (Majer et al., 2007). Thus, the introduction of pressurized water was a major change in the stress state of the rocks, allowing stresses built-up and maintained through geologic time to be rapidly released. In contrast, the GGF is near an active plate margin, and the EGS activities will be below an active geothermal field with ongoing injection and over 200 microseismic events with $M \geq 1$ per year including 60 events per year within the felsite itself. Thus, the EGS activities at E-7 will not introduce a significant perturbation to the existing stress regime and microseismicity response in the same way at the European and Australian sites. Thus, the maximum magnitudes shown in Table 2.2 are considered highly unlikely for the EGS Demo Project.

To characterize **IS** during Phase 1 of the EGS Demo Project, we turn to conventional geothermal projects and the limited EGS worldwide projects. Fortunately, the site of this EGS project, the GGF, is also one of the best studied conventional geothermal projects. This report reviews and updates operational **IS** at the GGF in the following sections. The projections of expected **IS** during and after the EGS Demo Project are discussed in Section 4 below.

Table 2.2: Summary of Largest Events at EGS Sites Worldwide (Bromley and Mongillo, 2008)

Site	Maximum Magnitude
Basel, Switzerland	3.4
Soultz-sous-Forêts, France	2.9
Landau, Germany	None
Cooper Basin, Australia	3.7
Rosemanowes, United Kingdom	3.1

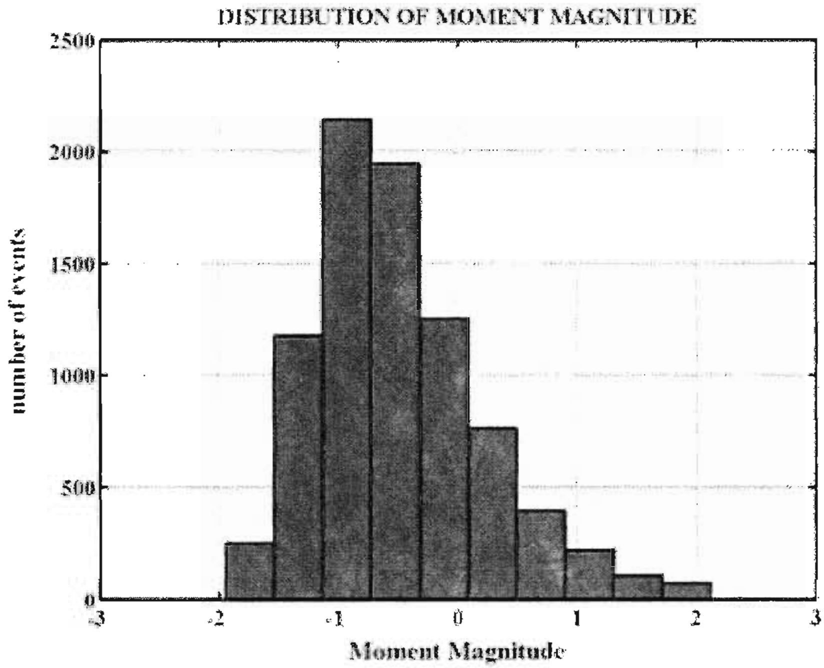


Figure 2.12: Distribution of Moment Magnitude Values at Soultz in 2003 (from Michelet et al., 2004); the Magnitude 2.9 Not Shown at this Scale

1. Comparison of Pre-2003 with Post-2003 IS Data

3.1 Normalized Data.

In order to compare seismic intensities of different source regions, the number of seismic events is often "normalized" by the area of the seismic source region. For this study, we compare seismic intensities of the Calpine SE area and the NCPA area. Using the number (N/year) of microseismic events of M≥1.5, the seismic intensity of the Calpine SE area (5.7 mi^2) is 21/year/mi^2 (1997-2002). For the NCPA area (7.1 mi^2), the intensity is 6/year/mi^2 (1997-2002). The ratio of the two intensities, NCPA/Calpine SE, is 0.29.

3.2 Changes of Injection Rate and ***IS***

Looking at Figure 2.2, we can see the relative positions of magnitude-frequency curves for the periods before and following the start-up of injection of LACOSAN wastewater in September of 1997 in the curves for Calpine SE 1992-1997 and Calpine SE 1997-2002. A similar relation is seen for the NCPA area for the same time periods. For magnitudes from 1.0 to 2.0, the curves are separated by a ratio of 3 (from N/year =2210/732). As discussed in Section 2.1, the b-slopes range from 1.46 down to 1.00, indicating a population of seismic events distinctive of **IS,** as natural seismicity nearly always has b-slopes less than 1.0.

Figure 3.1 presents annual totals of **IS** events (M≥1.5) and total-field injection in the NCPA leasehold (in billions of pounds) for the period 1993-8/31/2008. This chart also indicates a threefold increase in **IS** following the beginning of LACOSAN wastewater injection in September (in the third quarter) 1997. Figures 3.2a and -b present quarterly totals of **IS** events (M≥1.0) and injection at four different wells (in millions of gallons) chosen for analysis. Only one well, P-1, exhibits correlation between **IS** and injection in the four wells shown in Figure 3.2. Compared to the threshold of 1.38 million gallons/day (which is equivalent to about 125 million gallons per quarter) discussed in Section 2.1, the injection rates at P-1 are rather low. Wells A1 and N7 do exceed this rate for short periods during the 5 year span analyzed, while wells P1 and Q2 do not approach the thresholds. Therefore, it is possible that the lack of correlation in Figure 3.2 is due to the thresholds not being reached or that higher thresholds exist due to different injection styles or geologic setting.

The correlation between increased **IS** and increased injection shown in Figure 3.1, but not in Figure 3.2a and -b, may indicate that the locations of the events as reported in the NCSN database are not sufficiently accurate to demonstrate a clustering of events near the active injection wells. The locations of seismic events in the NCPA leasehold will be less accurate than the Calpine leasehold because NCPA is positioned near the periphery of the local array of USGS monitoring stations (Figure 1.1). Alternatively, the injected fluids may travel some distance away from the injector wells before triggering microseismic events.

3.3 Summary of Stress Regime Findings

Analysis of earthquake focal mechanisms (EFMs) to determine stress direction is analyzed in AltaRock (2008). The results of that analysis are summarized here. The EFMs in the GGF, NCPA lease, and E-7 shows a consistent extensional direction of 104°-116°. This direction is consistent with right-lateral shear on the 140° striking faults which bound the GGF on the northeast and southwest. Seismic events occur on both normal faults and strike-slip faults with a consistent extensional direction. This implies that the maximum horizontal stress and vertical stress are close in magnitude. Strike-slip faults are far less prominent among deeper events.

At the southern edge of the NCPA, 31 events within the BSCFZ, including two events with M>3.5, show a different stress regime with an extensional direction of 45°. This change in stress direction appears to be limited to the BSCFZ, and is likely related to the local weakness of the fault. The fault is not considered active at the surface; however, because of the recent minor seismic activity at depth and anomalous stress regime along the BSCFZ, EGS activity in E-7 should avoid getting too close to the fault zone. Since E-7 is more than 3,000 ft from the BSCFZ, this is not considered a problem. The hydroshear operational design plan calls for increasing the distance further by deviating the well to the north, away from the zone, as will be discussed in Section 4.3.

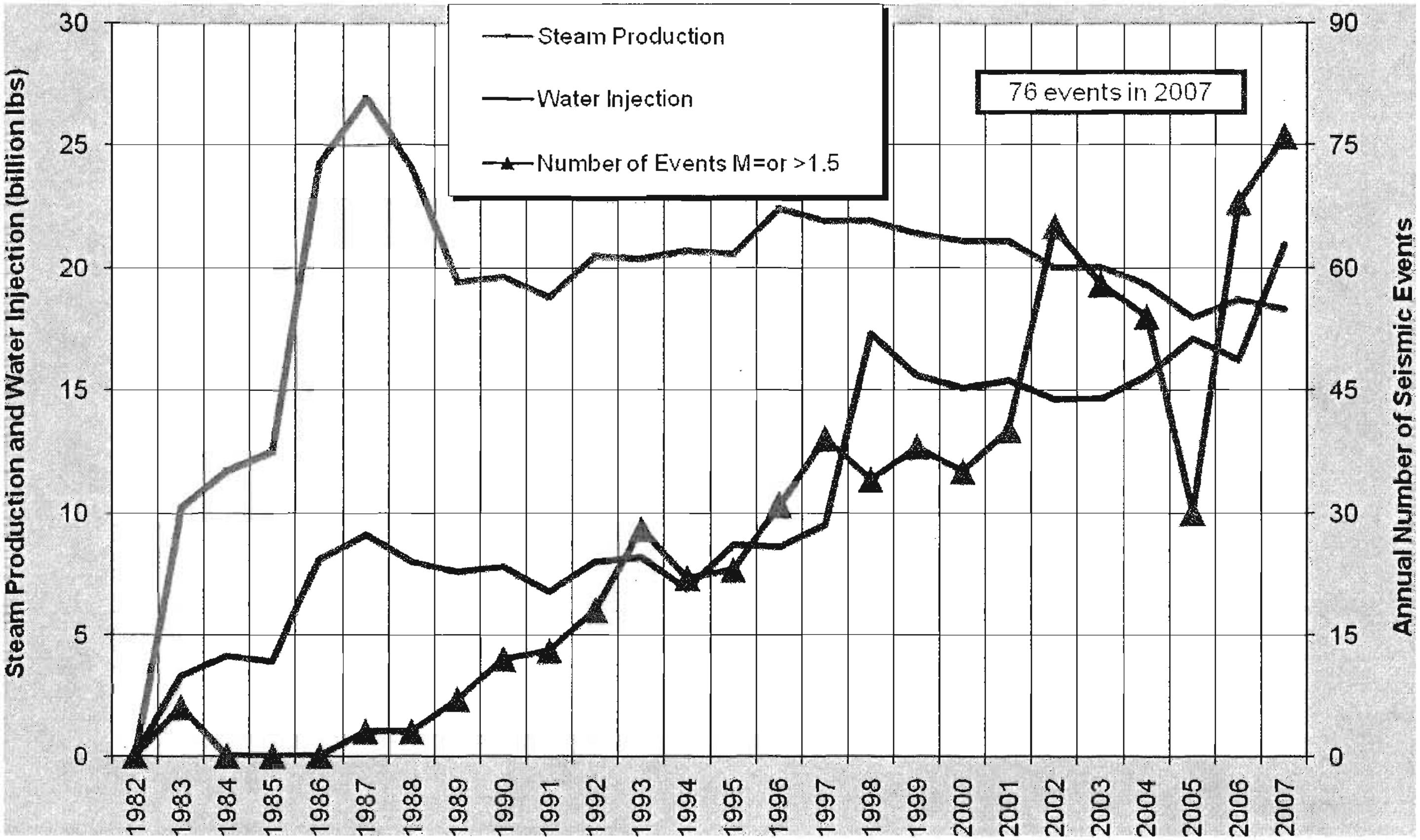
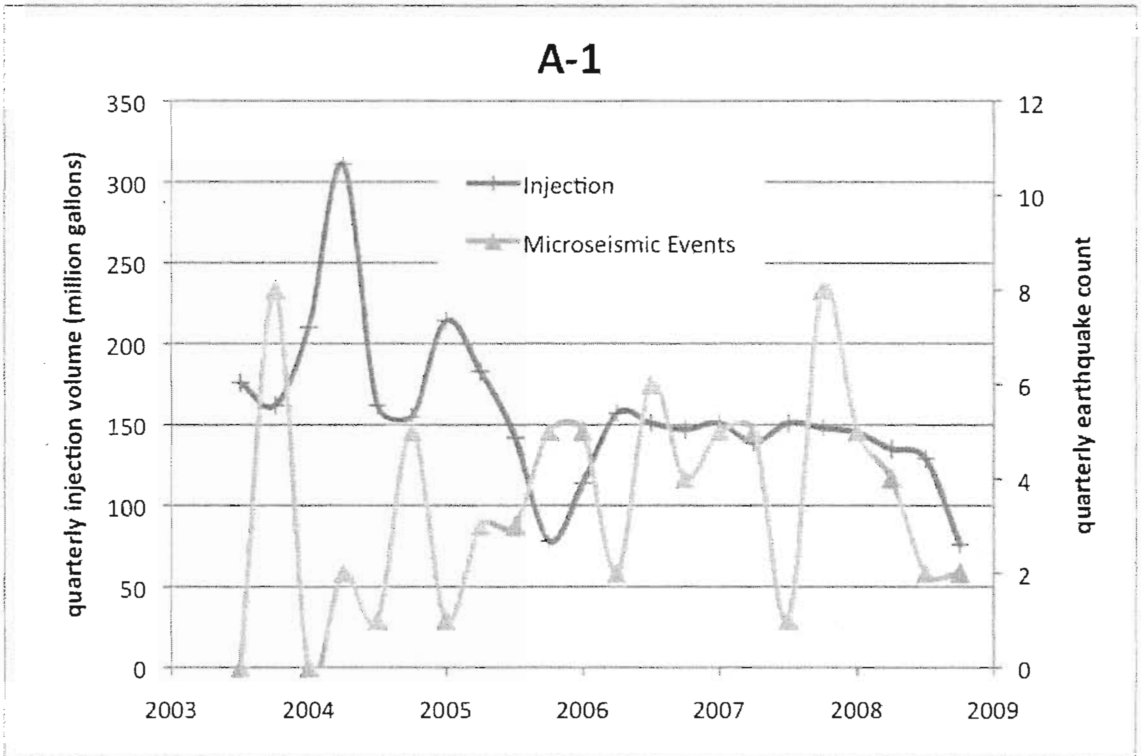


Figure 3.1: NCPA Annual Steam Production, Water Injection and Seismicity (NCPA, 2008



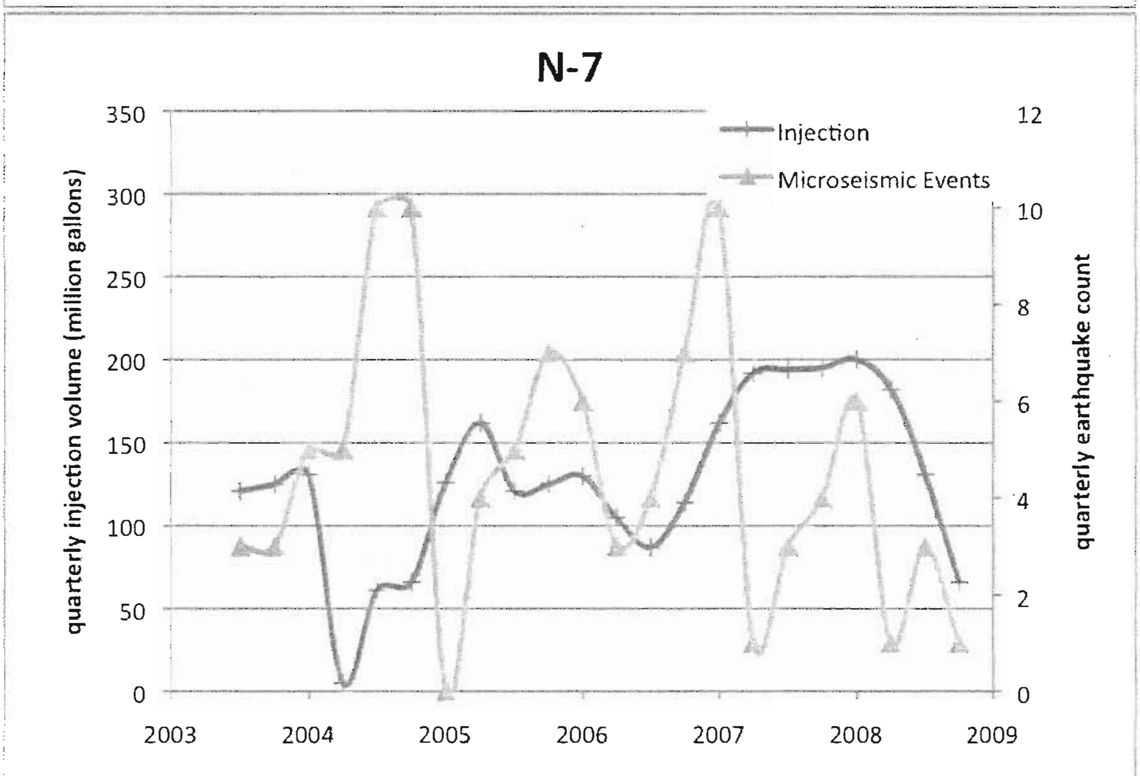


Figure 3.2a: Quarterly Well Comparison of Injection and Microseismicity in Wells A-1, and N-7 in the NCPA Lease Area

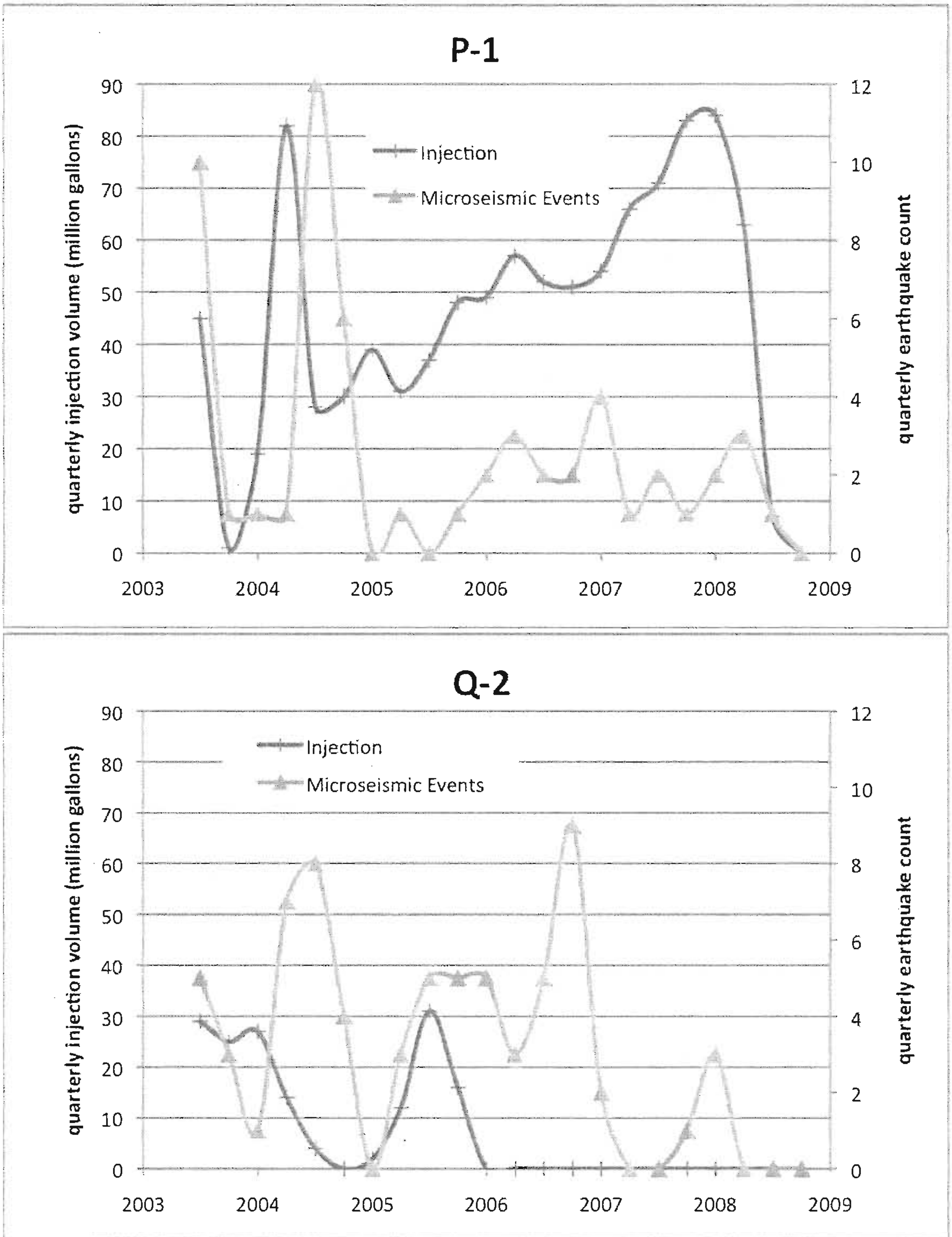


Figure 3.2b: Quarterly Well Comparison of Injection and Microseismicity in Wells P-1 and Q-2 in the NCPA Lease Area

4. Projection of Induced Seismicity During and Following Proposed EGS Project at NCPA

4.1 Update of Correlations of IS and Injection Rates until August 2008

Relationships between injection rate and **IS** are shown for four wells in Figure 3.2. Only well P-1 exhibits an apparent microseismic response to a sudden, large and brief pulse in the flow of injection (in early 2004, with a lag time of one quarter). For the Calpine leasehold, the third-order polynomial shown in Section 2.1 was derived to relate fluid injection at a well and seismicity at that well (Parsons, 2003a). Because the **IS** and injection cannot be directly correlated at NCPA on a wellby-well basis—probably because the rates seldom exceeded the 1.38 Mg/D threshold determined by Parsons (2003a)—the third order polynomial previously derived does not apply.

For NCPA, the relationship injection rate and **IS** rate is more convincing when total-field injection is considered, as shown in Figure 3.1. Looking broadly from left to right, we can see the very large increase of injection since 1998, with the onset of LACOSAN injection. The numbers of microseismic event also increases. The injection rate from 1993 through 1997 was relatively steady at around 8 billion pounds per year, and the average rate of **IS** with M≥1.5 in the same period was about 24 events per year; thus based on that time period of steady injection, we expect about three events per billion pounds of injected water. In fact, if we plot the injected fluid (W) versus the event rate for M≥1.5 (N) for each year (Figure 4.1), we see that a linear regression fit gives,

$$N_{yr} = 2.9 * W \qquad \text{(billion of injected pounds/year)}$$

Or, to be consistent with the units of Parsons (2003a), in events per month and million barrels/month

$$N_{mo} = 0.72 * V \qquad \text{(million barrels per month).}$$

Although there is significant scatter to the data, a linear fits seems reasonable (Figure 4.1) and as good as the cubic relation used previously. An important distinction between the previous fit (Parsons, 2003a) and the one given above, is that this fit relates field-wide injection and **IS** rather than well-specific injection and **IS**.

The above equation is valid for field-wide injection; however, for the EGS Demo Project at a single well we still prefer to re-use the single-well fit of Parsons (2003a) which for reasons explained above could not be re-derived for NCPA well-specific data. Given a rate of injection that exceeds one million bbl/month, that equation is

$$N = 5.01 + 1.86\,V + 4.75\,V^2 - 1.15\,V^3 \pm 4.75$$

where N is the monthly number of events with M≥0.7 and V is injection rate in *millions of bbl/month*. The standard error of estimate is 4.75.

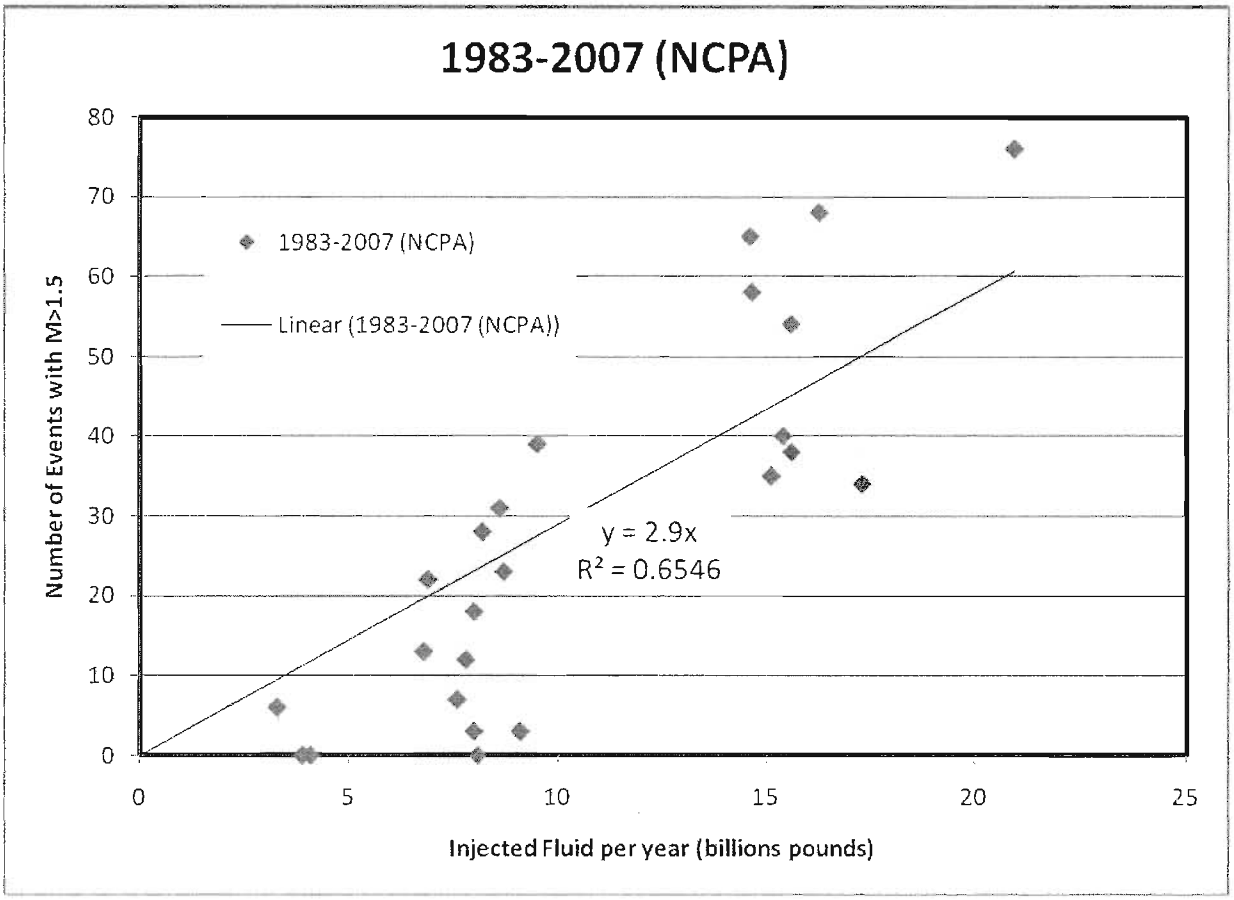


Figure 4.1: Relationship between NCPA Field-wide Total Annual Fluid Injection and Number of Microseismic (1.5<M≤3.0) and Seismic (M>3.0) Events

Using predicted injection rates for both phases of the EGS Demo Project (25 barrels/minute – 66 l/s for 21 days of hydroshearing in a single zone and 28 barrels/minute - 74 l/s for one month of circulation in three zones) gives 9 and 12 microseismic events per month with M≥0.7 per year. As noted in section 3.1, the ratio of normalized seismicity in the Calpine SE area and NCPA area is 0.29. Using that intensity correction predicts 3-3.6 microseismic events per month with M≥0.7 for the hydroshearing and circulation phases of EGS, respectively. The applicability of the Parsons (2003a) equation to hydroshearing is in doubt, but it does provide one estimate of the numbers of microseismic events expected. Compared to the >1000 microseismic events recorded in the GGF in 2007, 3 events during the hydroshearing month and 44 new microseismic events per year during the EGS production phase will have little discernible impact. The next section quantifies the maximum magnitude of an EGS related microseismic event.

*4.2 Subsurface **IS** Hazard Assessment for the Geysers E-7 Stimulation Operations*

This section is the executive summary of Appendix A, which provides the full details of the geomechanical assessment of the subsurface seismic hazard that might be associated with the

EGS development operations planned in the GGF. This assessment is based on geomechanical considerations and is therefore independent of observed seismicity statistics discussed above. Note that the magnitude calculations in Appendix A are given in moment magnitude (M_w) which is related to slip area and average displacement, rather than observed seismograph response to a seismic event, which is generically referred to as "M" in this report. At low M like those reported here, the differences in the various magnitude scales are insignificant for our purposes, and therefore in the main text, we just use magnitude (M).

The specific area of interest in this study is the felsite intrusive body underlying the existing E7 well-pad in the NCPA area to the southeast GGF.

In this study "subsurface seismic hazard" is defined in terms of the maximum potential size (i.e., magnitude or seismic moment) of an event induced by EGS stimulation operations around E-7), and the intensity of the seismicity likely to be generated during the stimulation operations, expressed as the number of events above a given threshold (e.g., magnitude or seismic moment).

The relationship between subsurface seismic hazard and surface hazard—that is, the hazard with the potential to cause damage and disturb people—is discussed in Section 5.

Three alternative approaches are used to estimate the maximum induced event magnitude for the proposed EGS stimulations. In each case a conservative approach has been taken and the results tend towards the worst case scenario. Table 4.1 summarizes the results of the seismic hazards assessment. Given our understanding of the geology of the EGS Demo Project and the seismic hazards assessment conducted, it appears unlikely that a single EGS microseismic event could exceed M=2.3, see discussion below.

Table 4.1: Summary of Geotechnical Models

Technique	Characteristics of technique	Maximum M
McGarr(1976)	Release of volumetric strain due to injection of a fluid volume ΔV	3.64
Estimated stress drop (Appendix A of this report)	Estimation of the maximum possible stress drop and fracture radius	2.3 (328 ft radius) 3.7 (1,640 ft radius)
Shapiro et al. (2007)	Relationship between injected fluid volume and observed Gutenberg-Richter magnitude / frequency relationship for area	2.5 (1 large hydroshear) 2.0 (3 hydroshears)

Application of these techniques using reasonable assumptions of the rock mass parameters for the Geysers felsite indicate that the maximum possible **IS** magnitude for the hydroshear of a spherical reservoir volume radius 1,640 ft. is M~3.7. This is smaller than the largest event detected to date at the Geysers of M~4.5 and smaller than the maximum upper limit for **IS** estimated by Parsons (2003a).

The current understanding of the felsite body is that structures with an effective fracture radius >328 ft are unlikely to be found within the stimulated rock volume. Hence it appears unlikely that a single EGS microseismic event could exceed M~2.3. This is consistent with the current levels of seismicity induced by geothermal operations within the Geysers.

The estimate of M≤2.3 is also consistent with an analysis of the Gutenberg-Richter magnitude-frequency data for the area (Shapiro et al., 2007), which indicates that a single M=2.5 microseismic event might be possible if the entire hydroshear fluid volume (~32.5 million gallons) were to be injected in one continuous injection. However, given that the hydroshearing will be split into 3 distinct and non-interfering injections of 10.8 million gallons each, the maximum size **IS** predicted by Shapiro et al. (2007) is more likely to be M~2.0. While all other estimates in Table 4.1 are considered worst case and extremely conservative, a maximum M~2.0 is considered the most likely scenario.

4.3 Predicted IS Event Frequency and Magnitude During EGS Demo Project

As discussed previously in Section 2.2, the EGS Demo Project will involve four different phases of **IS** monitoring: (1) background or pre-hydroshearing, (2) reservoir creation for 21 days during hydroshearing, (3) long-term data collection and monitoring, potentially two years in duration, and (4) potentially long-term production for 30 years or more.

For the reservoir creation phase, the analysis of Appendix A summarized in the previous section is applicable. The models of Shapiro et al. (2003) indicate that for a pumping scenario consistent with AltaRock's plans for hydroshearing, the probability of a M=2.0 microseismic event will be about even, while larger events are possible. The stress-drop model of Appendix A predicts a M=2.3 microseismic event for a 328 ft fracture. These predictions are consistent with the observations at the Soultz, which had a pumping scenario similar to AltaRock's plans. Most microseismic events at Soultz had magnitudes significantly less than 2.0 (Figure 2.12) with a few events between 2.0 and 3.0. The largest seismic event at Soultz was M=2.9; see Section 2.2 for details.

For the long-term production phases of the EGS Demo Project, there is uncertainty about the flow rate through the engineered reservoir created in the previous phase. As an initial estimate, we use 28 barrels/minute total for three hydrosheared intervals or 37% of the flow rate used to cause hydroshearing in each interval. The goal during the production phase will be to cause no additional shearing and the injection rate will be adjusted accordingly to ensure that no hydroshearing occurs. However, thermal contraction and some leak-off of fluid may cause some **IS** that can be estimated by the Parsons (2003a) equation reproduced in Section 4.1 above. Using that statistically derived equation would predict 44 events per year in the magnitude range of 1.5 to 3.0 per hydrosheared interval. However, there will be no net increase in total injection across NCPA. When injection water is taken from wells that apply it to the Geysers-normal reservoir above the felsite, the seismicity at those depths will decrease. This was documented in the seismicity maps of Preiss et al. (2002). For example, in 1989, geothermal power plant Unit No. 15 in the southwest part of GGF was shut down and microseismicity abated soon after. Thus there may be an increase in **IS** of 44 events/year during the long-term data collection and monitoring of the EGS Demo Project, but that increase should be offset by a comparable decrease in **IS** in the Geysers-normal reservoir. It is also possible that there will be very little or no IS during the long-term production phase of the EGS Demo Project. However, long-term records of microseismicity are not available because few EGS projects have operated for periods longer than six months.

4.4 EGS Demo Project Hydroshearing Plan

The planned geometry of the EGS well program is shown in Figure 4.2 along with key geological features in the area. At a depth of about 3,200 ft in E-7, the EGS Demo Project will mill a hole in the casing and drill out into the formation to drill through the graywacke reservoir rock into the felsite to a total depth between 11.500 ft. and 12,500 ft.

Near the felsite contact with the overlying metasediments (vertical depth of about 8,500 ft), the new well will be deviated 30° from vertical toward the north. Deviating from vertical will make intersecting existing fractures more likely and prevent the created hydroshear fractures from intersecting the casing above the hydroshear zone. The northerly well deviation will insure increasing distance from the BSCFZ and increased depth beneath the top of the felsite, since the felsite surface shallows to the north and west (see felsite contours in Figures 2.4 and A.1). The exact direction of well deviation will be determined by further modeling of fracture intersection probabilities, but for the purposes of this report, a well deviation direction of N45°E can be assumed. The open hole section within the felsite will run either from (9,500 to 11,500 ft, or from about 10,500 ft. to 12,500 ft total depth) according the depth of the top of the felsite and the predicted growth direction of the hydrosheared fractures. The depth of the casing and the bottom hole are planned to provide a buffer zone between the producing Geysers-normal reservoir and the created, engineered EGS reservoir. The well will undergo multiple proprietary hydroshearing activities, each lasting up to 7 days. We expect to inject up to about 11 million gallons per each 7 day hydroshearing activity. A total of 32.5 million gallons of water will be injected over the planned 21 day fracturing period. As discussed above, during this phase of EGS, microseismic events of M~2.0-2.3 are likely and events as large as M=2.9 are possible, given the example of Soultz.

The desired radius of the hydrosheared zone, 1,640 ft, is related to the desired spacing between the injection well and production well of 1,640 ft. This distance will allow sufficient heating of injected fluids for efficient energy production. The hydrosheared fractures will grow rapidly at first but as they extend away from the point of initial hydroshearing, they will slow down. As the hydroshearing proceeds, **IS** will occur and this will be mapped via an eight station MSA designed to detect microseismic events to a magnitude of M=-1 and allow mapping of the engineered reservoir. A BSCFZ buffer zone has been established to prevent interaction between the zone of hydroshear dilation and with the zone of anomalous stress direction with the fault zone (AltaRock, 2008). If the hydroshear fractures do not grow in the desired direction or the BSCFZ buffer zone is approached, the hydraulic injection will be modified to correct the growth direction.

The rate at which **IS** grows away from the well bore can be described by a diffusion equation (Shapiro et al., 1997; Parotidis et al., 2004). Figure 4.3 shows a graphical representation for stress diffusion for values of 0.0465 ft^2/s and 0.0186 ft^2/s, which are considered reasonable for this application and Figure 4.4 shows data from a very deep (29,500 ft) hydraulic fracturing experiment in Germany in 1994. A value of 0.0465 ft^2/s was used in Appendix A of this report as a conservative value to estimate the maximum possible magnitude of **IS.** . For the purpose of EGS Demo Project hydroshear design, the slowing rate of growth with hydroshear time is an important consideration. Given the two assumed diffusivities, the hydrosheared zone radius goal of 1,640 ft will be reached in 28-112 hours. The growth rate and direction will be monitored continuously through the detection of **IS** activity. When the radius approaches the 1,640 ft target, the hydroshearing will be terminated. Even if the injection continued for longer than anticipated, the BSCFZ buffer would not be intersected for another 220-1000 hours. In other words, because of the shape of the pressure diffusion curve, the risk of overshooting the hydroshearing region shut down point is low.

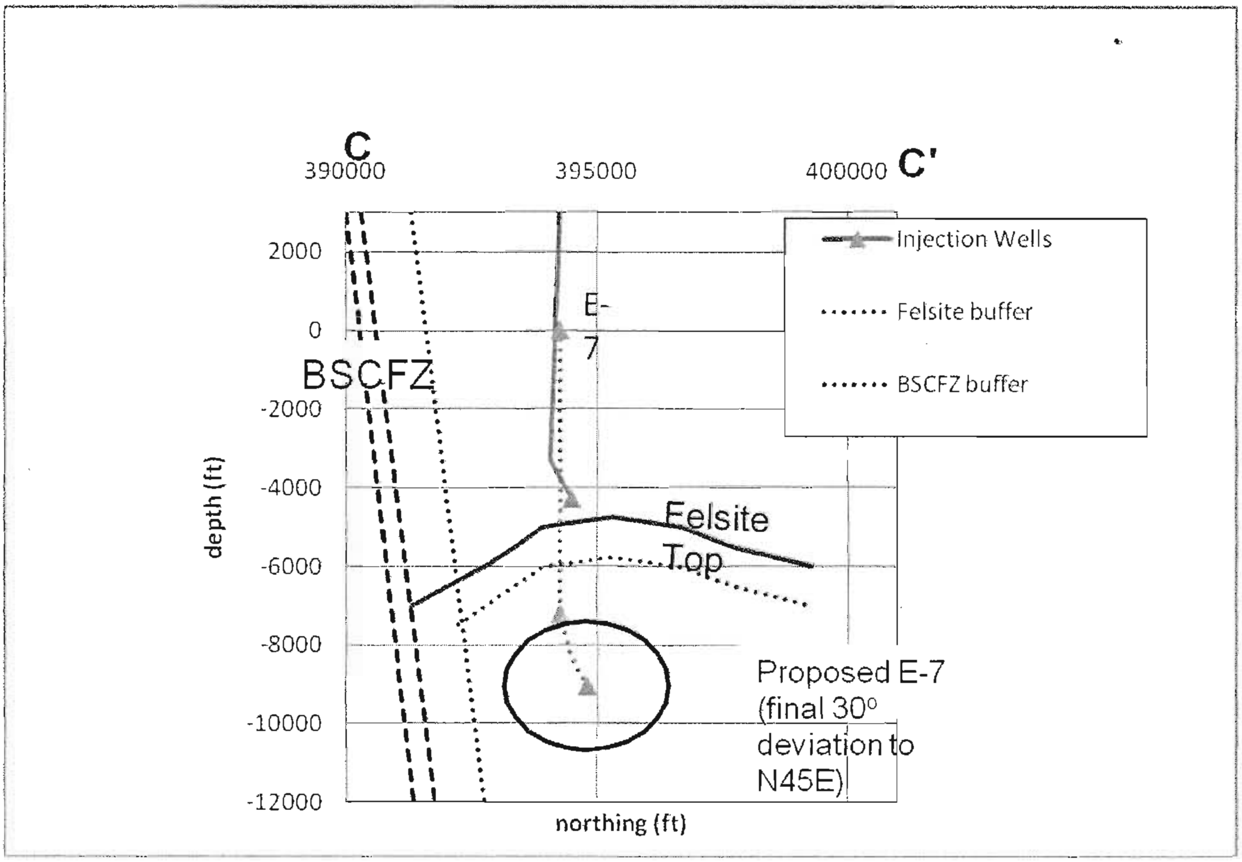


Figure 4.2: EGS Plan Shown on Cross-section C-C' (section line shown in Figure 2.5)

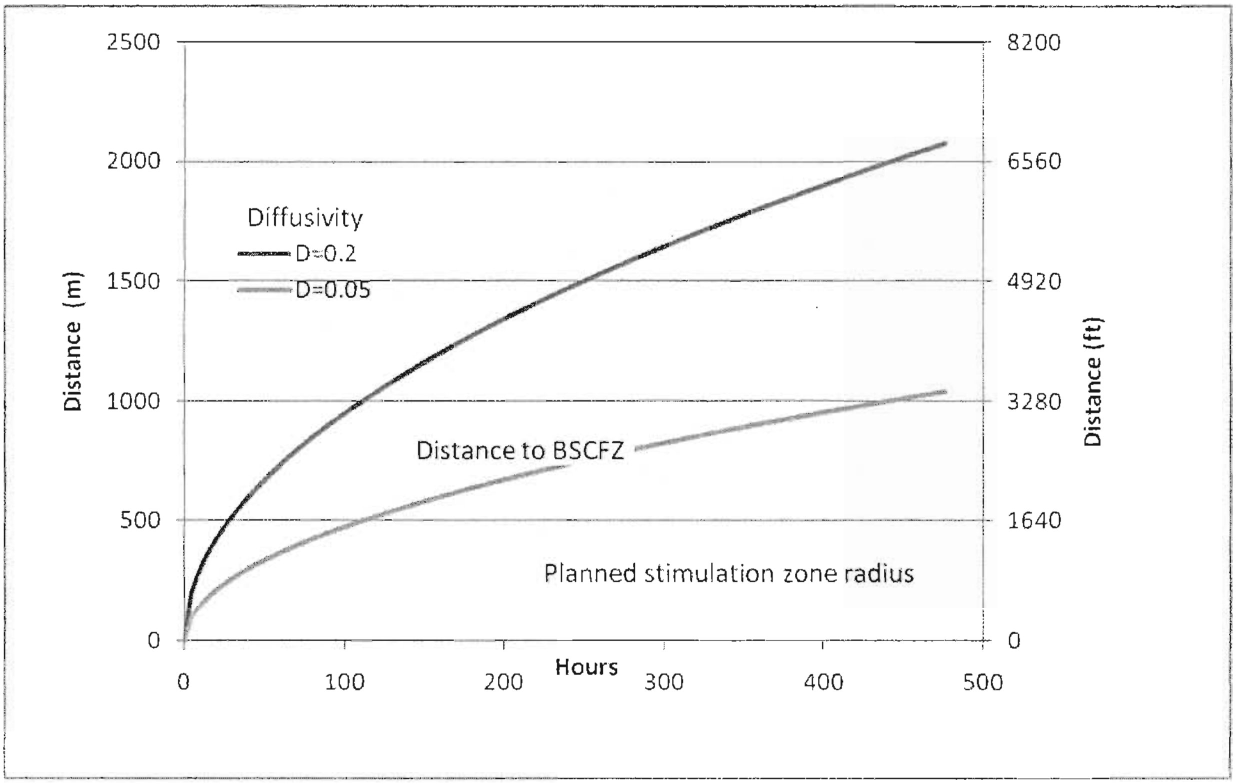


Figure 4.3: Modeled Pressure Effect: Distance versus Time

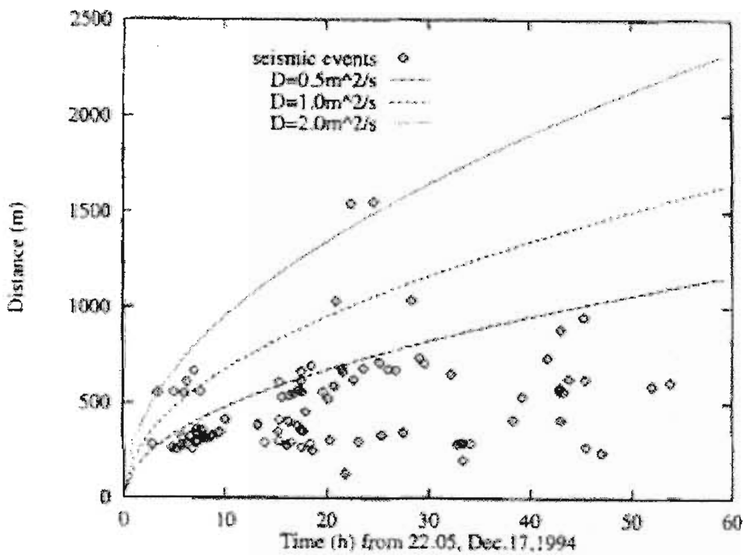


Figure 4.4: Distances of Microseismic Events (M = -1.5 to 1.2) from Injection Interval versus Occurrence Time for 90 Events at German Continental Deep Drilling Borehole, from Shapiro et al. (1997)

2. Seismic Hazards Risk Assessment

5.1 Background

In our case, where we are estimating the potential impacts of the EGS Demo Project, the seismic hazard risk analysis will consist of a seismic hazard analysis, and a seismic risk assessment. The seismic hazards analysis considers actual earthquake activity (seismicity), characterized by the magnitude and frequency of occurrence of earthquakes (**IS**), and its effects at a given location. Specifically, we are interested in the sources of IS within the NCPA leasehold, and the ground shaking expected from it at Anderson Springs. The hazard is usually stated in terms such as peak ground acceleration, velocity or displacement, or predicted seismic wavetrains. The seismic risk assessment is generally performed by structural and/or soils engineers in the design of earthquake resistant structures, and this typically concerns the response of overburden materials (such as alluvium or other non-cemented rocks) and engineered structures (buildings, dams, etc) built on them. This work is performed utilizing numerical (finite-difference codes) procedures on a computer. Its purpose is to predict the probabilities of one or more types of harm that might affect persons, or property, positioned in places of interest. This seismic risk assessment considers the probabilities of a seismic hazard causing harm such as nuisance and different damage states of structures.

This study will rely on analysis of probable impacts in terms of the MMI (the 1931 scale, with intensity grades I through XII), which classifies earthquakes in terms of effects on structures and the ground. The use of peak ground acceleration appears not to be useful. This judgment was made by comparing MMIs developed in this report, based upon felt- and slight-damage reports submitted by residents (logged by Jeff Gospe of the Anderson Springs Community Alliance) with peak ground accelerations (PGA) recorded on strong-motion seismographs (maintained in and near the town), along with felt effects for many earthquakes. These records are maintained by the Anderson Springs Community Alliance at www.andersonsprings.org, and are available in spreadsheet format. For magnitudes between M=2 and M=3.5, there appears to be no visible correlation between MMI from felt reports and PGAs. Much of this lack of correlation is caused by the "near-field" behavior of seismic waves and the inherent difficulty in their interpretation. For these near-field events, well-known empirical formulas that have been developed for greater distances from the source are not useful.

The MMI scale is comprised of qualitative grades of increasing effects that range from I to XII (see Table 5.2). These qualitative grades are known as "state-variables", which are useful in a statistical evaluation of distinct levels of harm. Grade I is not felt but can produce very small, often undetectable, disturbances. Higher grades include stronger and stronger felt effects, then minor, onward to major, damage to masonry (and other types of) structures. Effects X-XII are very rare at the GGF , usually requiring an earthquake magnitude of at least 6.5.

5.2 Historic and Recent Felt Earthquake Data

The project area lies near a number of seismically active regional faults, identified below, that may have been historically active (during the last 200 years) or active in the geologically recent past (about the last 11,000 years, referred to as Holocene in the geologic time scale). Since the mid-nineteenth century, several hundred earthquakes have been felt in Sonoma County, including in the GGF area (i.e., at the towns of Cobb, Anderson Springs, and Middletown).

Many seismic events have been centered along a number of active regional faults: the San Andreas, Healdsburg-Rodgers Creek, Maacama, Konocti Bay, West Napa, Green Valley, and Bartlett Springs Faults. These structures are Holocene in age and are therefore considered active. Portions of some of the major fault zones have been classified as Quaternary because they do not display evidence of Holocene movement, but displace geologic units of Quaternary age. Regional faults classified as Quaternary age are the Tolay, Americano Creek, Bloomfield, Dunham, Collayomi, Geyser Peak, and Cobb Mountain Faults (Wagner and Bortugno, 1982). Many earthquakes have been centered along these faults.

Five moderate seismic events occurred in the Santa Rosa area in the 1800s. Three of them (in 1865, 1893, and 1899) caused localized minor damage such as broken chimneys in Santa Rosa. They ranged in magnitude from less than 4 to 5.1. Epicenters of the first two were inferred to be in Bennett Valley and the third in Santa Rosa, based on detailed analysis of historical accounts and newspaper records (Toppozada et al.1981). In 1891, a magnitude 5.5 earthquake centered near Napa caused minor damage in Santa Rosa, and in 1898 a strong earthquake (magnitude 6.2) centered east of the southern end of the Rodgers Creek Fault, caused structural damage in Santa Rosa.

The "great" 1906 M-8, "San Francisco" earthquake caused extensive damage in San Francisco and in many other communities in central and northern California. Santa Rosa, Sebastopol, and Fort Bragg sustained relatively more damage than most other places in California during the earthquake. In Santa Rosa, strong ground shaking resulted in structural damage and a fire in the downtown area, causing the deaths of approximately 61 people (Lawson, 1908).

The October 1969 magnitude 5.6 and 5.7 earthquakes on the Healdsburg Fault caused several million dollars of damage in Santa Rosa and the vicinity. Numerous breaks in the water pipeline system occurred in the eastern part of Santa Rosa. More recently, the magnitude 4.9 earthquake along the Hayward Fault (January 26, 1986) and the magnitude 7.1 Loma Prieta earthquake on the San Andreas Fault (October 17, 1989) were felt in the county, but no structural damage was reported. These earthquakes were all natural tectonic events, unrelated to geothermal activities at the GGF.

A total of 21 felt seismic events were reported from the town of Cobb during the 13-year period from 1973 to 1985 (Tables 5.1a and 5.1b). These events ranged in intensity from II to V on the MMI scale (Table 5.2), with three of the 21 reported events classified as MMI=V. These seismic events occurred in May 1982, June 1983, and September 1984, (Parsons, 2003a).

The Anderson Springs Community Alliance has on its Web site, www.andersonsprings.org, somewhat detailed information on earthquakes felt there between August 1, 2003, and October 31, 2004. For a much longer time period, the felt earthquakes have been reported as emotionally disturbing, awakening people from sleep, and causing damage such as cracked driveways, rock walls and plaster in homes. Felt and minor-damage effects are recorded for 61 seismic events on the Web site. These effects have been classified for this report as having intensities from II to V; the cumulative distribution is given in Table 5.1c. The M=4.3 event of December 27, 2004, was felt in Anderson Springs, but no estimate of the MMI is available.

Table 5.1a: Historic Intensity Reports in the Geysers Region, Geysers Geothermal Field Events Felt at Cobb, 1973-1985

MMI1	Year	Mon.	Day	Latitude	Longitude	Magnitude
IV	73	11	29	38.82	122.8	2.3
IV	73	11	28	38.8	122.8	3.2
II	76	3	4	38.79	122.75	3.1
II	76	3	6	38.83	122.83	2.9
II	79	12	20	38.8	122.8	3
III	80	7	24	38.81	122.79	2.9
III	80	8	23	38.81	122.78	2.8
II	81	10	31	38.81	122.81	3.1
II	81	12	10	38.8	122.79	3.3
IV	82	3	25	38.8	122.8	3.4
V	82	5	29	38.8	122.82	4.3
II	82	5	29	38.84	122.83	2.9
IV	82	12	26	38.81	122.78	3.1
V	83	6	11	38.8	122.82	3.4
II	83	4	19	38.79	122.81	2.8
II	83	6	20	38.82	122.79	3.2
II	83	4	19	38.83	122.8	2.9
II	83	10	1	38.79	122.84	3
V	84	9	22	38.8	122.81	4.2
IV	85	3	30	38.82	122.82	3.3
II	85	7	26	38.8	122.8	3.5
II	85	7	26	38.79	122.79	3.8

[1]Maximum Modified Mercalli Intensity

Table 5.1. Modified Mercalli Intensity (MMI) Recurrence Intervals at Cobb, California for the Period 1980-1985 (b), and MMI Recurrence Interval for Anderson Springs, Period August 1, 2003 to October 21, 2004 (c)

MMI	Cum No.	T (days)
II	17	146
III	8	292
IV	6	365
V	3	730
VI	0	unknown
All	17	146

(b)

MMI	T (days)
II	7
III	7
IV	13
V	107
VI	unknown

(c)

Anderson Springs and Cobb have submitted "scoping comments" indicating that the number of earthquakes felt have increased substantially since LACOSAN injection began in September 1997. Comparing Table 5.1b (for Cobb) with Table 5.1c (for Anderson Springs), it is seen that the mean recurrence interval is much shorter at Anderson Springs, by factors of about one seventh for MMI=V and about 1/28 for MMI≥IV. Much of the difference is due to the fact that the data for Cobb are for the period prior to the onset of LACOSAN deep well injection, while those for Anderson Springs were collected in the following period. In addition, the surficial geology of the towns of Anderson Springs and Cobb differ, with more extensive alluvial fill in Anderson Springs (McLaughlin, 1978).

5.3 EGS Felt Earthquake Projections

The EGS Demo Project is expected to drill two wellbores (the injection and production well) at the NCPA leasehold that will undergo hydroshearing at two different times. As stated above, the EGS Demo Project is not expected to produce any noticeable increase of **IS** at Anderson Springs because any EGS-related IS should represent a very small increment over the present level of **IS,** and because this **IS** will offset Geysers-normal **IS** since there will be a redistribution of the water injected, and no net increase in injection water.

Based on experience worldwide, EGS project activity is expected to produce many small microseismic events (M<<3.0), but extremely few events with M≥3.0 and no events with M≥4.0. Mapping of EGS reservoir development, and the subsequent targeting of future wells, relies on the fact that a very large number of these microseismic events are generated during the EGS hydroshear dilation operations.

Calculations presented in Appendix A indicate that it is unlikely a single EGS **IS** event will exceed a possible moment-magnitude of 2.3, based on results of three technical approaches to estimating the maximum **IS** event. Our current understanding of the fracture state of the felsite intrusive is that effective fracture radius is not likely to exceed 328 ft. Application of these techniques, using reasonable assumptions about the rock-mass (e.g., fracture size) and physical (Young's Modulus) parameters for the Geysers felsite, indicate that the maximum possible event magnitude for the stimulation of a spherical reservoir volume of radius 328 ft is M=2.3. Note that the largest-magnitude seismic event detected in the GGF was M=4.6. Further analysis of the Gutenberg-Richter magnitude/frequency data for the NCPA leasehold applied to the EGS Demo Project indicates that if non-interfering hydroshear operations occur, the maximum magnitude could be as low as M~2.0. Finally, based on the discussion in Section 2.2 (see Table 2.2 and Figure 2.11) and by analogy to the Soultz project, M=2.9 would be the maximum probable microseismic event for the EGS Demo Project. The maximum possible seismic event is projected to have M=3.6, but this event size has an effective zero probability of occurring because it is based on an instantaneous energy release that could not take place.

5.4 Seismic Hazard Risk Assessment

An essential part of the probabilistic analysis of seismic event shaking at a particular location is what is termed an "attenuation relationship" that relates maximum ground shaking to epicentral distance and seismic event magnitude. MMI is what is termed a "state variable," which is a qualitative determination. It characterizes earthquake effects with increasing degrees of severity of felt and damaging effects (from barely felt to catastrophic failure of natural and man-made earthworks and buildings). For MMI, we could find no attenuation formula representing small events (M<5), and for the purposes of this report, it became necessary to develop one. This was accomplished using the method of Toppozada (1975) relating magnitudes and intensities, and linear regressions to compute local magnitude from areas felt with intensities of IV, V, VI, VII, and VIII. The linear regressions have the form:

$$M = C_k + B_k \log A_k,$$

where C and B are linear regression coefficients, A is felt area, and the subscript k refers to any one of the intensities listed above.

The study by Toppozada (1975) appears to provide the best available approach for predicting intensity as a function of the logarithm of epicentral distance, log R, and magnitude, M for M>2 because it incorporates felt-data for shocks with magnitudes as small as M=4.1. To predict MMI as a function of R (epicentral distance), intensities were plotted for each integer magnitude (running from M 2 to 8) and distance R (the square root of A) by assuming that felt areas are circular (a rough approximation of reality), so that the area (A) could be converted to radius, i.e., epicentral distance (R). At short epicentral distances—from approximately 2-6 miles—predicted intensities at a given magnitude are greater than observed, and it was necessary to fix maximum intensity at maximum epicentral levels, using data of Gutenberg and Richter (1956). The resulting set of curves is shown in Figure 5.1. A computer code was written to interpolate these curves by magnitude, and this was incorporated into the probabilistic ground shaking code described below.

Probabilistic analysis of seismic event ground shaking for a given location (Anderson Springs for this study) begins with definition of best-estimate seismicity rates (magnitude-frequency characteristics) and geometries of fault or area sources with respect to the site of interest. Altogether these data are termed the "source model". Results include the annual rate of exceedance, and probabilities of exceedance during specified exposure intervals, of site ground motions that exceed each one of a series of specified test values (e.g., for MMI we might select IV, V, VI etc.). Calculations were made by a computer program that uses standard numerical methods for this type of calculation, as outlined below. The ground-motion parameter (log peak ground acceleration PGA or MMI) is assumed to have a log-normal distribution about its predicted median value. Times and positions of seismic events are assumed to be uniformly distributed for/in each source; therefore, the number of events in any given time interval is Poisson-distributed. For each source, the annual rate of exceedance of each ground-motion test value is found by numerical integration over the source dimensions and magnitude range. Rates of exceedance for the total model are found by summing over all sources and probabilities of exceedance for given exposure periods are found directly from these rates. The recurrence interval is simply the reciprocal of the rate of occurrence.

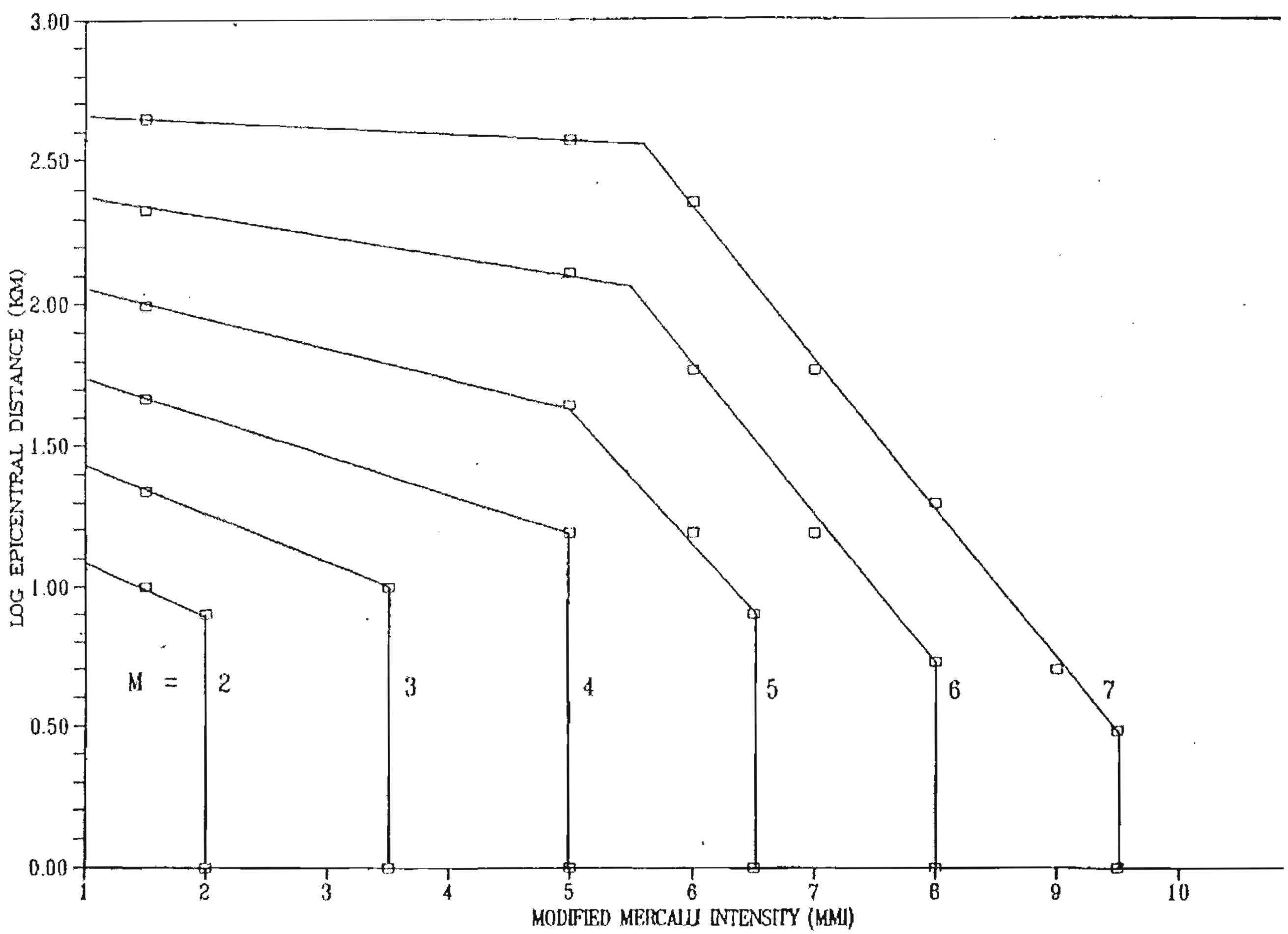
5.4.1 MMI at Anderson Springs

Looking at Figure 5.1, we see that M=2.9 at an epicentral distance of 4 mi is expected to produced MM =III-IV. and MMI=IV is already a frequent occurrence at Anderson Springs. Table 5.2c shows a mean recurrence interval of 13 days for MMI=IV. The EGS Demo Project is expected to produce only one such event (M=2.9), hence its effect at Anderson Springs is relatively very minor.

Table 5.2: Modified Mercalli Scale of Intensity 1931

I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
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. Standing motor cars rocked noticeably.
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 buildings 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.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

After Wood and Neumann (1931).



NOTE: CALCULATED FROM EQUATIONS BY TOPPOZADA, 1975

Figure 5.1: MMI vs. Magnitude and Epicentral Distance Based on Felt Areas.

5. Conclusions

The principal conclusion of this study is that the EGS Demo Project should have no additional discernible impact on the **IS** at the GGF or on felt events noticed by residents of Anderson Springs.

The largest seismic event that has occurred in the NCPA area since 1973 had a magnitude of 4.6, and is likely to represent natural, regional strain release rather than **IS,** due to its location outside of the Geysers-normal reservoir. Worldwide EGS project **IS** data indicate that the largest **IS** event linked to EGS activities was an M=3.7 in the Cooper Basin of Australia. The best analog model for the EGS Demo Project is the Soultz project where the maximum IS event was M=2.9.

The behavior of seismic event magnitudes versus frequency of occurrence indicates a rapid falloff of **IS** for M>3.0, and much more so for M>3.5, where b-slopes typically range from around 1.3 to 1.4. This probably represents a seismological-regime transition between **IS** and natural seismicity. Previous studies of GGF seismicity, and of the NCPA leasehold in particular, have reached the conclusion that deep-well injection in the GGF produces only small seismic events, with M≤3.5, and very few M≥3.0.

One uncertainty in this assessment is the stress regime associated with the BSCFZ, where the largest events are located. However, for engineering reasons, the EGS Demo Project activities will occur sufficiently far away from this zone that it should not be an issue. Continuous monitoring during EGS stimulation via the eight-station MSA will insure that the zone is not reached by injected fluid.

Consideration of three different geomechanical models used to assess the seismic hazards of posed by the EGS Demo Project indicates the maximum possible **IS** will most likely be less than M~2.3.

An updated seismic hazards risk analysis relates the intensity of past seismic events to MMI at the town of Anderson Springs. The results indicate that the probable maximum annual seismic event shaking expected in Anderson Springs corresponds to MMI=III-IV due an EGS-induced event of M<3.0. In order for shaking to reach to the next intensity level, MMI=V, would require a seismic event with a M>4.0, which is not considered possible. Importantly, the numbers of seismic events and microseismicity from the EGS Demo Project is fully expected to be within the range of present levels experienced at Anderson Springs.

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APPENDIX A

REPORT ON SUBSURFACE INDUCED SEISMIC HAZARD ASSESSMENT FOR THE GEYSERS EGS DEMONSTRATION PROJECT altcom

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Executive Summary

This study provides an assessment of the subsurface seismic hazard that may be associated with the EGS Demonstration Project (EGS Demo Project) proposed for the E7 well (E7) on the NCPA leasehold in the southeastern portion of the Geysers Geothermal Field (GGF). The specific area of interest in this study is the felsite intrusive body underlying the existing E7 well-pad (Figure A.1).

In this study "subsurface seismic hazard" is defined as:

1. The maximum potential size (i.e., magnitude or seismic moment) of an event induced by the EGS Demo Project around E7; and
2. The intensity of the seismicity likely to be generated during the hydroshear dilation operations, expressed in terms of the number of events above a given threshold (e.g., magnitude or moment)

Three alternative cases are used to estimate the maximum induced seismic event (event) magnitude for the proposed EGS Demo Project. Magnitude is expressed in the form of "Moment Magnitude" (M_w), as defined in Shearer (2006). M_w is related to slip area and average displacement rather than observed seismograph response to earthquake energy, as given by, for example, Richter magnitudes. The differences in the various magnitude scales are insignificant for our purposes, and such, in the main text, we use M, but in this seismic hazards assessment we use M_w.

In each case, a conservative approach has been taken and the results tend towards the worst-case scenario. This has been done to account for any uncertainties in the geomechanical models used and the geology within which the EGS Demo Project will take place. The worst-case scenario determinations as well as the most likely cases are discussed below. The following table summarizes the results of the study.

Technique	Characteristics of technique	Maximum M_w (Moment Magnitude)
McGarr (1976)	Release of volumetric strain due to injection of a fluid volume ΔV	3.64
Estimated stress drop (altcom Ltd 2008)	Estimation of the maximum possible stress drop and fracture radius	2.3 (328 ft radius fracture) 3.7 (1,640 ft radius fracture)
Shapiro et al. (2007)	Relationship between injected fluid volume and observed Gutenberg-Richter magnitude/frequency relationship for area	2.5 (single hydroshear dialtion[1]) 2.0 (three hydroshear dilations)

[1]See Section 1.2 in the main body of this report for definitions

Application of these techniques using reasonable assumptions of the rock mass parameters for the Geysers felsite indicate that the maximum possible **IS** magnitude for the hydroshearing of

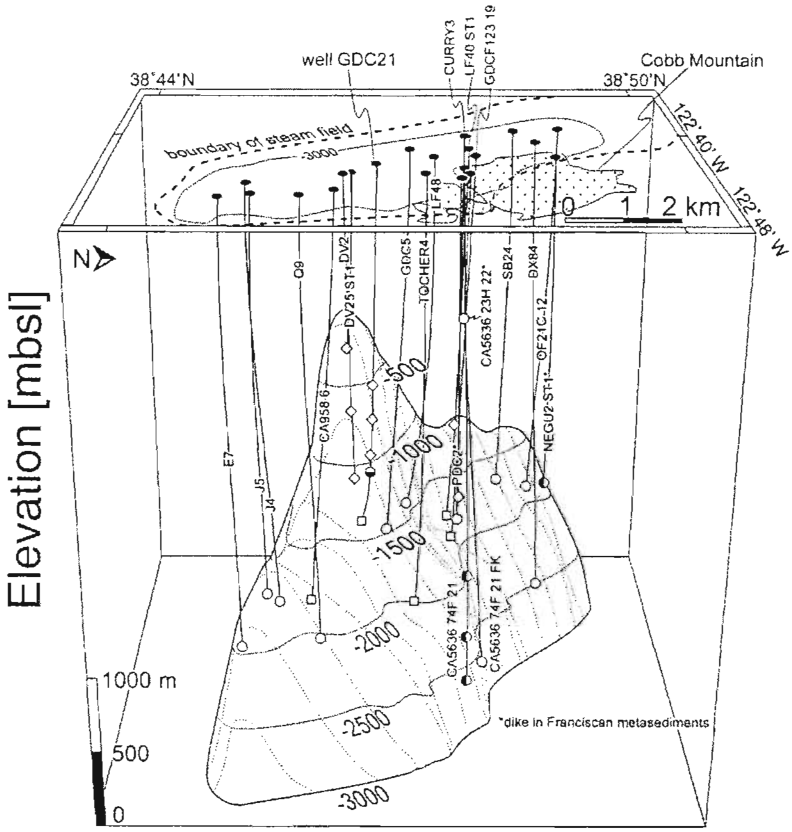

Figure A.1.1: Structure of Felsite Intrusive and Location of E-7 on Southeast Edge from Hulen and Nielson (1996)

the engineered reservoir with a volume radius 1,640 feet is M_w~3.6. This estimate is an unrealistic worst-case determination used to provide an extreme upper bound on the **IS.** The McGarr model describes the relationship between the cumulative injected fluid volume and cumulative seismic energy release and it makes no prediction of the distribution of individual event sizes, merely that their sum is proportional to the injected volume. We can consider this extreme scenario were there is no progressive release of strain energy during the EGS injections and that the resulting cumulative strain energy is released in a single seismic event.

While there is effectively zero probability of the McGarr model being applicable to the EGS Demo Project, due to the widely observed progressive energy release, it is helpful for illustrative purposes to evaluate very maximum the upper bound on Mw that could in theory be generated by the entire EGS injection operations if the accumulated strain was instantaneously released. Our analysis has shown that even though there is effectively zero probability of this scenario occurring, we can be reassured that the instantaneous release of the total stored strain energy from the EGS injections would be equivalent to a single **IS** event, which itself is well within bounds of historical and calculated **IS** in the area.

Worldwide EGS project experience indicates that seismic energy is released in a large number of much smaller microseismic events ($M<3.0$). In fact, the mapping of EGS reservoir development through a concentrated microseismic array (Figure A.1.2), and the subsequent targeting of future wells, relies on the fact that a very large number of small seismic events are generated during the EGS hydroshearing.

The current AltaRock Energy, Inc. (AltaRock) understanding of the felsite body is that structures with an effective fracture radius >328 ft are unlikely to be found within the hydrosheared rock volume. Hence, it appears unlikely that a single EGS event could exceed M_w~2.3. This appears consistent with the current levels of induced seismicity (**IS**) by geothermal operations within the GGF-normal reservoir.

The estimate of $M_w \leq 2.3$ is also consistent with an analysis of the Gutenberg-Richter magnitude/frequency data for the area, which indicates that a single $M_w=2.5$ event might be possible if the entire hydrosheared fluid volume (32.5 million gallons) were to be injected in one continuous injection. However, this will not be the case because AltaRock plans to divide the injection into three distinct and non-interfering pulses and the maximum **IS** event predicted under this condition is M_w~2.0.

A.1 Introduction

The objective of this investigation is to assess the subsurface seismic hazard that may be associated with the proposed EGS Demo Project in the southeast GGF. The specific area of interest is the felsite intrusive body underlying the existing E7 wellpad on the NCPA leasehold.

In terms of this study, the "subsurface seismic hazard" has been defined as:

1. The maximum potential size (i.e., magnitude or seismic moment) of an event induced by EGS induced fracturing operations around E7; and
2. The intensity of the seismicity likely to be generated during the hydroshearing operations, expressed in terms of the number of events above a given threshold (e.g., magnitude or moment).

The approaches adopted in this investigation are based on simplified geomechanical and geophysical models of the processes involved in EGS seismicity generation. The results are therefore complimentary to the assessment presented elsewhere in this report, that is based on a statistical analysis of the magnitude/frequency distribution of previous **IS** at the GGF.

The strategy has been to use several alternative hazard evaluation approaches, and then to combine the results into a comprehensive hazards assessment. This "alternative calculation" approach is common practice in engineering analyses, and hence adds weight to the conclusions.

In all cases, the risk assessment considers the worst case, in other words the largest induced event that is possible from the proposed induced fracturing operations. In reality, the seismicity is likely to occur as a large number of much less energetic events based on world-wide EGS project results. Hence this investigation should be considered cautious or conservative in its approach.

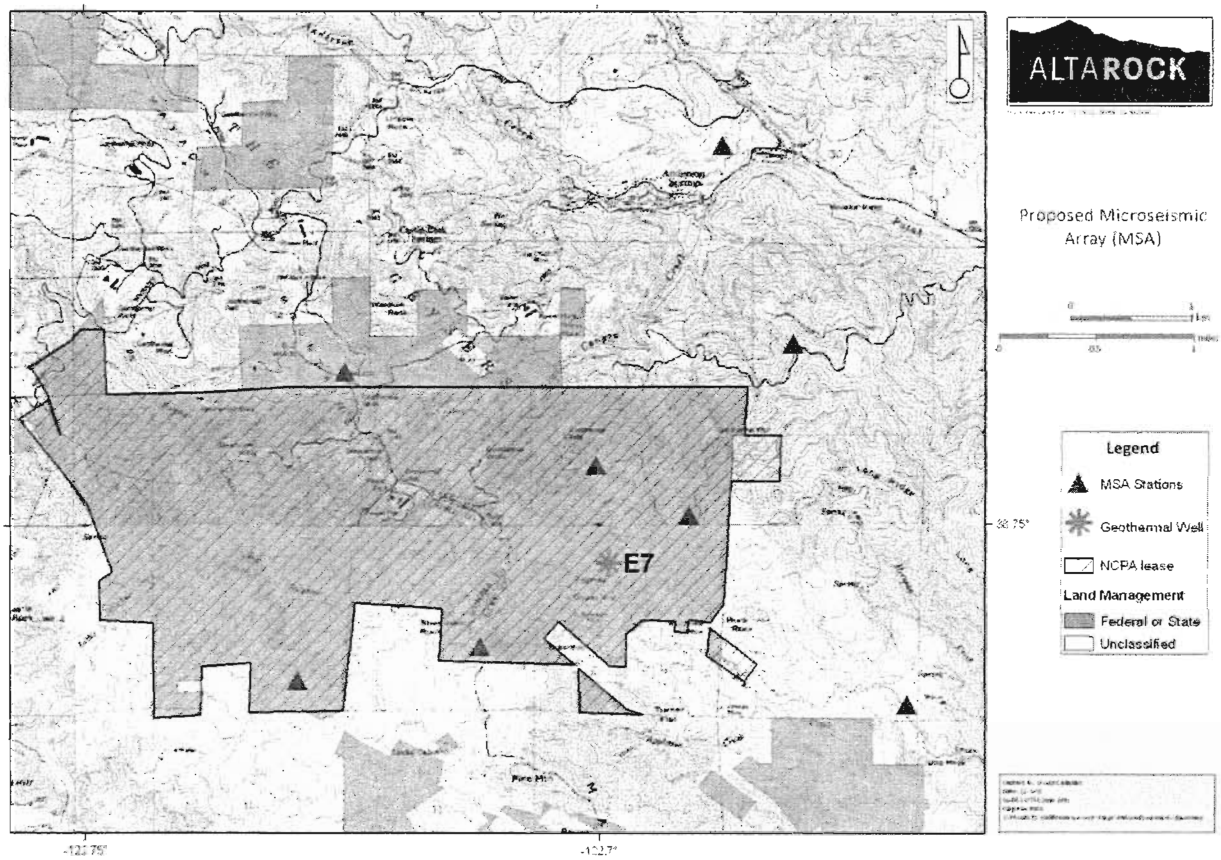

Figure A.1.2: Planned EGS Demo Project 8 Station Microseismic Array

A.2 Input data

A.2.1 In-situ stress state

A key input to the hazard assessment is the *in-situ* stress regime that might be experienced within the felsite body. These data are needed to estimate the stress drop and strain release that might be anticipated through the shear failure of faults and fractures during the hydroshearing operations.

To date, the stress data for the GGF and in particular the felsite body is very limited.

However, within the GGF area, it is generally accepted (Oppenheimer 1986) that the maximum principal stress (σ_1) is vertical (.i.e., $\sigma_1=\sigma_v$) and that the magnitude of the maximum horizontal stress is close, or equal, to the vertical stress (i.e., $\sigma_H=\sigma_2\approx\sigma_v$). This assumption is also adopted in this study.

The magnitude of the maximum principal stress ($\sigma_1=\sigma_v$) can therefore be estimated through integrating the rock density with depth:

$$\sigma_v(z) = g\int_0^Z \rho(z)dz \qquad \text{Equation A.2.1}$$

where Z is depth, ρ(z) is the rock density variation with depth and g is gravitational acceleration. Table A.2.1 summarizes the (z) function used in this study.

Table A.2.1: Rock Density Model Used to Evaluate Overburden Stress

Unit	Depth (m)	Depth (ft)	Density (g/cm^3)
Peridotite	0	0	2.51
Peridotite	500	1640	2.51
Graywacke	1000	3281	2.70
Graywacke	1500	4921	2.70
Graywacke	2000	6562	2.70
Graywacke	2500	8202	2.70
Felsite	3000	9843	2.70
Felsite	3500	11483	2.70
Felsite	4000	13123	2.70
Felsite	4500	14764	2.70
Felsite	5000	16404	2.70

The assumption of $\sigma_2=\sigma_1$ does not significantly affect the results of this investigation. This is because the most significant stress differential is between σ_1 and σ_3. Hence, a key parameter for this investigation is the magnitude of the minimum horizontal stress ($\sigma_h=\sigma_3$).

In tectonically active areas such as the GGF, it is reasonable to assume that the rock mass is in a "critical stress state" (e.g., Rutqvist and Oldenburg 2007; Oppenheimer, 1986). This is a situation where the magnitude of σ_3 is limited by the frictional strength of the faults and fractures. Evidence for this critical state is the abundant natural seismicity within the area, which indicates continuous tectonic strain relief and return to equilibrium.

By assuming a critical stress state, it is possible to place a limit on the magnitude of σ_3. This involves evaluating the maximum σ_3 that can be sustained by fractures that are critically aligned for shearing.

A number of authors (e.g., Pine and Batchelor, 1984) have shown that for a ubiquitous fracture distribution the critical ratio (*R*) of the maximum and minimum effective stress (σ'_1/σ'_3) is given by:

$$\frac{\sigma'_{max}}{\sigma'_{min}} = R = \frac{1+\sin\phi}{1-\sin\phi}$$ Equation A.2.2

where ϕ is the friction angle and σ'_{max} and σ'_{min} are the effective principal stresses. The effective stresses are equal to $\sigma'_{max} = \sigma_1 - P$ and $\sigma'_{min} = \sigma_3 - P$, where P is the fluid pressure.

The fluid pressure regime within the felsite is currently unclear. The working hypothesis is that the felsite intrusion is not hydraulically connected to the Geysers-normal steam reservoir. Therefore the most likely fluid pressure regime is hydrostatic, as given by

$$P(z) = \int_0^Z \rho(z)dz$$ Equation A.2.3

By combining Equations A.2.1, A.2.2 and A.2.3, and assuming representative values of the internal friction angle (ϕ) for granitic rocks, it is possible to place some constraints on $\sigma_3 \approx \sigma_h$. These estimates of σ_3 are summarized in Figure A.2.1 for the hydrostatic pressure case. The abrupt change in stress gradient at 3,280 ft. depth is due to the change in fluid pressure regime from the overburden to the Geysers-normal steam reservoir.

This is considered as the base stress/depth model for this study, where the depth range of interest to this study is from 9,840 ft. to 13,120 ft.) subsurface.

Figure A.2.2 illustrates an alternative fluid pressure regime where the felsite is well connected to the Geysers-normal steam reservoir. Hence, the fluid pressure is assumed to take a uniform value of 6,895psi, which is considered representative. Although this increases the differential between the total stresses σ_1 and σ_3, it, by definition, has an identical value of R. The assumption of hydrostatic or sub-hydrostatic pressure does not therefore have a significant effect on the results of the investigation, because of the assumed and probable critical stress state.

A.2.2 Other key input parameters

Table A.2.2 provides a summary of the other key geomechanics input data used in this hazard assessment. In many cases, the actual value for the felsite is unknown and so representative values are used. This is not a great concern as it can be shown that the seismic hazard assessment results are not highly sensitive to any single input value in Table A.2.2.

A.2.3 Hydroshearing parameters

The EGS hydroshear design is not yet finalized, but there is a preliminary design which provides some indicative values for use in this assessment. The current design comprises up to three separate hydroshear operations of 9.511 million gallons each, at injection pressures of between 1,7002,500 psi. These values are summarized in Table A.2.3.

The duration of the pumping phases will be about 7 days each at an average rate of 22.5-25 barrels/minute (60-66 l/s) which would be required to inject a total of 9.511 million gallons. This is significant for one of the analysis techniques.

It is also assumed that the target size for the engineered geothermal reservoir is about 1,640 ft. from the well.

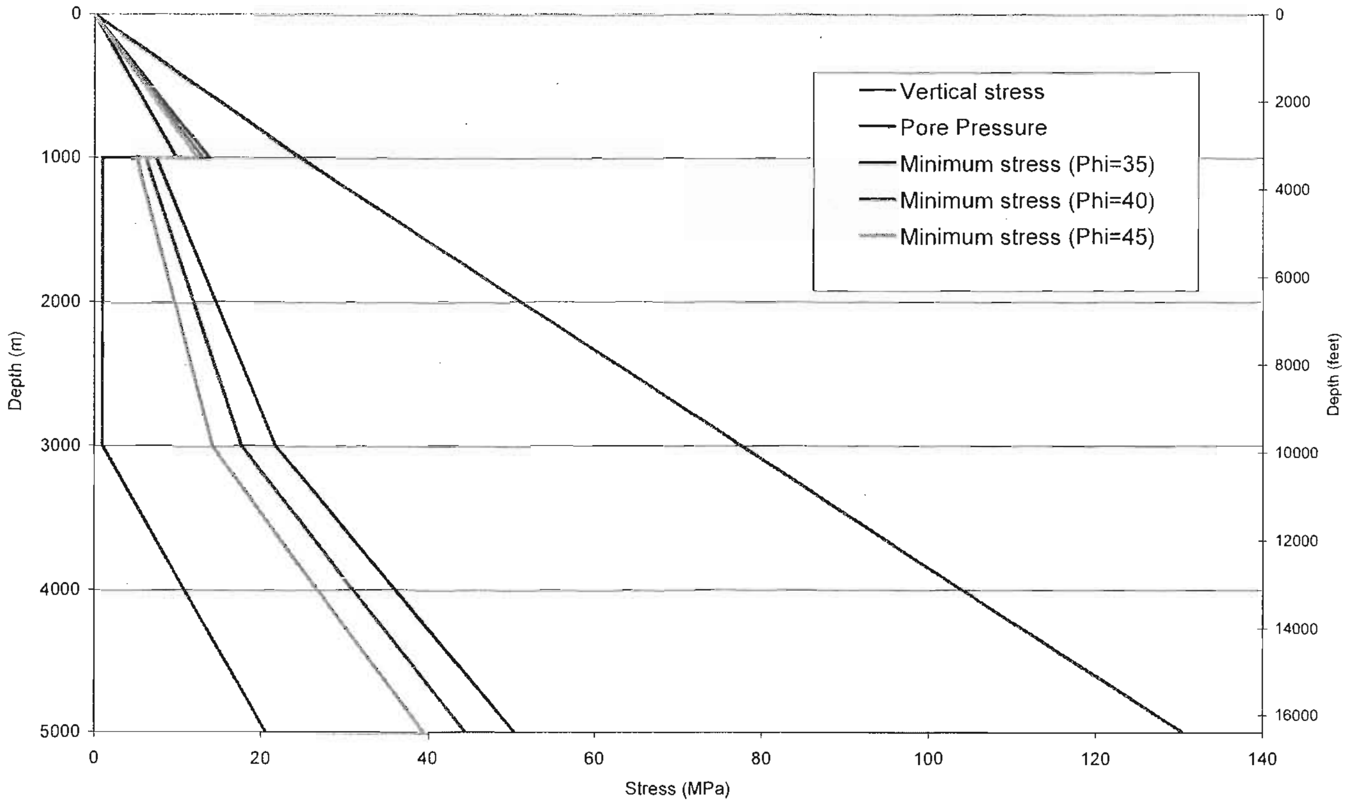

Figure A.2.1: Stress and Pressure Model for the Geysers Geothermal Field, Assuming Hydrostatic Pressure within the Felsite and a that the Rock Mass is Critically Stressed

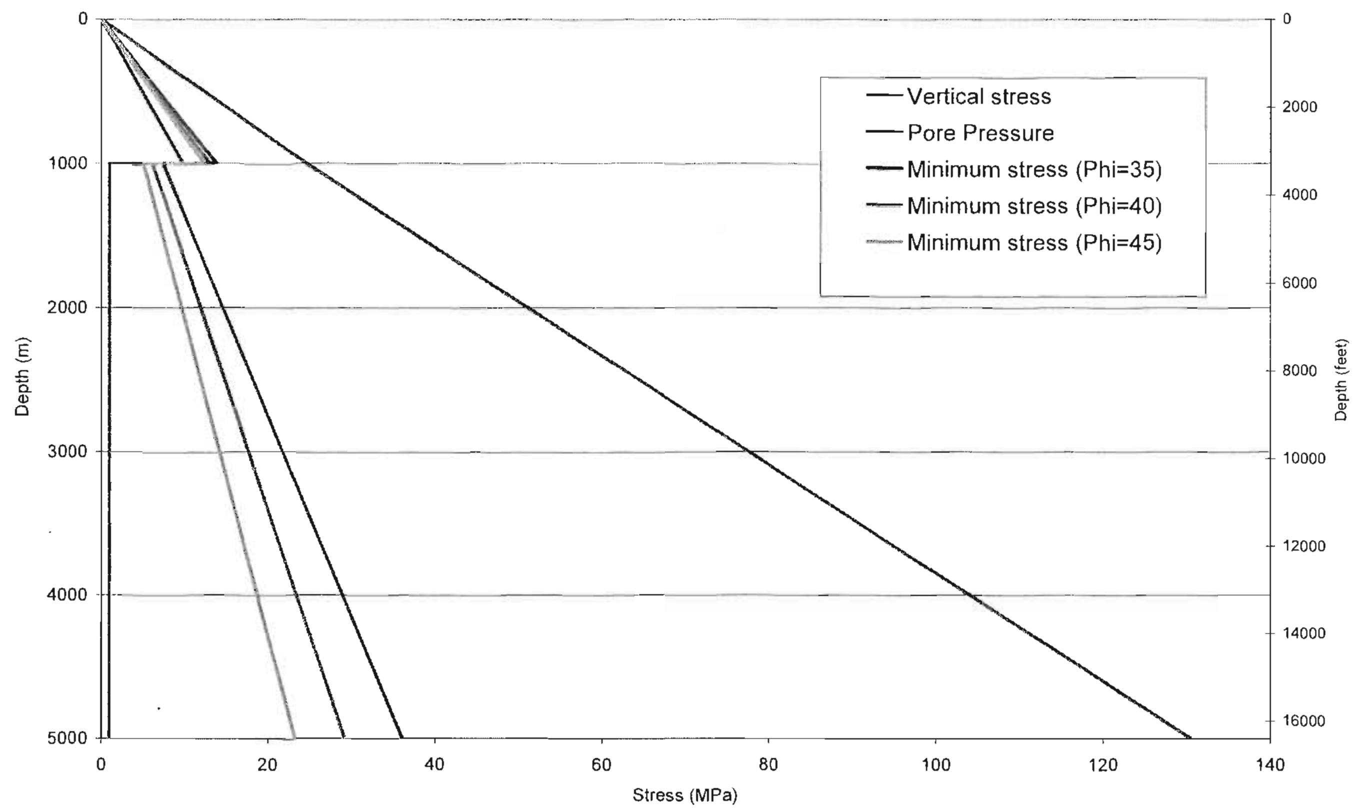

Figure A.2.2: Stress and Pressure Model for the Geysers Geothermal Field, Assuming Sub-hydrostatic Pressure within the Felsite and a that the Rock Mass Is Critically Stressed

Table A.2.2: Summary of the Input Data Used in this Seismic Hazard Assessment

Input parameter	Symbol	Value (SI Units)	Value (oilfield units)
Friction angle	ϕ	35°-45°	35°-45°
McGarr constant	K	~1.0	~1.0
Rock rigidity	μ	2.0->3.0 GPa	290,000->435,000 psi
Young's Modulus	E	5.0 GPa	725,000 psi
Poisson's ratio	ν	0.22	0.22
Hydraulic diffusivity	D	0.2 m^2/s	2 x10^{11} D/s
Stress drop	$\Delta\sigma$	10 MPa	1450 psi
Dynamic viscosity	η	0.0001 Pa.S	0.1 cP
Permeability	K	10-16 m^2	0.1 mD
Porosity	ψ	0.02	0.02
Crack density	ε	0.1	0.1

Table A.2.3: Preliminary EGS Demo Project Hydroshear Design Parameters Used in this Study

Input parameter	Symbol	Value (SI Units)	Value (oilfield units)
Pressure	P	11.7->17.2 MPa	1700->2500 psi
Volume per stimulation		36000->41000 m^3	9.5->11 Mgal
Rate	Q	59-68 l/s	16-18 gal/s
Duration per stimulation	t	7 days	7 days
Stimulation dimension	R	500 m	1640 ft
Well diameter		0.178 m	7 inch
Open hole length		610 m	2000 ft

A.3 Assessment methodology

A.3.1 Estimation of maximum potential event size

Several approaches have been used previously for EGS operations around the world. The most comprehensive and systematic study was that adopted by Pine (1982) and Pine (1987) for the Rosemanowes Hot Dry Rock (HDR) geothermal site in the United Kingdom.

All published approaches to the estimation of maximum event size used to date involve estimating the maximum energy release (in some form) from a single induced fracturing event. The energy release is then converted into an equivalent moment or magnitude.

This maximum energy release approach is also adopted in this investigation for the GGF.

Approach 1: after McGarr (1976)

This approach to seismic hazard assessment considers the seismicity induced by a volumetric strain taking place within the reservoir.

McGarr (1976) proposed the following relationship between the cumulative seismic moment and the injection (or extraction) of a fluid volume.

$$\sum M_o = K\mu \left|\Delta V\right| \qquad \text{Equation A.3.1}$$

Where μ is the rock mass rigidity, K is a constant ~1.0, and |ΔV| is the modulus of the volume change (i.e., injection or extraction). This approach was shown by McGarr (1976) to produce reasonable results for seismicity induced during the Denver Rocky-Mountain Arsenal injections.

Pine (1982) also used this approach to estimate maximum event size for the Rosemanowes HDR project by again making the extremely conservative assumption that the cumulative moment was released in a single event. This provided an estimate ~1.2 magnitude units larger than the largest event generated during 10 years of operations (M=1.9). Thus, Pine (1982) is conservative, but of value in the seismic hazard discussion. Hunt and Morelli (2006) used a similar approach based on distinct element numerical modeling of volumetric strain changes within the proposed Cooper Basin EGS reservoirs in Australia.

Figure A.3.1 presents a series of type-curves for the cumulative seismic magnitude (ΣM_w) against injected fluid volume for the proposed GGF EGS hydroshearing operations. The cumulative magnitude has been calculated using Equation A.3.1 and then converted to an equivalent moment magnitude (M_w) using the well known relationship of Kanamori (1977).

$$M_w = \frac{2}{3}\log_{10} M_0 - 6.07 \qquad \text{Equation A.3.2}$$

The estimated fluid volumes for the felsite stimulations are between 9.5-11 Mgal for each of three separate hydroshear operation. From Figure A.3.1 and Table A.3.1 it can be seen that the maximum event magnitude associated with a single induced fracturing operation is likely to be ~M_w=3.3. However, the reasonable expectation and the EGS Demo Project hydroshear design is such that the seismic strain energy change will be released through a large number of much smaller magnitude events. In fact, this is a necessity for the success of the EGS Demo Project because the objective is to create a relatively large region of fracturing rock, not a single large fracture. This objective will be insured by the planned microseismic mapping of the hydroshearing operation.

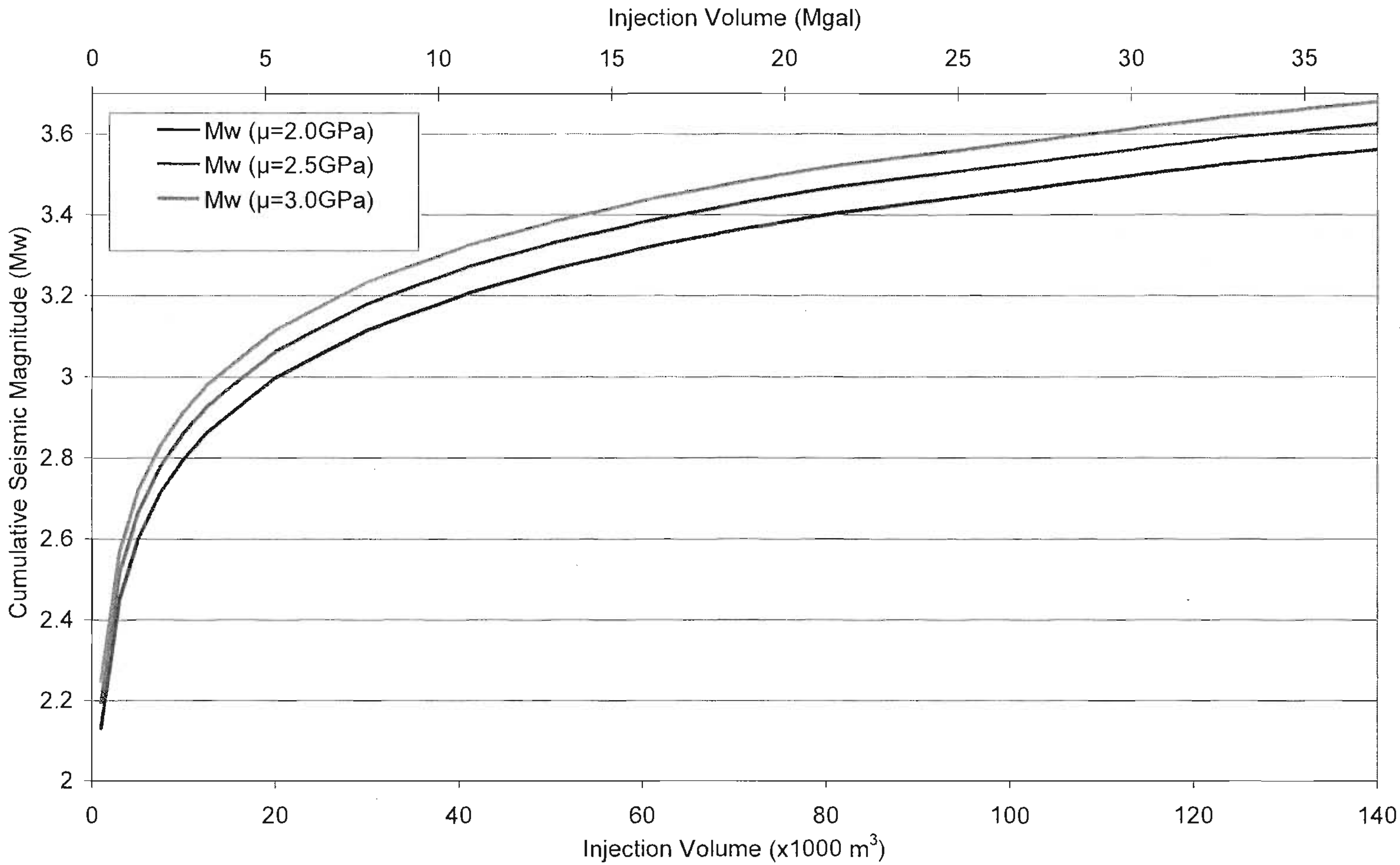

Figure A.3.1: Estimate of Maximum Event Magnitude for the Proposed Geysers EGS Induced Fracturing Operations Using McGarr (1976)

For completeness, we can also take the most conservative seismic hazard case where the fluid volume associated with all three separate induced fracturing operations contributes to a single event near the end of the third injection phase. The estimated magnitude of the single event is estimated to be around M_w~3.6, which is still considerably smaller than the largest event detected to date in the GGF.

Table A.3.1: Summary of Maximum Magnitude Estimates Using McGarr (1976)

Injected volume	M_w		
	μ=2.0GPa μ=290,000 psi	μ=2.5GPa μ=363,000 psi	μ=3.0GPa μ=435,000 psi
41,000 m^3 (11 Mgal)	3.21	3.27	3.32
82,000 m^3 (22 Mgal)	3.41	3.47	3.52
123,000 m^3 (33 Mgal)	3.52	3.59	3.64

Approach 2: Estimated stress drop approach

The second approach adopted in this study is based on the generally accepted seismic source model for a natural or induced (shear-slip) microseismic event. The scalar seismic moment (M_o) is given by the model (after Brune 1970).

$$M_0 = \frac{16}{7}\Delta\sigma \times r^3$$ Equation A.3.3

Where Mo is the seismic moment and r is the radius of an assumed circular rupture surface. The event Magnitude (M_w) can then be estimated using Equation A.3.2.

From Equation A.3.3, it is clear that the seismic moment is strongly dependent on the size of the rupture area. This is due to the fact that the amount of strain energy released is proportional to the rock volume in which the strain change is taking place.

Using the Coulomb failure criterion (Equation A.3.4) it is possible to place some realistic constraints on the size of the stress drop ($\Delta\sigma$).

$$\tau_F \geq \sigma_n^{'} \tan\phi$$ Equation A.3.4

The maximum fluid pressure (P_{max}) during the stimulation is known (i.e., Table A.2.3), and therefore it is possible to estimate the minimum effective normal stress that is likely to be acting on any fracture. Logically the maximum possible stress drop ($\Delta\sigma_{max}$) is the difference between the maximum applied shear stress and the minimum effective stress. In other words

$$\Delta\sigma_{max} = \tau_{max} - (\sigma_n - p_{max})\tan\phi \qquad \text{Equation A.3.5}$$

Therefore the maximum possible stress drop and seismic moment can be estimated from knowledge of the in-situ stress magnitudes, the maximum injection pressure during the stimulation and an estimate of the maximum fracture surface area likely to be encountered in the stimulation volume.

Based on the stress model in Figure A.2.1 it is possible to generate a series of estimates of maximum event magnitude against possible source radius. This is shown in Figure A.3.2 for the three critical stress cases in Figure A.2.1.

It can be seen from Figure A.3.2 and Table A.3.2 that the estimated maximum magnitude for a shear surface of radius 500 m (1,640 ft) is Mw~3.7.

Table A.3.2: Summary of Maximum Magnitude Estimates (Mw) Using the Maximum Stress Drop Approach

Source radius	M_w
328 ft	2.27
1,640 ft	3.66
3280 ft	4.27

The results in Figure A.3.2 are likely to be a realistic estimate of the maximum magnitude given the re-activation of a fault radius (r).

The question then is whether structures with length ~3,280 ft. (i.e., r=1,640 ft) exist within the engineered reservoir volume and can then be re-activated by the fluid injection. The current assumption is that structures >328 ft. radius are unlikely within the felsite, so it is likely that $M_w \leq 2.3$.

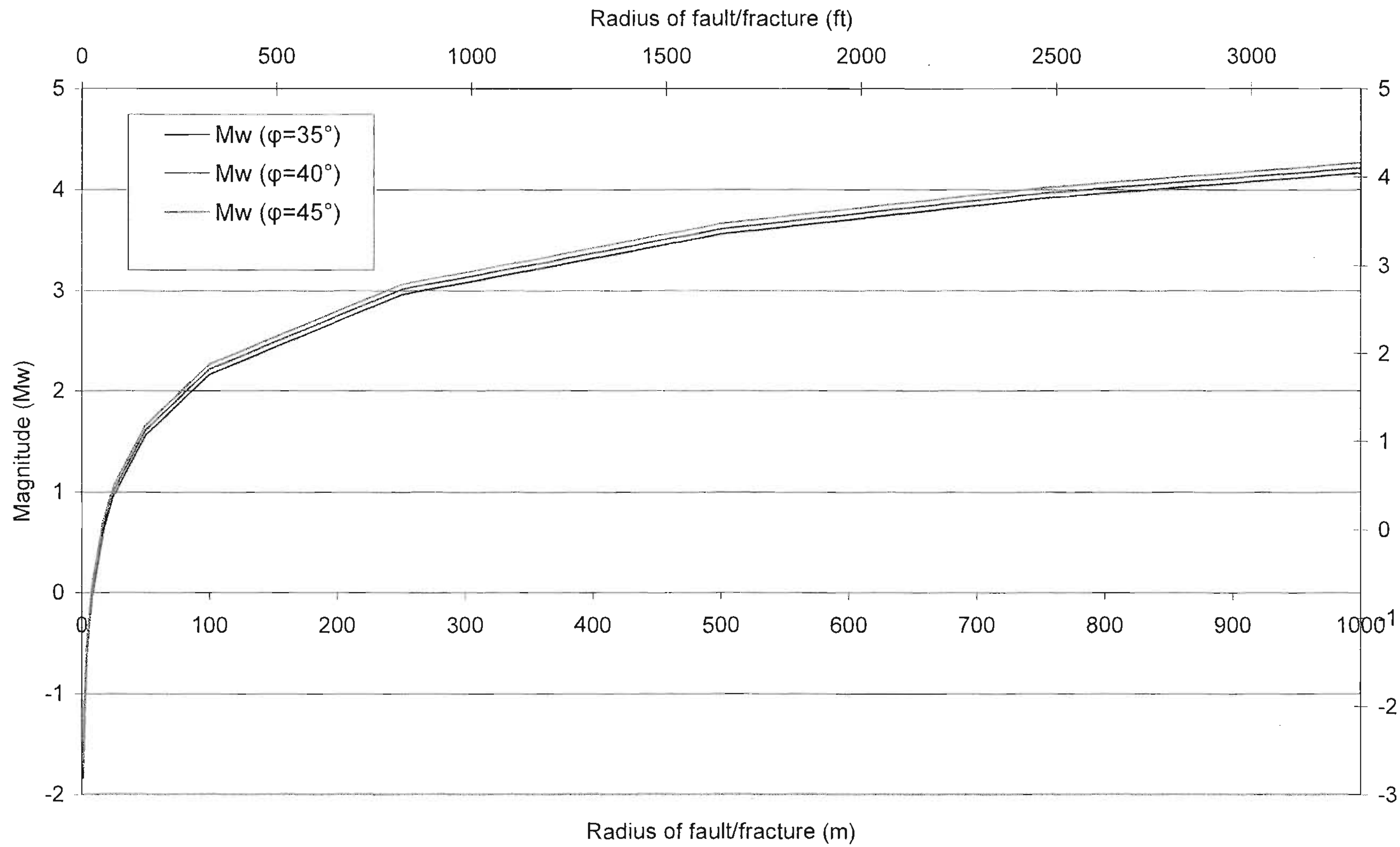

Figure A.3.2: Estimate of Maximum Event Magnitude for the Geysers Induced Fracturing Operations Using a Stress Drop Estimate Approach

A.3.2 Estimation of event rate (Shapiro et al. 2007)

Estimates of seismic event rate require some information of the frequency/magnitude distribution of induced seismic activity for similar operations within the same area. The Geysers is somewhat unique amongst EGS sites in that this historical information is available from existing injection operations within both the overall field and also the NCPA area.

The following analysis considers the relationship between the volume of injected fluid and the observed magnitude/frequency relationship for the area. This approach is based on theoretical considerations of the geomechanics and hydraulic behavior of the rock mass, but has been shown to reasonably match at least two injection operations.

Shapiro et al. (2007) developed an induced event magnitude probability relationship for **IS** based on the frequency-magnitude relation of Gutenberg-Richter. Key terms in the relationship are the Gutenberg-Richter parameters, A and b, which have been estimated previously for the Geysers and NCPA areas.

The relationship proposed by Shapiro et al. (2007) estimates the number of events with a magnitude ≥ M within a given time t, assuming an injection pressure Po, a rock mass diffusivity D and an effective injection surface area R.

$\text{Log } N_{\geq M}(t) = \log [4\pi P_0 RtD/F_t] - bM + A$ Equation A.3.5

The bracketed term encapsulates the fluid flow within the reservoir and is closely related to the fluid volume. The term F_t is known as the “criticality” term, which describes the density and stability of the fracture population. “A” and “b” are the coefficients of the Gutenberg-Richter magnitude frequency distribution.

Shapiro et al. (2007) has presented a reasonable match between this theoretical relationship and EGS **IS** in Ogachi, Japan, and also waste water disposal operations in Paradox Valley, Colorado.

A number of the individual terms in Equation A.3.5 warrant some further explanation, provided below.

R (effective radius) – this is the effective radius of the injection surface. It is the radius of a sphere with the same surface area as the injection interval within the borehole. In other words it is related to a radial diffusion type description of flow.

D (diffusivity) – this is the system Diffusivity (D/s). This quantification of the system hydraulic behavior is related to the permeability (K) through the relationship $D=K/(C\eta\Phi)$, where C is the fluid compressibility, η the dynamic viscosity and Φ the fracture porosity. The fracture porosity is typically quoted at ~0.02 for the Geysers fracture system.

F_t (tectonic potential) – It has units of energy. For the purposes of this study it is equal to P_{max}/ε, where ε is the average crack density. In this study we have assumed ε=0.1.

Clearly there is some uncertainty in each of these variables. However the values used in this study are considered indicative and the results obtained with Equation B3.10 can be compared with previously observed results from the GGF.

Figure A.3.3 presents a series of curves for various magnitude thresholds. These are plotted against injection time in days. The injection time will be about 7 days at a rate of 16-18 gal/s.

The "A" and "b" values used in this calculation are recently updated values from Greensfelder (2008). These values have been estimated for the NCPA area in the SE GGF. Greensfelder (2008) has obtained a "b" value of -1.02 for M≤2.5. For M≥2.5 the B value is somewhat lower and believed to reflect a transition from induced to natural seismicity. In this study we have adopted a constant "b" value of -1.02, hence, it tends to overestimate the number of events for M≥2.5. This is a reasonable and conservative approach to take in the hazard assessment.

Greensfelder (2008) has estimated an A value of 3.36, which reflects seismicity within a 1 year period. In this study, we have re-scaled the A value to -4.14 to represent seismicity during a 1 second period. This is necessary for Equation A.3.5.

From Figure A.3.3 it can be seen that the number of events M≥2.5 is less than 1 for each hydroshear operational phase. The curve for $M_w \geq 2.0$ intersects N 1.0 event near 9½ days of injection, so that we can estimate that the largest single event during 7 days injection at 16-18 gal/s is likely to be less than $M_w \sim 2.0$.

Assuming the worse case of the stimulations having a cumulative effect the number of events ≥2.5 after 27 days continuous injection is ≤1. Hence the largest event expected from 27 days continuous injection at 16-18 gal/s is $M_w \leq 2.5$.

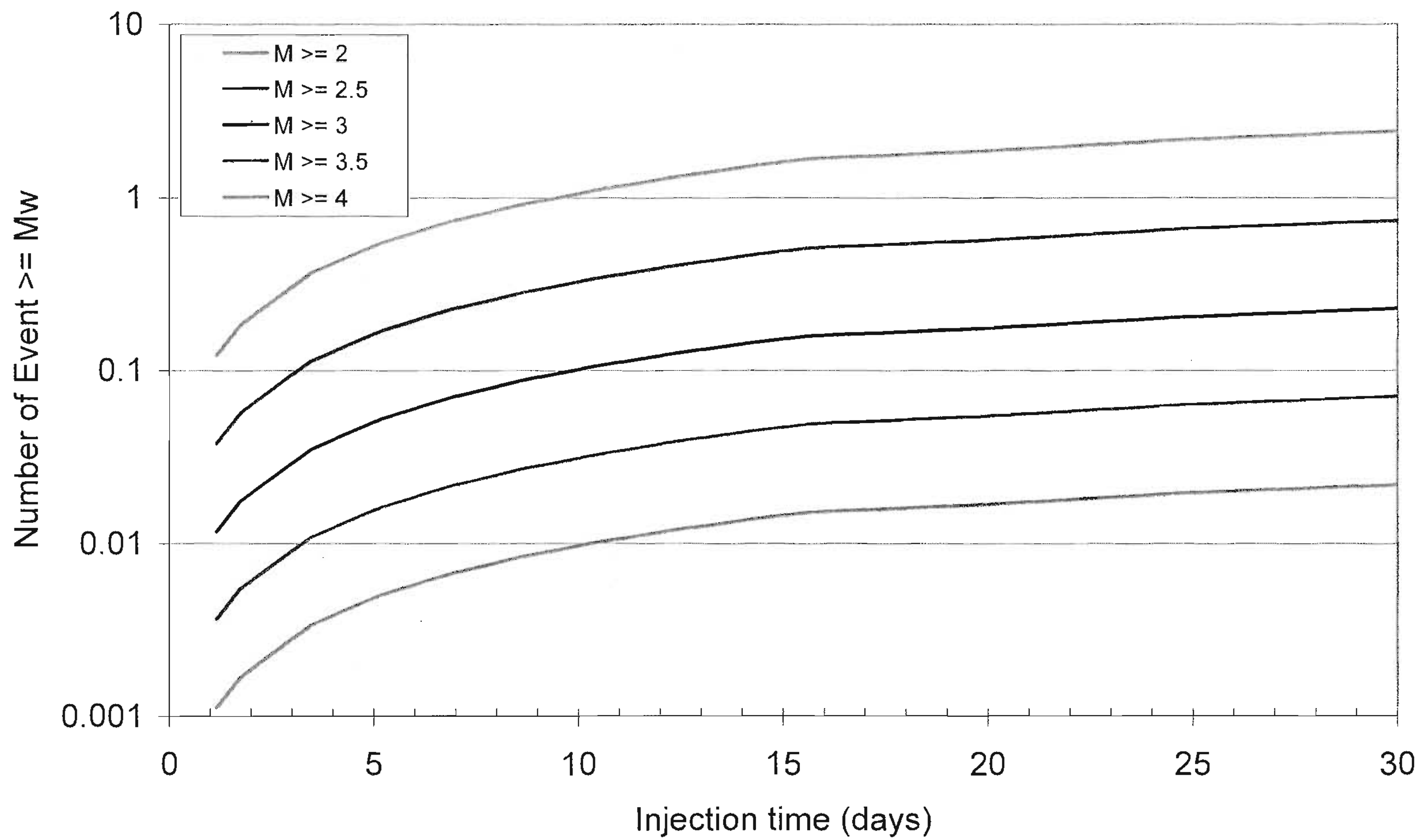

Figure A.3.3: Estimate of Microseismic Event Rate for the Geysers EGS Induced Fracturing Operations Using Shapiro et al. (2007)

A4 Summary and conclusions

Three alternative approaches are used to estimate the maximum induced event magnitude and event rate for the proposed EGS Demo Project hydroshearing operations. In each case, a conservative approach has been taken and the results indicate the worst case scenario. Table A.4.1 summarizes the results of the study.

Table A.4.1: Summary of maximum magnitude estimates (Mw) using the maximum stress drop approach

Technique	Characteristics	Maximum M_w
McGarr(1976)	Release of volumetric strain due to injection of a fluid volume ΔV	3.64
Estimated stress drop (altcom Ltd 2008)	Estimation of the maximum possible stress drop and fracture radius	2.3 – (328 ft radius) 3.7 – (1,640 ft radius)
Shapiro et al. (2007)	Relationship between injected fluid volume and observed Gutenberg-Richter magnitude/frequency relationship for area	2.5

It can be concluded from the application of these techniques, which are conservative, that the maximum possible event magnitude (M_w) for the hydroshear operation of an engineered reservoir radius 1,640 ft is ~3.6. This is somewhat smaller than the largest event detected to date at the GGF (M~4.3).

However, this estimate is conservative and assumes the instantaneous release of energy from the entire reservoir radius as a single event, which has an effective zero probability of occurring, but does indicate the very maximum upper bound of a potential EGS Demo Project related **IS** event. This conclusion is based on previous worldwide EGS project experience indicating that energy is released in a large number of much smaller microseismic events. In fact, the mapping of reservoir development and the targeting of future wells relies on the fact that a large number of small events are generated during the EGS hydroshear operations. This will be insured by the proposed EGS Demo Project through their planned microseismic mapping via a concentrated microseismic array centered on E7.

The current AltaRock understanding is that structures with an effective fracture radius 328 ft are unlikely to be found within the expected engineered rock volume. Hence, it appears unlikely that the magnitude (Mw) for a single EGS Demo Project **IS** could exceed M~2.3. This is within the current levels of seismicity induced by geothermal operations within the GGF.

This estimate of $M_w \leq 2.3$ is also consistent with the analysis of the Gutenberg-Richter magnitude/frequency data for the GGF which indicates that a single M_w=2.5 event may be possible if the entire fluid volume is injected in one continuous injection. The proposed EGS Demo Project plans to create the engineered reservoir by splitting the hydroshear operations into three distinct and non-interfering injections. Under this condition, the maximum event size is predicted to be M_w~2.0.

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APPENDIX B

RESUMÉS OF REPORT AUTHORS

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PROFESSIONAL EXPERIENCE

General. Dr. Greensfelder has 30 years of experience in applied research in seismology, geophysics, and geology. He has conducted many studies concerning seismic hazards in various parts of the United States, with most of them located in California. He also has taught undergraduate and graduate courses in geophysics.

He has conducted numerous seismic hazards studies for sites of power plants and dams, and for Environmental Impact Reports (EIRs). The studies were assessments of potential maximum ground shaking, usually in terms of peak ground acceleration or spectral response, often addressing soil amplification and the potential for soil liquefaction. These investigations developed models of seismicity based upon earthquake history and fault movement, and often utilized analysis of remote sensing imagery (Landsat and aerial photography).

Fluid Injection/Induced Seismicity (IS). Dr. Greensfelder has conducted five studies of **IS** likely to be induced by fluid injection in deep wells, and attendant seismic hazards, in The Geysers geothermal field (northern California) – these are the last five entries in the Publications listed on page 2. Four of these were for EIRs concerning projects to inject municipal wastewater into deep wells (project owners were the Lake County Sanitation District and the City of Santa Rosa, both in northern California).

Eastern California. He has investigated naturally occurring seismic hazards of eastern California and western Nevada in connection with geothermal power facilities (generating plant, transmission line, and substation) owned by Oxbow Geothermal. He performed several research projects dealing with the distributions of Holocene faults and contemporary seismicity in the Basin-and-Range Province of western Nevada and eastern California; these included the vicinity of Mammoth Lakes and Long Valley (see list of publications).

Other Facilities. These include nuclear power plants and waste disposal sites, and water supply projects (including dams). Innvestigation sites have been located in California, Nevada, Washington, Idaho, and several other states in the midwest and east. Many seismic hazard assessments have been conducted as portions of EIRs that have dealt with construction projects in northern California.

Dr. Greensfelder has served as an expert witness in court cases where potential failure of dams or related structures due to earthquake loading was at issue.

EDUCATION

Stanford University, Ph.D. Geophysics, 1981
University of Nevada, Reno, M.S. Geology, 1965

University of California, Berkeley, B.A. Geophysics, 1963

REGISTRATIONS AND MEMBERSHIPS

California Registered Geologist, 1973
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ROGER GREENSFELDER, PhD, Hercules, CA
Senior Seismologist, 1999-present

GREENSFELDER AND ASSOCIATES, Martinez, California,
Owner and Senior Scientist, 1988-present

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, Lafayette, California,
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URS/JOHN BLUME & ASSOCIATES, ENGINEERS, Berkeley, California,
Senior Seismologist, 1977-1984

GEOTHERMEX, Berkeley, California
Geophysicist/Seismologist, 1974-1977

CALIFORNIA DIVISION OF MINES AND GEOLOGY, Sacramento, California
Senior Seismologist, 1970-1974

UNITED STATES GEOLOGICAL SURVEY, National Center for Earthquake Research
Menlo Park, California, Geophysicist, 1965-1969

PARTIAL LIST OF PUBLICATIONS

Parsons Engineering (Parsons), 2003, Induced seismicity analysis. Santa Rosa Incremental Recycled Wastewater Program, Appendix F.1.

GeothermEx Inc., 2002. Potential production benefits and changes in seismicity associated with increased SEGEP injection in the NCPA area, The Geysers geothermal field, Report prepared for Environmental Science Associates, San Francisco, California, in Criterion Planners/Engineers, 2002.

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"Seismologic and crustal movement investigations of the San Fernando earthquake,"California Geology, Vol. 24, No. 4-5, 1974.

TRENTON CLADOUHOS

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EDUCATION

Cornell University, Ph.D., Geological Sciences, August 1993.

Thesis title: *Quantitative Analysis of Faults: Fault Kinematics from the Andes of NW Argentina and SW Bolivia, a Finite Strain Method, and a Fault Growth Model.*

Stanford University, B.S., Geology, January 1988.

EMPLOYMENT EXPERIENCE

2008- **AltaRock Energy** **Seattle, WA**
Senior Geologist-Responsible for development of stress, fracture and flow models, exploration activities and geological/geophysical studies for Engineered Geothermal Systems (EGS). Analysis of tectonic background seismicity and EGS-induced seismicity.

2000 to 2008 **WebPE, Inc.** **Seattle, WA**
Chief Technology Officer Software applications design and development, technical analysis, and hardware system architecture and administration. Primary architect for many WebPE applications, including Seattle Public Utilities *Scientific Information Management System*, and Fort Leonard Wood's *Sustainable Management and Reporting Tool*, Property Manager, Event Manager, Survey Manager, and Discussion Boards. Built out WebPE's hosting services with continued management of over 10 database, application, and development servers running on Linux, UNIX, and Windows NT/2000. Management of IT subcontractors and WebPE development staff.

1997 to 2000 **Golder Associates, Inc.** **Redmond, WA**
Project Geologist to Senior Geologist Analyzed geologic data and numerical modeling of fluid flow using Golder's software package, FracMan. Clients included nuclear waste repository designers in Japan, Sweden, Finland, and U.S., international oil and gas industry, and large civil engineering projects. Marketed, organized, and taught week-long software training workshops. Worked with programmers to design, debug, and verify new software modules. Project management and proposal preparation for funding. Prepared and gave oral technical presentations and written reports to clients. Hired and supervised interns.

1997 to date **Dept. of Geological Sciences, University of Washington** **Seattle, WA**
Affiliate Professor Taught *Fractured Rock Hydrogeology* (Spring 1998) and *Engineering Geology, Civil Engineering Dept.* (Fall 2003).

1996-1997 **Dept. of Geological Sciences, University of Washington** **Seattle, WA**
Lecturer and Postdoctoral Research Associate Taught *Structural Geology* (Spring 1996), and *Geomechanics* (Winter 1997). Conducted field and theoretical study of fault zones; including numerical modeling, field mapping, and characterization of fault rocks by optical microscopy, SEM, and XRD.

1993-1994 **CODELCO-Chile** **Rancagua, Chile**
Private consultant Mapped and analyzed faults adjacent to and within El Teniente copper mine.

PAPERS

Hayman, N.W., Housen, B.A., **Cladouhos, T.T.,** and Livi, K., 2004, Magnetic and clast fabrics as measurements of grain-scale processes within the Death Valley shallow-crustal detachment faults, J. Geophys. Res. 109, B05409.

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Cladouhos, T.T., and Allmendinger, 1993. Finite strain and rotation from fault-slip data. *Journal of Structural Geology*, v.15, p. 771-784.

Cladouhos, T., Bekele, E., and Cahill, T., 1989. The November 25, 1988 Saguenay earthquake: Isoseismal survey in Ithaca region, central New York: *Seismological Research Letters*, v. 60, no. 3, p. 131-133.

Lachenbruch, A.H., **Cladouhos, T.T.**, and Saltus, R.W., 1988. Permafrost temperature and the changing climate. *Permafrost, Fifth International Conference on Permafrost*, v. 3, p. 9-17.

ANREW JUPE

Altcom Ltd., Penzance Cornwall, UK

EDUCATION

2000 - PhD – Camborne School of Mines (University of Exeter) – Geophysics, Rock Mechanics and Reservoir Simulation - "Induced microseismicity and the mechanical behaviour of jointed rock during the development of an HDR geothermal reservoir"

1985 - BSc (Hons) 2.1 University of Reading - Geological Geophysics with Mathematics

EMPLOYMENT EXPERIENCE

2004 -	Director – altcom Limited, Penzance, Cornwall
1999 – 2004	Reservoir Geoscience Business Manager – ABB Offshore Systems Ltd
1993 - 1999	Earth Science Department Manager – CSMA Associates Ltd
1992 – 1993	Reservoir Engineer – CSMA Associates Ltd
1990 – 1992	Geotechnical Engineer – Soil Mechanics Associates Ltd, Wokingham
1989 – 1990	Reservoir Geophysicist – CSM HDR Geothermal Energy project

Current business activity

altcom Ltd (www.altcom.co.uk) is a software development and consulting business based in Cornwall, United Kingdom. The 3 altcom Directors all originated from the Camborne School of Mines Hot Dry Rock (HDR) Geothermal Energy project.

The altcom business consists of two integrated strands:

- consultancy and information services to the oil, gas and geothermal industries on microseismic technology and reservoir geomechanics
- consultancy and development of web and database/information management software

The consultancy activity is led by Dr Jupe and currently has oil industry clients in the Former Soviet Union, North America, Europe, the Middle East and SE Asia. Projects include oil, gas and condensate production, waste-water disposal, steam-assisted heavy oil production and hydraulic fracturing operations.

altcom is also the developer and operator of the www.microseis.net which is a web news, information and training portal providing up to date information to the hydrocarbons and geothermal industries on the development, implementation and value of microseismic monitoring technology.

Personal experience:

- 12+ years experience in planning and executing commercial microseismic monitoring projects worldwide, for clients such as BP, Shell, ChevronTexaco, ConocoPhillips, BG (British Gas), Petroleum Development Oman, Saudi Aramco, NAM, Japex, Statoil, TengizChevroil
- Delivered complete turnkey microseismic projects in the Middle East and Europe, including system design, installation, processing and data integration/interpretation
- Development of a geomechanics training programme and assessment methodology for "Sand production prediction" for major oil and gas producer
- Managed integrated fractured reservoir interpretation studies for Middle East carbonate fields (eg integrating reflection seismic, well logs, core studies, FMS/FMI interpretation and reservoir flow data)
- Managed the integration of client and third party services providers during microseismic field operations (eg well and seismic service providers)
- In depth knowledge and practical experience of the hardware and services supplied by most microseismic and borehole seismic service providers
- Led major R&D projects in thermal fracturing simulator development, borehole seismic hardware development, microseismic monitoring of waterflood and CRI (cuttings re-injection) pilot studies and integration of microseismics into dynamic reservoir modelling
- Specialist expertise in "realising reservoir value" – through the integration of microseismics with dynamic reservoir models and geomechanical behaviour
- Expertise in communicating the new technology concepts and work processes to clients within the international oil and gas industry
- 20+ scientific and conference papers on microseismic technology, reservoir fluid flow and geomechanical modeling
- Guest Editor of a Geothermics Special Issue on "HDR Reservoir modeling activities within Europe" and 8 years on the Editorial Board of Geothermics
- Previously the UK representative to the IEA Geothermal Implementing Agreement (GIA)
- Creation and implementation of Quality Management systems to achieve ISO9001:1996 and ISO9001:2000 in software development and geomechanical testing

ADDENDUM

This addendum means to clarify how the EGS Demo project might affect the number of felt microearthquakes and their MMIs at Anderson Springs. Table 5.1 (c) presents the mean recurrence interval of MMI intensities II through V, where it is seen that microearthquakes are expected to be felt (MMI = III to V) around once every seven days. These forecast recurrence intervals were based principally on felt reports from a 14-month period during 2003-2004, presented on the website maintained by the Anderson Springs Community Alliance (ASCA). All felt reports were for M >= 1.5; most had M >= 2.0; many had M >= 3.0 and two had M 4.2 and 4.4. The recurrence intervals are significantly shorter than those computed in the probability analysis, making the assessment conservative (i.e., tending to err towards shorter intervals).

Comparison of the felt reports and magnitudes tabulated on the ASCA website demonstrates that local earthquake magnitudes are poorly correlated with observed intensities (MMI). This occurs, in part, because ground shaking in the near-field, that is, within approximately 10 km of an earthquake's hypocenter (i.e. the subsurface position of the seismic energy source) varies a great deal with azimuth and distance from hypocenter. Also, shallow geologic structure, particularly the thickness of overburden (such as un-cemented silt, sand and gravel deposits) can cause major local increases above average predicted ground shaking.

It is noted that the southeastern portion of the Calpine leasehold (named Calpine SE) exhibits about three times the microseismicity of the adjacent NCPA leasehold. Thus, the recurrence intervals appropriate to NCPA microseismicity alone should be approximately one-third that of Calpine SE.

Most important for this EIR is the fact that present levels of microseismicity in the NCPA and Calpine SE leaseholds will dwarf any activity attributable to the EGS Demo project. It was pointed out in the document's Executive Summary that any water injected for this project would simply represent water diverted from existing injection wells. Thus, NCPA field-wide injection and field-wide induced microseismicity are not expected to vary significantly during the operation of the EGS Demo project;.

Appendix C Special-Status Species with the Potential to Occur in the Project Vicinity

California Department of Fish and Game
Natural Diversity Database
CNDDB Wide Tabular Report
Mount Saint Helena 7.5-minute Quad and Eight Surrounding Quads

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Accipiter striatus sharp-shinned hawk	G5 S3	CDFG:	Fed: None Cal: None	21 S:1	1	0	0	0	0	0	0	1	1	0	0
Actinemys marmorata marmorata northwestern pond turtle	G3G4T3 S3	CDFG: SC	Fed: None Cal: None	379 S:20	2	9	5	1	0	3	1	19	20	0	0
Agelaius tricolor tricolored blackbird	G2G3 S2	CDFG: SC	Fed: None Cal: None	424 S:1	0	1	0	0	0	0	0	1	1	0	0
Amorpha californica var. napensis Napa false indigo	G4T2 S2.2	CNPS: 1B.2	Fed: None Cal: None	45 S:14	2	1	2	1	0	8	6	8	14	0	0
Amsinckia lunaris bent-flowered fiddleneck	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	50 S:2	0	0	0	0	0	2	2	0	2	0	0
Anomobryum julaceum slender silver moss	G4G5 S1.3	CNPS: 2.2	Fed: None Cal: None	13 S:1	0	0	0	0	0	1	1	0	1	0	0
Antirrhinum subcordatum dimorphic snapdragon	G3 S3.3	CNPS: 4.3	Fed: None Cal: None	49 S:1	0	0	0	0	0	1	1	0	1	0	0
Antrozous pallidus pallid bat	G5 S3	CDFG: SC	Fed: None Cal: None	388 S:6	1	0	0	0	1	4	3	3	5	0	1
Arctostaphylos canescens ssp. sonomensis Sonoma canescent manzanita	G3G4T2 S2.1	CNPS: 1B.2	Fed: None Cal: None	25 S:3	0	1	0	0	0	2	2	1	3	0	0
Arctostaphylos densiflora Vine Hill manzanita	G1 S1.1	CNPS: 1B.1	Fed: None Cal: Endangered	4 S:1	0	0	0	0	0	1	1	0	1	0	0
Arctostaphylos manzanita ssp. elegans Konocti manzanita	G5T2 S2.3	CNPS: 1B.3	Fed: None Cal: None	34 S:10	0	0	0	0	0	10	10	0	10	0	0
Ardea herodias great blue heron	G5 S4	CDFG:	Fed: None Cal: None	86 S:1	0	0	0	0	0	1	1	0	1	0	0
Astragalus claranus Clara Hunt's milk-vetch	G1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Threatened	6 S:2	0	1	1	0	0	0	0	2	2	0	0
Astragalus rattanii var. jepsonianus Jepson's milk-vetch	G4T2 S2.2	CNPS: 1B.2	Fed: None Cal: None	29 S:4	0	2	0	0	0	2	2	2	4	0	0
Athene cunicularia burrowing owl	G4 S2	CDFG: SC	Fed: None Cal: None	1181 S:1	0	0	0	1	0	0	0	1	1	0	0

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Brodiaea californica var. leptandra narrow-anthered California brodiaea	G4?T2T3 S2S3.2	CNPS: 1B.2	Fed: None Cal: None	29 S:11	1	3	0	0	1	6	7	4	10	1	0
Brodiaea coronaria ssp. rosea Indian Valley brodiaea	G4T1 S1.1	CNPS: 1B.1	Fed: None Cal: Endangered	13 S:1	1	0	0	0	0	0	0	1	1	0	0
Calystegia collina ssp. oxyphylla Mt. Saint Helena morning-glory	G4T3 S3.2	CNPS: 4.2	Fed: None Cal: None	9 S:8	2	1	0	0	0	5	5	3	8	0	0
Calystegia purpurata ssp. saxicola coastal bluff morning-glory	G4T2 S2.2	CNPS: 1B.2	Fed: None Cal: None	30 S:1	0	0	0	0	0	1	0	1	1	0	0
Ceanothus confusus Rincon Ridge ceanothus	G2 S2.2	CNPS: 1B.1	Fed: None Cal: None	26 S:13	0	1	0	0	0	12	12	1	13	0	0
Ceanothus divergens Calistoga ceanothus	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	26 S:11	2	2	1	0	0	6	9	2	11	0	0
Ceanothus sonomensis Sonoma ceanothus	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	22 S:1	0	0	0	0	0	1	0	1	1	0	0
Central Valley Drainage Rainbow Trout/Cyprinid Stream	G? SNR		Fed: None Cal: None	2 S:1	0	0	0	0	0	1	1	0	1	0	0
Centromadia parryi ssp. parryi pappose tarplant	G4T2 S2.2	CNPS: 1B.2	Fed: None Cal: None	23 S:3	0	1	0	0	0	2	2	1	3	0	0
Chlorogalum pomeridianum var. minus dwarf soaproot	G5T1 S1.2	CNPS: 1B.2	Fed: None Cal: None	18 S:1	1	0	0	0	0	0	0	1	1	0	0
Clear Lake Drainage Resident Trout Stream	G? SNR		Fed: None Cal: None	3 S:1	0	1	0	0	0	0	1	0	1	0	0
Coastal and Valley Freshwater Marsh	G3 S2.1		Fed: None Cal: None	60 S:1	0	0	1	0	0	0	1	0	1	0	0
Corynorhinus townsendii Townsend's big-eared bat	G4 S2S3	CDFG: SC	Fed: None Cal: None	216 S:4	0	0	0	0	0	4	3	1	4	0	0
Cryptantha clevelandii var. dissita serpentine cryptantha	G5T1 S1.1	CNPS: 1B.1	Fed: None Cal: None	10 S:3	1	1	0	0	0	1	1	2	3	0	0

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Dichanthelium lanuginosum var. thermale Geysers dichanthelium	G5T1Q S1.1	CNPS: 1B.1	Fed: None Cal: Endangered	8	2	4	0	0	0	2	2	6	8	0	0
Downingia pusilla dwarf downingia	G3 S3.1	CNPS: 2.2	Fed: None Cal: None	117 S:3	0	1	0	0	1	1	0	3	2	0	1
Elanus leucurus white-tailed kite	G5 S3	CDFG:	Fed: None Cal: None	111 S:1	0	0	0	0	0	1	1	0	1	0	0
Eriastrum brandegeeae Brandegee's eriastrum	G3 S3.2	CNPS: 1B.2	Fed: None Cal: None	47 S:1	0	0	0	0	0	1	1	0	1	0	0
Erigeron greenei Greene's narrow-leaved daisy	G1 S1.2?	CNPS: 1B.2	Fed: None Cal: None	12 S:3	0	0	0	0	0	3	3	0	3	0	0
Eriogonum nervulosum Snow Mountain buckwheat	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	12 S:4	0	0	0	0	1	3	2	2	3	0	1
Eryngium constancei Loch Lomond button-celery	G1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Endangered	3 S:2	1	1	0	0	0	0	0	2	2	0	0
Falco mexicanus prairie falcon	G5 S3	CDFG:	Fed: None Cal: None	445 S:2	0	0	0	0	0	2	2	0	2	0	0
Falco peregrinus anatum American peregrine falcon	G4T3 S2	CDFG:	Fed: Delisted Cal: Endangered	33 S:3	1	1	1	0	0	0	0	3	3	0	0
Fritillaria pluriflora adobe-lily	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	97 S:1	0	0	0	0	0	1	1	0	1	0	0
Gratiola heterosepala Boggs Lake hedge-hyssop	G3 S3.1	CNPS: 1B.2	Fed: None Cal: Endangered	87 S:1	1	0	0	0	0	0	1	0	1	0	0
Haliaeetus leucocephalus bald eagle	G5 S2	CDFG:	Fed: Delisted Cal: Endangered	241 S:2	0	1	0	0	0	1	0	2	2	0	0
Harmonia hallii Hall's harmonia	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	16 S:3	0	0	0	0	0	3	3	0	3	0	0
Hesperolinon adenophyllum glandular western flax	G2 S2.3	CNPS: 1B.2	Fed: None Cal: None	40 S:3	0	0	0	0	0	3	3	0	3	0	0
Hesperolinon bicarpellatum two-carpellate western flax	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	25 S:16	4	2	0	0	0	10	11	5	16	0	0

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Hesperolinon didymocarpum Lake County western flax	G1 S1.2	CNPS: 1B.2	Fed: None Cal: Endangered	6	0	1	2	0	0	3	2	4	6	0	0
Hesperolinon sp. nov. "serpentinum" Napa western flax	G2 S2.1	CNPS: 1B.1	Fed: None Cal: None	39 S:2	0	0	1	0	0	1	1	1	2	0	0
Horkelia bolanderi Bolander's horkelia	G1 S1.2	CNPS: 1B.2	Fed: None Cal: None	10 S:1	0	0	0	0	1	0	1	0	0	1	0
Hydrochara rickseckeri Ricksecker's water scavenger beetle	G1G2 S1S2	CDFG:	Fed: None Cal: None	13 S:1	0	0	0	0	0	1	1	0	1	0	0
Hysterocarpus traski pomo Russian River tule perch	G5T2 S2	CDFG: SC	Fed: None Cal: None	4 S:2	0	0	2	0	0	0	0	2	2	0	0
Imperata brevifolia California satintail	G2 S2.1	CNPS: 2.1	Fed: None Cal: None	27 S:1	0	0	0	0	0	1	1	0	1	0	0
Lasionycteris noctivagans silver-haired bat	G5 S3S4	CDFG:	Fed: None Cal: None	138 S:1	0	0	0	0	0	1	1	0	1	0	0
Lasiurus blossevillii western red bat	G5 S3?	CDFG: SC	Fed: None Cal: None	91 S:1	0	0	0	0	0	1	0	1	1	0	0
Lasiurus cinereus hoary bat	G5 S4?	CDFG:	Fed: None Cal: None	217 S:2	0	0	0	0	0	2	1	1	2	0	0
Lasthenia burkei Burke's goldfields	G1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Endangered	30 S:6	0	1	2	0	0	3	3	3	6	0	0
Lavinia symmetricus navarroensis Navarro roach	G5T1T2 S1S2	CDFG: SC	Fed: None Cal: None	4 S:2	0	1	0	1	0	0	0	2	2	0	0
Layia septentrionalis Colusa layia	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	44 S:6	0	0	0	0	0	6	5	1	6	0	0
Legenere limosa legenere	G2 S2.2	CNPS: 1B.1	Fed: None Cal: None	61 S:2	1	0	0	0	0	1	2	0	2	0	0
Leptosiphon jepsonii Jepson's leptosiphon	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	11 S:5	0	0	0	0	0	5	4	1	5	0	0
Limnanthes floccosa ssp. floccosa woolly meadowfoam	G4T4 S3.2	CNPS: 4.2	Fed: None Cal: None	54 S:1	1	0	0	0	0	0	0	1	1	0	0

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Limnanthes vinculans Sebastopol meadowfoam	G2 S2.1	CNPS: 1B.1	Fed: Endangered Cal: Endangered	39 S:3	1	0	0	0	1	1	1	2	2	0	1
Linderiella occidentalis California linderiella	G3 S2S3	CDFG:	Fed: None Cal: None	367 S:1	0	1	0	0	0	0	0	1	1	0	0
Lupinus sericatus Cobb Mountain lupine	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	45 S:32	0	1	4	0	1	26	27	5	31	1	0
Microseris paludosa marsh microseris	G2 S2.2	CNPS: 1B.2	Fed: None Cal: None	31 S:2	0	0	0	0	0	2	2	0	2	0	0
Mielichhoferia elongata elongate copper moss	G4? S2.2	CNPS: 2.2	Fed: None Cal: None	20 S:1	0	0	0	0	0	1	0	1	1	0	0
Monardella villosa ssp. globosa robust monardella	G5T2 S2.2	CNPS: 1B.2	Fed: None Cal: None	31 S:1	0	0	0	0	0	1	1	0	1	0	0
Myotis evotis long-eared myotis	G5 S4?	CDFG:	Fed: None Cal: None	87 S:1	0	0	0	0	0	1	0	1	1	0	0
Myotis thysanodes fringed myotis	G4G5 S4	CDFG:	Fed: None Cal: None	80 S:2	0	0	1	0	0	1	0	2	2	0	0
Navarretia leucocephala ssp. bakeri Baker's navarretia	G4T2 S2.1	CNPS: 1B.1	Fed: None Cal: None	40 S:6	0	1	0	0	1	4	5	1	5	0	1
Navarretia leucocephala ssp. pauciflora few-flowered navarretia	G4T1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Threatened	8 S:2	0	0	0	0	0	2	2	0	2	0	0
Navarretia leucocephala ssp. plieantha many-flowered navarretia	G4T1 S1.2	CNPS: 1B.2	Fed: Endangered Cal: Endangered	7 S:5	2	2	1	0	0	0	3	2	5	0	0
Navarretia myersii ssp. deminuta small pincushion navarretia	G1T1 S1.1	CNPS: 1B.1	Fed: None Cal: None	1	0	1	0	0	0	0	0	1	1	0	0
Northern Basalt Flow Vernal Pool	G3 S2.2		Fed: None Cal: None	28 S:1	0	0	0	0	0	1	1	0	1	0	0
Northern Hardpan Vernal Pool	G3 S3.1		Fed: None Cal: None	126 S:1	1	0	0	0	0	0	1	0	1	0	0
Northern Vernal Pool	G2 S2.1		Fed: None Cal: None	20 S:1	0	0	0	0	0	1	1	0	1	0	0

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Oncorhynchus kisutch coho salmon - central California coast ESU	G4 S2?	CDFG:	Fed: Endangered Cal: Endangered	11 S:1	0	0	1	0	0	0	0	1	1	0	0
Oncorhynchus mykiss irideus steelhead - central California coast ESU	G5T2Q S2	CDFG:	Fed: Threatened Cal: None	29 S:2	1	1	0	0	0	0	0	2	2	0	0
Orcuttia tenuis slender orcutt grass	G3 S3.1	CNPS: 1B.1	Fed: Threatened Cal: Endangered	76 S:1	0	1	0	0	0	0	1	0	1	0	0
Pandion haliaetus osprey	G5 S3	CDFG:	Fed: None Cal: None	433 S:1	0	0	0	0	0	1	1	0	1	0	0
Penstemon newberryi var. sonomensis Sonoma beardtongue	G4T1 S1.3	CNPS: 1B.3	Fed: None Cal: None	11 S:9	3	0	0	0	0	6	7	2	9	0	0
Plagiobothrys strictus Calistoga popcorn-flower	G1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Threatened	3	0	2	0	0	0	1	1	2	3	0	0
Poa napensis Napa blue grass	G1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Endangered	2	0	2	0	0	0	0	0	2	2	0	0
Progne subis purple martin	G5 S3	CDFG: SC	Fed: None Cal: None	45 S:5	1	4	0	0	0	0	2	3	5	0	0
Rana boylii foothill yellow-legged frog	G3 S2S3	CDFG: SC	Fed: None Cal: None	464 S:22	5	13	2	1	0	1	0	22	22	0	0
Sedella leiocarpa Lake County stonecrop	G1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Endangered	6 S:3	0	1	0	0	0	2	2	1	3	0	0
Sidalcea hickmanii ssp. viridis Marin checkerbloom	G3T2 S2.2?	CNPS: 1B.3	Fed: None Cal: None	7 S:1	0	0	0	0	0	1	1	0	1	0	0
Sidalcea oregana ssp. hydrophila marsh checkerbloom	G5T2? S2?	CNPS: 1B.2	Fed: None Cal: None	23 S:4	0	0	0	0	0	4	4	0	4	0	0
Sidalcea oregana ssp. valida Kenwood Marsh checkerbloom	G5T1 S1.1	CNPS: 1B.1	Fed: Endangered Cal: Endangered	2 S:1	0	0	1	0	0	0	0	1	1	0	0
Streptanthus brachiatus ssp. brachiatus Socrates Mine jewel-flower	G2T1 S1.2	CNPS: 1B.2	Fed: None Cal: None	8	1	1	1	0	0	5	7	1	8	0	0
Streptanthus brachiatus ssp. hoffmanii Freed's jewel-flower	G2T1 S1.2	CNPS: 1B.2	Fed: None Cal: None	12 S:11	4	6	0	0	0	1	8	3	11	0	0

Name (Scientific/Common)	CNDDB Ranks	Other Lists	Listing Status	Total EO's	Element Occ Ranks A	B	C	D	X	U	Population Status Historic >20 yr	Recent <=20 yr	Presence Pres. Extant	Poss. Extirp.	Extirp.
Streptanthus breweri var. hesperidis green jewel-flower	G5T2 S2.2	CNPS: 1B.2	Fed: None Cal: None	20 S:5	0	0	0	0	0	5	4	1	5	0	0
Streptanthus morrisonii see individual subspecies!	G2 S2	CNPS:	Fed: None Cal: None	36 S:7	1	1	0	0	0	5	4	3	7	0	0
Syncaris pacifica California freshwater shrimp	G1 S1	CDFG:	Fed: Endangered Cal: Endangered	18 S:2	0	2	0	0	0	0	0	2	2	0	0
Trachykele hartmani serpentine cypress wood-boring beetle	G1 S1	CDFG:	Fed: None Cal: None	3 S:2	0	0	0	0	0	2	2	0	2	0	0
Trifolium depauperatum var. hydrophilum saline clover	G5T2? S2.2?	CNPS: 1B.2	Fed: None Cal: None	19 S:1	0	1	0	0	0	0	0	1	1	0	0
Viburnum ellipticum oval-leaved viburnum	G5 S2.3	CNPS: 2.3	Fed: None Cal: None	20 S:2	0	0	0	0	0	2	2	0	2	0	0

U.S. Fish & Wildlife Service

Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species that Occur in or may be Affected by Projects in the Counties and/or U.S.G.S. 7 1/2 Minute Quads you requested

Document Number: 090115120003

Database Last Updated: December 24, 2008

Quad Lists

Listed Species

Invertebrates

Syncaris pacifica
California freshwater shrimp (E)

Fish

Hypomesus transpacificus
delta smelt (T)

Oncorhynchus kisutch
coho salmon - central CA coast (E) (NMFS)

Oncorhynchus mykiss
Central California Coastal steelhead (T) (NMFS)
Central Valley steelhead (T) (NMFS)
Critical habitat, Central California coastal steelhead (X) (NMFS)

Oncorhynchus tshawytscha
California coastal chinook salmon (T) (NMFS)

Amphibians

Ambystoma californiense
California tiger salamander, central population (T)

Rana aurora draytonii
California red-legged frog (T)

Birds

Strix occidentalis caurina
northern spotted owl (T)

Plants

Astragalus clarianus
Clara Hunt's milk-vetch (E)

Limnanthes vinculans
Sebastopol meadowfoam (E)

Navarretia leucocephala ssp. plieantha
many-flowered navarretia (E)

Sidalcea oregana ssp. valida
Kenwood Marsh checkermallow (=checkerbloom) (E)

Quads Containing Listed, Proposed or Candidate Species:

DETERT RESERVOIR (517A)

MOUNT ST. HELENA (517B)
MARK WEST SPRINGS (517C)

County Lists

Lake County

Listed Species

Invertebrates

Desmocerus californicus dimorphus
valley elderberry longhorn beetle (T)

Syncaris pacifica
California freshwater shrimp (E)

Fish

Oncorhynchus kisutch
coho salmon - central CA coast (E) (NMFS)
coho salmon, So OR/No CA (T) (NMFS)
Critical habitat, coho salmon, So OR/No CA (X) (NMFS)

Oncorhynchus mykiss
Northern California steelhead (T) (NMFS)

Oncorhynchus tshawytscha
Critical habitat, California coastal chinook salmon (X) (NMFS)

Amphibians

Rana aurora draytonii
California red-legged frog (T)

Birds

Brachyramphus marmoratus
marbled murrelet (T)

Strix occidentalis caurina
Critical habitat, northern spotted owl (X)
northern spotted owl (T)

Plants

Eryngium constancei
Loch Lomond coyote-thistle (=button-celery) (E)

Lasthenia burkei
Burke's goldfields (E)

Navarretia leucocephala ssp. pauciflora
few-flowered navarretia (E)

Navarretia leucocephala ssp. plieantha
many-flowered navarretia (E)

Orcuttia tenuis
Critical habitat, slender Orcutt grass (X)
slender Orcutt grass (T)

Parvisedum leiocarpum
Lake County stonecrop (E)

Key:

(E) *Endangered* - Listed as being in danger of extinction.

(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.

(P) *Proposed* - Officially proposed in the Federal Register for listing as endangered or threatened.

(NMFS) Species under the Jurisdiction of the National Oceanic & Atmospheric Administration Fisheries Service. Consult with them directly about these species.

Critical Habitat - Area essential to the conservation of a species.

(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.

(C) *Candidate* - Candidate to become a proposed species.

(V) Vacated by a court order. Not currently in effect. Being reviewed by the Service.

(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, **or may be affected by** projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Amphibians will be on the list for a quad or county if pesticides applied in that area may be carried to their habitat by air currents.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regardless of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the area covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist and/or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list. See our Protocol and Recovery Permits pages.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compensates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our Map Room page.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Species of Concern

The Sacramento Fish & Wildlife Office no longer maintains a list of species of concern. However, various other agencies and organizations maintain lists of at-risk species. These lists provide essential information for land management planning and conservation efforts. More info

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6580.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be April 15, 2009.