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Final Environmental Impact Statement

Geothermal Demonstration Program

50 MW Power Plant

Baca Ranch
Sandoval and Rio Arriba Counties
New Mexico

U.S. Department of Energy

January 1980

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COVER SHEET
FINAL ENVIRONMENTAL IMPACT STATEMENT
GEOTHERMAL DEMONSTRATION PROGRAM; 50 MWe POWER PLANT
SANDOVAL AND RIO ARRIBA COUNTIES, NEW MEXICO
DOE/EIS-0049

(a) Lead Agency: U.S. Department of Energy

Cooperating Agency: U.S. Department of Agriculture, Forest Service, Region 3

(b) Proposed Action: The cost sharing by the Department of Energy and commercial partners in the construction and initial operation of a 50 MWe geothermal demonstration power plant in Redondo Canyon on the Baca Ranch in the Valles Caldera located in Sandoval and Rio Arriba Counties, New Mexico.

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For Copies of the EIS Contact: Mr. Bennie G. DiBona at the address noted above.

(d) Designation: Final EIS

(e) Abstract: The statement assesses the potential environmental impacts associated with the construction and operation of a 50 MWe geothermal power plant at the Baca Ranch Location in Redondo Canyon within the Valles Caldera in New Mexico. Impacts assessed include potential interference with Indian religious and cultural practices; conflicts with future land use plans; possible threat to the National Natural Landmark status of the Baca Ranch; potential contamination of surface water and groundwater; possible non-compliance with the State ambient air quality standard for hydrogen sulfide; the presence on the site of a State-declared endangered species; potential impacts on a Federally declared endangered species; a potential for drawdown of surface springs; potential impact on water rights; possible induced seismicity; presence of sites of archeological significance; and potential impacts of transmission corridors through the Santa Fe National Forest, the Bandelier National Monument, and private recreation lands. Additionally, the statement presents an assessment of potential long range and cumulative impacts of possible future expansion of the resource to support a 400 MWe power plant complex. A post-EIS monitoring plan to assess the effectiveness of the planned mitigation measures is also presented.

(f) The range of alternatives assessed includes no Federal action, delayed action, selecting another location for the demonstration plant, and alternative non-electric uses of the resource. Alternative power plant conversion cycles, and alternative transmission line corridors are also assessed.

(g) The no-action period for the final EIS ends 30 days after its availability is announced in the Federal Register weekly report of the Environmental Protection Agency.

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Final Environmental Impact Statement

Geothermal Demonstration Program

50 MW Power Plant

Baca Ranch
Sandoval and Rio Arriba Counties
New Mexico

Responsible Official

Ruth C. Clusen
Assistant Secretary for Environment

U.S. Department of Energy
Washington, D.C. 20545

January 1980

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1. SUMMARY

In pursuit of the Federal Geothermal Program objective to accelerate the commercialization of geothermal energy in an environmentally sound manner, the DOE issued a program opportunity notice (PON) on September 30, 1977, inviting organizations to submit proposals for the design, construction, and operation of a geothermal electric power plant. The PON specified that the power plant must (1) use a liquid-dominated geothermal reservoir, and (2) be located in the United States. The objectives of the PON were chosen to provide the maximum stimulus to non-Federal development of the widest spectrum of hydrothermal resources that can be used for electricity production.

The Federal action addressed by this Environmental Impact Statement is joint funding by the Department of Energy and commercial partners of a 50-MW(e) geothermal well field, power plant, and transmission line at the Baca Location in Sandoval County, New Mexico. The power plant will utilize a single-flash steam separation system and mechanical-draft cooling towers and will use cooled geothermal fluid for cooling. The geothermal well field will initially consist of up to 17 wells producing fluid from an area of approximately 300 ha (746 acres), including up to 17 new wells to be added during the 30 years of operation.

A 115-kV transmission line will be constructed from the project site to the TA-3 substation near Los Alamos. The line will be capable of carrying up to 150 MW of capacity and will be approximately 30 km in length. The two routings proposed will traverse private land, portions of the Santa Fe National Forest, and the Los Alamos Scientific Laboratory. One of the proposed routes will cross the Bandelier National Monument.

The proposed plant is situated along the Redondo and Jaramillo Creeks graben within the Valles Caldera, a major Quaternary volcanic center superimposed upon the western margin of the Rio Grande rift, a first-order tectonic feature. Volcanic rocks and caldera fill material of Pleistocene age crop out at the surface, overlying a sequence of perhaps 3800 m (12,400+ ft) of older Quaternary and Tertiary volcanics, Tertiary sands, Paleozoic sedimentary rocks, and a Precambrian granitic basement complex. Reduced heat flow values at the site are high, exceeding 3μcal/cm^2. A gravity anomaly of 25 milligals is coincident with the project area. The closest known active fault zone, the Jemez, lies to the southwest of the Valles Caldera. No significant seismic events have been recorded near the project site.

The geothermal resources of the project area include both a liquid- and a vapor-dominated reservoir. The calculated weight of fluid in place in the major, liquid-dominated reservoir is 1.8×10^{12} kg (4×10^{12} lb). The average reservoir fluid temperature is in excess of 260°C (500°F). The main production and injection zone is the lower Bandelier Tuff; the upper Bandelier forms the caprock.

The principal effluents from the power plant are nonflashed, hot geothermal fluid, which will be injected, and geothermal vapor released to the atmosphere from the cooling towers. The liquid contains slightly concentrated dissolved solids, and the vapor contains small amounts of noncondensable gases, including hydrogen sulfide.

Releases of hydrogen sulfide during normal operation will result in increases in H_2S concentrations in the air of less than 2 ppb at the Baca boundary and less than 10 ppb at other locations within the Baca Location. Accidents or abnormal operation conditions may infrequently result in concentrations exceeding these values for infrequent intervals of up to several hours.

Induced subsidence of the land surface resulting from geothermal fluid production is not expected to be likely or measurable at the surface and may even be less significant than that occurring naturally. The proposed fluid injection pressures and temperatures are within a range not likely to initiate any significant earthquake activity as a result of hydraulic fracturing or thermal stress cracking of the reservoir rocks. Induced seismicity at the project site will probably be obscured by natural seismicity.

Potential impacts resulting from development of the 50-MW(e) geothermal well field, power plant, and transmission line are summarized in Table 1-1 and the following paragraphs. The impact on groundwater resulting from the proposed action will be primarily to the deep (geothermal) system in the vicinity of the project site; shallow aquifers

Table 1.1. Summary of potential impacts of development of the 50-MW(e) geothermal well field, power plant, and transmission line at the Baca site[a]

Ecology (Sects. 4.1.4, 4.2.4, and 4.4.1.2)	Land use (Sects. 4.1.1, 4.2.1, and 4.4.1.1)	Geology (Sect. 4.2.5)	Socioeconomics (Sects. 4.1.5 and 4.2.7)	Cultural resources (Sects. 4.1.5.2, 4.1.7, and 4.4.1.4)	Air (Sects. 4.1.3 and 4.2.3)	Water (Sects. 4.1.2 and 4.2.2)
• Disturbance of important winter elk range	• Grazing and logging largely unaffected	• Induced subsidence and seismicity are very unlikely	• Minor effects of disassociation between costs of services and tax benefits	• Potential impact on identified archaeological sites	• Impact of release of approximately <6 grams/sec (50 lb/hr) of hydrogen sulfide during plant operation	• Consumptive water requirement of plant (107 kg/sec or 820,000 lb/hr) requires withdrawal of approximately 5.67 ha (14 acres) of land from irrigation over the 30 year life of the plant
• Loss of habitat for Jemez Mountain Salamander (state endangered species)	• Major recreational resources affected (decreased accessibility and visual impact of transmission corridors)		• Potential impacts of increased traffic volumes on Indian Pueblos	• Potential disruption or desecration of Indian religious sites, sacred areas or sacred objects (plants, animals, water, etc.)	• Impact of release of approximately 0.22 kg/sec (1900 lb/hr) of cooling tower drift during plant operation	• Geothermal fluid withdrawal will reduce the flow in the Jemez River by approximately 0.78 liters/sec (12.36 gal/min)
• Potential effects on rare plant species	• Potential threat to designated National Natural Landmark			• Potential interference with access to Indian religious sites, sacred areas, or collecting grounds for sacred objects		
• Increased stream sedimentation and possible damage to trout fishery	• Possible conflicts with future public acquisition of the Baca property			• Potential interference with Indian religious ceremonies		
	• Estimated land requirements are: disturbance for plant and wells: 18.2 ha (45 acres) transmission line right-of-way: corridor 1: 97.5-106.7 ha (approximately 241-264 acres) corridor 2: 112.8-126.5 ha (approximately 279-313 acres)			• Withdrawal of geothermal fluids may affect discharge of Indian sacred springs		

[a]Identification and quantification of the impacts of development of 150 MW(e) and 400 MW(e) is purely speculative and was not included in this table for that reason. The impacts which result from development to 150 MW(e) and 400 MW(e) will be similar to those presented in this table; however, their magnitude will differ. Discussions of the impacts of development of 150 MW(e) and 400 MW(e) are found in Sect. 4.5.

will not be impacted unless accidental casing rupture should occur. The maximum geothermal reservoir depletion during the 30-year life of the 50-MW(e) power plant, at proposed fluid withdrawal rates, will amount to about 98,690,000 m^3 (80,000 acre ft). Reduction in the flow of springs and wells fed in part by geothermal reservoir outflow is expected to occur; however, the total amount of depletion is not known at this time. If known geothermal discharges along the Jemez River are derived from the production reservoir, the best available estimate of Jemez River flow reduction as a result of geothermal reservoir drawdown is approximately 0.78 liters/sec (12.36 gal/min), or 1% of the lowest recorded flow as of 30 years of plant operation.

Evaporative losses may increase the total dissolved solids concentration of the fluid by approximately 12%. Temperature degradation of the reservoir is expected to occur because of the mixing of the relatively cool injection water with hot reservoir water. Pressure will decline within the reservoir during fluid production. Past activities with private funding have disturbed approximately 8.1 ha (20 acres) of vegetation.

Over the 30-year life of the power plant, approximately 300 ha (746 acres) of land within Redondo Canyon will be committed solely to geothermal activities, of which 10 to 20% will actually be disturbed by construction and well-field development. Competing land uses in Redondo Canyon are grazing, private recreational use, and religious and other cultural uses by the Pueblos. The greatest potential for land-use impact lies in the superposition of geothermal power production upon a natural area surrounded by recreational sites, archaeological resources, and public lands. The major impacts will be related to conflicts with recreational uses of surrounding public lands as a result of visual impacts of transmission lines. The entire Baca Location has been designated a national natural landmark to protect the Valles Caldera. Geothermal development could be incompatible with the natural landmark status. The Valles Caldera is being considered for possible public acquisition. The proposed 50-MW(e) plant and future geothermal development encouraged by its success could prove incompatible with use of the western portion of the Caldera as a potential future public park or recreation area.

Impacts of the proposed project on the terrestrial ecosystem will result from construction of the plant and transmission lines and well field development. Clearing of vegetation associated with these activities will be predominantly within the mixed-conifer vegetational community. The resultant loss of wildlife habitat should not significantly affect most species, however, two species have been identified as being of some concern. Areas within Redondo Canyon and along the transmission routes have been identified as habitat for the Jemez Mountains salamander, a species designated as endangered by the State of New Mexico. Construction of the plant, transmission line, and well pads will inevitably result in some loss of salamander habitat. Mitigation of these losses will be achieved by survey of and avoidance of prime habitat areas. Redondo Canyon has been identified as an elk winter use area. Disturbance resulting from project construction and operation will probably result in an unquantifiable loss of elk winter habitat. Sufficient data on the Jemez elk herd does not exist to determine the significance of the loss.

Potential sedimentation of stream beds in Redondo Creek, San Antonio Creek, and the Jemez River, resulting from erosion at the site during construction and well-field development, could be a threat to the aquatic biota. Sedimentation of these streams would reduce the suitability of the Jemez River and San Antonio Creek (below Redondo Creek) for trout and could seriously diminish the recreational value of those fisheries. Because the geothermal fluids are to be reinjected, neither surface water quality nor aquatic ecology should be adversely affected by normal plant operation. Accidental releases of geothermal fluids into Redondo Creek would have severe impacts on the biota of Redondo Creek. Concentrations of arsenic, bromine, and iron in the Jemez River during both low and average flows, after an accidental spill of geothermal fluids into Redondo Creek, could be at levels toxic to fish and other biota.

Socioeconomic impacts will be minimal because of the relatively small size of the project. Farming productivity from irrigated lands may be adversely affected by unmitigated flow depletion of the Jemez River. Also, Indian Spring on Jemez Pueblo, used by the native Americans for bathing purposes, could be similarly affected by geothermal fluid production. Some aesthetic impacts will result to recreational areas nearby from heavy vehicles operating on the public roads during plant construction. Otherwise, noise off site will not be above residential standards and may be totally inaudible.

The project is likely to infringe on Indian religious practices in one or more of the following ways: (1) by destroying religious sites; (2) by destroying sacred objects including areas, plants, water, animals, birds, trees, and shrubs; (3) by increasing the opportunity for invasions of privacy; (4) by contaminating and/or reducing the availability of water for sacred practices; (5) by depleting the flow of sacred springs; and (6) by interferring with access to religious sites. However, the full extent of any possible infringement is not known because information on the location of religious sites, dates and times of ceremonies, and other specific information on religious practices is not known. DOE will consult with Indian religious leaders during the design, siting, and construction phases of the project in order to minimize the project's impacts on areas of religious significance. DOE will also consult with Indian religious leaders throughout the operating period of the facility to assure that interference with religious rights and practices is minimized.

Impacts of the transmission line will depend upon which route is chosen. Impacts to biota will result from clearing vegetation along the right-of-way. Up to 38 km of the right-of-way along one proposed route is within forest. Clearing will result in habitat alteration for wildlife species that depend upon closed-canopy, dense forest. Right-of-way clearing will create an earlier successional vegetation of predominately shrubby species. This will create some habitat for wildlife species that prefer open canopy habitats. Construction activities along the line could result in the avoidance of the immediate area around the line by sensitive wildlife species during construction. Impacts of the transmission line will be greatest in relation to the visual resources of the public recreation lands. Line placement in the corridor will avoid areas of Indian religious and of other cultural or historic significance to the extent possible. Where avoidance is not possible, areas will be identified to the administering agency and mitigation measures as defined in the appropriate mitigation plan will be followed. Both routes cross sensitivity-one travel routes and use areas and will be visible to recreational visitors to surrounding public lands.

Alternatives to the proposed action are: (1) to delay or not pursue the proposed project, (2) to utilize the resource through non-electric applications, (3) to select another site within the Baca Location, (4) to select another site at another geothermal area, and (5) to alter plant design and transmission line routes of the proposed project. An environmental trade-off analysis of these alternatives indicates that while some alternatives may be more environmentally attractive, they may be less attractive from the economic or technologic aspect. Because of the competitive selection process, alternatives requiring a location other than that proposed or major design changes might require another competitive award.

Future expansion up to 400 MW in the Baca Location and more on leases outside the Baca may be encouraged by the 50-MW demonstration project; these potential impacts of this future activity are addressed in lesser detail than for the proposed Federal action. It is assumed that 150 MW of capacity may be constructed in Redondo Canyon, resulting in a factor of three times the impact for most areas of analysis. An additional 250 MW is assumed to be the potential in the Sulfur and Alamo Canyon regions for the 400-MW total.

Expansion to 400 MW will require construction of a 345-kV transmission line along one of five feasible routes out of the Baca Location. Expansion to 400 MW will represent an eightfold increase over the initial 50 MW in the impact on vegetation and wildlife habitat and sedimentation impacts on the Jemez River. Expansion to 400 MW could affect additional salamander habitat and elk wintering areas as well as affect elk calving grounds in the Alamo Canyon Valles Seco area. It will also possibly affect peregrine falcon habitat. Expansion will involve the Sulfur Creek watershed and the San Antonio Creek watershed and would potentially affect an important trout fishery in San Antonio Creek. The likelihood of an accidental release of hydrogen sulfide is increased eightfold over that for 50 MW. Land use impacts of expansion to 400 MW would accrue mainly from increased visibility of the well fields, power plants, and cooling tower plumes from nearby public recreation areas and residential developments in the Santa Fe National Forest. Because of uncertainties concerning connections between geothermal reservoirs in Redondo Canyon and elsewhere and connections to the shallow groundwater systems and surface water, hydrologic impacts of 400 MW may not necessarily be increased eightfold. The extent of impact to surface water at 400 MW cannot be confidantly predicted. Because the 400 MW of capacity will not all be in the same drainage basin, ambient H_2S concentrations will not necessarily increase eightfold from the initial 50 MW. However, it is likely that the odor threshold will be exceeded in localized areas, especially near NM-4 south of the site. The magnitude of the effect of development beyond 50 MW cannot be predicted. However, the potential for infringement on Indian religious practices and sites will increase as the area assumes a more industrial character.

Comments on the DEIS were grouped into the major categories of (1) inadequate analysis of expansion beyond the Federal action, (2) inadequate treatment of American Indian religious impacts, (3) critiques of the technical methods of impact estimation, particularly for hydrology and air quality, (4) potential future public ownership of the Baca Ranch, and (5) transmission line alternative discussions. These comments have been included in Appendix I of the EIS, addressed generally in Sect. 12, and resulted in expanded discussion in appropriate sections of the EIS.

2. DESCRIPTION OF THE PROPOSED FEDERAL ACTION

SUMMARY OF CHANGES

In response to comments in the DEIS, Sect. 2.5 of this document has been changed and expanded to describe potential development of geothermal resources in the Valles Caldera Known Geothermal Resource Area (KGRA) as a result of this project.

INTRODUCTION

The Federal action addressed by this environmental impact statement is joint funding by the Department of Energy (DOE) and commercial partners of a 50-MW(e) demonstration geothermal power plant in northern New Mexico. These partners are Union Geothermal Company of New Mexico (Union), who will develop the geothermal steam supply and disposal systems, and Public Service Company of New Mexico (PNM), who will construct and operate the electrical generation and distribution facilities. This project was selected by DOE from responses to a PON issued September 30, 1977. The PON invited organizations to submit a proposal to design, construct, and operate a geothermal electric power plant using a liquid-dominated geothermal reservoir. The purpose of the demonstration plant is to demonstrate the reliability, economic feasibility, and environmental acceptability of electrical generation from two-phase (or "liquid-dominated") geothermal resources.

The proposed demonstration plant will be located within the Valles Caldera at the Baca Location about 30 km (19 miles) west of Los Alamos, New Mexico. The proposed power plant is a single-flash steam unit generating 50 MW(e) gross from 710-kPa (103-psi) steam to be supplied by 15 or 17 geothermal wells (number depends on reservoir productivity). The geothermal reservoir is liquid-dominated, and steam will be separated by flashing the flow from several wells in satellite separators between the wellheads and the power plant, so that only saturated steam flows to the power plant. Since only steam reaches the turbine from the wells, the power plant will be very similar (from the standpoint of power cycle design) to the closed condenser system now being designed and constructed at The Geysers in northern California.

This impact statement will evaluate the potential environmental impacts resulting from well drilling, pipeline construction, and geothermal fluid withdrawal; from power plant construction and operation; and from transmission line construction for the 50-MW(e) demonstration plant. A general discussion of the potential consequences of further commercial development in the area of geothermal energy beyond 50 MW(e) following a successful demonstration is also presented.

2.1 PURPOSE AND POLICY OBJECTIVES

The goal of the Federal Geothermal Program is to accelerate commercial development of geothermal energy in an environmentally sound manner. In pursuit of this goal, a program opportunity notice (PON) was issued to prospective offerers on September 30, 1977, inviting organizations to submit proposals to design, construct, and operate a geothermal electric power plant in the United States using a liquid-dominated geothermal reservoir. The objectives of the PON were selected to provide the maximum stimulus to non-Federal development of the widest spectrum of hydrothermal resources usable for electrical production. The project described herein is that selected by DOE from responses to the PON.

The objectives of the demonstration plant are to provide information on the economic, technologic, and environmental aspects of electrical generation from a liquid-dominated resource. Current geothermal technology in the United States is based on the generation of electricity from a vapor-dominated resource and the use of liquid-dominated resources for nonelectrical applications. Because all the geothermal resources in the United States, with the exception of those at The Geysers and two national parks, are likely to be liquid-dominated and since the development risks of liquid-dominated resources are not well known, this demonstration is aimed at enhancing development of electrical production from the bulk of the U.S. geothermal resource.

Specific objectives included in the PON are as follows:

1. demonstrate the social and environmental acceptability and the readiness of state-of-the-art technology for the production of electrical power using a low- to moderate-salinity liquid-dominated hydrothermal resource,
2. demonstrate reservoir performance characteristics of a specific liquid-dominated hydrothermal reservoir,
3. demonstrate the validity of reservoir engineering estimates of reservoir productivity (capability and longevity),
4. demonstrate a conversion system technology at commercial scale,
5. provide Federal assistance needed to initiate development at a resource of large potential,
6. act as a pathfinder for the regulatory process and other legal and institutional aspects of geothermal development, and
7. provide a basis for the financial community to estimate the risks and benefits associated with geothermal investments.

2.2 GENERAL DESCRIPTION OF PROPOSED PROJECT

The proposed project consists of geothermal well-field development, power plant and transmission line construction, and operation of a 50-MW(e) electrical generating facility. The power plant includes a turbine generator building, cooling tower, hydrogen sulfide abatement system, and an electrical switchyard. The well-field system consists of geothermal wells, piping, steam separators, and a liquid injection system. Electricity will be transmitted from the plant by a newly constructed transmission line. During operation, fluid will be transported from wellheads through pipelines to localized or "satellite" flash separators, from which steam will be piped to the power plant, and unflashed liquid will be sent to an injection plant. Noncondensable gases will be removed from the geothermal fluid in the turbine condenser and processed through a hydrogen sulfide abatement system.

Unless indicated otherwise, the information contained in this chapter came from the Union/PNM Proposal to DOE, through personal communications with the Union/PNM staff, or by direct analysis of the data obtained from these and other referenced sources.

2.2.1 Historical project information

Figure 2.1 depicts the present surface ownership of the original Baca Location No. 1 Land Grant and the general location of the well field and power plant site within the grant area. The lands comprising the original Baca Location No. 1 Land Grant are owned by the United States government (Forest Service and National Park Service) (4%), by Dunigan Enterprises and the Baca Land and Cattle Company (96%), and by the Los Alamos Ski Club (less than 1%). In 1971 Union Geothermal and its predecessors entered into a geothermal trade agreement with Dunigan Enterprises and the Baca Land and Cattle Company for the exclusive rights to explore for, produce, and sell geothermal energy and to construct and operate generating and transmission facilities for the electricity produced. This agreement covered all portions of the Baca Location No. 1 Land Grant that were under surface ownership by Dunigan Enterprises and the Baca Land and Cattle Company, which included at that time the portion now owned by the National Park Service as an addition to Bandelier National Monument (Fig. 2.1). In 1976, the National Park Service purchased that parcel from Dunigan Enterprises and the Baca Land and Cattle Company with all geothermal rights and encumberances intact.

For the purpose of simplicity, in the present document the Baca Location No. 1 Land Grant will be referred to as "the Baca Location," which will refer to the entire 49,470-ha-square (100,000-acre) original land grant. The term "Baca Ranch" will refer to only those portions currently owned by the Baca Land and Cattle Company and Dunigan Enterprises (excluding the section now owned by the National Park Service).

Before this project was selected by DOE, a considerable amount of exploration and reservoir confirmation had taken place. There have been 15 geothermal wells drilled in the Redondo Creek area, four of which have been tested extensively. In addition, 7 wells have been drilled in the Sulfur Creek area, for a total of 22 wells in an area of 108 km^2 (43 square miles). The results of well testing have confirmed a 50-MW(e) energy supply and indicate that the fluid energy of the reservoir may be capable of supplying 400 MW(e) for 30 years.

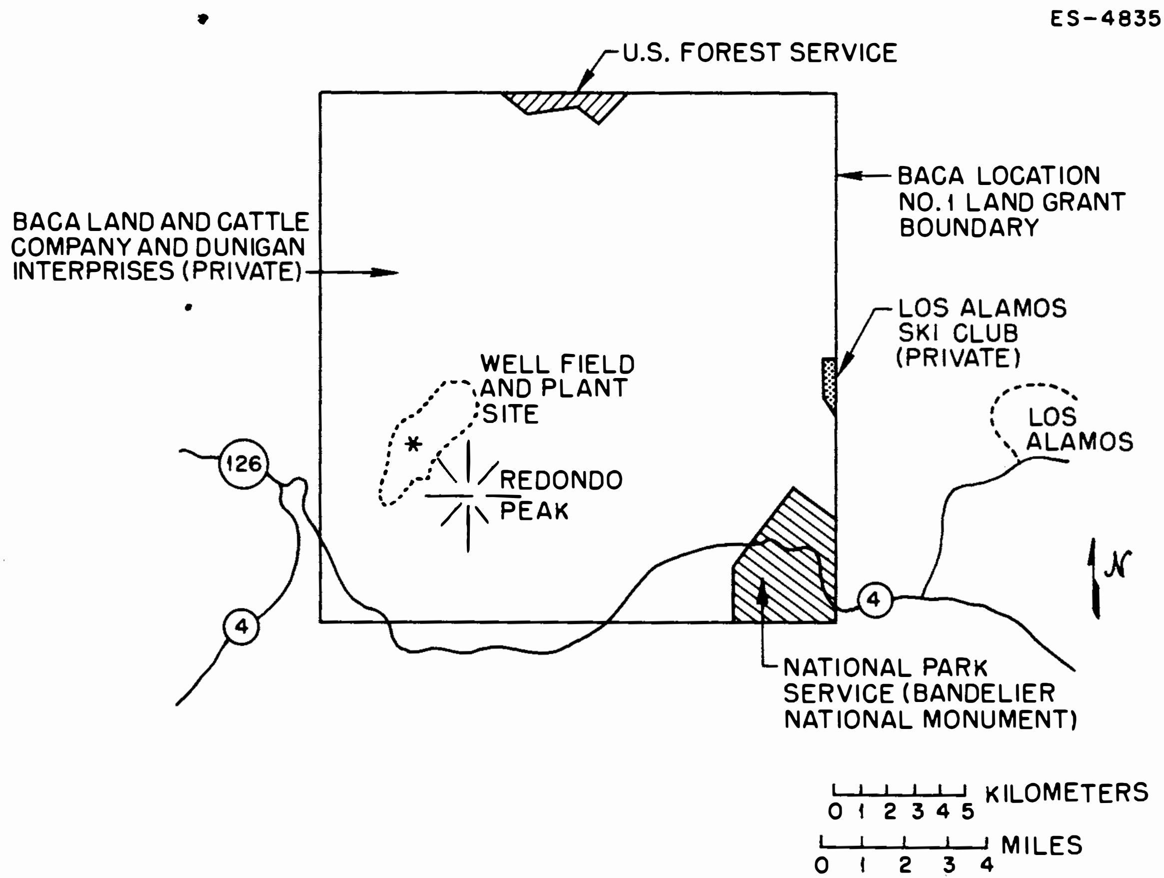

Fig. 2.1. Present surface ownership of the Baca Location No. 1 Land Grant and the general location of the well field and plant site.

In support of and resulting from this past activity, well pads, a gravel road, laydown areas, staging areas, and a drilling rig are now present in the Redondo Creek area. In addition, a project office area consisting of an office trailer and temporary living quarters for some project people is located near the highway entrance.

2.2.2 Site location and surface features

Figure 2.2 depicts the regional location of the Baca Location and the project area (well field and plant site). The Baca Location is located in north-central New Mexico within portions of Sandoval and Rio Arriba counties. The well field and plant site are located approximately 96 km (60 miles) north of Albuquerque and 30 km (19 miles) west of the town of Los Alamos. The project area is within Township 19 north and

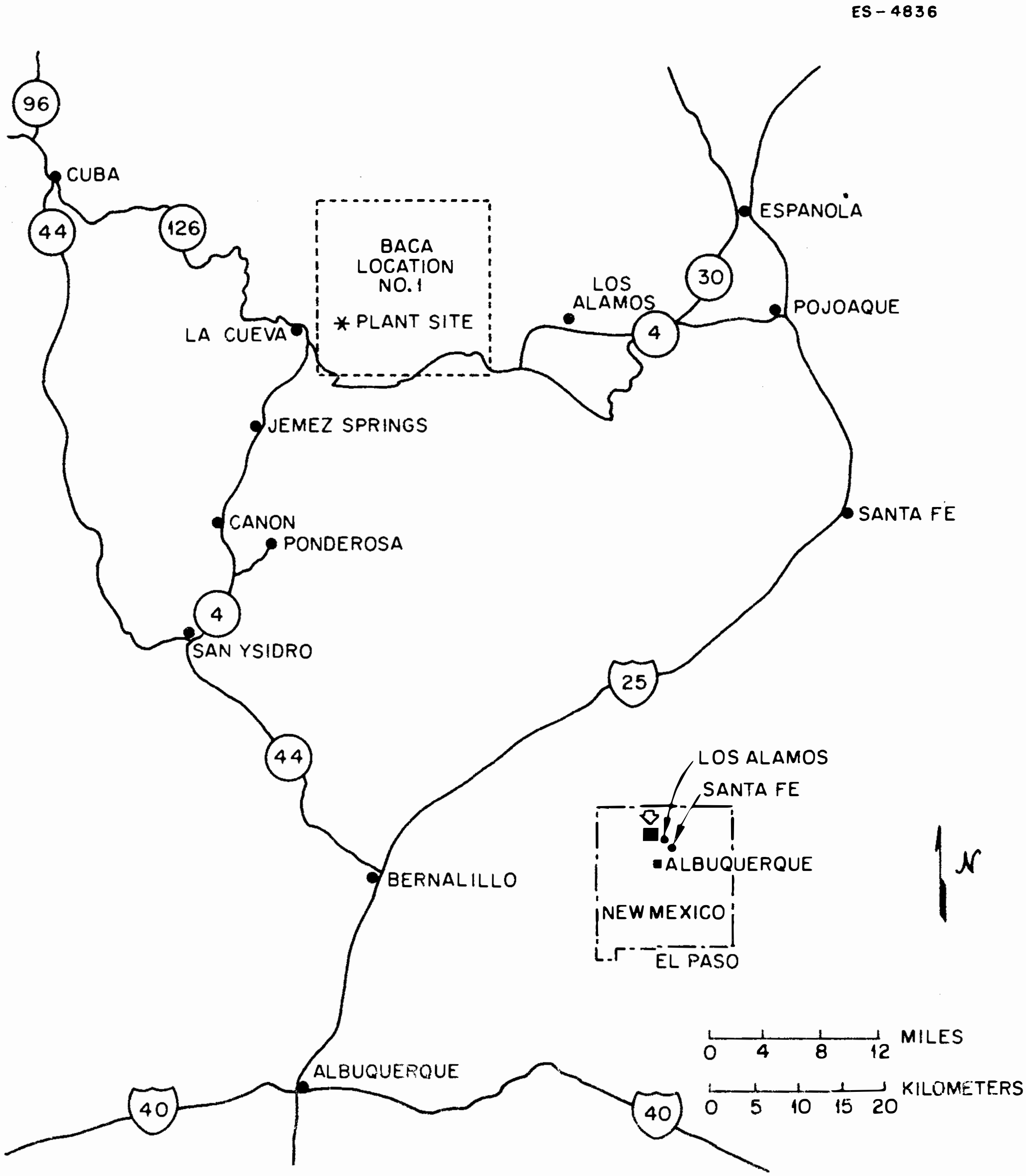

Fig. 2.2. Regional location of the Baca Location No. 1 Land Grant and the plant site and surrounding well field. Source: Mountain West Research, Inc. *Socioeconomic Analysis for the Proposed Baca Geothermal Project,* 1979.

Range 3 east of the New Mexico Base Meridian; the power plant site is centered at 106° 35'10" west longitude and 35° 52'58" north latitude. A 115-kV transmission line will connect the plant site to the TA-3 substation near Los Alamos. The line will follow one of two possible routes discussed in detail in Section 2.2.4.

Access to the project area is via a secondary road off New Mexico Highway 4 (NM-4), at a point about 2.5 km (1.5 miles) from the plant site. The majority of the lands surrounding the Baca Location are part of the Santa Fe National Forest. A number of public campgrounds are located to the west and south at least 6.4 km (4 miles) from the project area. The Parajito Ski Area, privately owned, is adjacent to the Baca Location on the east, 17 km (11 miles) from the project area. The southeast corner of the Baca Location adjoins Bandelier National Monument 13 km (8 miles) from the project; the northeast corner adjoins the Santa Clara Indian Reservation 19 km (12 miles) from the project. Department of Energy lands, which comprise the Los Alamos Scientific Laboratory (LASL), are located 30 km (19 miles) east of the Baca Location.

The Baca Location contains almost all of the Valles Caldera, a prominent geologic feature in the Jemez Mountains. The elevation of the caldera floor averages 2575 m (8500 ft) above mean sea level, with the sides rising from just over 100 m (330 ft) to 610 m (2000 ft) above the floor. The flanks of the Valles Caldera drop off to the desert lowlands and are cut by a number of steep-sided, narrow canyons. Much of the floor of the caldera is occupied by extensive grassy meadows. The edge of the largest of the meadows, the Valle Grande, is located about 6.5 km (4 miles) east of the project area. The meadows are surrounded by forested mountains within the caldera, the highest of which is Redondo Peak, at an elevation of 3425 m (11,254 ft). The project area is located in Redondo Canyon, which is a relatively narrow forested canyon adjacent to Redondo Peak (Fig. 2.2). Elevations in Redondo Canyon range from 2440 m (8000 ft) to 2925 m (9600 ft). Drainage from the well field and plant site is to Redondo Creek and subsequently to the East Fork of the Jemez River, southwest to the Jemez River, and eventually to the Rio Grande.

2.2.3 Well-field development and plant construction

Activities necessary to construct the proposed project are those associated with full-scale geothermal well-field development and with power plant and transmission line construction. The total area of land disturbed by well-field development and plant construction (exclusive of transmission lines) is approximately 18.2 ha (45 acres) in Redondo Canyon.

2.2.3.1 Drilling and well testing

Of the 15 wells drilled previously in the Redondo Creek area, 4 have been confirmed as adequate fluid producers for the proposed project. The most pessimistic estimate of new well success would require the drilling of 15 new wells. It is more likely that well success ratio and production capability would require drilling of only 12 new wells. In the most pessimistic case, a total of 17 new and existing wells would supply steam for plant operation, whereas in the more likely case, a total of 15 new and existing wells would suffice.

Three nonproducing wells already in existence will be used to satisfy the total injection requirement for the plant.

It is estimated that the worst case reservoir depletion will require that one additional well for each initial well be drilled to replace lost production, or a maximum of 17 additional wells for 30 years of plant life. The more likely replacement schedule will be one well every three years of operation, or a total of 10 additional wells.

Initial well spacing of wells will allow approximately 17 ha (42 acres) per well, decreasing to approximately 8 ha (20 acres) per well over the 30 years of plant operation. Thus, maximum total area of the well field will be approximately 285 ha (715 acres) initially and will not increase over 30 years. The actual disturbed area, however, will be only about 10-20% of this larger area, as discussed in the following paragraphs.

Where possible, existing well pads will be used for drilling new wells, and multiple wells will be drilled from single pads, thus only six or seven new well pads are planned for the entire plant life. The new well sites will each be cleared, leveled, and compacted for an area of up to 1000 m^2 (1/4 acre) to provide drill pads; from 0.8 to 2.4 ha (2 to 6 acres) per drill site will be used with minor disturbances for other equipment, sumps, and laydown areas at each site. A drilling mud sump will be provided to hold the drilling fluids at each drill pad, and each site will be sloped toward the sump to provide a drainage catchment. Figure 2.3 is a layout of a typical drilling site arrangement that may be used with minor modifications.

The drilling operations to be used in this project are typical of geothermal drilling practices. For each well, a hole of decreasing diameter will be drilled using a diesel-powered drilling rig, and a conductor pipe and surface casing will be installed as a part of the drilling operation. The first 450 m (1500 ft) of the hole will be drilled using a closed system of circulating mud that consists principally of water, bentonite clay, and caustic soda. Up to 25,000 liters (6300 gal) of water per day is used for mud-drilling operations. Water has been obtained from Redondo Creek in the past for this purpose but currently comes from geothermal fluid. Creek water, well water, or geothermal fluid may be used for drilling water in the future. For each well drilled, Union currently has a permit to withdraw 150 bbl/day of water for 30 days. The mud discharged at the surface is separated from the drill cuttings and held in the sump for recycle or neutralization and evaporation. Treated water, possibly aerated, will be used for circulation to a depth of 900 m (3000 ft), and aerated water will be used for drilling at greater depths.

A steel casing and liner will be set in each well with cement to a depth of approximately 900 m (3000 ft).

The total depth of each well and the exact depth of casing and liner schedules will be determined by the geological and hydrothermal conditions of each hole. After confirmation that a production zone has been reached, test equipment will be installed at the wellhead as shown schematically in Fig. 2.4. A production test over approximately 30 days

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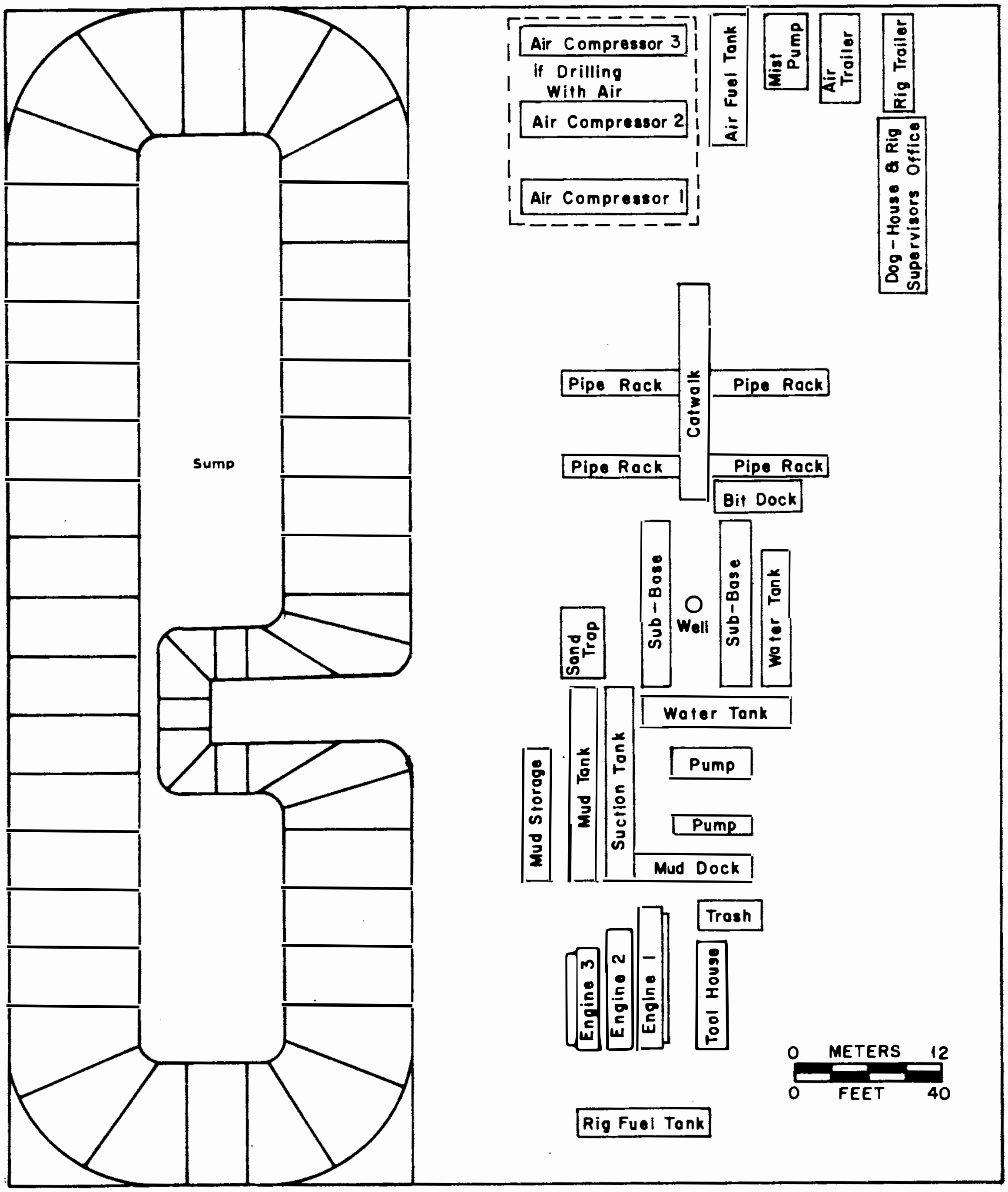

Fig 2.3. Typical equipment layout of a geothermal exploration well.

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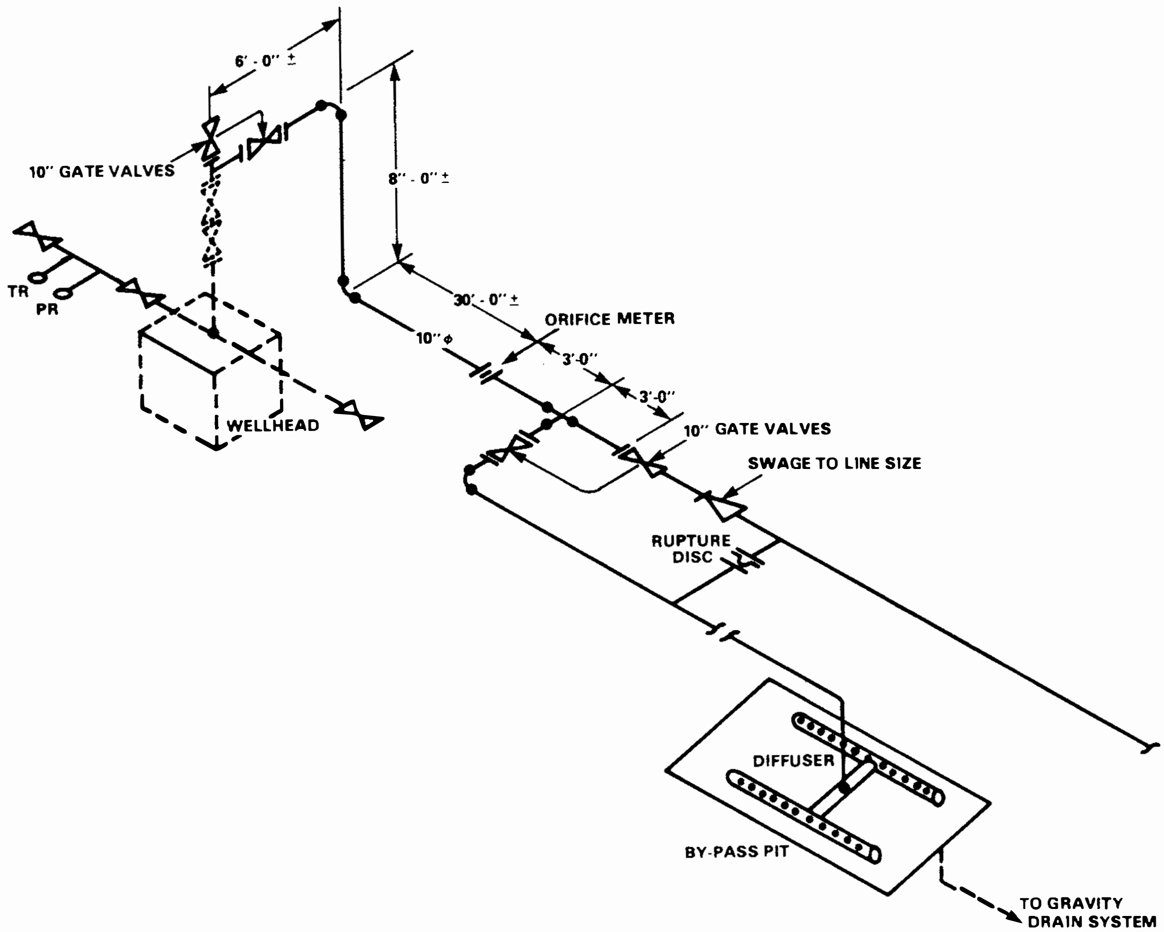

Fig 2.4. Typical flow schematic of two-phase well. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

will determine the wellhead and separator flow rates and the pressure, temperature, enthalpy, chemical composition, and noncondensable gas content of the fluids. The average mass flow rate from each well to be tested is estimated as 91,000 kg/hr (200,000 lb/hr), the unflashed portion of which will be contained by the bypass pit shown in Fig. 2.4.

2.2.3.2 Road and pipeline construction

Drilling activities require access roads for each drill site. Where possible, the access roads will be designed to disturb a minimum area by using existing roads or trails, by following the natural topography, and by using good design practices. Roads will be 4.5 to 6 m (15 to 20 ft) wide with an average disturbed area of 0.5 ha per kilometer of roadway (2 acres per mile), with turnouts provided in the more level areas. Roads will be sloped inward toward a culvert drainage collection system in which runoff is held in settling basins prior to release to the natural drainage system.

Previous exploration and drilling were facilitated by the construction of 12 km (7 miles) of roadway. Future wells for the 50-MW(e) plant will require an additional 3.2 km (2 miles) of roadway in Redondo Canyon. An old logging road connecting Redondo Canyon and Sulfur Creek canyon has been used by off-road vehicles, snowmobiles, and ski patrols for activities such as meteorological data collection and exploration for future expansion.

The power plant will require 8.8 km (5.5 miles) of geothermal fluid supply piping and 5.4 km (3.4 miles) of injection piping ranging from 6 in. to 36 in. nominal diameter. Since 2 km (1.2 miles) of injection piping will use the same supports as the supply piping, the net length of the piping routes will be 12.2 km (7.6 miles). Up to five supply wells will be connected to each of four satellite steam separators, from which steam will be provided to the turbine and liquid will be sent to the injection plant. A schematic of a possible arrangement of the steam supply piping is shown in Fig. 2.5, and the possible arrangement of injection piping is shown in the schematic Fig. 2.6. The exact connections and locations of future wells are subject to change as the field is developed.

Piping will be supported aboveground and insulated to a maximum diameter of 1.2 m (48 in.). Piping rights-of-way will be cleared of vegetation (except grasses) to a maximum width of 15 m (50 ft) during construction but allowed to revegetate to a width of approximately 4.5 m (15 ft), except for about 50% of the piping that will be constructed within the disturbed area of access roads. The total cleared area for piping will be about 12 ha (30 acres). Expansion loops will be provided approximately every 450 m (1500 ft) and will be about 6 m (20 ft) high.

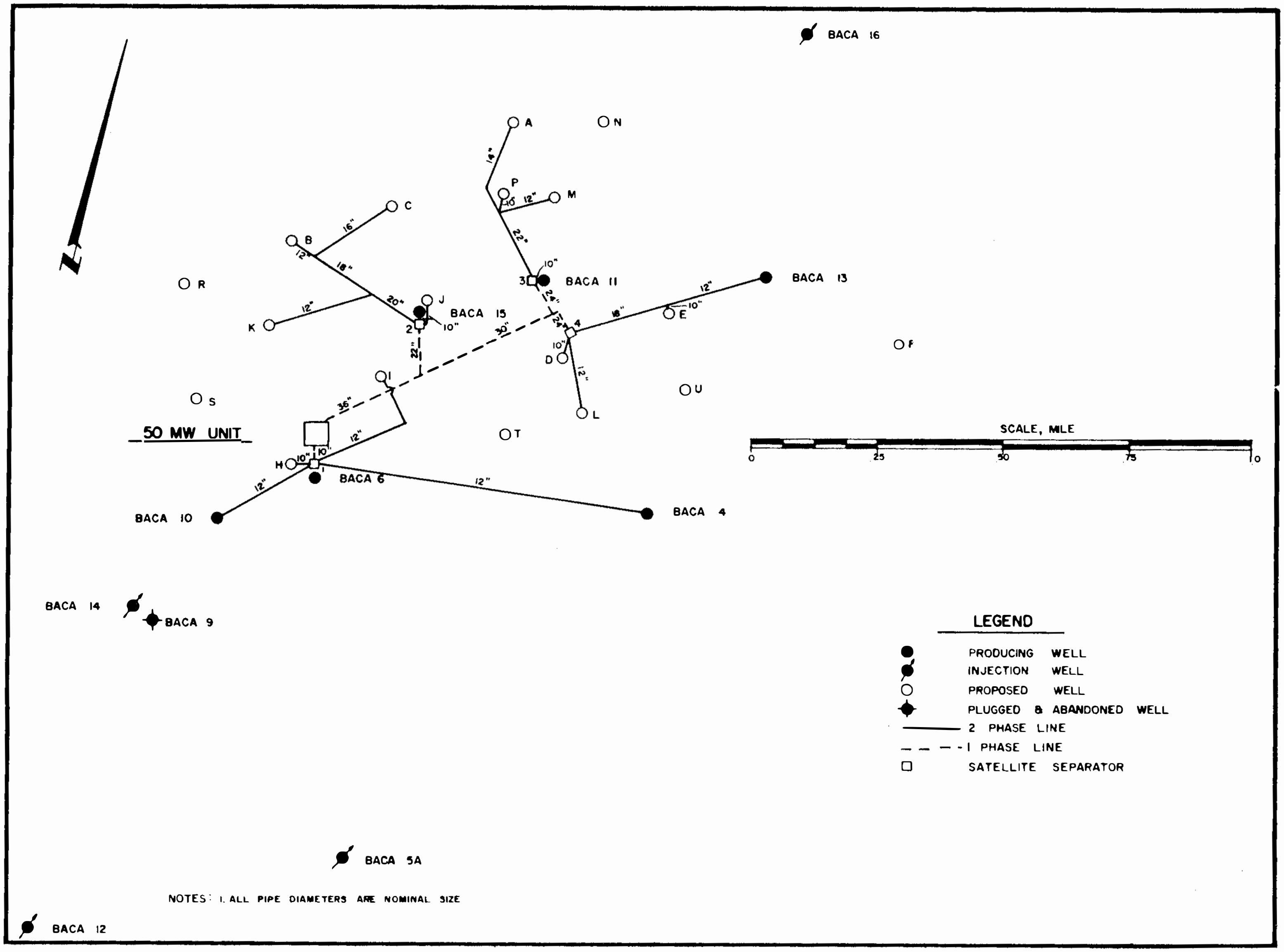

Fig. 2.5. Fluid production pipeline system. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

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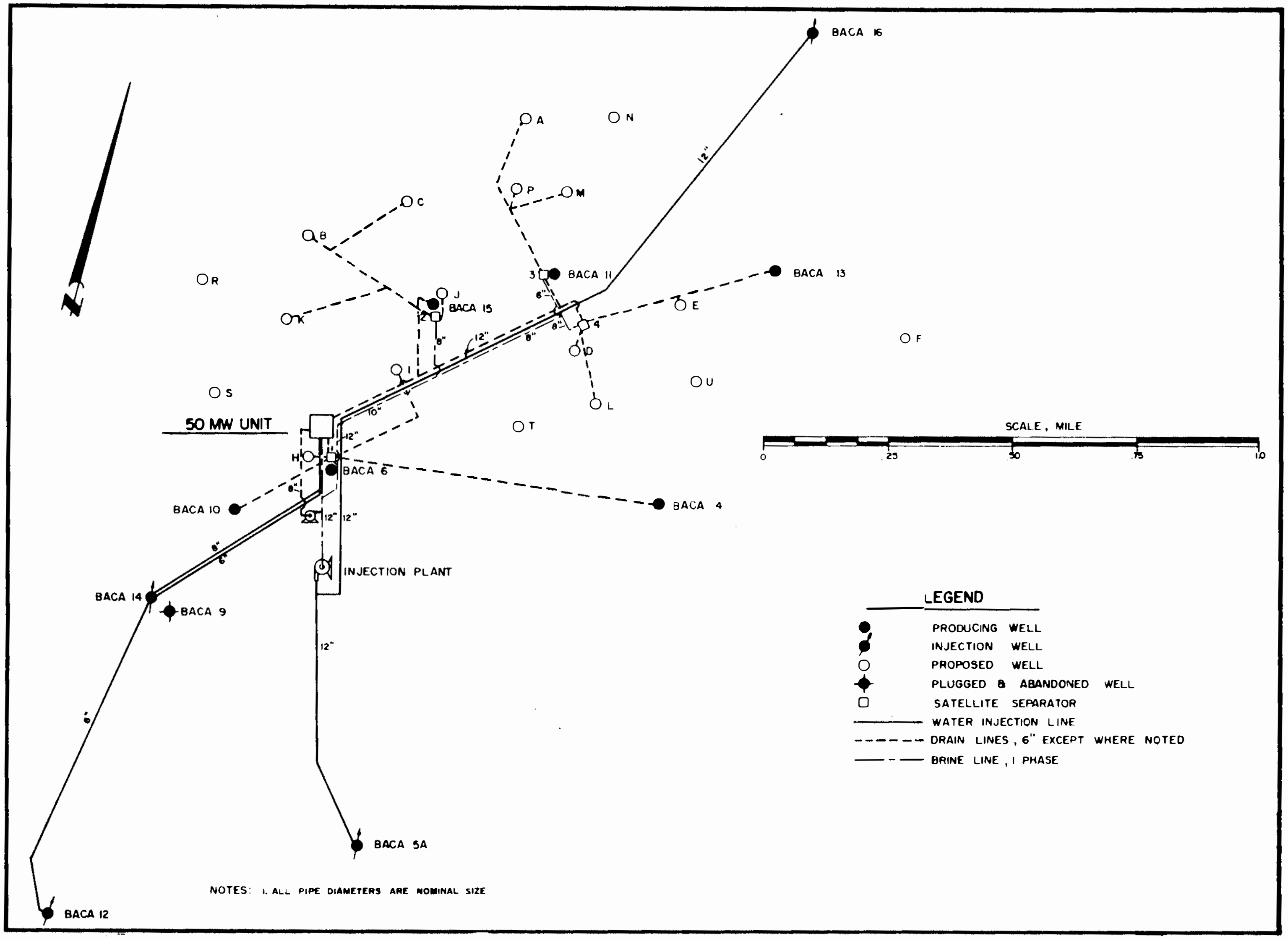

Fig 2.6. Injection pipeline system schematic. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

2.2.3.3 Power plant construction

The power plant will be located immediately northeast of well Baca No. 6, as shown in Figs. 2.5, 2.6, and 2.7, on a relatively flat, previously disturbed area at an elevation of 2651 m (8750 ft) above mean sea level. The total permanent land commitment for the turbine building, cooling tower, switchyard, and hydrogen sulfide abatement area will be less than 2 ha (5 acres). The major components will be arranged as shown in Fig. 2.8. The spent fluid injection station will be located about 300 m (1000 ft) south of the power plant on an additional 0.8 ha (2 acres) of land. The total space requirement for the plant for equipment laydown, maintenance shops, and service areas will be less than 8 ha (20 acres).

Construction activities will consist of earth moving, concrete pouring, equipment installation, and field fabrication and erection of major systems that will extend over a period of about four years. The peak labor force on site will be about 240 persons, of which only about 165 will be present during 25% of that time. All major components and construction materials will be shipped to the plant site by truck.

The turbine building will be the tallest structure, having an overall height of 21 m (70 ft). The building will be a steel-frame structure on a concrete foundation designed for the snow, wind, seismic, and soil bearing loads at the site. Floor plan dimensions will be 20 m by 29 m (65 ft by 96 ft).

The cooling tower will be the largest structure, although it is only 18 m (60 ft) high. It will consist of eight 15 m by 15 m (50 ft by 50 ft) mechanical-draft cells, each having a 9-m (30-ft) fan, arranged in line for an overall length of 121 m (400 ft).

As much as is practicable, all structures will be of a color that blends with the natural setting.

2.2.4 Transmission lines

A new 115-kV transmission line will be constructed from the Baca 50-MW demonstration plant to the TA-3 substation, a distance of approximately 32 km (20 miles). The TA-3 substation is operated by the Public Service Company of New Mexico (PNM) and located on DOE property within

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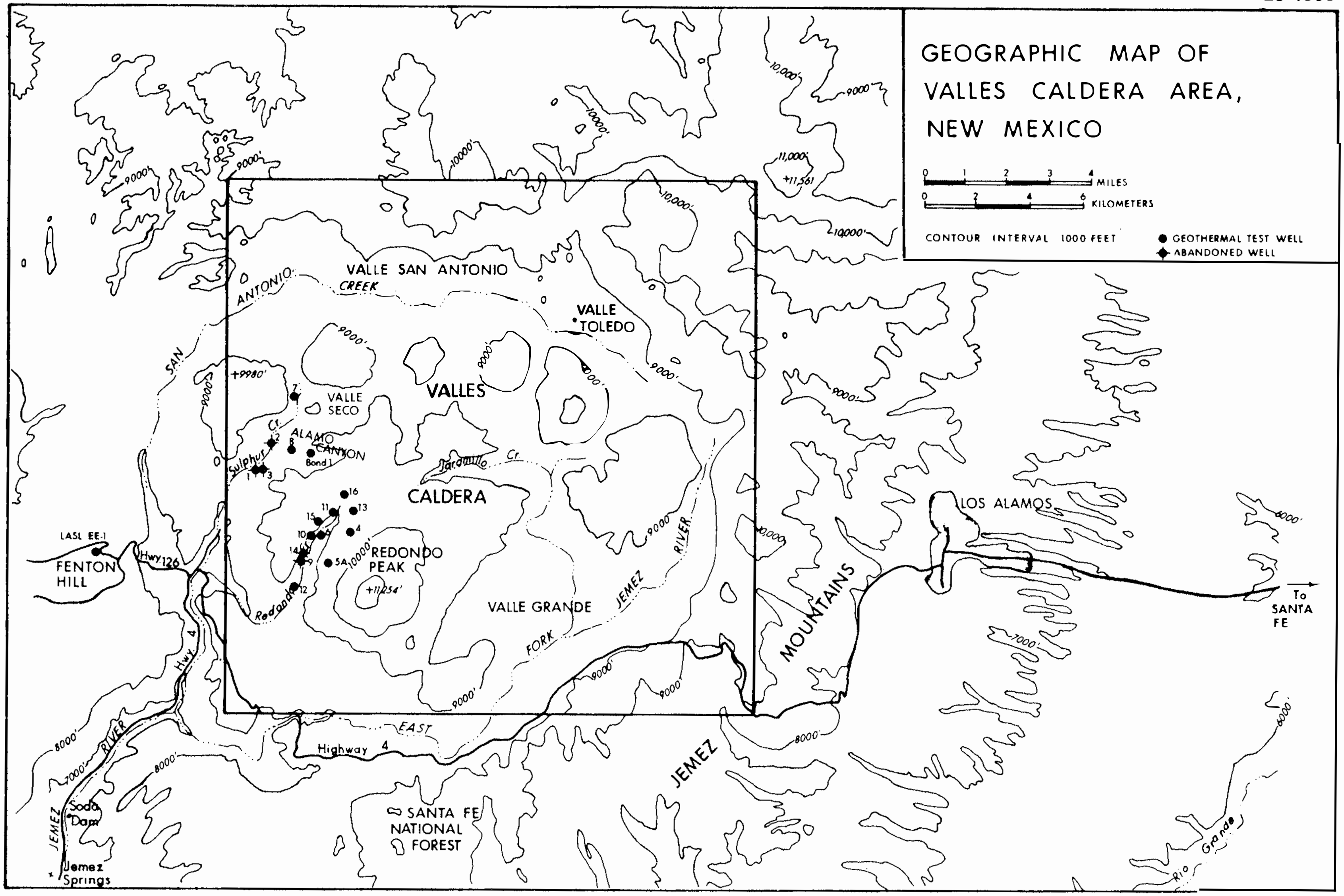

Fig. 2.7. Geographic map of the Valles Caldera. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

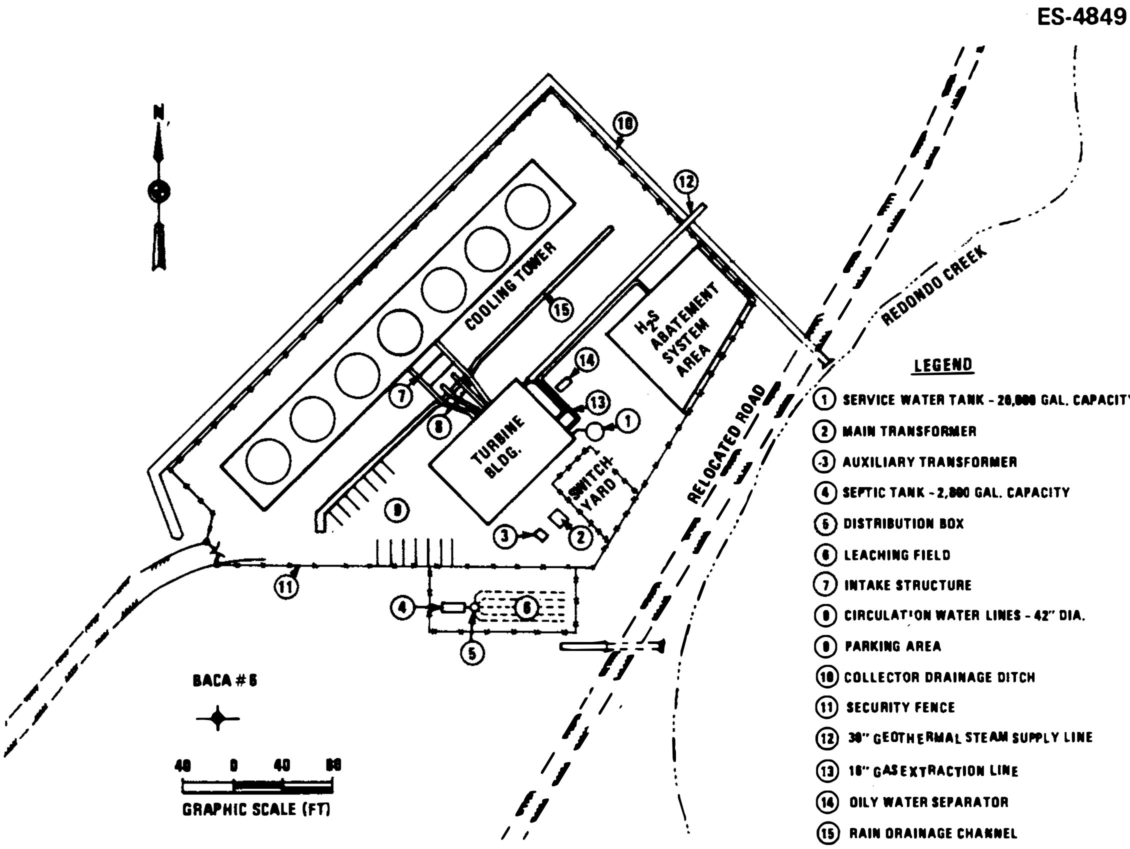

Fig. 2.8. Power plant site plan. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal,* 1978.

the Los Alamos Scientific Laboratory (LASL) restricted area. The TA-3 substation was chosen as the preferred terminus for the new line because it represents the shortest route for egress of power from the Baca plant and because Los Alamos is a major PNM load center capable of using the entire 50 MW of generation output. The additional power will help solve an existing voltage fluctuation problem at Los Alamos. This routing also represents the only feasible route by which PNM will directly serve its own customers; other routes for power egress terminate at load centers serving customers of another utility.

Based on preliminary environmental and engineering studies and discussions of rights-of-way with landowners or land managers, two feasible routes between the Baca plant and the TA-3 station have been identified. These routes are depicted as corridor 1 (the Baca corridor) and corridor 2 (the southern corridor) in Fig. 2.9. Alternative links within each corridor are labeled x, y, and z for corridor 1 and A, B, C, and D for corridor 2. This EIS will consider a 1.6-km-wide (1-mile) corridor along both routes 1 and 2, only one of which will ultimately be chosen for the new transmission corridor. The choice of route will be based upon data contained in this impact analysis and landowner/land manager negotiations for right-of-way.

2.2.4.1 Transmission line design

Support structures for the 115-kV line will consist of wooden pole H-frame structures similar to that depicted in Fig. 2.10. Special structures will be used at angles, dead-ends, and for long-spans or where special visual considerations exist. Height of the structures will range from 20 to 32 m (65 to 105 feet) to provide a minimum clearance of 8.25 m (27 feet) between the conductors and the ground surface. Additional structure height to maintain minimum ground clearance will be required where the terrain dictates or where the conductors cross distribution lines, telephone lines, or highways. A 30.5-m (100-foot) right-of-way will be utilized for the transmission line. The average span length between structures will be 245 m (803 feet), resulting in approximately 4.1 structures/km (6.6/mile). Long spans will be utilized where terrain or visual considerations dictate.

The transmission line will have three aluminum conductors, steel-reinforced, one per phase. Each phase will be suspended from the structure by a single seven-bell insulator string, with spacing between phases of 4.4 m (14.5 feet). The conductors will be protected from lightning strikes by two overhead shield wires mounted on the tops of the wooden poles and connected by ground wires to ground rods driven into the earth at the bottom of poles.

Subsequent to the selection of one of the two proposed corridors (Fig. 2.9), determination of the location within the corridor of right-of-way centerline and structure sites will be based upon further negotiations with landowners or land managers and upon detailed right-of-way surveys. These surveys will consist of engineering, environmental,

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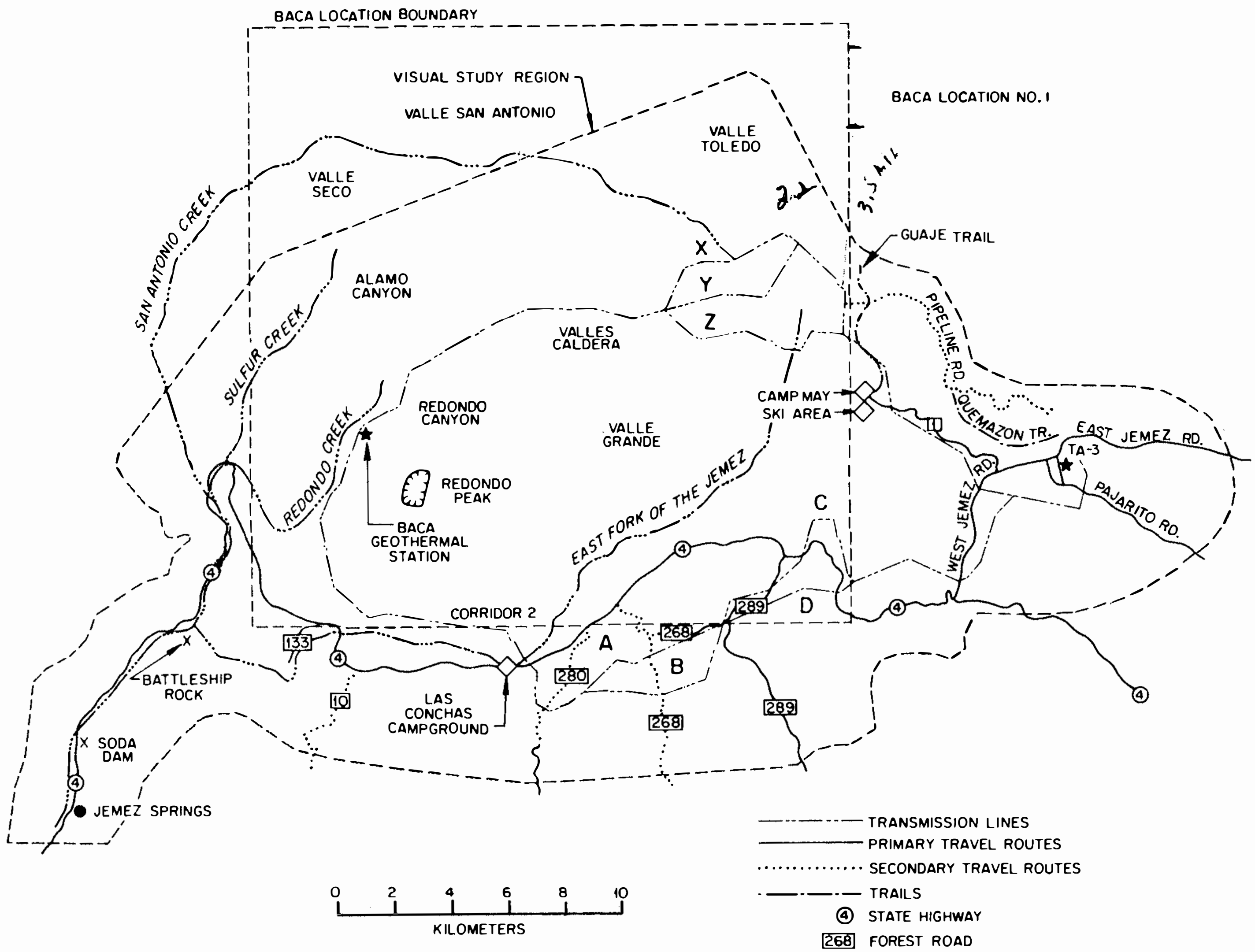

Fig 2.9. Map showing proposed transmission corridor.

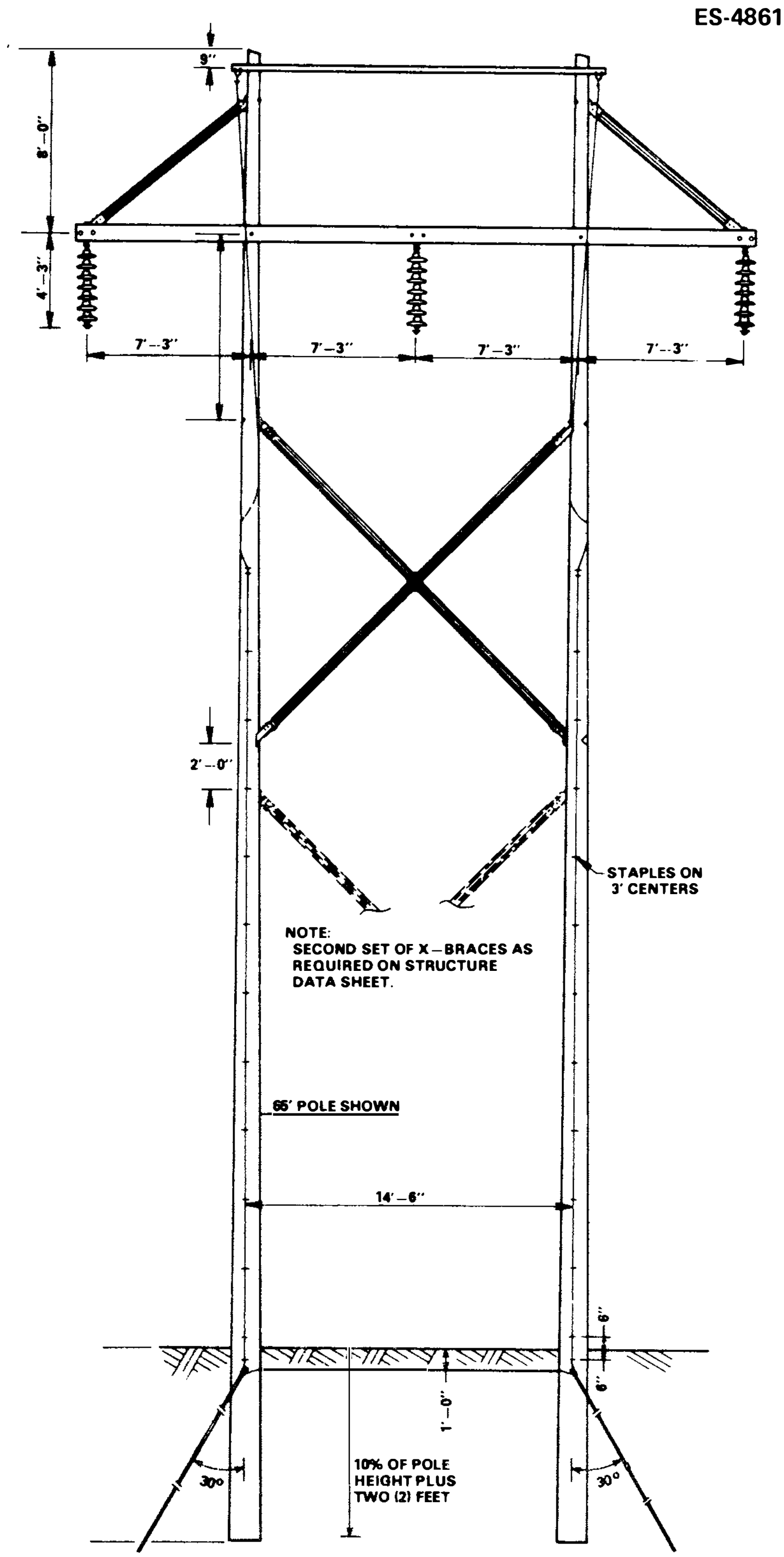

Fig. 2.10. Typical 115-kV wood-pole H-frame transmission tower structure. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

and archaeological studies. Field surveys will be performed by a survey crew using four-wheel drive vehicles and utilizing existing roads as much as possible. No roads will be constructed during this phase of activity. Only a minimum amount of disturbance of vegetation to allow accurate operation of surveying instruments would be necessary.

2.2.4.2 Transmission line construction

Construction of the transmission line will proceed after final right-of-way determination and will probably coincide with plant construction. Construction activities will consist of clearing and site preparation for the right-of-way, structure sites, and access roads; erection of transmission structures and line stringing; and clean-up and reclamation.

Site preparation and vegetation clearing

The amount of clearing and grading necessary for construction of the right-of-way cannot be accurately estimated before detailed surveys are conducted along the chosen right-of-way. However, along the major portion of the right-of-way, vegetation clearing will be limited to topping or removal of large trees to provide minimum conductor clearance. Outside of the right-of-way, danger trees and trees that might contact the lines during wind-induced swing will also be removed or topped. Clearing crews will make a minimum number of passes through the right-of-way utilizing access roads as much as possible.

For each transmission structure a 30- by 46-m (100- by 150-ft) site will be cleared and levelled for structure assembly and erection. Levelling will be accomplished with a bulldozer. In addition to the structure assembly sites, conductor stringing sites will be levelled and cleared at approximately 5-km (3.1-mile) intervals along the right-of-way. These stringing sites will be about 30- by 60-m (100- by 200-ft) and will be used twice — once to pull conductors into place and once for tensioning the conductors.

Where existing roads cannot be used for access to the right-of-way, new ones will be cleared. It is not possible to estimate accurately the number of miles of new access roads that will be required in all before the final centerline surveys of the right-of-way are complete.

All vegetation will be removed along newly constructed access roads, and the roads will be graded with a caterpillar tractor. After construction of the transmission lines, access roads will be restored and closed to public access.

Line construction

A wagon drill mounted on a truck or caterpillar tractor will be used to dig holes for the wooden structures. The structures will be transported to each site in sections and assembled on-site. After erection and placement of the structures, the footings will be cemented and the holes backfilled. Various pieces of heavy construction equipment are used in the transport, assembly, and erection of the structures.

The transmission line conductors will be attached to the structures by a "tension-stringing" method whereby a bulldozer or tractor caterpillar will be used to pull the sock line (a lightweight leader cable) down the center of the right-of-way. The sock line is then used to pull the conductors into place under tension. Normally, the vehicle used to string the sock line will make one cross-country trip down the right-of-way centerline. The area of disturbance is a narrow band down the center of the right-of-way created by the tracks of the bulldozer (approximately 1 m in width). To allow passage, hindering shrubs and trees may be cut down or driven over by the dozer during this operation. To minimize disturbance, PNM is considering using a helicopter to string the sock line over portions of the transmission line.

Cleanup and reclamation

Vegetation cleared during line construction will be ground up, removed, concealed, burned, stacked, or scattered depending on the stipulations of the land management agency or landowner. Disturbed areas will be smoothed where necessary. All roads made during construction will be closed from access, restored, and reseeded. All areas disturbed during line construction will be reseeded with appropriate native species. Revegetation techniques will vary according to each vegetation type along the transmission right-of-way.

2.2.4.3 Transmission line maintenance

The line will be patrolled by helicopter each month to check for problems. When maintenance is needed, the area in question will be reached by existing access if possible. Otherwise, four-wheel-drive vehicles will be used overland to reach the area. The landowner or land management agency will be notified in advance of such action whenever possible. All land disturbed as a result of maintenance will be restored and reseeded as necessary.

2.2.5 Plant operation

The proposed power plant turbine will have a gross electrical capacity of 50 MW when operated at design conditions. Auxiliary power requirements in the plant will be approximately 5 MW, resulting in a net capacity to the PNM system of 45 MW. The plant will be operated as a base-loaded facility. The following approximate design parameters may vary slightly as designs are finalized.

2.2.5.1 Power cycle

The power cycle selected for the proposed plant is a single-flash, once-through steam cycle in which liquid geothermal fluid or a mixture of steam and liquid is flashed to steam in satellite steam separators connecting several geothermal wells to common steam lines. A schematic drawing of this arrangement is shown in Fig. 2.5. From the separators the steam is delivered by insulated pipe to the turbine inlet at saturation conditions of 710 kPa (103 psia) and 166°C (330°F), and the liquid is sent to the injection plant. Figure 2.11 shows a simplified schematic diagram of the power system with approximate flow rates for each subsystem. This system is very similar to the new designs for The Geysers power plant in northern California for the portion of the system after the steam has been separated from the liquid in the satellite separators.

Geothermal fluid condensate from the turbine is collected and circulated through the cooling tower, where it is cooled and recirculated to the turbine condenser as cooling water. This recirculation of the geothermal fluid frees the plant from the requirement for large quantities of fresh water, as is common with closed-cycle steam systems in fossil-fueled and nuclear power plants. The major difference between this system

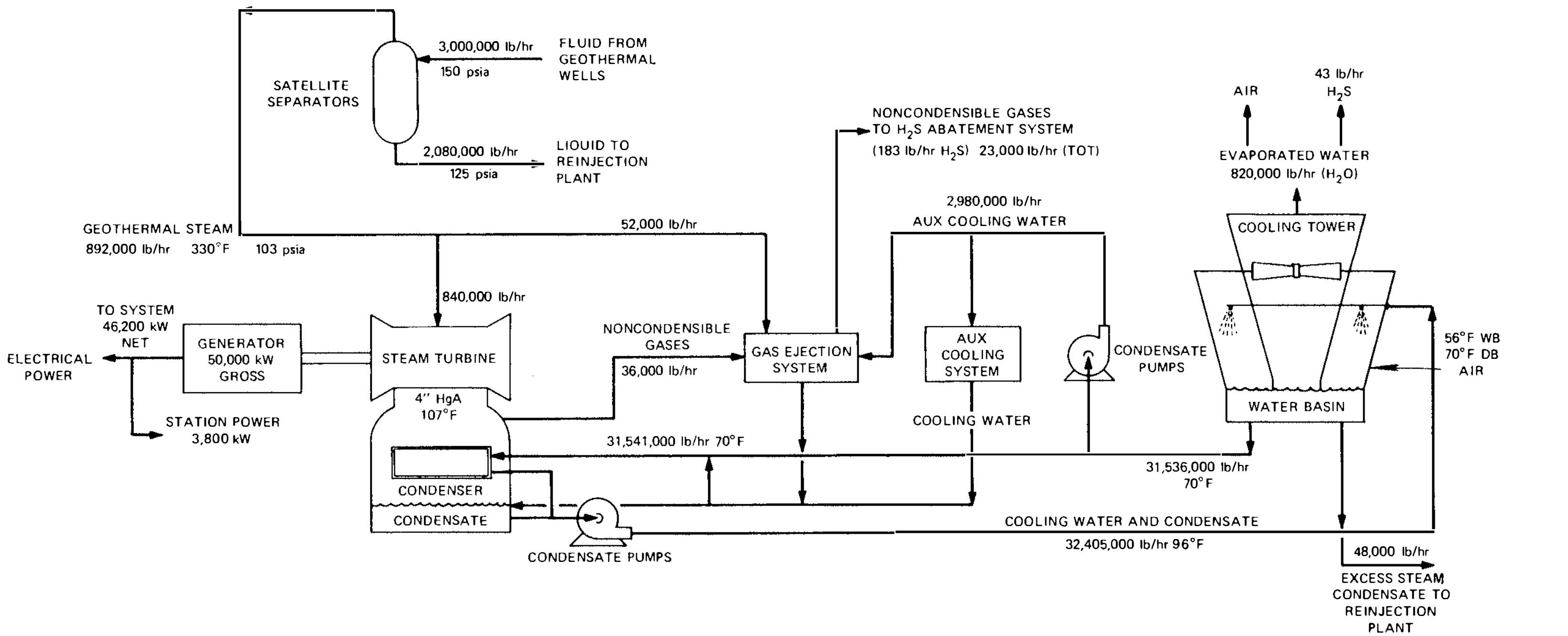

Fig. 2.11. Schematic diagram of power system.

and past geothermal systems is that the steam condensate and the cooling water are not mixed in the condenser, thereby providing for more thorough extraction of noncondensable gases before the fluid passes through the cooling tower. The extracted gases are circulated to the hydrogen sulfide abatement system, where they are treated by the Stretford process, which converts a high percentage of the hydrogen sulfide into elemental sulfur.

Experience with geothermal power plants of this size at The Geysers (without the Stretford process) shows that a plant reliability factor of 70 to 80% over the life of the facility is reasonable. New generating units at The Geysers power plant use the Stretford process to remove hydrogen sulfide. This design feature should improve plant reliability. Hence, the Baca demonstration plant can approach the reliability factor of The Geysers.

The plant will require full or partial shutdown for repair or maintenance of major steam supply components, major generating system components, or the hydrogen sulfide abatement system. Any substantial cutback of steam flow to the turbine will require that the steam bypass the condenser and hydrogen sulfide abatement system by venting to bypass pits at the satellite steam separators. Any flow interruption to the separators will require total fluid bypass to the bypass pit (see Fig. 2.4). This abnormal operation will be discussed in Sect. 4.3.

2.2.5.2 Effluents of operation

A lower percentage of the hydrogen sulfide in the fluid that circulates through the cooling tower will be removed by prior treatment, resulting in a release of hydrogen sulfide to the atmosphere at the low rate of less than 6 g/sec (50 lb/hr), based on the worst-case fluid composition from the wells. The more likely fluid composition will result in a release rate for hydrogen sulfide of less than 5 g/sec (43 lb/hr).

Other effluents of operation consist of the Stretford process fluids, cooling tower blowdown and excess geothermal fluid, which are sent to the injection station, and geothermal fluid in the form of water vapor and drift droplets released to the atmosphere. Approximately 0.2%, or 0.22 kg/sec (1900 lb/hr), of the total cooling tower discharge is in the form of drift (approximately 0.005% of cooling tower circulation).

The vapor and drift released to the atmosphere will contain dissolved solids and noncondensable gases that are present in the geothermal steam. Table 2.1 shows the expected levels of these constituents. Although the gases will be present in the same amount, the drift and liquid to be injected will contain dissolved solids in slightly higher concentrations than the average produced from the geothermal wells, as discussed in Sect. 3.1.2.3, because of the recirculation of cooling water and the evaporative losses to the atmosphere. Total dissolved solids in the cooling tower effluents are estimated to be about 400 ppm, compared with 30 ppm in the steam condensate leaving the turbine.

Table 2.1. Average chemical analysis of steam (without scrubbing)

pH, 4.5

Constituent	Concentration (mg/liter)
Solids	
Suspended solids	7
SiO_2	35
HCO_3	5
SO_4	2
Cl	21
Na	8
K	3
Ca, Mg, Ba, B, F	1.0

Constituent[a]	Concentration (ppm)	
	By weight	By moles
Noncondensable gases		
CO_2	28,250	12,000
H_2S	204	125
N_2	56	37
H_2	2	14
CH_4	2	2

[a]Weighted average of noncondensable gases, 2.64% of steam.

Periodically a nonoxidizing biocide may be introduced for algae control in addition to a silica scale remover. The necessity of using such additives and to what degree they will concentrate if they are used is unknown at this time; however, their infrequent use is expected to contribute insignificant concentrations in the circulating fluid.

2.2.5.3 Water use

The release of vapor by the cooling tower is the primary consumptive use of water by the plant — about 107 kg/sec (820,000 lb/hr). Other plant services will be supplied by treatment of geothermal steam, and potable water will be brought into the plant or obtained from surface sources.

In order to supply the turbine with 112 kg/sec (892,000 lb/hr), the geothermal wells must supply a total flow of 378 kg/sec (3,000,000 lb/hr) of geothermal fluid to the steam separators. The 262 kg/sec (2,080,000 lb/hr) of unflashed fluid from the separators is mixed with the power plant effluent and sent to the injection plant. Thus, the 107 kg/sec (820,000 lb/hr) of water vapor that is released to the atmosphere during operation represents a 27% loss, or net withdrawal, of geothermal fluid from the reservoir.

Union has applied for a permit to withdraw a total of 14 ha (34.59 acres) of irrigated crop land from irrigation by Jemez River water to offset possible reduction in surface water flow in the Jemez resulting from geothermal operations at Baca. This is equivalent to approximately 44 acre-feet of water as defined in the permit application. The land will be retired in increments at five-year intervals over a period of 50 years starting January 1980. The proposed 50-MW plant will be responsible for the retirement of an estimated 5.67 ha (14 acres), equivalent to 17.7 acre-ft of water, over the 30-year life of the plant. The remaining acres will be reserved for possible future expansion of geothermal activities beyond 50 MW.

The Pueblos of Jemez, Zia, and Santa Ana and the Bureau of Indian Affairs (BIA) have protested Union's permit application (Ortega 1979). The protest identifies three issues: "(1) the report submitted with the application does not accurately address the true hydrologic conditions; (2) any further reduction in the base flow of the Jemez River or its tributaries would be in derogation of prior reserve rights of the Jemez, Zia, and Santa Ana Indian Pueblos; and (3) the Office of the State Engineer has no jurisdiction to grant an application for appropriation of nonpotable groundwater 2,500 ft. below the ground surface (NMSA 72-12-25 1978)." The State Engineer's Office will hold a public hearing in an attempt to resolve this protest.

2.3 RECLAMATION AND RESTORATION

All land cleared during construction around the plant site, except for that needed for the facility and associated storage areas and parking, will be graded and reseeded with appropriate native plant species (refer to Sect. 3.1.5). Likewise, to prevent soil loss, areas disturbed by drill pad and pipeline construction will be revegetated as soon as possible after completion of construction activities. The areas immediately surrounding the drill pads and separators, which will receive heavy vehicle use, will be graveled or otherwise stabilized to prevent erosion. Along the transmission line route, areas adjacent to the towers, structure-loading sites, wire-stringing sites, and some access to structures will be cleared to the extent that reclamation will be required. These areas will be reseeded as necessary with plant species appropriate for the particular vegetative community (see Sect. 3.1.5). Access roads for the transmission lines will not be permanently maintained.

The anticipated life of the project will be at least 30 years. In the event the project and further development are terminated, the plant will be decommissioned and the wells capped. Standard well abandonment practices will be used. All land disturbed during project activities will then be recontoured and reseeded with appropriate native plant species.

2.4 BENEFITS

The principal benefit of the proposed project is the intangible benefit of enhancing geothermal development through the demonstration of electrical production from low- to moderate-salinity liquid-dominated geothermal fluids. Tangible benefits are therefore not the primary purpose of DOE involvement in the project, although they are important.

The principal benefits are the annual supply of 320,000,000 kWhr of electrical energy to the PNM system for at least 30 years and the development of technical and environmental information related to electrical production from low- to moderate-salinity liquid-dominated geothermal fluids. This information will assist future developers of this type of geothermal resource. Secondary benefits will be construction wages averaging $2,000,000* per year during four years of peak construction activity and annual wages of $1,500,000* during the 30 years operating life of the facility.

2.5 EXPANSION OF GEOTHERMAL DEVELOPMENT BEYOND 50 MW(e)

This EIS evaluates the potential impact of a proposed Federal action limited to shared funding of a 50-MW(e) geothermal demonstration power plant. A successful demonstration of 50-MW(e) capacity is expected to enhance the development of liquid-dominated geothermal resources in general and at the Valles Caldera KGRA in particular. Although there are no DOE plans for participation in geothermal development in the Valles Caldera KGRA beyond the five-year operation of the 50-MW(e) plant at the Baca Location, the potential impacts of future development are outlined and discussed briefly in this EIS because of the relationship between this 50-MW(e) plant and decreased risk to developers of other geothermal resources in the area. In this section the potential for future development is described. The potential environmental impacts of future development are discussed in Sect. 4.5.

Because of the developmental nature of the geothermal resource potential in the Baca Location, it is not possible to describe a

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*1978 dollars.

development scenario beyond 50 MW(e) with any high degree of certainty. The locations, construction schedule, and ultimate capacity to be developed are highly dependent upon results of exploration and well-field development which are expected to proceed as the proposed 50-MW(e) plant is constructed and operated. A development scenario can be postulated on the basis of what is now known about the Valles Caldera KGRA and the Baca Location, but because it is highly speculative, its use should be limited to reference. This scenario gives a very high probability for a 50-MW(e) power plant resource in Redondo Canyon (the proposed plant), a somewhat lower probability for an additional 100 MW(e) in Redondo Canyon [two additional 50-MW(e) plants], and a considerably lower probability for a resource potential for an additional 250 MW(e) in Sulfur and Alamo Canyons adjacent to Redondo Canyon [five additional 50-MW(e) plants]. This development scenario is confined to leases held by the commercial partners on the privately owned Baca Ranch.

In addition to the above-mentioned leases, there are at least 14 geothermal exploration leases on Federal land in the Valles Caldera KGRA surrounding the Baca Location. These lease locations are shown in Fig. 2.12 along with the wells drilled by the commercial partners on the privately owned Baca Ranch. The area of potential 150-MW(e) development by the commercial partners is within the stippled area nearest Redondo Peak, while the area of additional 250-MW(e) development [to a total of 400 MW(e)] will be from well locations outside the stippled area. This development is likely to occur in Sulfur Canyon, Alamo Canyon, San Luis Canyon, Valles Seco, and, possibly, portions of Valles San Antonio. The potential for development in the Valles Caldera KGRA has been estimated to be between 1000 and 3000 MW(e) total (U.S.G.S. Circular 790, 1979); the latter figure is based on assumptions of new resource discoveries and new technology for energy conversion.

Therefore, there are four stages of development each with a lesser degree of certainty: (1) the proposed 50-MW(e) demonstration power plant; (2) a total of 150 MW(e) in Redondo Canyon; (3) a total of 400 MW(e) in Redondo, Sulfur, and Alamo Canyons; and (4) between 1000 and 3000 MW(e) for the whole Valles Caldera KGRA. The impacts of these stages are discussed in this EIS in detail commensurate with the certainty of development [i.e., much detail for 50 MW(e), less detail for 150 MW(e), even less detail for 400 MW(e), and only a cursory discussion of 1000 to 3000 MW(e)]. The two reasons for this are: (1) little environmental data is available for the areas outside Redondo Canyon and the proposed transmission line routes, and (2) the DOE has no participation in, nor influence on, the plans for development of this project beyond 50 MW(e). Any attempt to project impacts beyond 50 MW(e) is speculative at this time.

2.5.1 Development of 150 MW(e)

Specific sites for three 50-MW(e) power plants do not necessarily exist in Redondo Canyon. It is assumed, however, that two additional power plants can be located in the Canyon within about 3.2 km (2 miles) on either side of the proposed 50-MW(e) power plant. It is also assumed that within the time period for the construction schedule there will not be any significant technological changes in the power cycles, cooling systems, or effluent treatment systems. Therefore, the well-field area, power-plant size, and effluents are assumed to be the same for each additional plant as for the original proposed plant. In addition, the initial 115-kV transmission line has adequate capacity to handle 150 MW(e), thereby eliminating the requirement for transmission lines in addition to the proposed line out of the Baca Location for this stage of development.

2.5.2 Development of 400 MW(e)

Geothermal development beyond 150 MW(e) will probably occur in Sulfur Creek Canyon and Alamo Canyon (see Figs. 2.7 and 2.12). Preliminary exploration by Union prior to this project indicates a possible resource potential of up to 250 MW(e) (but less certain than the potential in Redondo Canyon), bringing the total goethermal potential for the Redondo Creek, Sulfur Creek, and Alamo Canyon areas to 400 MW(e). Where these plants might be located with respect to one another, to the terrain, or to the Baca Location boundary is not known. The possibility of development in this area is also highly speculative until more exploration wells are drilled and until successful operation of the proposed demonstration plant.

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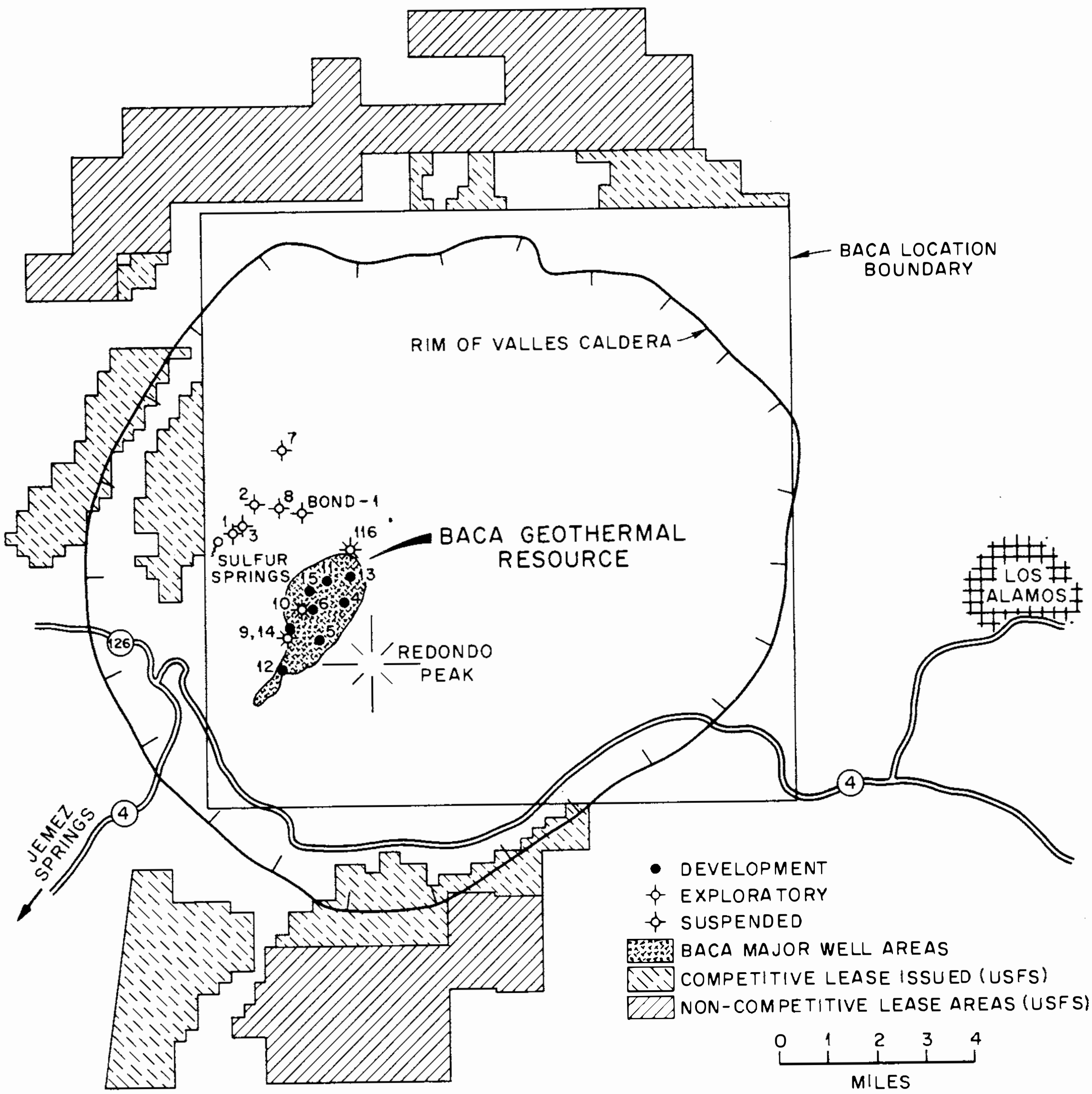

Fig. 2.12. Geothermal leases on Federal land surrounding the Baca Location.

The time at which these plants might come on line is far enough in the future (beyond six or more years) that it may be possible to assume new technology for power cycles, cooling systems, and emission control. However, it has been assumed in this EIS that the plants will be virtually identical to the proposed 50-MW(e) plant in Redondo Canyon, thereby providing a "worst case" estimate of potential impacts. Any alternatives discussed in Sects. 9 and 10, such as dry cooling towers or steam pretreatment for hydrogen sulfide abatement, that might reduce the effluents or consumptive use of resources by the plants will reduce the impacts described in this EIS for the development beyond 150 MW(e).

Additional transmission line capacity will be needed for development beyond 150 MW(e) (probably a 345-kV line along one of the corridors discussed in Sect. 4.5).

2.5.3 Future transmission systems for 400 MW(e)

Development of the geothermal resources located on or near the Baca Location to 400-MW(e) capacity or greater will necessitate egress for the power via one or two 345-kV transmission lines. The PNM has analyzed general egress routes for this power and have identified, very generally, five feasible broad corridors for potential 345-kV transmission lines from the Baca site into the power distribution grid. Figure 4.8 in Sect. 4.5 illustrates the placement of these corridors and that of existing and currently planned 115-kV and 345-kV distribution systems in the Baca/Albuquerque area. A general discussion of potential environmental concerns related to construction of a 345-kV line along each of these five corridors may be found in Sect. 4.5.

2.5.4 Expansion beyond 400 MW(e)

Expansion beyond 400 MW(e) is assumed to involve development on the geothermal leases shown in Fig. 2.12. No information is currently available on development plans except that PNM will be the utility used for power distribution out of the Valles Caldera KGRA should any electricity be marketed. General paths for egress of the power are discussed in the following section and in Sect. 4.5.

Because of the uncertainty of development outside the Baca Location, most of the available environmental information for expansion beyond 400 MW(e) relates to transmission line construction, operation, and maintenance. The U.S. Forest Service is currently preparing a coordinated transmission line development and geothermal plan based on total resource development in and around the Baca Location.

2.5.5 Future transmission system for greater than 400 MW(e)

The discussion of transmission systems for 400 MW(e) in Sect. 4.2.3 is applicable to systems for greater than 400 MW(e) as well.

REFERENCE FOR SECTION 2

Ortega, Lotario D. 1979, personal communication (letter) to S. E. Reynolds, New Mexico State Engineer, July 20, 1979.

3. DESCRIPTION OF EXISTING ENVIRONMENT

SUMMARY OF CHANGES

The following discussion of the existing environment is divided into two sections. The first section characterizes the regional setting and the main project area (well field and power plant site) in Redondo Canyon. The second section describes the two proposed transmission corridors. The impacts of the project will be discussed in Chapter 4.

In response to comments on the DEIS, editorial changes have been made in the this section for clarification. In addition, Sect. 3.1.1.4 was expanded to amplify on potential, future public ownership of the Baca Ranch and Sect. 3.1.10 was added to better identify Indian cultural and religious issues.

3.1 REGIONAL SETTING AND MAIN PROJECT AREA

The following is a description of the land use, geology, hydrology, ecology, socioeconomics, climate, air quality, and cultural resources in the project area and vicinity. Many preproject environmental studies characterized the area on a regional basis. The definition of study regions varied according to the subject of the particular study and is delineated for each of the subjects.

3.1.1 Land use

The land-use study region is depicted in Fig. 3.1. The following discussion of land use is for the most part condensed from a land-use inventory prepared by Wirth Associates (1979). The study region was chosen to characterize areas in addition to the main project area that could potentially be affected by project activities. The description of land use along the transmission corridors (Sect. 3.2) draws upon information presented in this section.

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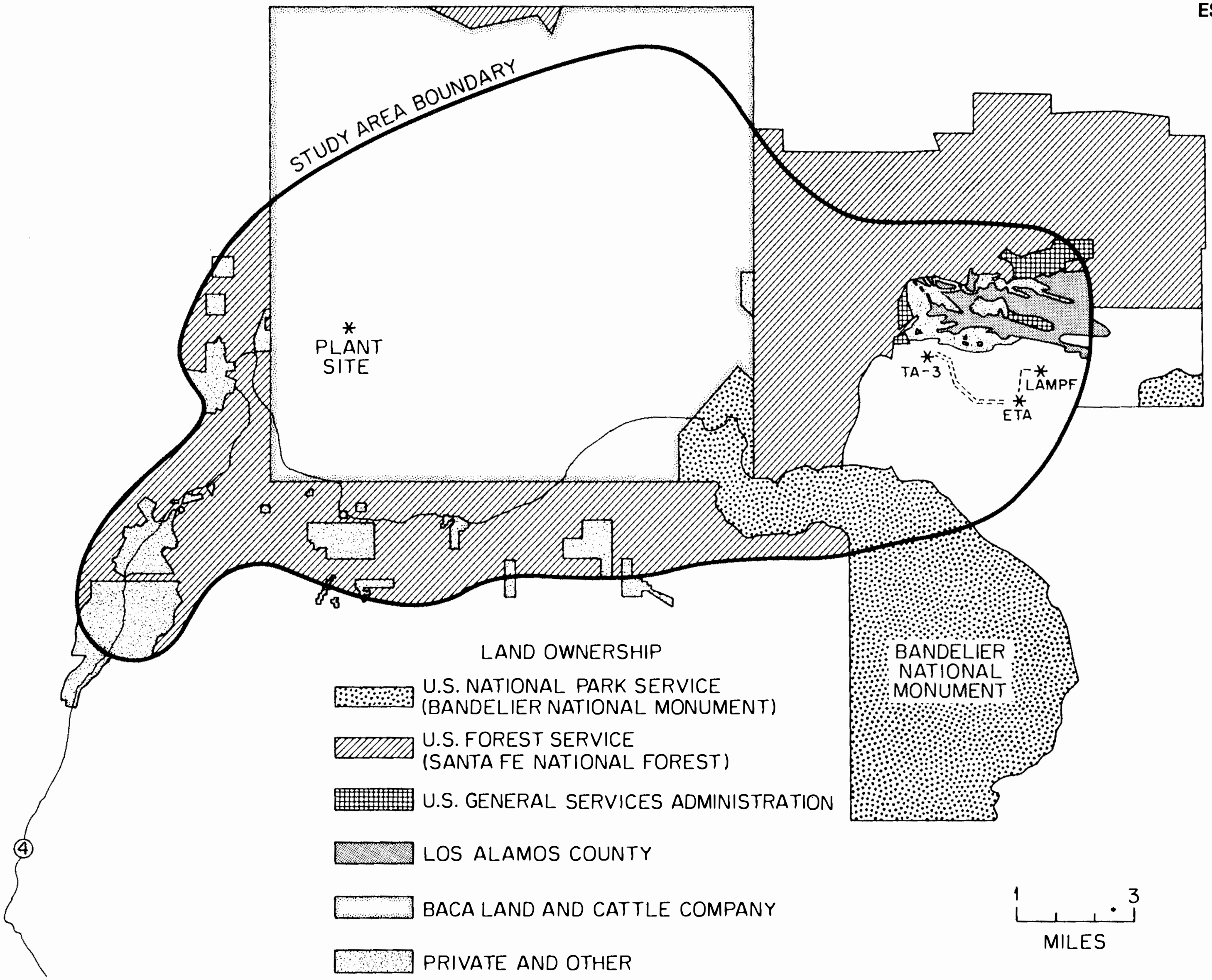

Fig. 3.1. Land ownership of area surrounding Baca Location.

3.1.1.1 Land ownership

Figure 3.1 depicts surface ownership for the general study region. There are four major categories of land ownership: Federal, Native American, Los Alamos County, and private.

Federal lands include the Santa Fe National Forest, administered by the Department of Agriculture, Forest Service; Bandelier National Monument, administered by the Department of the Interior, National Park Service; Los Alamos Scientific Laboratory (LASL), operated for the Department of Energy (DOE); and parcels of land held by the General Services Administration. Bandelier National Monument and the Santa Fe National Forest are further described in Sect. 3.1.1.2. Section 3.1.1.3 contains a brief discussion of the LASL facilities. The General Services Administration presently administers three parcels of land totaling approximately 496 ha (1225 acres) adjacent to the Los Alamos townsite. This land will eventually be released to another governmental agency or to private ownership (Wirth Associates 1979).

Native American land borders the study region to the north, east, and south. The Santa Clara Indian Reservation is adjacent to the Baca Location (Fig. 3.2). The San Ildefonso Reservation is outside the study region to the east. Three other reservations that could be affected by an unlikely southern alternative transmission route (Sect. 9.7) are not shown in Fig. 3.2. These are the Jemez, Zia, and Santa Ana Reservations, located in the vicinity of the town of San Ysidro, approximately 35 km southwest of the Baca Location.

The incorporated county of Los Alamos came into existence when the Federal Government released its jurisdiction over the area to the State in 1949. Nearly all the land owned by Los Alamos County is within the Los Alamos townsite and is situated within the steep canyons between the inhabited mesas. Most of the county land is devoted to open space (Wirth Associates 1979).

The Baca Ranch, approximately 39,790 ha (98,320 acres), comprises the major portion of the private land within the study region. It is owned by the Baca Land and Cattle Company and Dunigan Enterprises. Other private land consists of the Pajarito Ski Area, owned by the Los

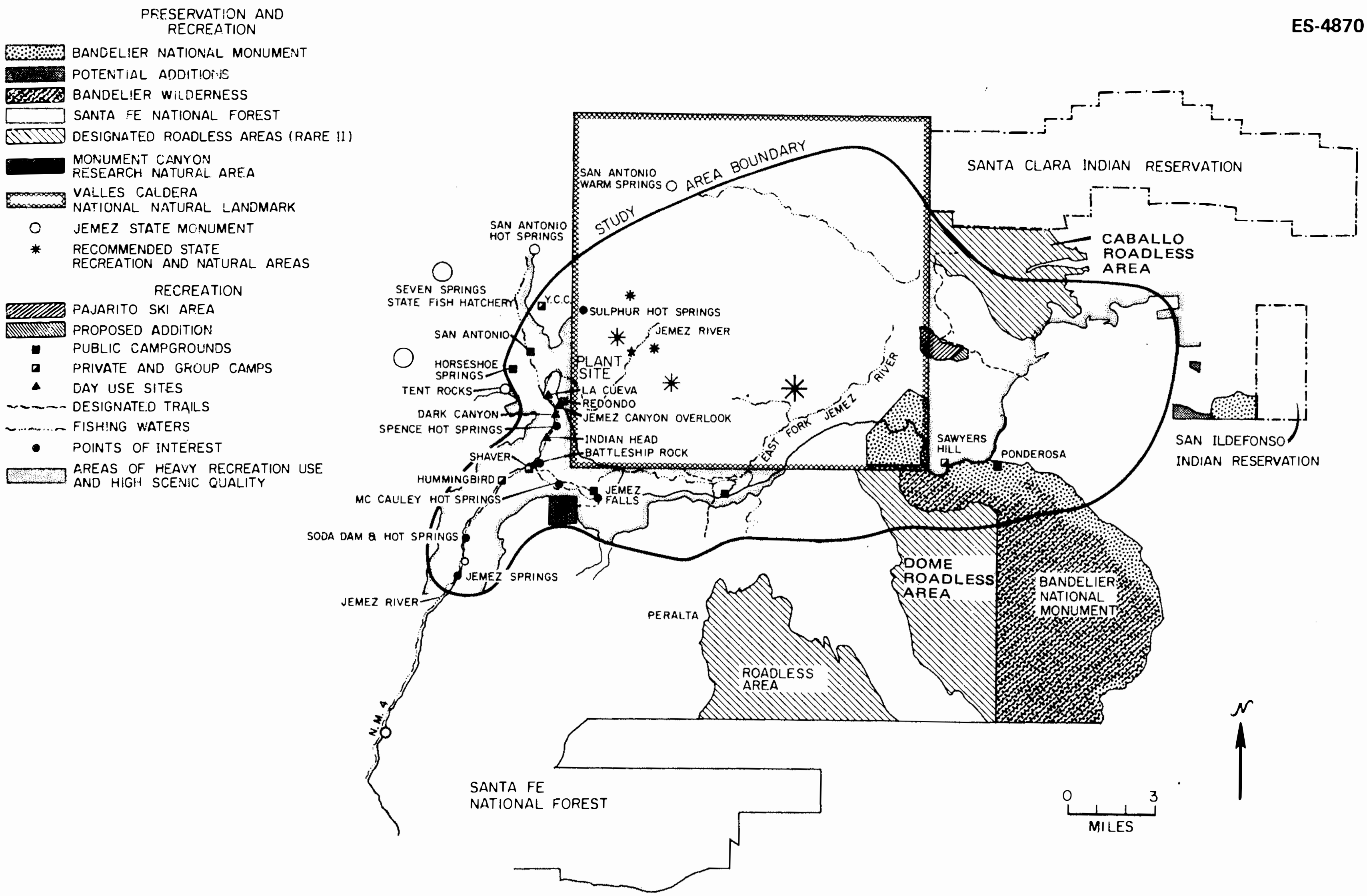

Fig. 3.2. Preservational and recreational areas surrounding Baca Location.

Alamos Ski Club, three private children's camps, and private residences within summer-home areas of the Santa Fe Forest and the Los Alamos townsite, which are further described in Sect. 3.1.1.3.

3.1.1.2 Preservational designations and recreational uses

The Jemez Mountains are highly scenic and are relatively undeveloped. They possess outstanding geologic features, wildlife values, and archaeological resources. Thus, there are a number of preservational designations and recreational use areas in the study region. Figure 3.2 depicts the preservational boundaries and recreational use areas within the study region.

Preservational designations include those areas that have been recognized for their unique or undisturbed natural environments. These areas are Bandelier National Monument and Wilderness Area; Santa Fe National Forest, its designated roadless areas, and Monument Canyon Research Natural Area; the Valles Caldera National Natural Landmark; the Jemez State Monument; and recommended state natural areas.

Bandelier National Monument and Wilderness Area. The monument is composed of two separate regions. The main section is within and to the southeast of the study area; the smaller Tsankawi section is about 10 km (6 miles) to the northeast outside the study region. Two proposed additions to the monument are located near the Tsankawi section (see Fig. 3.2). In recent years the monument has had approximately 300,000 vistors annually (Mountain West Research, 1979). Most visitor use of the monument is during spring and fall weekends and in summer. The monument was set aside mainly to preserve the outstanding prehistoric aboriginal ruins. There are over 600 ruins, including pueblos with up to 400 rooms (Wirth Associates 1979). The monument is situated in the canyon lands and mesas of the steeply dissected Pajarito Plateau, which reaches from the base of the Valles Caldera to the Rio Grande. In 1976, the great majority of this main section of the monument was designated as a wilderness area (Fig. 3.2). The Park Service is presently studying the wilderness potential of the latest addition to the monument, the upper

Frijoles Canyon (the wedge-shaped section out of the Baca Location, Fig. 3.2), which was acquired after the designation of the Bandelier Wilderness (Wirth Associates 1979). The portion of this section south of State Highway 4 (NM-4) is the most promising for wilderness (Wirth Associates 1979).

Santa Fe National Forest. The Sante Fe National Forest is composed of two divisions; most of the study region is within the Jemez Division, located west of the Rio Grande. The San Pedro Parks Wilderness is currently the only wilderness area in the Jemez division. It is located 19 km (12 miles) northwest of the study region (Fig. 3.2). Areas under consideration for wilderness as part of the Forest Service Roadless Area Review and Evaluation II (RARE II) are indicated in Fig. 3.2. Two areas, Caballo and Dome, are within the study region. The Final Environmental Statement for RARE II, released in January 1979, recommends the Caballo area for further study and recommends the southern third of the Dome area for wilderness with the remainder of Dome as nonwilderness (U.S. Forest Service 1979, Siebertson 1979). However, final determination of the status of these areas will await Presidential and congressional decisions sometime in 1979. Until a final decision is made, no development would be allowed in areas recommended for wilderness or for further study (Siebertson 1979).

Another area within the Santa Fe National Forest has been restricted from development. This is the 259-ha (640-acre) Monument Canyon Research Natural Area, which was established to protect a virgin ponderosa pine stand (U.S. Forest Service 1977).

Valles Caldera National Natural Landmark. Under the Natural Landmarks Program, currently administered by the Heritage Conservation and Recreation Service, the entire Baca Location No. 1 Land Grant was designated as a national natural landmark in August 1975 (National Park Service 1975) and appears in the April 1978 complete listing of Landmarks (U.S. Heritage Conservation and Recreation Service 1978). The Baca Location contains most, but not all, of the Valles Caldera, which is of national significance as one of the largest calderas in the world. Landmark status was also conveyed because the site has been relatively well preserved in its natural state as a result of protection afforded it by the present landholder. Although the landmark is privately owned, it can be viewed by the public from NM-4. The briefs accompanying the landmark status recommendation for the Valles Caldera/Baca Location (Fitzsimmons 1975a) describe the area as a scenic wonderland and identify geothermal development activities as the major threat to the integrity of the landmark.

State preservation designations. The Jemez State Monument, located just north of the village of Jemez Springs (Fig. 3.2), protects the ruins of the 17th century mission. State monuments are under the administration of the Museum of New Mexico. Jemez State Monument is also listed in the National Register of Historic Places (U.S. Department of Interior, 1979).

Other areas within the study region have been recommended as State natural areas. The New Mexico Heritage Program of the Natural Resources Department has been responsible for compiling an inventory of New Mexico natural areas and has also conducted a study of unique ecosystems for the U.S. Fish and Wildlife Service (USFWS). As part of the ecosystems study, all of the Baca Ranch was recommended to the USFWS as worthy of preservation. Redondo Peak and Redondo Border, located on either side of the well field in Redondo Canyon, were singled out as especially unique and valuable as prime habitat for the endangered Jemez Mountain salamander and as excellent elk habitat (New Mexico Heritage 1979). Two fumarole areas on the Baca Location, one within Redondo Canyon, the other within Alamo Canyon, have been identified by the Heritage Program as unique geologic features (New Mexico Heritage 1978). The aforementioned areas have as yet no formal designation but will probably become part of the New Mexico State natural area system, to be established by 1982 (Wirth Associates 1979).

In 1972 the State Planning Office undertook a study to identify portions of State rivers as part of the State Wild and Scenic Rivers Systems. Two classes of rivers, wild river areas and recreational river areas, were used for the purposes of the inventory. Two streams in the study area, San Antonio Creek and Jemez River (including the East Fork of the Jemez River), were classified as recreational river areas (Wirth Associates 1979). Recreational river areas are defined as natural free-flowing bodies of water that are readily accessible by road or railroad that may have some development along their shorelines, but that still possess actual or potential scenic recreational values. Management criteria for these areas specify that "public utility transmission lines, gas and water lines, etc., be placed underground. Existing rights-of-ways should be located to minimize their effect on scenic recreational and related areas" (Wirth Associates 1979).

Recreation areas. Recreational use areas within the study region include the Pajarito Ski Area, public and private campgrounds, day-use areas, and trails. The ski area adjoins the Baca Location to the east (see Fig. 3.2). There are plans to expand the ski area toward the east (Wirth Associates 1979). The locations of all campgrounds are indicated in Fig. 3.2; most are in the Santa Fe National Forest to the west and south of the Baca Location. Day-use sites are mostly picnic areas located in Santa Fe National Forest. Camp May is at the ski area. Extensive trail systems are located in the Santa Fe National Forest and in Bandelier National Monument. Forest trails west of Los Alamos receive heavy use, particularly the Camp May trail near the ski area.

Points of interest that receive significant recreational and sightseeing use are indicated in Fig. 3.2. Soda Dam, Spence, and McCauley are hot springs located on easily accessible public land. Sulfur Hot Springs is within the private Baca Ranch. Jemez Falls are on the East Fork of the Jemez River south of the project area. Battleship Rock is at the confluence of the East Fork with San Antonio Creek, where the stream becomes the Jemez River.

The Jemez Mountains receive heavy recreational use in the summer and light to medium use in the winter months. The prime recreational areas within the Jemez Mountains received an estimated 700,000 visitor-days in 1974; the number of vistor-days is steadily increasing (Wirth

Associates 1979). All the developed recreation sites occur within the canyons of major drainages or along the principal State and Forest Service roads. Probably 90-95% of the recreational use takes place at these sites and along the roads (U.S. Forest Service 1977). In the Final Environmental Statement for Geothermal Leasing in the Santa Fe National Forest, the Forest Service (1977) identified areas of heavy recreation use and high scenic quality and recommended that they be excepted from geothermal leasing. These scenic areas near the study region are identified in Fig. 3.2. They include the primary roads, recreation sites, and scenic areas discussed above.

3.1.1.3 Other existing land uses

Because of the importance of the study region as a recreation area, recreational uses are discussed separately (Sect. 3.1.1.2). Other existing land uses in the region include residential, timber harvesting, grazing, and activities on the LASL technical site. Geothermal exploration and some aspects of the LASL site are the principal industrial land uses within or near the study region. According to the U.S. Soil Conservation Service (Appendix C), there are no prime or unique farmlands in the study region.

Residential. The Los Alamos townsite is the largest residential area within the study region. The town has a population of approximately 16,500. Figure 3.3 depicts the location of the urbanized portion of the Los Alamos townsite. For the most part, the residential areas are situated along three east-west-trending mesas; the intervening canyons, owned by Los Alamos County, are devoted to open space.

Other residential areas within the study region are also depicted in Fig. 3.3. The La Cueva area and Horseshoe Springs Summer Home Area, located approximately 6.4 km (4 miles) west of the plant site, and the Vallecitos de los Indios settlement, located approximately 8 km (5 miles) south of the plant site, are primarily second-home residential areas. Second-home sites are also being sold on Thompson Ridge, Tent Rocks, Primos Hermanos, Deer Canyon, and Cerro Pelado (see Fig. 3.3). The

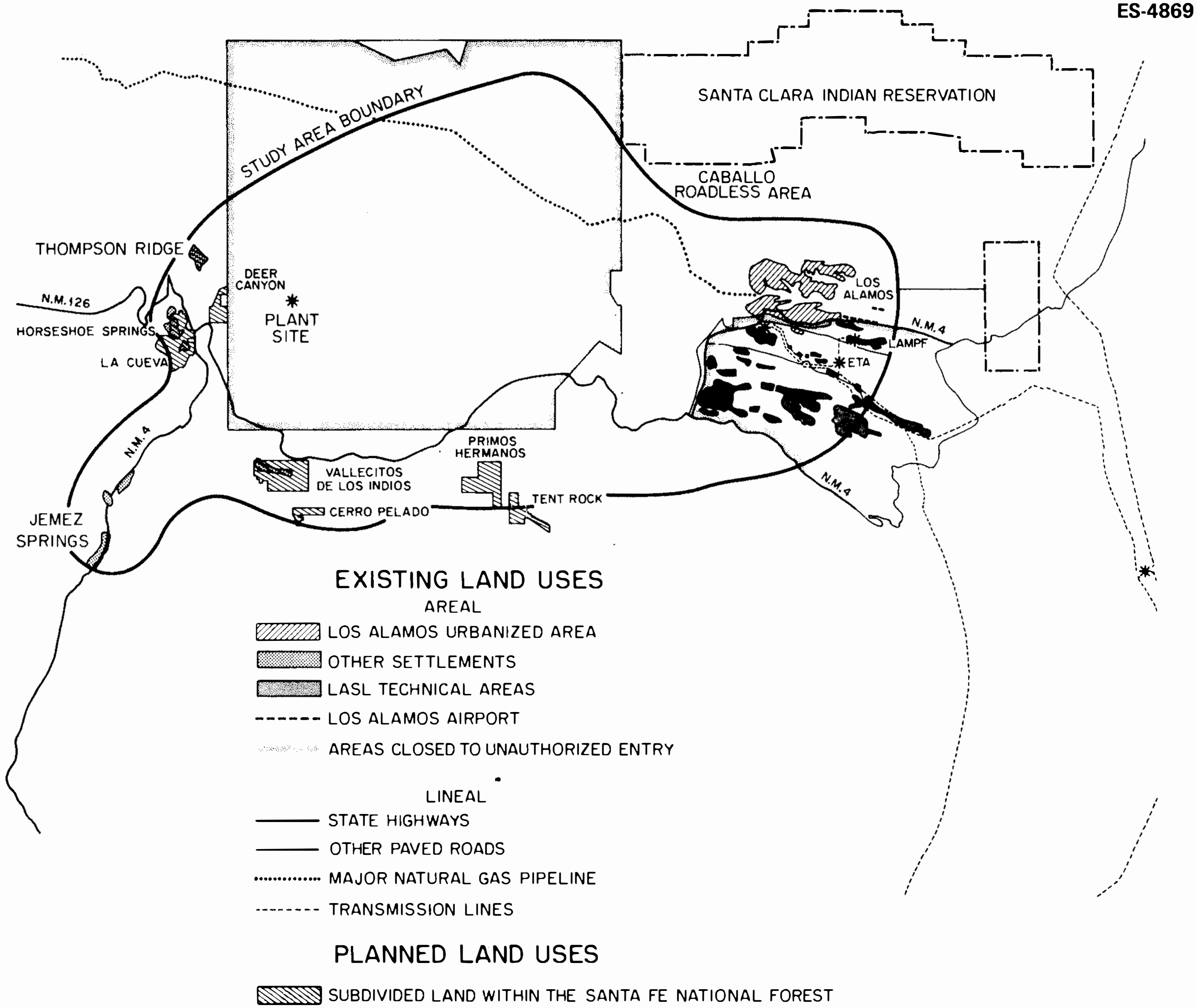

Fig. 3.3. Existing and planned residential land use and services in Baca study region.

community of Jemez Springs, located about 14.5 km (9 miles) southwest of the project site, has a population of approximately 450 year-round residents.

Travel routes. The locations of major paved roads are depicted in Fig. 3.3. Two state highways, NM-4 and NM-126, are located within the study region. NM-4 includes an alternate business loop that serves the Los Alamos townsite. The West Jemez Road (NM-4 alt.), the East Jemez Road, and the Pajarito Road are major travel routes that serve the LASL technical sites. There is a system of unpaved but improved roads that provide access to recreation areas and second-home developments within the Santa Fe National Forest. Some of these roads are indicated as "Forest roads" in Fig. 3.25, on p. 130.

Services. A 12-in. natural gas pipeline passes through the northern portion of the study region (see Fig. 3.3) The gas line is buried beneath a graveled access road. The terminus for this pipeline is the Los Alamos townsite.

All existing electrical transmission lines having a capacity over 69 kV are depicted in Fig. 3.3. All the identified transmission lines are located south of Los Alamos and within the LASL technical area. The locations of three electrical substations, TA-3, ETA, and LAMPF, are also depicted in Fig. 3.3.

The Los Alamos airport is located east of the townsite. It is a private airport, owned by the Federal Government, under the administrative jurisdiction of the DOE.

Los Alamos Scientific Laboratory site. The DOE lands that comprise the LASL reservation are closed to unauthorized entry, because of the sensitive and often secret nature of the research performed. The entire LASL reservation includes 30 technical areas and 124 principal buildings. Most of the technical areas are fenced. The use of LASL land includes building sites, test areas, waste disposal locations, roads, and utility rights-of-way. These uses account for only a small fraction of the total land area; the remainder of the land is used to provide isolation for security and safety and as reserves for future structural locations (U.S. Department of Energy 1978).

Grazing and timber harvesting. The study region is important for cattle forage production. The great majority of the Santa Fe National Forest is open to grazing, except the portion of the forest within Los Alamos County (Wirth Associates 1979). Grazing allotments within the forest are detailed in the Final Environmental Statement for Geothermal Leasing in the Santa Fe National Forest (U.S. Forest Service 1977). These grazing allotments are used primarily from May through October (Wirth Associates 1979). Additionally, the main use of the land owned by the Baca Land and Cattle Company (the Baca Ranch) is for cattle grazing. Approximately 4500 head of cattle are grazed on the property, primarily on the large *valles*, the high mountain meadows within the Valles Caldera; the grazing season is from spring to autumn (Wirth Associates 1979). The LASL reservation allows no grazing.

Timber harvesting in the region began in the early 1900s and continues to the present. There are few virgin timber stands remaining (U.S. Forest Service 1977). Commercial sawtimber species existing in the study region include ponderosa pine, Douglas fir, white fir, spruce, and aspen. Past timber harvesting practices included both clear-cutting and selective logging. Large sections of Baca Ranch were clear-cut in the recent past and are scarred with logging roads. These areas are indicated on the vegetation map (Fig. 3.19) in Sect. 3.1.5. Timbering is no longer conducted on the Baca Ranch.

Other commercial uses. There are no mineral production or major mining activities in the general vicinity of the study region. Pumice is the only product currently mined in the general region surrounding the study area. All three of the operating pumice pits are, however, outside the study region. Geothermal leasing and exploration activities are occurring in the Santa Fe National Forest, on and near the Baca Location. Geothermal resources are discussed in greater detail in Sect. 3.1.2.3.

3.1.1.4. Planned future land uses

The study region is located within portions of Sandoval and Los Alamos Counties. The incorporated county of Los Alamos adopted a comprehensive plan in 1976 (Wirth Associates 1979). Sandoval County, however, is only in the initial stages of formulating a general plan. Two other major planning efforts are under way in the study region. The master plan for the Los Alamos Scientific Laboratory is scheduled for completion sometime in mid-1980. The land management plan for the Santa Fe National Forest is also being prepared, with an expected completion date of February 1980. This final plan will be the basis of forest management practices for the ensuing ten years.

Expansion of the LASL reservation is constrained by adjacent land ownership and the topographic character of the land. Consequently, nearly all future laboratory growth is expected to be within the confines of the existing reservation. Likewise, future expansion of the Los Alamos urbanized area is restricted by topography and adjacent land ownership. Figure 3.3 depicts areas within the Santa Fe National Forest where inholdings of private land have been subdivided and are expected to be developed (second homes) in the next few years. These areas are east, south, and west of the Baca Location. The La Cueva-Horseshoe Springs and Vallecitos de los Indios settlements have considerable development in progress and are expected to expand. The Deer Canyon site is completely subdivided, the Cerro Pelado area is expected to develop in about five years, the Primos Hermanos area is only partly subdivided, and Thompson Ridge and Tent Rocks are currently being developed (Wirth Associates 1979).

Three major new roads are planned within the Los Alamos urbanized area as part of its comprehensive plan. All three are planned to serve as access routes into expanding residential areas. Only one significant change in the National Forest road system is planned within the study region. Forest Route 268 will be realigned to the east to provide improved access to NM-4 for the residents of the Tent Rock and Primos Hermanos residential areas, on the south edge of the study region. Finally, as part of the proposed project development, Union Geothermal plans to pave the access road it presently maintains from NM-4 to the well field within Redondo Canyon.

Potential public acquisition of the Valles Caldera. The Baca Location/Valles Caldera is currently being considered for possible public acquisition. The Department of Interior recently completed a study of management alternatives for the Valles Caldera which considered potential environmental and socioeconomic impacts, effects of public use, and general costs of each alternative (U.S. DOI 1979b). Five feasible management alternatives were outlined, including continued private ownership, acquisition by the State of New Mexico as part of the state park system, and Federal acquisition by either the National Park Service, the U.S. Fish and Wildlife Service, or the U.S. Forest Service. Major findings and salient details of the study are summarized below.

The Valles Caldera is one of the largest examples of a collapse subsidence volcanic caldera in the world. The catastrophic eruption that created the Valles Caldera may have been ten times greater than that at Krakatoa, and it spread ash as far away as Kansas. The Valles Caldera is significant also because of its long volcanic history, its relatively recent termination of volcanism, and the variety of volcanic materials that have been deposited. These features of the interior of the caldera are readily observable. The caldera supports eight major plant associations and a diversity of wildlife. The scenic characteristics of the caldera are unique because of its unusual topography and the juxaposition of the diverse vegetation types.

The study determined that the Baca Location/Valles Caldera qualifies as nationally significant on the basis of the following values: (1) it is an outstanding example of a geologic landform which is extremely rare in the nation, (2) it possesses high ecological and geologic diversity, (3) it possesses outstanding scenic values, (4) it is a true example of essentially unspoiled natural history, and (5) Federally designated endangered species have been observed to occur in the caldera. The Valles Caldera further meets the qualifications of a national recreation area and fits into at least four natural history themes of the National Park Service's Southern Rocky Mountains Natural Region classification.

Four major threats to the preservation of the caldera's natural resources were identified: (1) under continued private ownership, possible subdivision of the land into seasonal homesites and commercial developments; (2) possible abusive land management practices under private ownership (such as overgrazing or extensive logging); (3) geothermal development; and (4) lack of an effective wildlife management plan resulting in expansion of the resident elk herd to exceed the land's carrying capacity. Because of the present geothermal leasing agreement, it was determined that any management alternative would have to accommodate some form of geothermal development. The study concluded that continued private ownership could not assure long-term protection of the area's resources. Each of the four public management alternatives would have a measure of success in protection of the area's resources; acquisition by the National Park Service appeared to present the broadest protection for both natural and cultural resources. The study made no final recommendations as to which public management alternative should be adopted. There was no indication of when such a decision might be forthcoming. In its comments on the DEIS, the Department of the Interior recommended that, pending a decision on the issue of public ownership, the project be delayed or moved to an alternative location (see Appendix I, Comments and Responses, pp. I-14 and 15).

3.1.1.5 Well field and plant site

The well field and power plant site, which together encompass the main project area, are located within Redondo Canyon on Baca Ranch land, owned by the Baca Land and Cattle Company and Dunigan Enterprises, Inc. Figure 3.6 indicates the location of the project area and Redondo Canyon with respect to the entire Baca Location, all of which is a designated National Natural Landmark (see Sect. 3.1.1.2). Redondo Canyon is bordered by Redondo Peak and Redondo Border, both of which are recommended as unique ecosystems (see Sect. 3.1.1.2).

Geothermal development activities are currently the major use of the land within Redondo Canyon. Livestock may be grazed in the canyon during certain seasons. The private landowner also has access to the project area for his own uses. Figure 3.4 indicates the locations of existing and planned wells and access roads within the canyon connected with the geothermal activities. Figure 3.21 in Sect. 3.1.5 shows the topography of the canyon in relation to the existing wells. The nearest resident to the main project area is approximately 3 km west.

3.1.2 Geology, soils, and geothermal resources

3.1.2.1 Geology

The geology of the Jemez Mountains and the Valles Caldera is complex. Significant regional as well as local structural elements coincide within the area. Evidence of geologically recent volcanic activity is provided by the presence of numerous rhyolite domes and widespread volcaniclastic material.

3.1.2.1.1 Regional

The Valles Caldera is a central structural feature of the Jemez Mountains of north-central New Mexico. Jemez and Pajarito Plateaus bound Valles Caldera on the west and east respectively. The Jemez Mountains comprise a complex volcanic pile that occurs within the southern portion of the Rocky Mountain belt. This mountain system extends from Canada southward into Mexico, attaining a width of 80 to 160 km (50 to 100 miles) in New Mexico (West 1973). The Jemez Mountains are the locus of intersection of two regionally significant geologic features: the eastern rim of the Colorado Plateau to the west, along which various volcanic fields occur, and the Rio Grande rift to the east (Fig. 3.5) (Dondanville 1978).

The Rio Grande rift is a major north-south-trending tectonic feature of the North American continent. It is a structural trough which seismic data indicate occurs along a transition zone between typical Cordilleran crust and upper mantle and High Plains crustal structure. The rift, which is Miocene to Holocene in age, includes a central graben as well as flanking faults and uplifts. The rift zone is several hundred kilometers in width, extending from at least north-central Colorado southward into

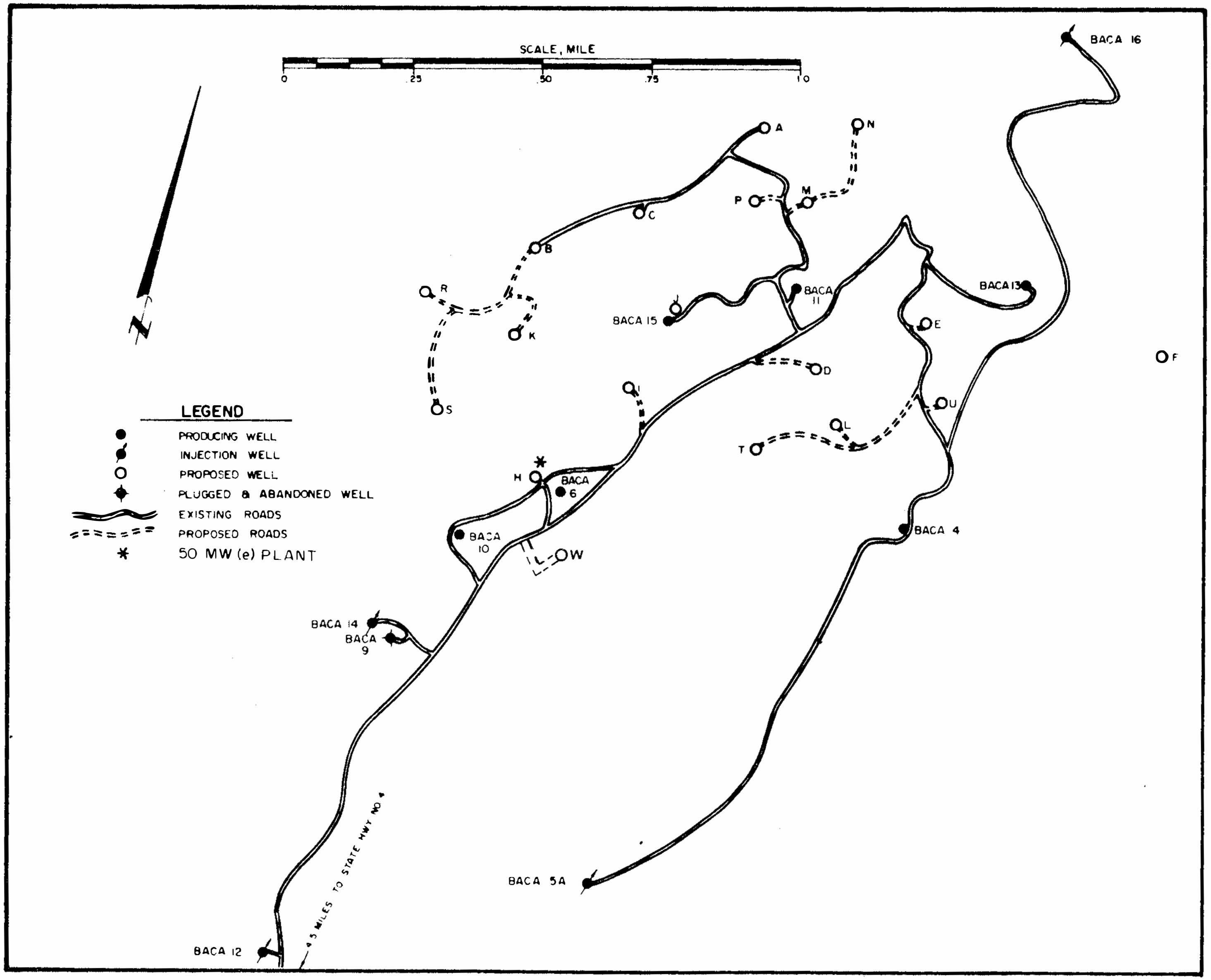

Fig. 3.4. Location of proposed and existing wells and roads within well field in Redondo Canyon. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

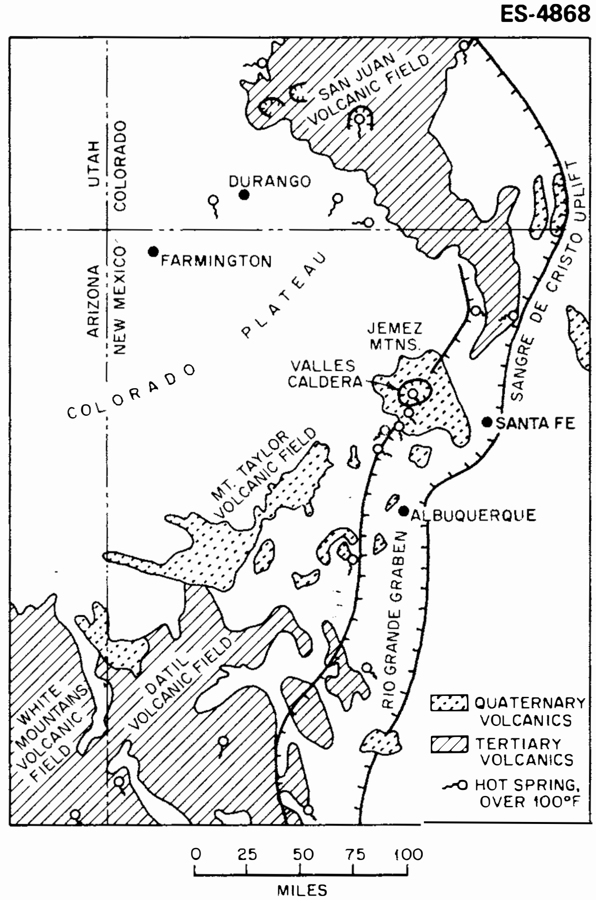

Fig. 3.5. Regional geologic setting of the Valles Caldera.

Mexico. The inner graben is from 25 to 50 km (15.5 to 31 miles) wide, extending from Leadville, Colorado, southward to Socorro, New Mexico. The graben is characterized by en echelon offsets in New Mexico, although it remains an essentially continuous feature (Cordell 1978; Ramberg, Cook, and Smithson 1978) through which the Rio Grande has flowed for more than 4 million years (Edwards, Reiter, Shearer, and Young 1978).

A positive heat-flow anomaly [more than 2.5 μcal/cm^2 sec (HFU)] is associated with the Rio Grande graben in north-central New Mexico; heat flow data (reduced to compensate for a possible crustal radiogenic heat component) indicate that the depth of the nonradiogenic source within the crust and upper mantle is no greater than 15 to 35 km (9.3 to 21.7 miles). Other geophysical data indicate partially melted material upwarped beneath the rift zone. The presence of a shallow, mobile thermal source is in agreement with the existence of recent extensive basaltic volcanism. Indeed, there is evidence of increased rates of volcanism in the area (Ramberg, Cook, and Smithson 1978; Edwards, Reiter, Shearer, and Young 1978).

3.1.2.1.2 Site-specific

The Valles Caldera is located within the northeastern portion of Sandoval County, New Mexico, approximately 97 km (60 miles) north of Albuquerque and 8 km (5 miles) west of Los Alamos. The caldera (Fig. 3.6) is a subcircular depression of volcanic origin that ranges from 19 to 24 km (12 to 15 miles) in diameter. Within the structure, numerous rhyolite domes divide the area into several valleys, the largest of which is Valle Grande. Valle Grande lies at an altitude of about 2585 m (8480 ft) and attains a width of 4.8 km (3 miles). The elevations of the depression's rim vary from 60 m (a few hundred feet) to more than 610 m (2000 ft) above the floor. Redondo Peak, which is composed of an outcropping of Bandelier Tuff, is the highest of the interior domes, reaches a maximum elevation of 3431 m (11,254 ft) above mean sea level, creating a relief of nearly 915 m (3000 ft) (Dondanville 1978; Conover, Theis, and Griggs 1963).

The geologic history of Valles Caldera is complex. No known precaldera rocks crop out within the caldera (Union Oil Co. 1978). Figure 3.7 is a geologic map of Valles Caldera. Figure 3.8 shows the geology of Redondo Creek Canyon. A Precambrian basement of microcline granite was intruded and deformed prior to deposition of Paleozoic units. The oldest Paleozoic rocks existing beneath the caldera are sedimentary rocks of the Magdalena Group. This 244+ m (800+ ft) thick sequence of limestones, shales, and arkosic sandstones was deposited in shallow seas during the Pennsylvanian (and Permian?). Subsequent to filling of the shallow depositional basins, continental sediments accumulated. These Permian deposits are the Abo Formation, composed primarily of beds of calcareous, arkosic sandstones and shales. Underneath Valles Caldera, the Abo commonly exceeds 488 m (1600 ft) in thickness. Uplift accompanying folding and faulting then occurred during the early Cenozoic

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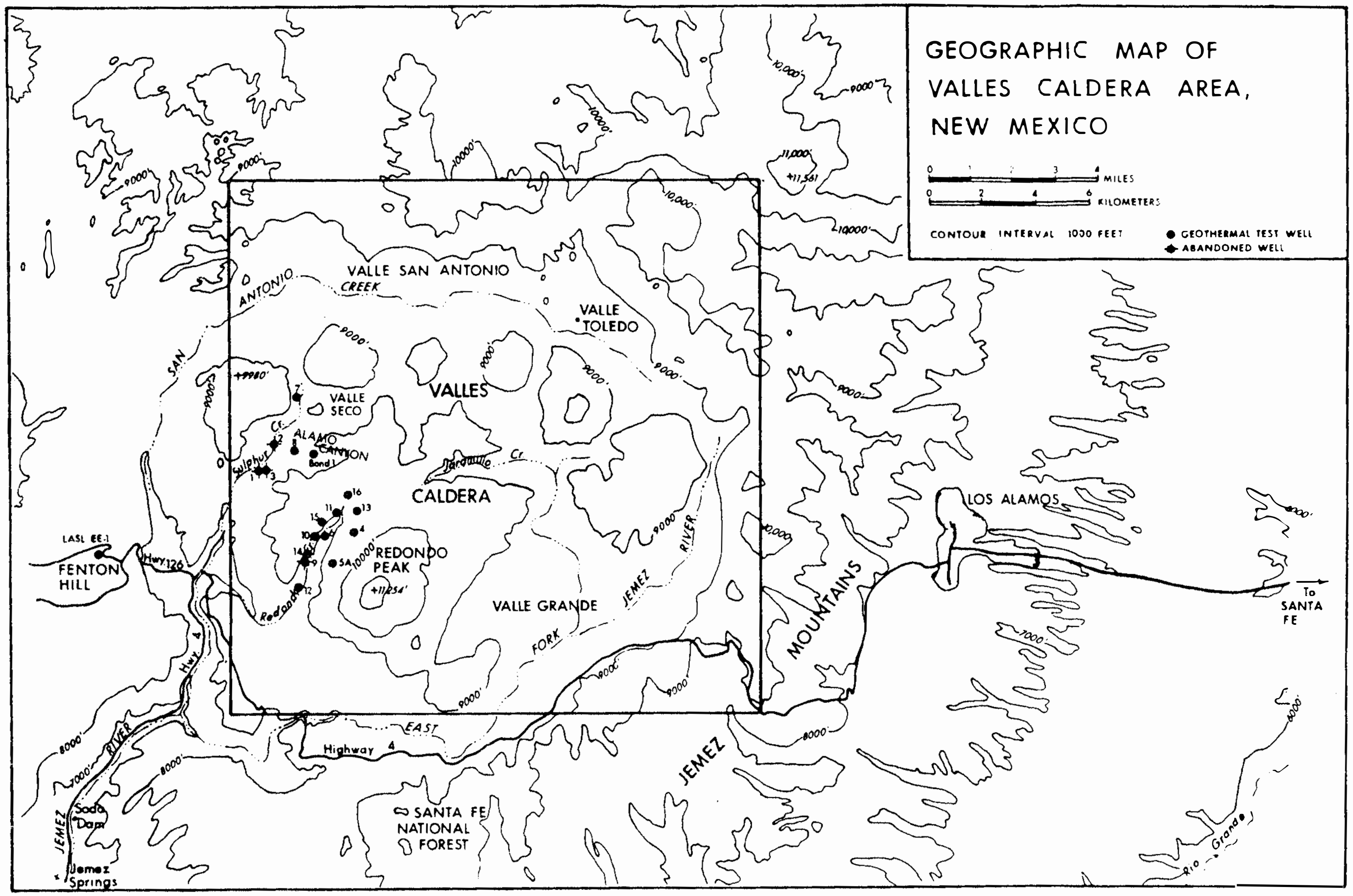

Fig. 3.6. Geographic map of Valles Caldera. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

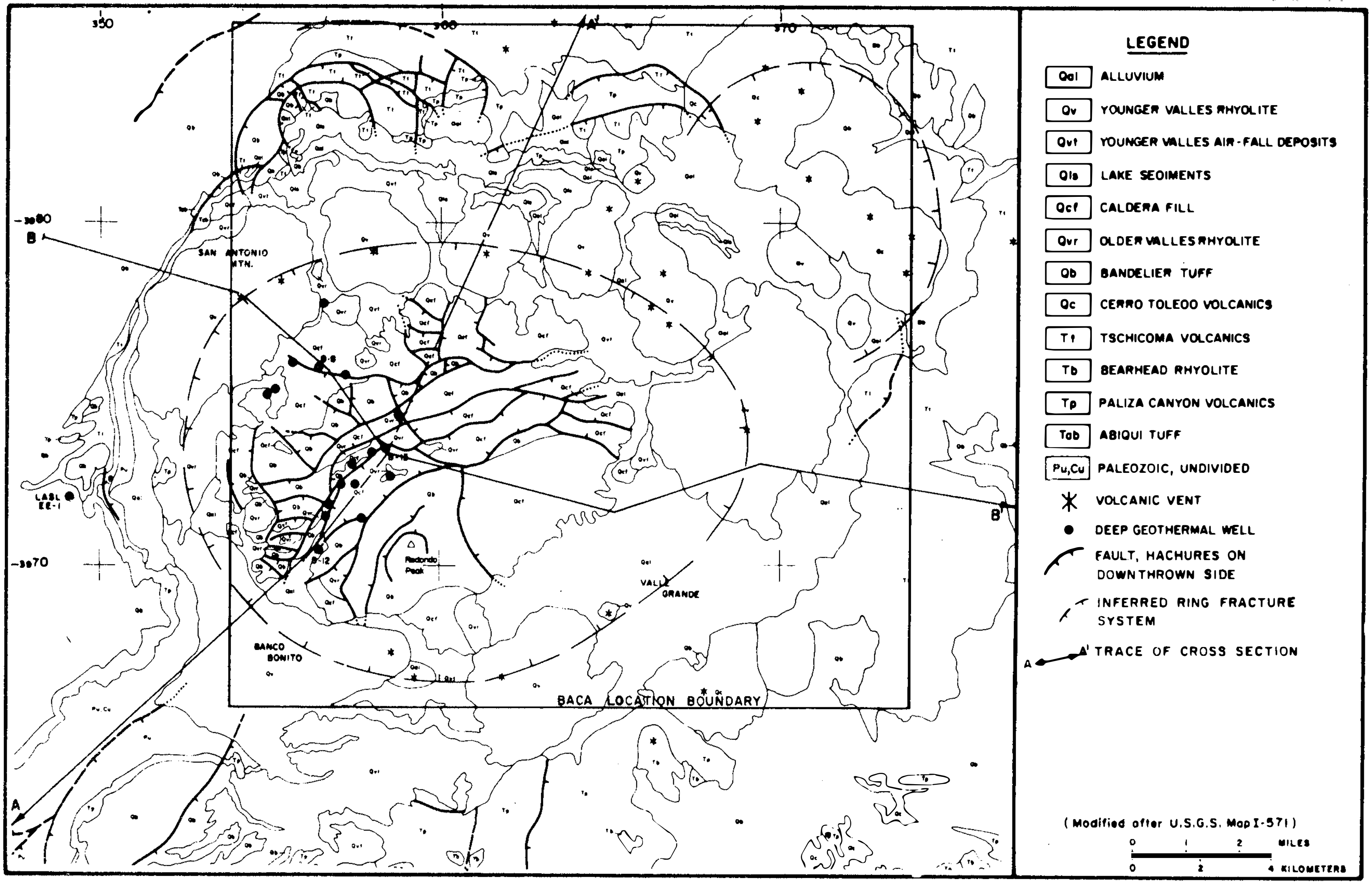

Fig. 3.7. Geologic map of Valles Caldera. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

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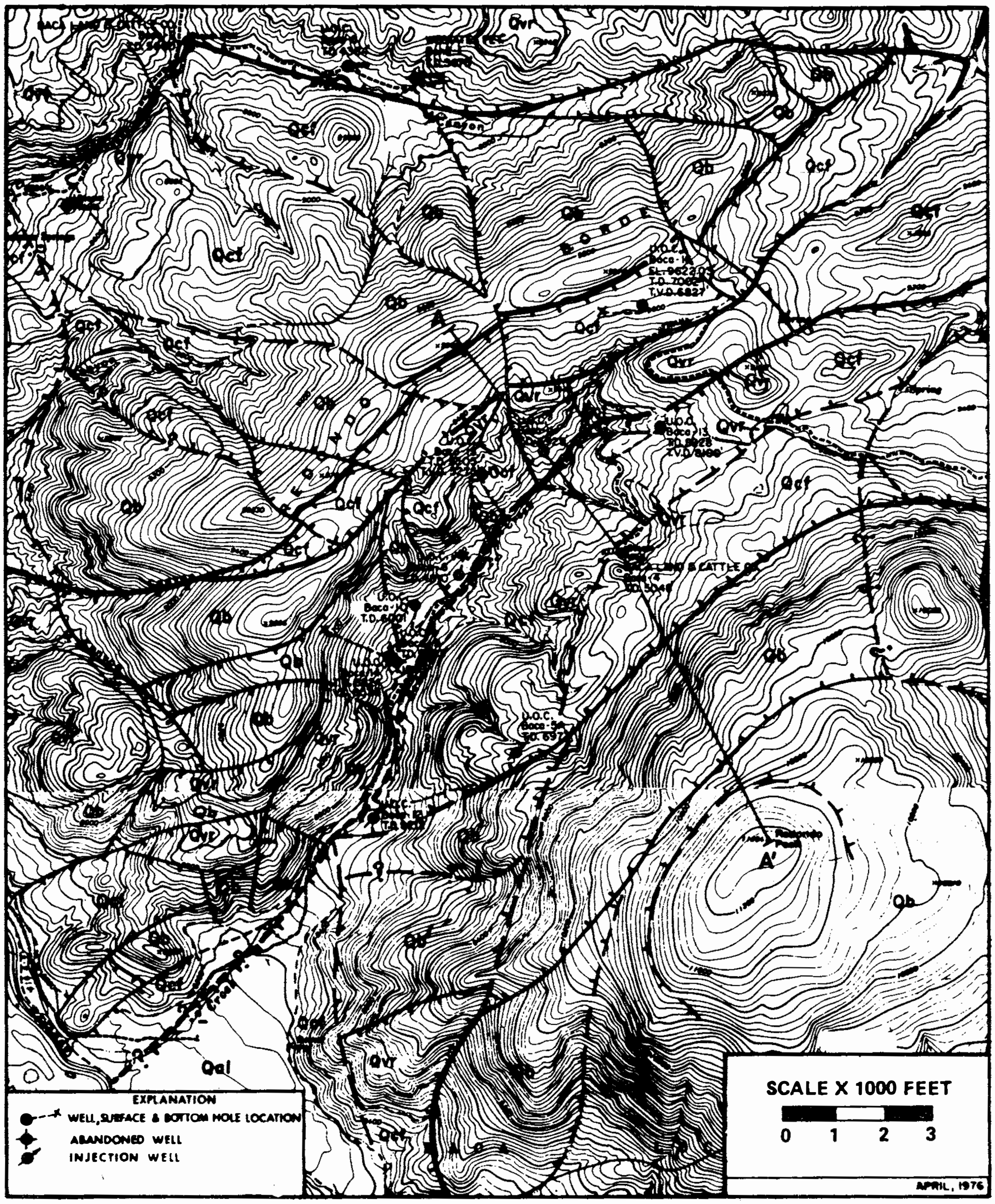

Fig. 3.8. Geologic map of Redondo Creek. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

period. Associated erosion cut down into the Abo, removing younger rocks. Tertiary sands of mid-Pliocene age are present in restricted areas, up to a thickness of 150 m (500 ft) (Union Oil Co. 1978, Griggs and Hem 1964, Purtymun 1973).

Volcanic activity began in the Valles Caldera area in latest Miocene to earliest Pliocene time. A large, shallow magma chamber was implaced, and basalt-rhyolite volcanic sequences were erupted. The interior mass of the Jemez Mountains volcanic pile is represented by the Paliza Canyon and Tschicoma Volcanics. The Paliza Canyon Volcanics are a series of andesites, dacite flows, and tuffs. They range from 91 to 732 m (300 to 2400 ft) in thickness. Overlying the Paliza Canyon are the Tschicoma Volcanics, comprised of latite and quartz latite flows and pyroxene andesite flows. Their thickness in the caldera area is quite variable, up to perhaps 914 m (3000 ft) (Union Oil Co. 1978, Dondanville 1978, Griggs and Hem 1964, Purtymun 1973).

Following a period of quiescence and erosion, two violent pyroclastic eruptions of volatile-rich material occurred 1.4 and 1.1 million years ago (mid-Pleistocene). An estimated total of 2110 km^3 (50 cubic miles) of material was erupted during each of these catastrophic events; the then-unsupported roofs of the magma chambers collapsed to form caldera structures. The first eruption-collapse formed the Toledo Caldera (on the northeast rim of Valles Caldera) and laid down the lower Bandelier Tuff. The second event created Valles Caldera and deposited the upper Bandelier Tuff. As a result of the simultaneous eruption-collapse events, the Bandelier attains a thickness of 1830 m (6000 ft) within Valles Caldera; the maximum thickness outside the depression is 305 m (1000 ft). The Bandelier Tuff consists of unconsolidated pumice deposits, pumiceous rhyolite tuff breccia, and welded rhyolite tuff (Union Oil Co. 1978, Dondanville 1978, Griggs and Hem 1964). Caldera fill consisting of landslide debris and caldera (crater) lake sediments accumulated to a depth of 610 m (2000 ft) within the depression. Uplift and doming of a rejuvenated magma chamber created the central Redondo Peak; associated faulting formed the Redondo and Jaramillo Creeks graben. Episodic eruptions of rhyolite along the caldera ring graben fractures from about 1 to 0.1 million years ago formed both domes and flows.

These rock units are represented by the Redondo Creek (older Valles Rhyolite) and Valles Rhyolites (Union Oil Co. 1978).

Valles Caldera is a collapsed structural dome superimposed on an extension of the Rocky Mountain belt between the San Juan Basin to the west and the Rio Grande rift zone to the east. The Nacimiento high-angle reverse fault (overthrust) delineates the east side of the San Juan Basin and the west boundary of the Jemez uplift (West 1973). Valles Caldera is situated along the western margin of the Rio Grande rift; marginal faults striking northeast are located near Jemez Pueblo and San Isidro, southwest of the project site (Trainer 1978). The fault zone most likely trends across the caldera, though obscured by sediments and volcanics. The Pajarito Plateau on the east side of the caldera is characterized by steeply dipping normal faults, downthrown toward the central Rio Grande graben on the east. Surficial rocks of the plateau have an eastward regional dip of 1 to 2° (Griggs and Hem 1964).

The structural elements of the Valles Caldera consist primarily of high-angle, normal faults. Concentrically arranged in a zone 3 to 5 km (2 to 3 miles) wide, they form an inner ring graben, or circular down-dropped fault block, along which rhyolite domes were episodically extruded. This is approximated in Fig. 3.7 as the inferred ring fracture system. The Redondo and Jaramillo Creeks graben is another primary structure within the area. Numerous subordinate fault structures are also present, as can be seen in the structure cross sections of Figs. 3.9 and 3.10.

The geophysical environment of the general project area is anomalous, because rocks of widely varying compositions and properties have been brought into proximity by tectonic and igneous activity. The individual geophysical anomalies (temperature, gravity, electrical, magnetic), furthermore, are coincident in the Valles Caldera–Jemez Mountains area (West 1973).

Reduced heat flow values for the Jemez Mountains are high, exceeding 3.2 $\mu cal/cm^2$ sec (heat flow units, or HFU). Within this area, radioactive decay adds only 0.38 HFU to unreduced heat flow values. The above-average heat flow is therefore primarily attributable to elevated crustal isotherms and increased thermal conductivity of the rocks (Edwards, Reiter, Shearer, and Young 1978, West 1973). High subsurface temperatures are

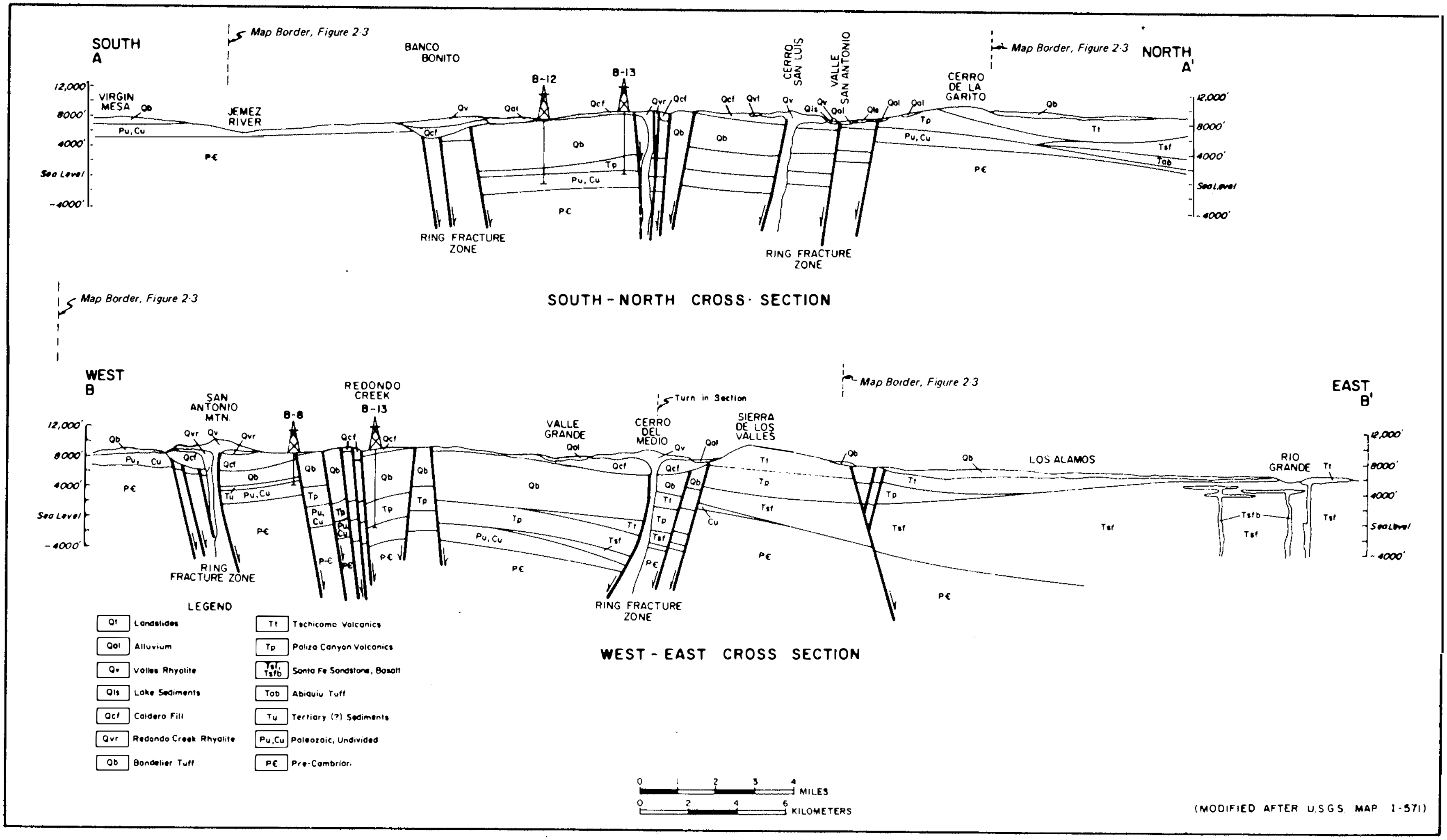

Fig. 3.9. Cross section of the Valles Caldera. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal,* 1978.

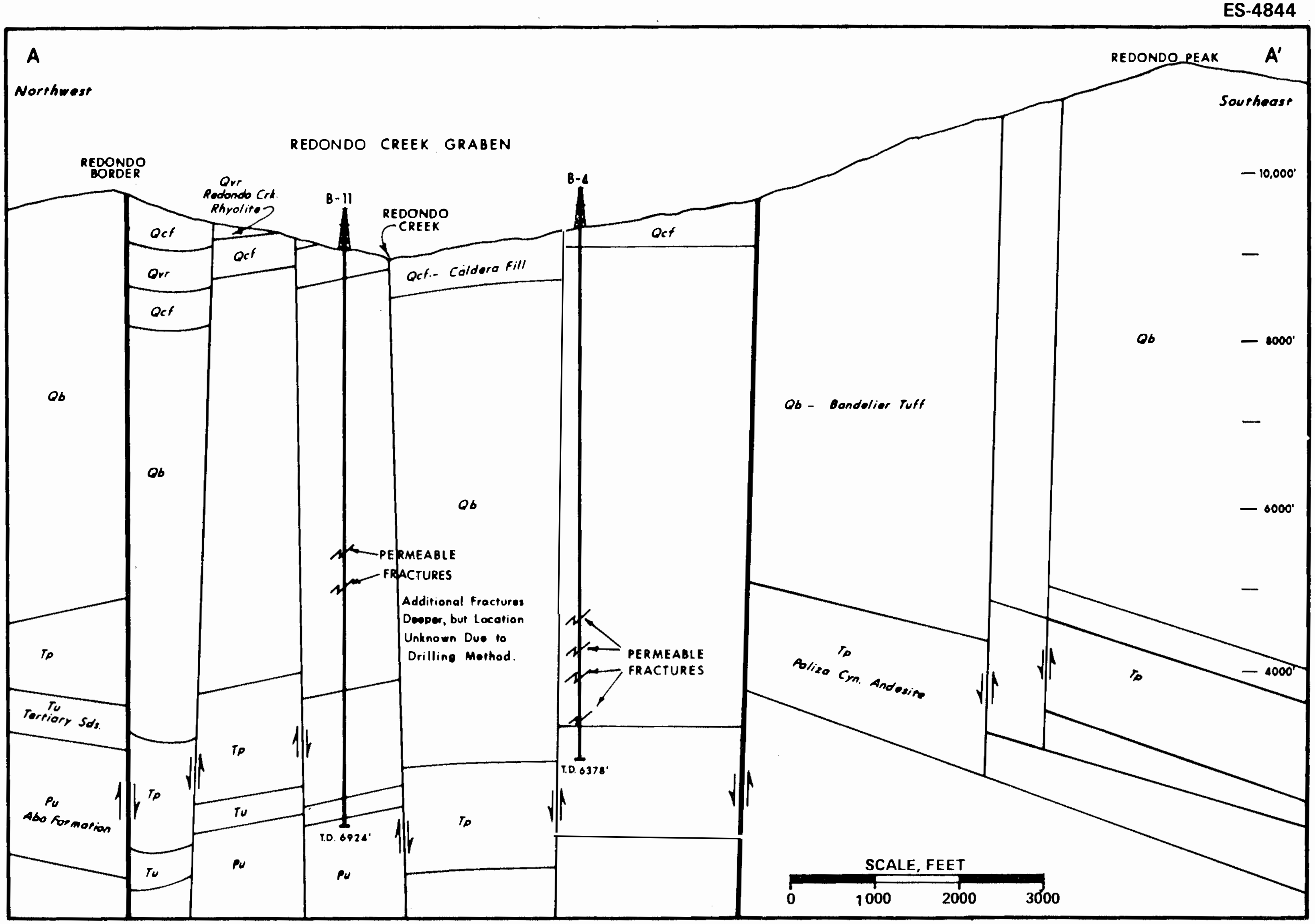

Fig. 3.10. Structure section of Redondo Creek. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

characteristic of the northwestern half of Valles Caldera; shallow temperature gradients exceed 0.08°C per meter or 80°C per km (0.15°F per foot or 792°F per mile) over 130 km^2 (50 square miles) of the caldera (Union Oil Co. 1978, Dondanville 1978).

Valles and Toledo Calderas coincide with a negative gravity anomaly of 25 milligals (Fig. 3.11). Although this is typically indicative of an intruded granitic pluton at the project site, it is ascribed primarily to the thick accumulation of relatively low-density rocks within the collapsed calderas (Dondanville 1978). Magnetic anomalies occur in an arcuate pattern in the vicinity of Valles Caldera; the magnetic data depict dike zones along the ring-fracture system (West 1973).

Electrical conductance surveys show that the eastern half of Valles Caldera contains highly resistant rocks, in contrast to the remainder of the area. The high conductance characteristic of the western half of the depression indicates the presence of a high-porosity, high-salinity, or high-temperature (or a combination of these parameters) reservoir (Union Oil Co. 1978). From information given in Sect. 3.1.3.2.1, highly saline water can be disregarded.

3.1.2.1.3 Seismicity

New Mexico has historically been an area of low to moderate seismic risk. There is a long history of faulting (presumably accompanied by earthquakes) associated with the Rio Grande rift zone and volcanic activity in the Jemez Mountains. The most active region at present is the Rio Grande valley between Santa Fe and Socorro. The fault zones closest to the project area are the Pajarito and Jemez. The Pajarito fault, which lies immediately east of Valles Caldera, is on the western border of the Rio Grande rift zone. It has had a long period of movement, although it is now believed to be inactive. The Jemez fault zone, which is also believed to be part of the Rio Grande system, lies to the southwest of Valles Caldera. It is an active fault area, although present movement is slight (Keller 1968, Rea 1977).

Los Alamos Scientific Laboratory operated a seismic net consisting of four continuous-recording seismographs for a nine-day period during

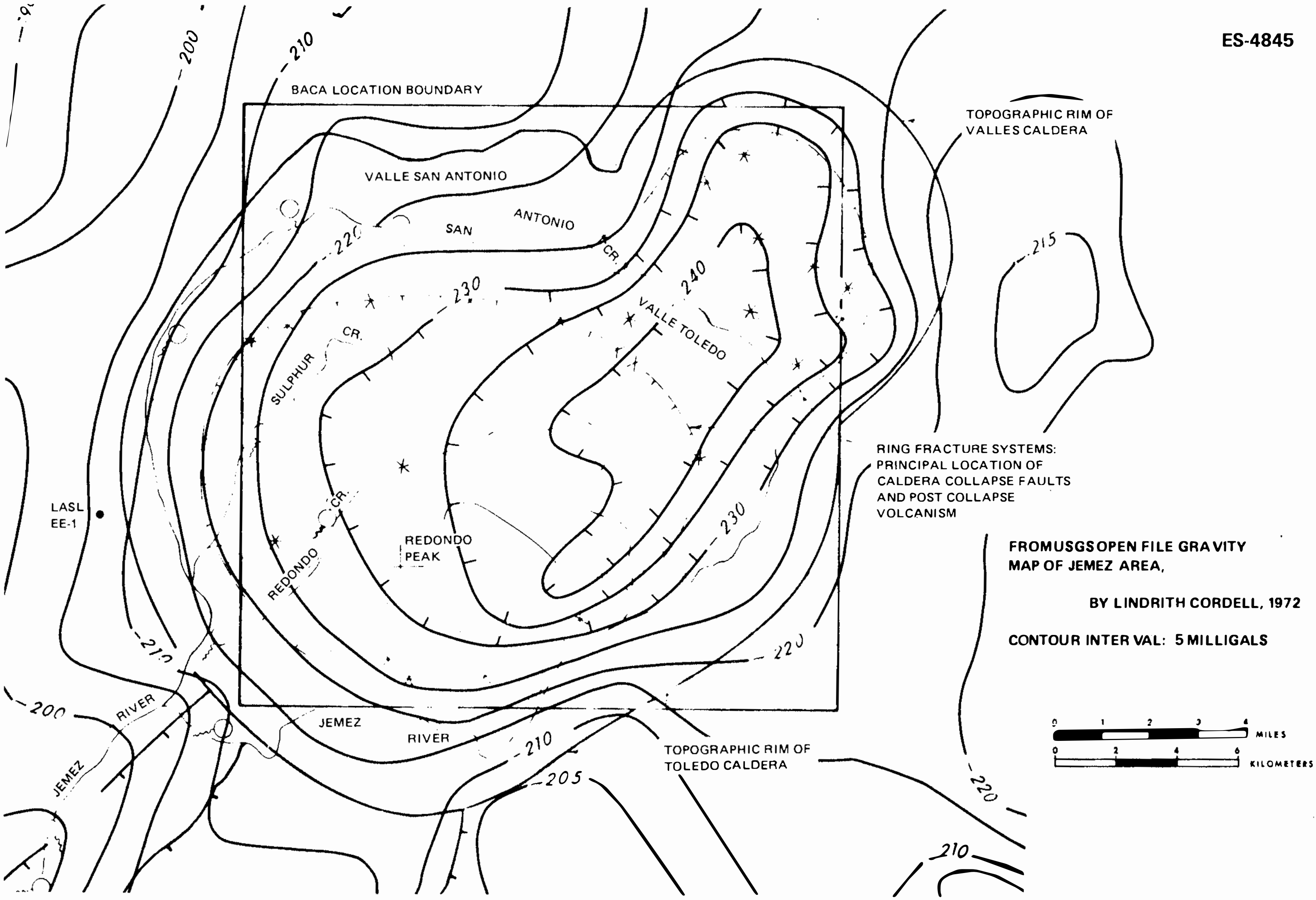

Fig. 3.11. Bouguer Gravity map of Valles Caldera. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

March and April 1967. The nearest recorded seismic events were 20 km (12.4 miles) away (Keller 1968). A regional seismic net that was functional in 1973 recorded fairly large events on September 25, 27, and 29, 1975. The main shock had a magnitude of 3.2 (see Table 3.1); its epicenter was along the Nacimiento fault zone west of Valles Caldera. As of January 1977, no other significant shocks (magnitude greater than 0.7) had been recorded near the project site (Rea 1977).

Table 3.1. Earthquake intensity and magnitude scale

Modified Mercalli intensity	Approximate equivalent shallow magnitude	Corresponding horizontal acceleration (% gravity)	Effects
I		<0.03	Not generally felt
II	2.5	0.03–0.05	Felt by few at rest
III		0.05–0.1	Felt noticeably indoors
IV	3.5	0.1–0.3	Windows rattled
V		0.3–0.5	Windows broken
VI		0.5–1	Objects upset
VII	5.5	1–3	Moderate damage
VIII	6	3–5	Very destructive to weak structures
IX		5–10	Total destruction of weak structures
X		10–30	Only best buildings survive
XI	8	30–50	Few buildings survive
XII	8.5	50–>100	Total destruction

Source: Modified after H. O. Wood and F. Neumann, "Modified Mercalli Intensity Scale of 1931," *Bull. Seismol. Soc. Am.* 21:278–283 (1931).

3.1.2.1.4 Geologic hazards

Geologic hazards of possible significance within the Baca project area include seismic activity, landslides, and renewed volcanism. Seismic hazards are ground-shaking earthquake events. Since active faulting is known to exist (Sect. 3.1.2.1.3), there is a definite possibility that felt and possibly structure-damaging earthquakes could occur. Landslides are another potential hazard. The rock units in Valles

Caldera are mostly competent. Landslides have, however, occurred in the past. Isolated rock falls and slumping of unconsolidated material can be expected to occur along the slopes of the caldera rim and the interior domes.

Renewed volcanism is a definite possibility. The Jemez Mountains area (and Valles Caldera in particular) is one in which volcanism has occurred in the geologically recent past. The volcanic activity has occurred intermittently with periods of dormancy. The caldera is quiescent at present, but it has not been determined whether the volcano is merely dormant or has become extinct (Keller 1968). It is interesting to note that the time interval between volcanic events as indicated by age-dated rhyolite domes (Fig. 3.12) is approximately 0.1 million years. The last known extrusion took place about 0.1 million years ago (Union Oil Co. 1978). No volcanism is expected to be induced by project activities.

3.1.2.2 Soils

A number of known soil mapping units are present in the well field and along the transmission line corridors. An area in which soils data are not available is within the Baca Location, from its southern boundary north to Redondo Creek. Table 3.2 gives the ratings of the known soil mapping units for different criteria with respect to their limitations for engineering purposes. Soil mapping units of the well field and transmission lines are included in Figs. 3.13, 3.14, 3.15, and 3.16. Detailed descriptions of all known area soil mapping units are provided in the references cited (Daugherty and Buchanan 1979; Nyhan et al. 1978; and U.S. Forest Service and Earth Environmental Consultants 1979).

Figure 3.13 shows the distribution of soil mapping units within the well field. The proposed power plant and most of the existing production wells are located on the Glossoboralf-Rubble land association (GH), which has a general rating of moderate to severe. The other project site soils and their general ratings are: Hesperus-Seco (HS), slight to moderate; Rock outcrop, steep (RS), severe; Glossoboralf-Argiboroll (GA), slight to moderate; and Cryoboralfs-Rubble (CT), moderate.

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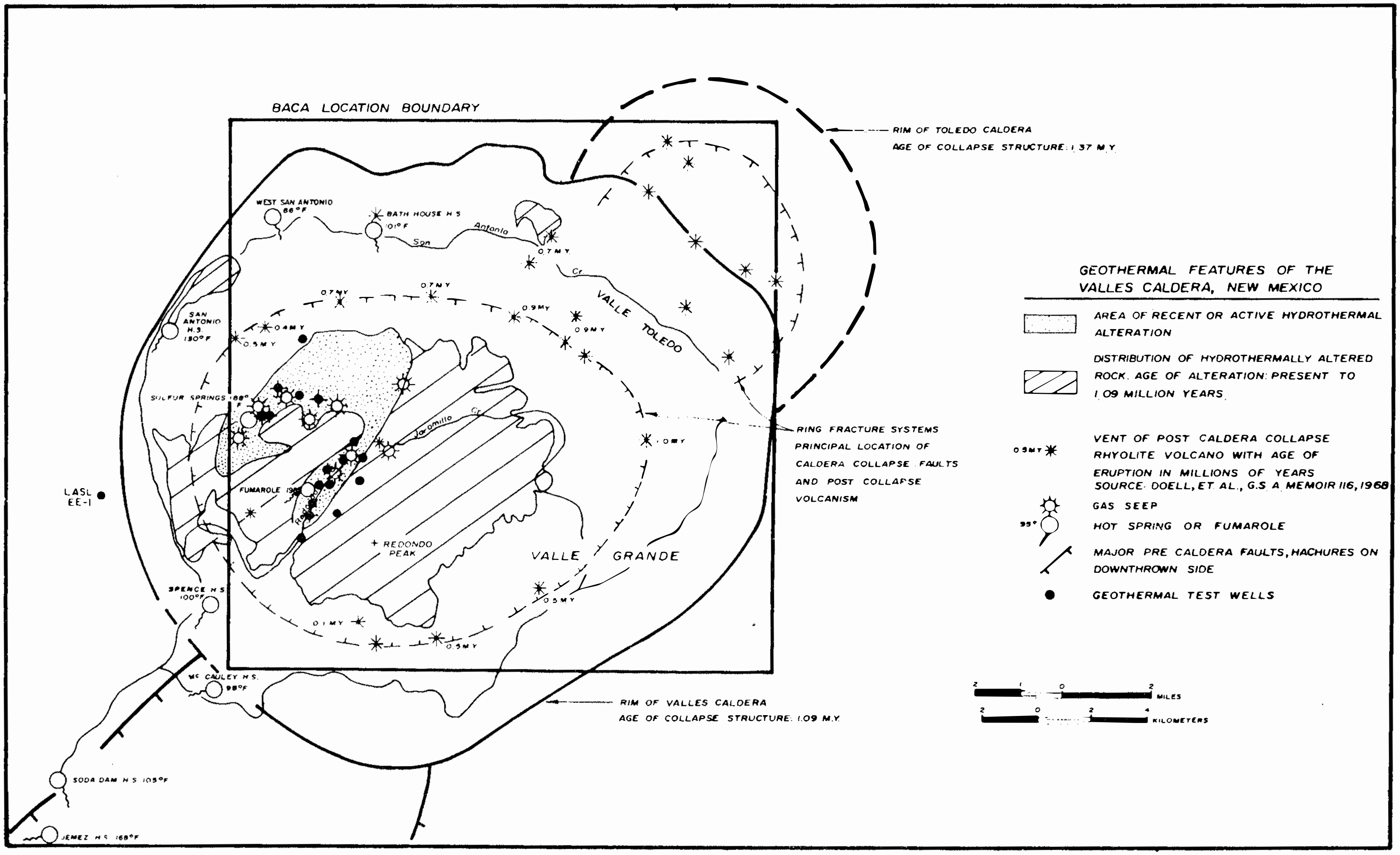

Fig. 3.12. Geothermal features of the Valles Caldera. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca Geothermal Demonstration Plant Project Proposal*, 1978.

Table 3.2. Interpretation of the soil mapping units of the Baca project site and proposed transmission line route

Map unit		Erosion	Depth	Stability (shrink-swell)	Drainage	Top-soil	Runoff	Corrosivity	General sensitivity
Aquic Haplustolls 1–13% slopes	7	Slight	Severe	Slight	Slight–Moderate		Slight–Moderate		Moderate
Argic Cryoborolls–Rock Outcrop Complex	15	Slight–Moderate	Moderate	Slight–Moderate	Moderate–Severe		Moderate–Severe		Severe
Abrigo loam	AB	Moderate	Slight	Moderate	Slight	Good	Slight	Slight	Slight–Moderate
Arriba–Copar Complex	AC	Moderate	Moderate	Moderate	Slight	Fair	Slight	Slight	Moderate
Armstead loam	AR	Moderate	Slight	Severe	Slight	Poor	Slight	Slight	Moderate–Severe
Cryoboralf–Cryochrept Assoc., 15–35% slopes	CA	Slight	Slight	Slight	Slight	Poor	Slight	Severe	Moderate
Cryoboralf Assoc., 15–35% slopes	CC	Slight	Slight	Slight	Slight	Poor	Slight	Severe	Moderate
Cuervo gravelly loam, 0–15% slopes	CL	Moderate	Moderate	Slight	Slight	Poor	Slight	Slight	Moderate
Carjo loam	CR	Moderate	Severe	Moderate	Slight	Poor	Slight	Slight	Severe
Cuervo gravelly loam, 16–40% slopes	CS	Moderate	Moderate	Slight	Slight	Poor	Moderate	Slight	Moderate
Cryoboralfs–Rubble Assoc., >35% slopes	CT	Slight	Slight	Moderate	Slight	Poor	Moderate	Moderate	Moderate
Cryoborolls 16–40% slopes	679	Severe							
Cumulic Haploborolls–Eutric Glossoboralfs Complex 0–15% slopes	14	Slight–Moderate	Moderate	Slight–Moderate	Slight–Moderate		Slight–Moderate		Moderate
Entic Dystrandept, frigid-Peralta Complex, 0–15% slopes	620		Severe						Severe
Eutric Glossoboralfs Complex, 5–10% slopes	12	Slight–Moderate	Slight	Moderate	Slight–Moderate		Slight–Moderate		Moderate
Eutric Glossoboralfs–Rock Outcrop Complex 20–45% slopes	13	Slight–Severe	Moderate	Moderate	Moderate–Severe		Moderate–Severe		Severe
Frijoles very fine Sandy loam	FR	Moderate	Slight	Slight	Slight	Poor	Slight	Slight	Slight–Moderate
Glossoboralfs–Argiboroll Assoc., 15–35% slopes	GA	Slight	Slight	Slight	Slight	Poor	Moderate	Moderate	Slight–Moderate
Glossoboralfs Assoc., 15–35% slopes	GE	Slight	Slight	Moderate	Slight	Fair	Moderate	Slight	Slight–Moderate
Glossoboralf Assoc., 0–15% slopes	GG	Slight	Slight	Moderate	Slight	Fair	Slight	Slight	Slight
Glossoboralf–Rubble Assoc., >35% slopes	GH	Slight	Moderate	Moderate	Slight	Poor	Moderate	Slight	Moderate–Severe
Glossoboralf–Rubble Land Assoc., >35% slopes	GL	Moderate	Moderate	Moderate	Slight	Poor	Moderate	Slight	Slight–Moderate
Glossoboralf–Dystrochrept–Paleboroll Assoc., 15–35% slope	GP	Moderate	Slight	Slight	Slight	Poor	Moderate	Slight	Slight–Moderate
Griegos Cobbly loam, 16–40% Slopes	GR 16 667	Moderate	Slight	Slight	Slight	Poor	Moderate	Slight	Moderate
Griegos Cobbly loam, 41–80% Slopes	GS 16 668	Severe	Slight	Slight	Slight	Poor	Moderate	Slight	Moderate–Severe

Table 3.2. (continued)

Map unit		Erosion	Depth	Stability (shrink-swell)	Drainage	Top-soil	Runoff	Corrosivity	General sensitivity
Griegos–Rock Outcrop Complex	GT	Severe	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Hackroy sandy loam	HA	Moderate	Severe	Slight	Slight	Poor	Slight	Slight	Severe
Hackroy–Rock outcrop complex	HR	Severe	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Hesperus–Seco Assoc., 3–15% slopes	HS	Slight	Slight	Moderate	Slight	Fair	Slight	Slight	Slight–Moderate
Kwage–Pelado–Rock Outcrop Complex	KW	Moderate	Slight	Slight	Slight	Fair	Moderate	Slight	Slight–Moderate
LaJara–Irim Assoc., 0–5% slopes	LI	Moderate	Slight	Moderate	Severe	Fair	Slight	Slight	Severe
Nyjack loam	NJ	Slight	Moderate	Moderate	Slight	Fair	Slight	Slight	Moderate
Pueblo stony loam	PB	Moderate	Slight	Slight	Slight	Poor	Slight	Slight	Slight–Moderate
Paleboroll–Cryoboralf Assoc., 3–15% slopes	PC	Slight	Slight	Moderate	Slight	Fair	Slight	Severe	Moderate
Pavo–Cryoboralf Assoc., >35% slopes	PE	Moderate	Slight	Moderate	Slight	Fair	Slight	Slight	Slight–Moderate
Pelado cobbly loam	PL	Moderate	Slight	Slight	Slight	Poor	Slight	Slight	Slight–Moderate
Pelado–Anesa Complex 16–40% slopes	670	Moderate	Moderate						Moderate–Severe
Pelado–Anesa Complex, 16–40% slopes	671	Moderate	Moderate						Moderate–Severe
Pelado–Anesa Complex, 41–80% slopes	672	Moderate	Moderate						Severe
Pelado–Anesa–Rock Outcrop Complex 41–120% slopes	673	Moderate	Moderate						Severe
Peralta–Anesa Complex 41–80% slopes	621	Moderate–Severe	Moderate						
Peralta–Anesa Complex 41–80% slopes	622	Moderate–Severe	Moderate						Severe
Peralta–Anesa–Rock Outcrop Complex 41–120% slopes	623	Moderate–Severe	Moderate						Severe
Quemazon–Arriba–Rock outcrop complex	QU	Moderate	Moderate	Slight	Slight	Poor	Slight	Slight	Moderate
Rubble Land–Cryoboralfs Assoc., >35% slopes	RC	Slight	Severe	Severe	Slight	Poor	Moderate	Moderate	Severe
Rock Outcrop–Pelado-Kwage complex	RD	Moderate	Moderate		Slight–Moderate		Slight–Moderate		Moderate
Rock Outcrop–Pines–Tentrock Complex	RE	Moderate	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Rock Outcrop, Frigid	RF	Moderate	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Rock Outcrop, Mesic	RM	Moderate	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Rock Outcrop–Colle–Painted Cave Complex	RO	Moderate	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Rock Outcrop, steep	RS	Severe	Severe	Slight	Slight	Poor	Moderate	Slight	Severe
Rabbit–Tsankawi Rock Outcrop Complex	RT	Moderate	Severe	Slight	Slight	Poor	Slight	Slight	Severe
Rock Outcrop–Pelado Complex, 41–120% slopes	124	Moderate							Severe

Table 3.2. (continued)

Map unit		Erosion	Depth	Stability (shrink-swell)	Drainage	Top-soil	Runoff	Corrosivity	General sensitivity
Santa Klara—Armstead Complex	SC	Moderate	Severe	Severe	Slight	Poor	Slight	Slight	Moderate—Severe
Seaby loam	SE	Moderate	Severe	Slight	Slight	Poor	Slight	Slight	Severe
Talus slopes, cryic	TA	Slight	Severe	Severe	Slight	Poor	Slight	Slight	Severe
Typic Eutroboralfs, Clayey-skeletal	TC	Moderate	Slight	Moderate	Slight	Poor	Slight	Moderate	Slight—Moderate
Turkey—Cabra Rock Outcrop Complex	TE	Moderate	Severe	Moderate	Slight	Poor	Slight	Slight	Severe
Tranquilar—Jarmillo Complex, 3—10% slopes	TJ	Slight	Slight	Severe	Moderate	Fair	Slight	Slight	Moderate—Severe
Typic Eutroboralfs, fine-loamy	TL	Moderate	Slight	Moderate	Slight	Fair	Slight	Slight	Slight—Moderate
Tocal very fine sandy loam	TO	Moderate	Severe	Moderate	Slight	Poor	Slight	Slight	Severe
Typic Ustorthents—Rock Outcrop complex	TR	Moderate	Moderate	Slight	Slight	Poor	Slight	Slight	Moderate
Typic Eutroboralf fine	TS	Moderate	Slight	Severe	Slight	Poor	Slight	Slight	Moderate—Severe
Totavi gravelly loamy sand	TV	Slight	Slight	Slight	Slight	Poor	Slight	Slight	Slight—Moderate
Typic Eutroboralf, mixed-Cabra—Rock Outcrop Complex 41—120% slopes	677	Moderate—Severe	Moderate						Severe
Very steep Rhyolite Tuff Rock Outcrop 45—120% slopes	5		Severe				Severe		Severe

3.1.2.3 Geothermal resources

Surface manifestations of a geothermal resource are present not only within Valles Caldera but also to the southwest, along the Jemez River. Within the caldera, geothermal indicators consist of recent rhyolite volcanoes, hydrothermally altered areas, hot mineral springs, and gas seeps and fumaroles. A number of rhyolite volcanoes are aligned along the ring-fracture system, some of which are geologically quite recent (Sect. 3.1.2.1.4). Active or recently active areas of hydrothermal alteration total approximately 39 km^2 (15 square miles); the most notable occurrence of hydrothermally altered ground is at Sulphur Springs, northwest of Redondo Canyon (Fig. 3.12). Sulphur Springs is also an area of sulfate-rich hot springs of low pH and strongly acid

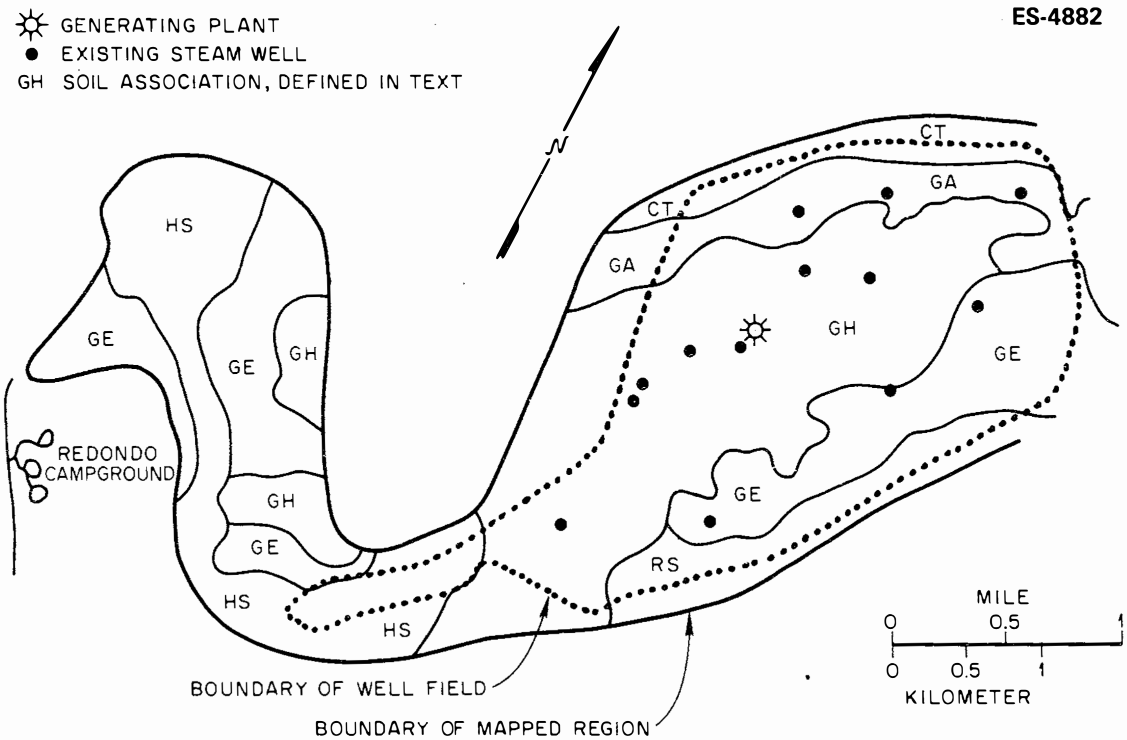

Fig. 3.13. Generalized soils map of the project site.

fumaroles. Carbon dioxide and hydrogen sulfide gas seeps occur here and have been detected elsewhere in the western portion of Valles Caldera. Hot mineral springs are found southwest of Redondo Creek and outside of the caldera, along the Jemez fault zone. The most notable of these springs, which derive a portion of their flow from geothermal fluid, are Soda Dam Springs and Jemez Springs (Union Oil Co. 1978, Dondanville 1978, Water Resources Associates 1977).

The geothermal resource of Valles Caldera consists of two systems. The major reservoir is a liquid-dominated system containing on the order of 2×10^{12} kg (4.7×10^{12} lb) of hot water, extending over an area of 100 km^2 (40 square miles). The reservoir temperature, as calculated from geothermetric data, averages 329°C (624°F). The primary production-injection zone is the lower half of the Bandelier Tuff; the pumicey basal 305 m (1000 ft) of the Bandelier is the best production zone. The upper part of the Bandelier Tuff is very densely welded and forms the

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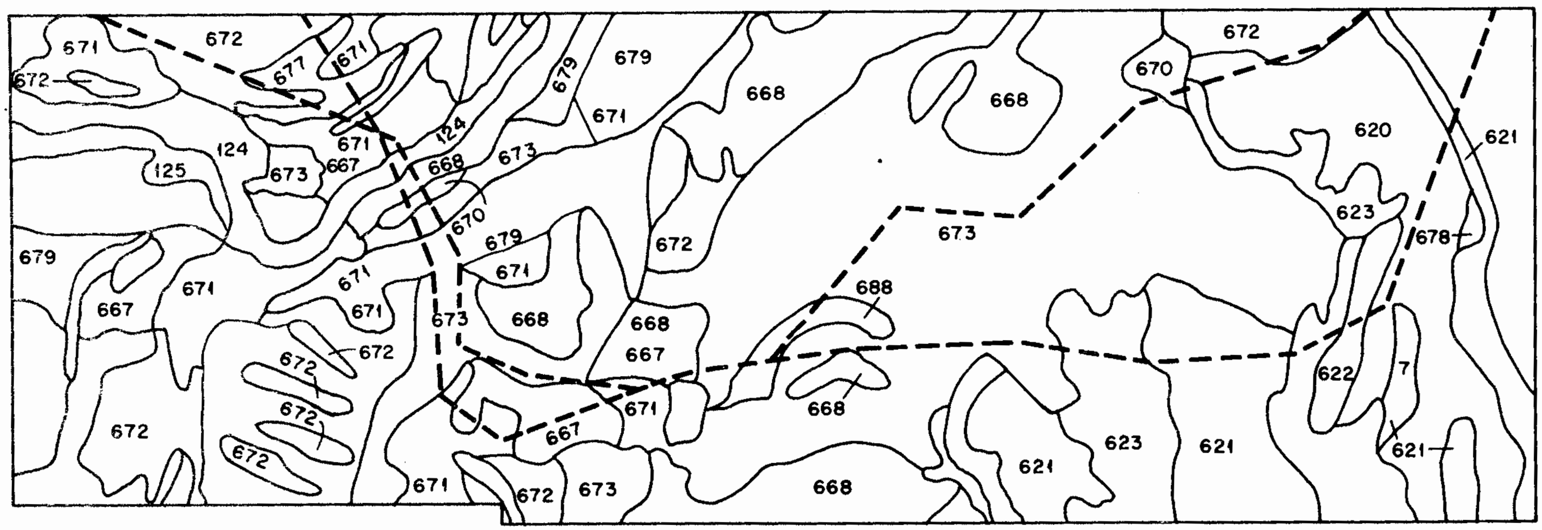


- - - - PROPOSED TRANSMISSION LINE ROUTE (S)

Fig. 3.14. Soil map of Sante Fe County, New Mexico, along the proposed transmission line route. From: *Soils Information for the Proposed Baca Geothermal Project,* Public Service Company of New Mexico, 1979.

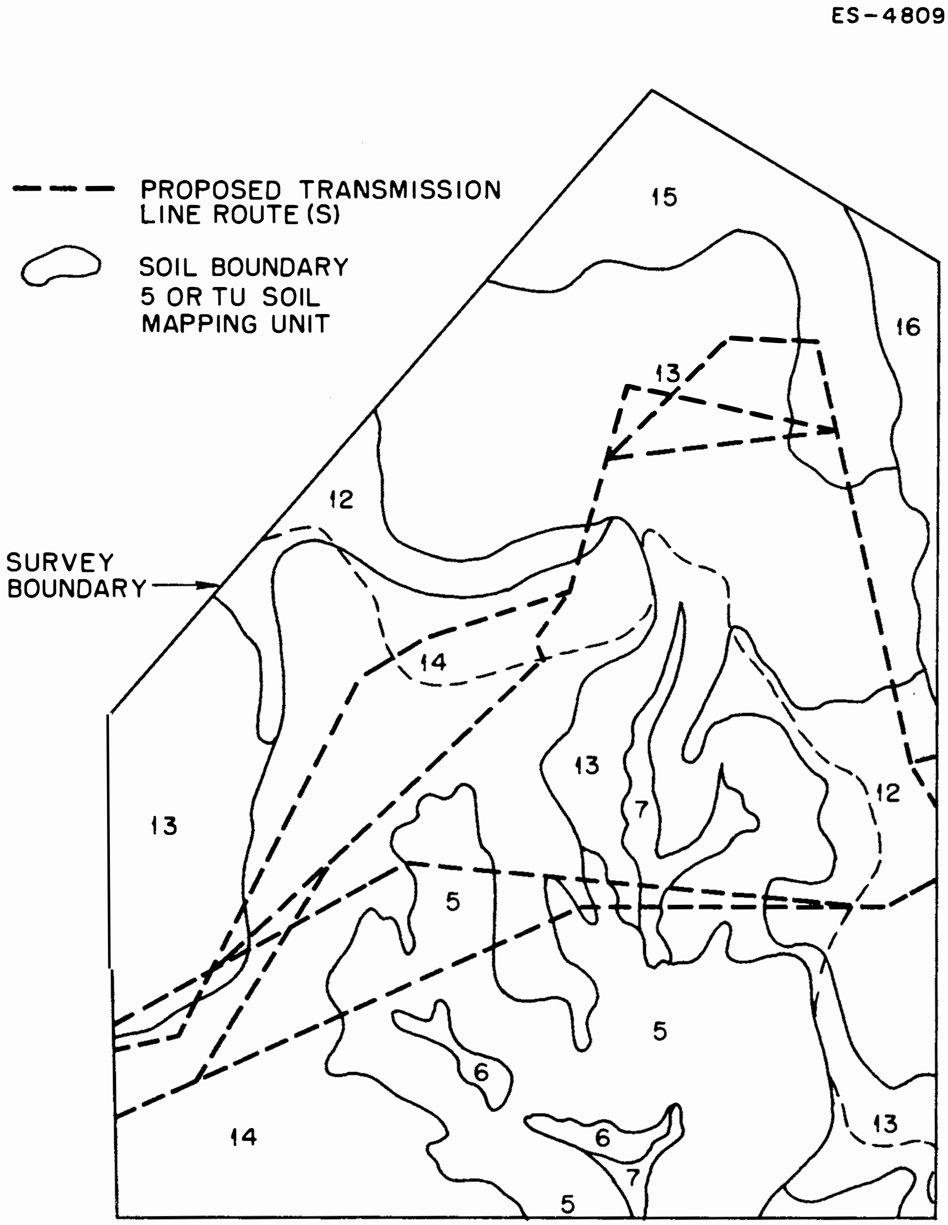


Fig. 3.15. Soils map of the portion of Bandelier National Monument with the Baca Location. From: Earth Environmental Consultants, Inc., June 1978.

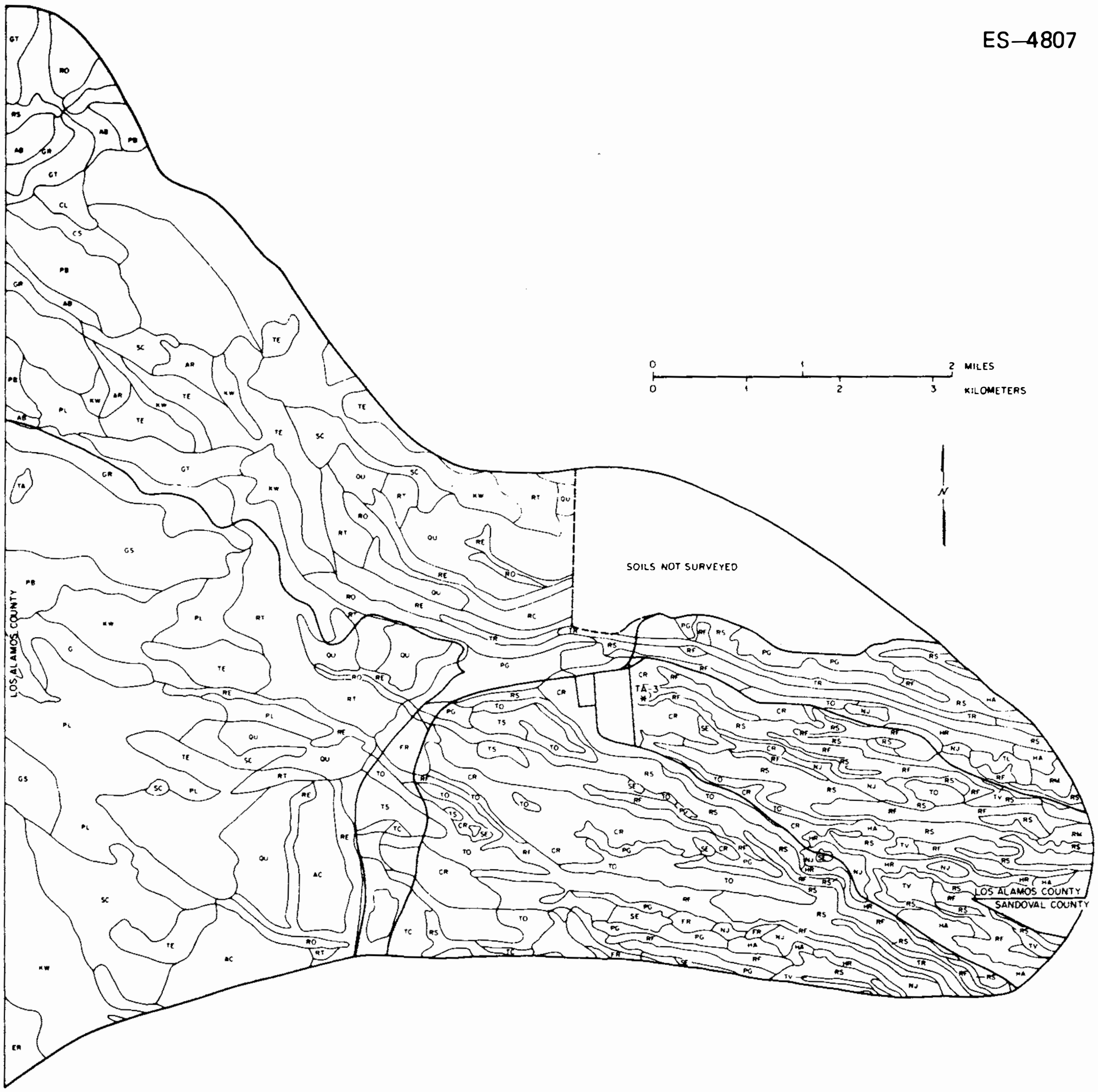


Fig. 3.16. Soils map of Los Alamos County, New Mexico, along proposed and alternate transmission line corridors. From: *Soil Survey of Los Alamos County, New Mexico*, Los Alamos Scientific Laboratory Informal Report LA-6779-MS, June 1978.

reservoir cap rock. The reservoir is not restricted to the Bandelier Tuff but extends to depth in the underlying volcanic and sedimentary rocks. The potential source of the fluids is thought to be the underlying Tertiary sands; the fluid can migrate upward to shallower zones under the Redondo Creek area, where the associated graben faults act as conduits (Union Oil Co. 1978).

The second system is a vapor-dominated system as evidenced by several of the geothermal wells, and probably overlies the liquid-dominated reservoir in Baca wells 4 and 11 (U.S. Geological Survey Circular 790 1978). Baca well 15 is completed within a vapor-dominated zone. The extent of this steam system is not known; however, it appears to trend to the northwest (Union Oil Co. 1978).

3.1.3 Hydrology and water quality

The hydrologic environment of Valles Caldera, and Redondo Canyon in particular, consists of both surface-water and groundwater systems. Several streams drain the caldera, the primary ones being San Antonio, Redondo, and Sulfur Creeks and the East Fork of the Jemez River. Shallow as well as deep (geothermal) groundwater systems are present; they discharge through numerous nonthermal and thermal springs.

3.1.3.1 Surface water

The base flows of surface waters in the Jemez Mountains are from three general sources: (1) a rapidly circulating shallow groundwater system, (2) perched aquifers in the volcanic rocks of the caldera, and (3) thermal and/or mineral springs (Purtymun et al. 1978). Each base flow source has distinct chemical characteristics and ionic composition. The base flows in the surface waters of the region are modified by runoff from precipitation, and the chemical composition of the water from a given stream site can vary widely over time as the amount of precipitation in the drainage water changes (Purtymun et al. 1978). Similarly, the chemical composition of stream water can change considerably with location because of differing relative contributions of the various base flows. Influx of highly mineralized spring water produces pronounced spatial gradients in the chemical composition of many local streams (Purtymun et al. 1974, Trainer 1978). The chemistry of surface waters draining the Jemez Mountains is consequently complex and strongly affected by precipitation. About half the annual precipitation in Redondo Canyon falls as snow during the winter months (Sect. 3.1.4.1). Most of the remainder occurs as rain from July through October. The spring months (April, May, and June) are usually dry. Precipitation during the summer months is generally localized, and it is not valid to extrapolate weather events from one area in the mountains to another (Albright et al. 1978). Estimates of average annual precipitation in Redondo Canyon range from 46 cm (18 in.) (Union Oil Company 1978, Sect. 4.1.4.1) to more than 76 cm (30 in.) (Trainer 1978).

Redondo Canyon, described in Sect. 2.2.2, is drained by Redondo Creek, a small first-order stream (Fig. 3.17). The source spring of Redondo Creek is in the interior of Redondo Canyon at an elevation of 2914 m (9560 ft). Redondo Creek runs for 9.3 km (5.8 miles) to its confluence with Sulfur Creek at an elevation of 2355 m (7730 ft). About 2.5 km (1.6 miles) of the length of Redondo Creek is adjacent to geothermal developments such as well sites, roads, etc. (Flavill and Whitford 1978). After its confluence with Sulfur Creek, the stream (now called Sulfur Creek) flows for 1.3 km (0.8 mile) to its confluence with San Antonio Creek, inside the rim of the Valles Caldera near the head of San Diego Canyon (Fig. 3.17). The stream (now called San Antonio Creek) runs 4.7 km (2.9 miles) to its confluence with the East Fork of the Jemez River near Battleship Rock. The Jemez River flows southward through San Diego Canyon and eventually joins the Rio Grande near Bernalillo, about 32 km (20 miles) north of Albuquerque, New Mexico.

The physical characteristics of Redondo Creek, recently surveyed and described by Flavill and Whitford (1978), vary considerably along its length. Redondo Creek is well mixed and is riffle along almost its entire length with very little pooling. The slope of the stream ranges from about 2 to 18%. Most sections of the stream channel are erosional; however, some areas accumulate fine bottom material. The stream bottom composition ranges from 100% rubble to fine mud. The channel banks of Redondo Creek vary from stable to eroded. Typical stream widths range

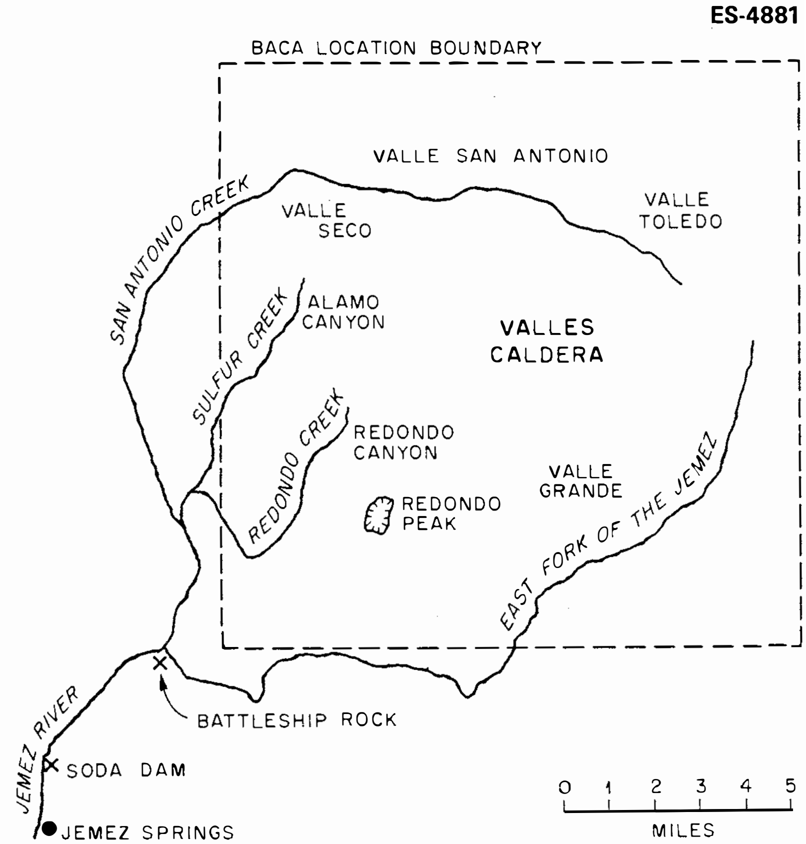


Fig. 3.17. Surface waters in the vicinity of the Baca Geothermal Project.

from about 0.6 to 1.0 m and depths from about 5 to 15 cm. The stream is shaded for about 70% of its length and runs through a diverse array of terrestrial habitats, including forest, alder thickets, and open meadow. Redondo Creek receives a small, apparently unnamed tributary approximately 6.7 km (4.2 miles) from its source spring.

Little information on the stream discharge of Redondo Creek is available. The discharge from Redondo Creek was monitored by Water Resources Associates for one year starting in November 1975. However, the data collected were incomplete and of poor quality (Table 1-2 of Appendix I of Water Resources Associates 1977). The discharge was measured for only 143 days during the year-long monitoring period, and no data were collected during January and February. The minimum discharge recorded was 4.5 liters/sec (0.16 cfs), and the maximum discharge recorded was 39.4 liters/sec (1.39 cfs). The average daily discharge for a given month ranged from 5.4 liters/sec (0.19 cfs) during October to 24.6 liters/sec (0.87 cfs) during May.

The discharge of the Jemez River at Battleship Rock, directly below the confluence of San Antonio Creek and the East Fork of the Jemez River, has been monitored since 1949 by the U.S. Geological Survey. Complete records of the discharge at this station were obtained from 1960 to 1975. The maximum discharge recorded was 70,000 liters/sec (2500 cfs) on April 21, 1958. The minimum and maximum discharges for the period 1960-1975 were 93 liters/sec (3.3 cfs) and 29,200 liters/sec (1030 cfs), respectively. The mean annual flow averaged 850 liters/sec (30 cfs) and ranged from 450 to 1850 liters/sec (16 to 65 cfs) during 1960-1975.

3.1.3.1.1 Surface-water quality

During normal flow, turbidity levels in the streams draining the Jemez Mountains are low, averaging between 5 and 10 Formazin turbidity units (FTU) (U.S. Forest Service 1977). However, after heavy storms, turbidity can increase tremendously in these streams, with peak turbidity as high as 100 FTU. The suspended load in most New Mexico streams varies considerably, ranging over 3 to 5 orders of magnitude (U.S. Geological Survey 1965).

The waters of Redondo Creek are of good chemical quality. Water from the creek was collected and analyzed during the period from 1974 to 1976 by the Union Oil Company (Table 3.3). Independent data on major chemical constituents in Redondo Creek water, published by investigators at the Los Alamos Scientific Laboratory (Purtymun et al. 1978), agree reasonably well with Union Oil Company's data and are included in Table 3.3 for comparison. Samples were collected during September 5-7, 1974, from three locations on Redondo Creek at altitudes of 2374, 2560, and 2621 m (7800, 8400, and 8600 ft) (sites BC-8, BC-9, and BC-10) (Union Oil Company 1978, Table 4-1). Only 2 of the 31 chemical constituents summarized in Table 3.3 (arsenic and suspended solids) varied appreciably

Table 3.3. Water chemistry of Redondo Creek

Samples were collected near the Baca Ranch property line at an elevation of about 7800 ft (station BC-8).

Parameter	Sept. 5–7, 1974[a]	Oct. 2, 1975[b]	Oct. 14, 1976[c]	1976[d]
pH	7.7	7.3	6.4	7.4
Concentration (mg/liter)				
Bicarbonate	48	37	32	39
Chloride	43	20	36	46
Fluoride	<0.2	0.58	<0.2	0.5
Silica	41	34	16	33
Sulfate	6	8	10.7	8.6
Total organic carbon	<1	4	3	
Total dissolved solids	218	115	144	223
Suspended solids	16	52	6	
Al	0.2	0.3	0.1	
As	0.004	0.018	<0.001	
Ba	0.013	0.09	0:2	
Be	<0.01			
B	<0.2			
Cd	<0.02			
Ca	26	14	19	22
Cr	0.008	0.003	0.004	
Co	<0.02			
Cu	<0.02			
Fe	0.8	0.6	0.4	
Pb	<0.05			
Mg	3.0	2.0	2.4	5
Mo	<0.02	0.03		
Mn	0.10	0.08	0.04	
Ni	<0.05			
Se	<0.005			
Ag	<0.03			
Na	19	11	10	18
Hg	<0.0005	0.005	<0 0005	
V	<0.2	<0.03	<0.05	
Zn	0.1	0.06	<0.05	

[a]Data from Table 4-1 of proposal (location BC-8).

[b]Data from Memo ARS 75-370M from R. N. Wheatley to K. E. Guziak, Union Oil Company, Dec. 8, 1975.

[c]Data from Memo ARS 76-424M from R. N. Wheatley to W. A. Smith, Union Oil Company, Dec. 15, 1976.

[d]Data are from W. D. Purtymun, W. H. Adams, and A. K. Stoker, "Water Quality in Vicinity of Fenton Hill Site, 1976," Los Alamos Scientific Laboratory Informal Rep. No. LA-7307-MS, Los Alamos, N.M. (1978), and are averages for samples collected Apr. 27, Aug. 8, and Nov. 19, 1976.

among the three sites; therefore, data from the single station BC-8 are probably representative of the entire Redondo Creek system at the time of each sampling. The range of pH values reported for Redondo Creek is 6.4-7.7; however, the pH is probably between 7.0 and 7.5 at most times. The water in Redondo Creek is soft. During mid-August of 1978, hardness ranged from about 30 mg/liter (as $CaCO_3$) at the source spring to about 35 mg/liter (as $CaCO_3$) above the confluence of Redondo Creek with Sulfur Creek (Flavill and Whitford 1978). Purtymun et al. (1978) reported total hardness ranging from 72 to 80 mg/liter (as $CaCO_3$) in Redondo Creek water during 1976. Alkalinity and hardness of Redondo Creek water result primarily from bicarbonate (Flavill and Whitford 1978). Because the stream is well mixed, the dissolved oxygen content of the water is usually near saturation. The concentrations of trace elements in Redondo Creek water are generally low (Table 3.3). Levels of fluoride and sulfate are low relative to the concentrations in many nearby surface waters (Griggs 1964, Purtymun et al. 1974, Trainer 1978). The chemical composition of Redondo Creek water can be expected to vary from year to year with the differing hydrologic inputs of precipitation runoff in the base flow of the stream (Pettitt 1976).

Sulfur Creek receives highly mineralized, acidic water from thermal springs in Alamo Canyon. The principal ions in Sulfur Creek water are calcium and sulfate (Purtymun et al. 1978). The water quality in Sulfur Creek improves downstream from the thermal spring area as a result of influx of groundwater and runoff from precipitation. Downstream concentrations of dissolved constituents in Sulfur Creek water are substantially reduced (generally by more than 50%) after its confluence with Redondo Creek (Purtymun et al. 1978). Water quality data collected by the U.S. Forest Service on the combined flows of Sulfur and Redondo Creeks are shown in Table 3.4. Data collected independently by Purtymun et al. (1978) agree well with the U.S. Forest Service data and are included in Table 3.4 for comparison.

San Antonio Creek drains the western and northern parts of the Valles Caldera (Fig. 3.17). The principal ions in the base flows of San Antonio Creek are calcium and bicarbonate (Purtymun et al. 1974). There is

Table 3.4. Average water quality data for the combined flows of Sulfur and Redondo Creeks (Sulfur Creek)

Range is given in parentheses under each mean. A dash indicates that data were not given

Parameter	Mean/(range)	
	U.S. Forest Service data[a]	Purtymun et al. (1978) data[b]
Discharge (cfs)	1.9 (1.1–4.1)	
Temperature (°C)	9 (0–23)	5 (0–11)
pH	6.1 (4.6–8.0)	6.2 (4.3–7.5)
Concentration (mg/liter)		
Bicarbonate		9 (4–14)
Chloride	17 (0–70)	27 (16–33)
Fluoride	0.3 (0–0.5)	0.4 (0.3–0.4)
Silica		37 (33–39)
Sulfate	142 (40–265)	133 (102–156)
Total dissolved solids	149 (0–330)	221 (194–258)
Total hardness (as $CaCO_3$)	102 (60–190)	156 (125–172)
Total alkalinity (as $CaCO_3$)	13 (0–35)	
Ca		46 (36–54)
Mg		10 (9–12)
Na		20 (15–24)

[a]Published in W. D. Purtymun, F. G. West, and W. H. Adams, "Preliminary Study of the Quality of Water in the Drainage Area of the Jemez River and Rio Guadalupe," Los Alamos Scientific Laboratory Informal Rep. No. LA-5595-MS, Los Alamos, N.M. (1974).

[b]W. D. Purtymun, W. H. Adams, and A. K. Stoker, "Water Quality in Vicinity of Fenton Hill Site, 1976," Los Alamos Scientific Laboratory Informal Rep. No. LA-7307-MS, Los Alamos, N.M. (1978). Data for samples collected Apr. 27, Aug. 8, and Nov. 19, 1976.

very little difference in the concentrations of most chemical constituents in San Antonio Creek water between points above and below its confluence with Sulfur Creek (Purtymun et al. 1974: Table 1). Water temperatures in San Antonio Creek are often above 20°C (68°F) during the summer, and the maximum temperature reported is 24°C (75.2°F) (U.S. Forest Service data from Table 3 in Purtymun et al. 1974). The pH values reported for San Antonio Creek range from 7.3 (Flavill and Whitford 1978) to 8.8 (Purtymun et al. 1974). The total hardness and alkalinity of San Antonio Creek water are primarily a result of bicarbonate; these average about 50 and 60 mg/liter (as $CaCO_3$), respectively. Fluoride concentrations are higher in San Antonio Creek than in either Redondo or Sulfur Creek and average about 1.3 mg/liter (Purtymun et al. 1974). The discharge of San Antonio Creek, measured on 11 occasions by the U.S. Forest Service (Purtymun et al. 1974: Table 3), ranged from about 225-4250 liters/sec (8 to 150 cfs) and averaged about 850 liters/sec (30 cfs).

The concentrations of many chemical parameters in Jemez River water (e.g., bicarbonate, chloride, sulfur, arsenic, boron, iron, lithium, and sodium) vary substantially with location, primarily because of changes in the base flow caused by the influx of highly mineralized spring water (Trainer 1978). Data on the chemical composition of Jemez River water at Battleship Rock are summarized in Table 3.5. A soda dam occurs on the Jemez River approximately 6.44 km (4 river miles) downstream from Battleship Rock. The water in both the Jemez River and San Antonio Creek is of sufficient quality to support healthy resident populations of brown trout (Sect. 3.1.5.2).

3.1.3.1.2 Surface water use

Because most of Redondo Creek is located on private land, there is essentially no use of Redondo Creek by the public (Flavill and Whitford 1978). However, downstream areas such as San Antonio Creek and the Jemez River are heavily used by the public for recreation, including trout fishing, bathing, and camping (Moody 1979). Many of the highly mineralized spring waters in the area are also used by the public for

Table 3.5. Water chemistry of the Jemez River at Battleship Rock, immediately below the confluence of San Antonio Creek and the east fork of the Jemez River

Parameter	Nov. 14, 1974[a]	1976[b]
pH		7.7
Concentration (mg/liter)		
Bicarbonate	71	64
Chloride	6	7
Fluoride	0.9	0.6
Silica	50	48
Sulfate	13	9.4
Total dissolved solids	133	160
Total hardness (as $CaCO_3$)	50	54
As	0.006	
B	0.04	
Br	0.0001	
Cd	0.001	
Ca	15	15
Cr	<0.001	
Fe	0.06	
Pb	0.004	
Li	0.08	
Mg	3	4
Mn	<0.001	
Se	<0.001	
Ag	<0.001	
Na	17	16
Hg	<0.0001	
Zn	<0.01	

[a] F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geol. Survey Water Resources Investigation 77-131 (1978). Data from Table 6.

[b] W. D. Purtymun, W. H. Adams, and A. K. Stoker, "Water Quality in Vicinity of Fenton Hill Site, 1976," Los Alamos Scientific Laboratory Informal Rep. No. LA-7307-MS, Los Alamos, N.M. (1978). Data are averages for samples collected Apr. 27, Aug. 4, and Nov. 19, 1976.

bathing. Additional downstream users are various Native American Pueblos; uses include bathing, irrigation, and medication.

All local Department of Fish and Game and university personnel who were contacted emphasized the importance of San Antonio Creek and the Jemez River as a sport fishery. These streams constitute a major portion of the fishable surface waters within a one-day (round trip) excursion from Albuquerque, Santa Fe, and Los Alamos. The New Mexico Department of Fish and Game has collected statistics on angler use and harvest in these streams (Patterson 1977); these are summarized in Table 3.6. The fish harvest consists mainly of rainbow and brown trout (Sect. 3.1.5.2). The Jemez River system, including San Antonio Creek and the East Fork of the Jemez River, is located in New Mexico Department of Fish and Game Management Unit 7. Only 3 of the 35 management units in the State exceed this unit in angler-days and harvest (Patterson 1977). In addition to its recreational and aesthetic values, the fishery of the combined Jemez River system has an annual economic worth of over a million dollars (Table 3.6).

Table 3.6. Statistics on fishing effort, harvest, and economic values of the Jemez River fishery during the 1975–1976 license year

Location	Angler days[a]	Trout harvest[a,b] (number)	Economic value[c] (dollars/year)
San Antonio Creek	4,671	14,886	$126,000
East fork of the Jemez River	5,871	18,292	$159,000
Jemez River	27,884	77,715	$753,000
Management Unit 7	110,213	270,906	$2,976,000

[a]Estimates from R. R. Patterson, "Postal Survey to Determine Angler Use and Harvest," New Mexico Dept. of Fish and Game, Santa Fe (1977).

[b]Species harvest is probably close to the statewide ratio of six rainbow trout to one brown trout (personal communication, T. M. Moody, New Mexico Dept. of Fish and Game).

[c]Based on a value of $27 per resident angler day (personal communication, R. R. Patterson, New Mexico Dept. of Fish and Game), revised from T. O. Kirkpatrick, "The Economic and Social Values of Hunting and Fishing in New Mexico," Bureau of Business Res., Univ. New Mexico, Albuquerque (1965).

The flows of San Antonio Creek and the Jemez River are fully appropriated. Indians living on the Jemez River are among those having rights to surface water (Table 3.7). Their major use of surface water is irrigation of farmlands. Surface water is used in Indian religious practices (Sect. 3.1.10). Shallow wells along the Jemez River provide water for domestic use in campgrounds and cabins along the river. Domestic water for larger communities is from wells or springs.

3.1.3.2 Groundwater

3.1.3.2.1 Occurrence and quality

Groundwaters in the Valles Caldera area can be classified according to either shallow or deep occurrence. The shallow systems are those in which groundwater circulation takes place close to the land surface. The deep system is that of the geothermal reservoir, which contains deeply circulating hot mineralized fluids and underlies at least a portion of Valles Caldera.

Shallow aquifers in Valles Caldera are of several types: (1) alluvial fan and terrace deposits and (2) valley (caldera) fill sediments. Igneous rocks generally do not contain any significant aquifers in the area, but they serve as temporary storage reservoirs and are important areas of groundwater recharge. The unconsolidated sand, gravel, and silt deposits of the alluvial fans and stream terraces are located at higher elevations back from the existing stream valleys and up the slopes of the rhyolite domes. Groundwater occurs under water-table (unconfined) conditions in these aquifers. The potentiometric surface may be as much as 9.1 m (30 ft) below land surface in the higher terrace areas (Conover, Theis, and Griggs 1963; Griggs and Hem 1964).

Pumiceous sand and gravel deposits within the intermountain basins comprise the primary aquifer of Valles Caldera. The permeable sand and gravel units may be as much as 268.2 m (880 ft) thick; these are overlain by, and interfinger with, clay beds. Within Valle Grande, the largest valley of the caldera, the clay unit overlying the aquifer is confined by the clay zone (artesian), and the potentiometric surface can be more than 7.5 m (25 ft) above the land surface (Conover, Theis, and Griggs

Table 3.7. Records of thermal [temperature above 15°C (59°F)] springs in the Valles Caldera—Jemez Valley region, New Mexico

Index map and location number[a]	Owner or name	Aquifer	Date	Discharge [liters/sec (gal/min)]	Temperature [°C (°F)]	Specific conductance (micromhos/cm)	Use[b]
A 1	US BLM	Chinle	05/02/73	0.06 (1)	16.5 (61.7)	10,900	N
A 2	US BLM	Chinle	05/02/73	<0.06 (<1)	16.5 (61.7)	1,400	N
A 3	US BLM		12/20/74		25.0 (77.0)	11,200	
A 6	Jemez Pueblo	Magdalena	09/14/24		21.0 (69.8)		N
A 7	Jemez Pueblo Bluewater Spring	Chinle	09/05/73	0.13 (2)	15.0 (59.0)	2,500	N
A 8	Jemez Pueblo Owl Spring	Magdalena	05/24/73	0.95 (15)	15.6 (60.08)	900	N
A 11	Jemez Pueblo Indian Spring	Q alluv	08/30/73		22.6 (72.68)	7,000	O
A 12	Jemez Pueblo	Q alluv	09/05/73	<0.06 (<1)	18.5 (65.3)	3,200	N
C 4	Zia Pueblo Ojito Spring	Mancos	06/05/73	0.13 (2)	21.0 (69.8)	10,100	N
D 1	Santa Fe National Forest	Abo	08/31/73	<0.06 (<1)	15.0 (59.0)	700	N
D 4	Jemez Pueblo Log Spring	P camb	05/23/73	0.57 (9)	15.0 (59.0)	450	S
D 6	Jemez Valley School	P camb	08/21/73	0.50 (8)	18.5 (65.3)	1,000	N
E 9	Santa Fe National Forest	Q alluv	06/06/73	0.13 (2)	17.5 (63.5)	580	N
H 2	Aqua Durme Spring	Volcanic	05/08/73	6.31 (100)	16.0 (60.8)	160	P
H 3		Magdalena	07/13/73	0.13 (2)	15.0 (59.0)	1,450	N
			12/01/72		48.0 (118.4)	8,000	O
H 6		Magdalena	03/08/73		45.5 (113.9)	8,000	O
H 7		Magdalena	03/22/78		37.0 (98.6)	8,000	N
H 8		Magdalena	10/31/72		36.5 (97.7)	7,800	N
H 9		Magdalena	11/17/72		36.0 (96.8)	6,320	N
H 10		Magdalena	11/17/72		29.0 (84.2)	6,280	N
H 13		Q alluv	11/17/72		47.0 (116.6)	3,100	N
			12/02/72	0.13 (1)	75.0 (167.0)	3,930	N
H 14	Jemez Springs Village	Q alluv	02/21/73	0.13 (1)	71.5 (160.7)	4,700	
H 15	Jemez Springs Village	Q alluv	12/02/72		69.0 (156.2)	4,000	O
H 16	Jemez Springs Village	Q alluv	12/02/72	0.28 (4.5)	55.0 (131.0)	5,500	N
H 19	Abousleman	Q alluv	05/18/73		48.5 (119.3)	3,600	N
H 26		Volcanic	12/04/72		19.0 (66.2)	165	N
H 27		Volcanic	12/04/72		15.0 (59.0)	215	P
H 31	Santa Fe National Forest	Magdalena	09/24/73	<0.06 (<1)	16.5 (61.7)	2,700	N
H 32	Santa Fe National Forest	Magdalena	01/17/73	1.01 (16)	18.5 (65.3)	2,200	N

Table 3.7. (continued)

Index map and location number[a]	Owner or name	Aquifer	Date	Discharge [liters/sec (gal/min)]	Temperature [°C (°F)]	Specific conductance (micromhos/cm)	Use[b]
H 36	Santa Fe National Forest	Volcanic	09/29/72		31.0 (87.8)	185	N
H 38	Santa Fe National Forest	Magdalena	09/29/72		31.0 (87.8)	190	N
H 39	McCauley Spring	Volcanic	01/16/73	23.22 (368)	31.5 (88.7)	180	O
H 40	Santa Fe National Forest	Abousleman	07/03/73	<0.06 (<1)	21.0 (69.8)	1,780	N
H 41	Santa Fe National Forest	Abousleman	05/10/73		16.5 (61.7)	1,470	N
H 42	Spence Spring	Volcanic	12/01/72	2.78 (44)	40.05 (104.9)	282	O
H 43	Santa Fe National Forest	Volcanic	09/29/72	0.13 (2)	34.0 (93.2)	240	N
P 2	Sulphur Spring	Q uncon	11/04/63		87.0 (188.6)	13,800	N
P 11	Santa Fe National Forest	Volcanic	10/12/72	0.06 (1)	20.5 (68.9)	110	N
			09/28/72	9.91 (157)	40.0 (104.0)	130	O
			12/01/72	13.88 (220)	40.5 (104.9)	120	
P 12	San Antonio Hot Spring	Volcanic	05/16/73	20.38 (323)	40.0 (104.0)	110	
P 13	Santa Fe National Forest	Volcanic	10/04/72	<0.06 (<1)	16.5 (61.7)	105	N
P 14	Santa Fe National Forest	Volcanic	10/04/72		28.5 (83.3)	130	N
P 15	Santa Fe National Forest	Volcanic	10/04/72		29.0 (84.2)	125	N
P 16	Santa Fe National Forest	Volcanic	10/04/72	<0.06 (<1)	22.0 (71.6)	130	N
P 19	Baca Land and Cattle Co.	Q uncon	07/28/49		24.5 (76.1)	644	S

[a] Refer to Appendix A.
[b] D, domestic supply; P, public supply; S, livestock supply; N, not used or used occasionally; O, other use.
Source: Modified from F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI 77-131, 1978.

1963; Griggs and Hem 1964). An aquifer test in Valle Grande determined a coefficient of transmissibility of at least 2000 liters/day/m (25,000 gal/ day/ft) for the caldera fill sediments; the coefficient of storage was not determined. The specific capacity of the pumped well was approximately 0.8 liter/min/m (10 gal/min/ft) of drawdown; a specific capacity of 4 liters/min/m (50 gal/min/ft) of drawdown could probably be expected in the intermountain basin areas. A potential groundwater pumpage of 63 liters/sec (1000 gal/min) could be developed per well in the Valle Grande area alone; however, such development would reduce groundwater outflow (springs, base flow of streams) correspondingly (Conover, Theis, and Griggs 1963).

Interior domes are not classified as major aquifers, but in the caldera area, some notable circulation occurs in relationship to them. Three significant warm springs issue from the Valles Rhyolite of volcanoes along the ring-fracture system of the caldera. These are San Antonio Hot Spring, Spence Spring, and McCauley Spring (Table 3.7). Chemical analyses indicate that the water is not derived from the geothermal reservoir. The depth of circulation is not known, but flow appears to be restricted entirely to the Valles Rhyolite and not underlying formations such as the Abo (Trainer 1974).

The shallow groundwater reservoirs are recharged primarily by precipitation (rain and meltwater from snow) on the slopes of the interior domes, the inner caldera rim escarpment, and the alluvial fans. Spring rivulets also infiltrate alluvial fans, contributing to groundwater locally. Minor recharge occurs on valley floors. The blocky, porous rhyolite dome crusts provide infiltration routes. Recharging water moves down and laterally through the surficial dome material and alluvial fan and terrace deposits into the main aquifer (Fig. 3.18). Shallow groundwater movement within Valles Caldera is mainly toward the spring area heading the East Fork of the Jemez River. The East Fork is a gaining stream whose flow is maintained by goundwater outflow. Groundwater outflow in Valle Grande alone is estimated to be 86 liters/sec (2200 acre-ft/year)(Conover, Theis, and Griggs 1963). Minor movement of groundwater is toward Jaramillo Creek, which may gain as much as 31.6 liters/sec (500 gal/min) of flow.

The East Fork of the Jemez River and Jaramillo Creek are, therefore, major groundwater discharge areas, as are a number of springs within the caldera (Griggs and Hem 1964). An extremely important discharge area of the Valles Caldera aquifer is the main aquifer of the Los Alamos area. This aquifer, which comprises the Puye and Tesuque Formations of the Santa Fe Group, discharges into the Rio Grande. Calculated outflow (and recharge) is 168 to 215 liters/sec (4,300 to 5,500 acre-ft/year) within an 18.4-km (11.5-mile) gaining reach (Purtymun and Johansen 1974).

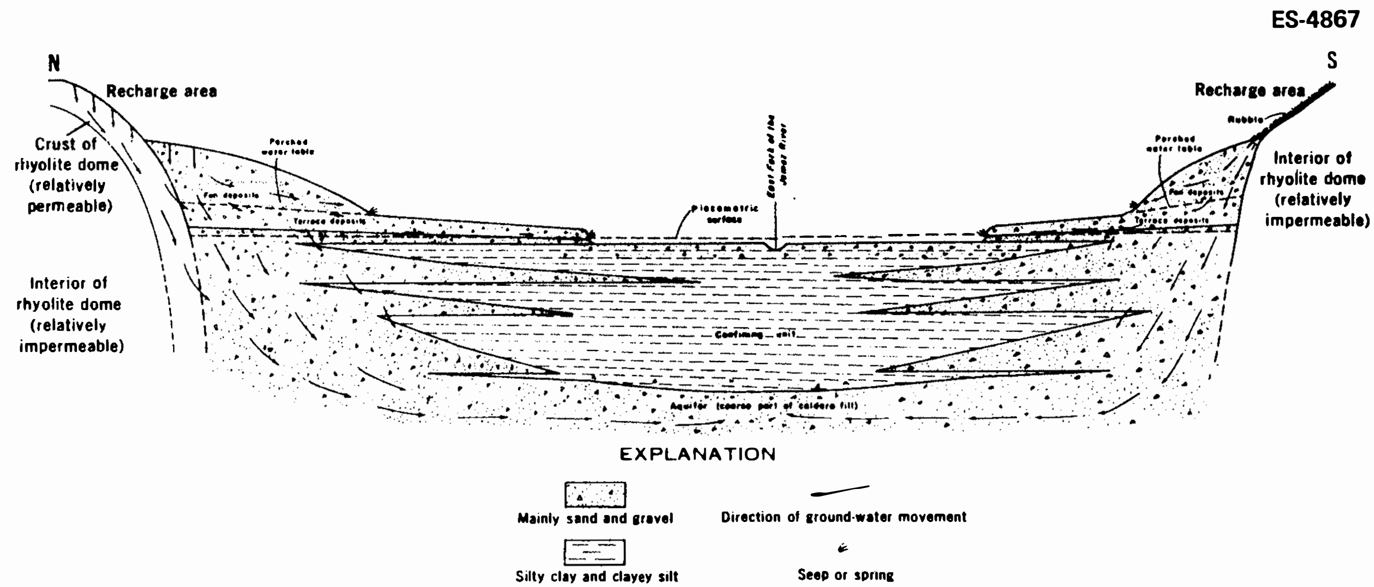


Fig. 3.18. Generalized schematic diagram of Valle Grande showing movement of groundwater. Source: Union Oil Company of California and Public Service Company of New Mexico, *Baca geothermal Demonstration Plant Project Proposal*, 1978.

Shallow groundwater quality in the Valles Caldera is considered good. The water is low in total dissolved solids, which range from 125 to 165 ppm. Hardness (as $CaCO_3$) varies between 19 and 96 ppm. Fluoride concentrations are surprisingly low for an area of volcanic terrain, ranging from 0.2 to 0.8 ppm. Silica concentrations fall between 44 and 75 ppm (Conover, Theis, and Griggs 1963).

The deep groundwater (geothermal) system is described in Sect. 3.1.2.3. The reservoir is comprised primarily of fractured volcanic and underlying sedimentary rocks. The fractured material contains and transmits reservoir fluids (Union Oil Co. 1978). Limestone (Magdalena Group) of the downdropped caldera interior could possibly be important to the geothermal reservoir in that porosity and permeability would be greatly developed by solutioning from the hot carbon dioxide-rich volcanic water (carbonic acid) (Trainer 1974). The reservoir fluids are under artesian conditions, confined by overlying altered country rock (Sect. 3.1.2.3). Static fluid levels in steam wells are 244 to 366 m (800 to 1,200 ft) below land surface (Union Oil Co. 1978).

Reservoir properties were determined from preliminary data calculated from pressure-buildup analyses and a six-month reservoir interference test. The permeability-thickness product Kh ranged from 2025 to 8630 millidarcy-feet. The Kh for the entire reservoir is taken to be 6,000 ± 500 millidarcy-feet. The reservoir porosity-thickness product, ϕh, has been determined to be 27.4 m (90 ft) (Union Oil Co. 1978). The "best estimate" of transmissibility used in a reservoir depletion model (Sect. 4.2.2.2) was equal to 2.4 m^2/day (26.10 ft^2/day); this was based on a static head of 2316.5 m (7,600 ft), a porosity of 10%, and a fluid withdrawal rate of 6242.98 m^3/day (2.206×10^5 ft^3/day) (Water Resources Associates 1977).

Ultimate recharge areas for the Valles Caldera geothermal system are probably the same as those for the shallow groundwater system. Isotope data show a meteoric origin of undetermined age (Union Oil Co. 1978). Groundwater contained within the Valles Caldera aquifers slowly recharges the geothermal system at depth by leakage through confining layers such as the altered caprock and by percolation downward through joints, fractures, and fault zones. The recharging waters move downward and laterally through the geothermal reservoir. During their residence, the meteoric waters are chemically altered by wall-rock and perhaps juvenile water contribution and are heated by the underlying magma body.

Possible discharge areas are indicated in part by the locations of thermal springs (Table 3.7). Although not all thermal springs (e.g., McCauley Spring) contain geothermal reservoir fluids, many thermal and some cold springs in the general area do. Geothermal fluids are known to discharge along the Jemez River in San Diego Canyon, southwest of the caldera. Suspected discharge areas lie even farther from the caldera, at the western foot of the Sierra Nacimiento (Trainer 1974). It should be pointed out that the geothermal discharges could be derived from one or more reservoirs separate from that underlying the project area.

The principal addition to the base flow of the Jemez River between the caldera rim and its confluence with Rio Guadalupe is discharge from Soda Dam and Jemez Springs (Fig. 3.2 and Table 3.7) (Trainer 1974). The contribution from a geothermal reservoir at these springs has been calculated to be 10.35 liters/sec (164 gal/min) using arsenic dilution ratios (Water Resources Associates 1977) and at least 13.7 liters/sec (217 gal/min) using dilution ratios of chloride, bromide, boron, and lithium (Trainer 1975). From the confluence with the Rio Guadalupe downstream to San Ysidro, mineralized geothermal-reservoir-derived, nonthermal as well as thermal springs contribute to river base flow. The distribution of the reservoir-fluid discharge points coincides with known fault zones. The deep, interconnected faults accommodate drainage from a geothermal reservoir, which might or might not be the one underlying Redondo Creek Canyon. Warm mineralized waters in the Sierra Nacimiento could have the same provenance, since a known fault network exists between that locality and the caldera (Trainer 1974).

The reservoir fluid quality has been analyzed for five of the Baca wells (Table 3.8). The average chemistry of the produced fluids is given in Table 3.9; as can be seen, the reservoir fluid is a sodium chloride-type water of approximately neutral pH (Union Oil Co. 1978).

The fluid to steam fraction ranges from 22% (in Baca well 6) to 61% (Baca well 15). The weighted average of the noncondensable gases is 2.51% (Table 3.10). More than 99% of the noncondensable gas fraction is

Table 3.8. Geothermal fluid analyses for Baca wells

(Data provided by applicants)

	Number of samples	Number of wells sampled	Range		Concentration known toxic to aquatic biota[a]
			Minimum	Maximum	
pH	11	5	6.0	9.5	
Constituent, mg/liter					
TDS	14	5	3170	7860	
Fluoride	12	5	6.3	21.2	
Ag	1	1		<0.03	
Al	2	2	0.2	1.0	
As	16	5	0.3	10	0.022
B	13	5	11.2	40.2	0.69
Ba	1	1		0.3	5.3
Be	2	2	<0.01	0.021	
Br	2	2	4.6	9.0	0.18
Cd	2	2	0.000	<0.02	
Co	2	2	0.000	<0.02	
Cr	1	1		<0.004	0.005
Cu	1	1		<0.02	0.0006
Fe	6	4	0.13	18	0.2
Hg	2	2	0.0001	0.0009	0.0001
Mg	8	5	<0.1	5.3	
Mn	2	2	0.016	0.11	0.35
Mo	2	2	0.010	0.1	
Ni	1	1		<0.05	0.03
Pb	1	1		0.1	0.007
Se	4	2	<0.005	<0.01	
V	1	1		<0.02	
Zn	2	2	0.01	0.1	0.01
Rb	1	1		4.3	14.0

[a]Cushman, Hildebrand, Strand, and Anderson (1977).
[b]Total dissolved solids.

composed of carbon dioxide; minor amounts of hydrogen sulfide, nitrogen, hydrogen, and methane comprise the remainder (Union Oil Co. 1978).

The Sulfur Springs area is a group of about a dozen hot springs and fumaroles (Sect. 3.1.2.3). Although believed to be disconnected from the main fluid-dominated reservoir supplying the project well field, their hydrologic system deserves mention. The springs (Table 3.7) discharge small quantities of low-pH, high-temperature, sulfate-rich water along with carbon dioxide and hydrogen sulfide gases. The Sulfur Springs area is thought to be underlain by a vapor-dominated reservoir,

Table 3.9. Average chemistry of produced fluid

	Brine uncorrected for flash		Condensate	
	Average	No. of samples	Average	No. of samples
pH	7.2	26	4.5	20
Suspended solids, mg/liter	319	13	4.9	16
Total dissolved solids, mg/liter	6093	24	29	21
SiO_2, mg/liter	599	40	29	21
$CO_3{}^{2-}$	19	27	0	20
$HCO_3{}^{-}$	127	26	6.6	19
S^{-}	2	15	8.6	1
$SO_4{}^{2-}$	64	23	1.8	17
$C1^{-}$	3061	43	17	25
Na	1749	43	6	23
K	370	43	1.4	23
Ca	15	42	0.4	19
Mg	0.3	21	0.2	21
Ba	0.05	6	0.04	7
B	23	26	0.8	21
F	6	21	<0.2	8

Source: Baca Demo Plant Project Proposal.

Table 3.10. Average noncondensable gas chemistry

Noncondensable gases in steam phase:
2.15% by weight (29 samples), 1.04% by volume

Constituent	Average ppm by weight	Average ppm by volume	No. of samples
CO_2	28,254	11,973	28
H_2S	204	125	31
N_2	42	28	26
H_2	1.6	14	31
CH_4	1.4	1.6	21

which is recharged by intracaldera precipitation. Water at or near the boiling point at the potentiometric surface rises through an unsaturated zone, condensing as it nears the land surface. Most of the condensate infiltrates back downward to the reservoir; however, a portion is carried upward along with the associated gases. The aggressive fluid attacks the country rock, hydrothermally altering it. Hydrogen sulfide is oxidized to sulfuric acid near the land surface, contributing to the acidic, high-sulfate spring water (Trainer 1974).

3.1.3.2.2 Use

Groundwater from wells and springs in the Valles Caldera region is used primarily for livestock and domestic supplies. The uses given in Table 3.7 for springs apply also to wells. The "other" category includes such uses as bathing, drinking, and picnic ground and camping supplies. The Pueblos use groundwater primarily for domestic purposes, such as drinking and bathing. Springs also have religious significance to the Indians in the area.

Thermal springs known to derive a portion of their flow from the geothermal reservoir are used for bathing. One of the thermal springs (H-15) at Jemez Springs (Figs. 3.2 and A-6 and Table 3.7) is used to supply a commercial public bath. In addition, a thermal spring (H-6) at Soda Dam (Figs. 3.2 and A-6 and Table 3.7) is used occasionally for bathing, as is Indian Spring (D-6, Figs. 3.2 and A-4 and Table 3.7) by Jemez Pueblo (Trainer 1974 and 1978).

3.1.4 Meteorology and air quality

3.1.4.1 Climate

3.1.4.1.1 General influences

New Mexico has a mild, arid or semiarid continental climate characterized by light precipitation totals, abundant sunshine, low relative humidities, and relatively large annual and diurnal temperature ranges. Location and topography play major roles in determining the climate for any specific locality. The project site is located in Redondo Canyon at an altitude of 2700 m (8858 ft) above sea level, with nearby peaks ranging up to 3400 m (11,155 ft). The canyon floor slopes from north-northeast to south-southwest, with an elevation change of about 300 m (984 ft).

3.1.4.1.2 Winds

Surface wind observations exist for the project site, for two sites (Upper Forks and Lower Forks) near the head of the canyon and for the Meadow site, a flat location below the mouth of the canyon (Fig. 3.21). All of these wind observations were obtained using Meteorology Research Incorporated mechanical weather stations (models 1071 and 1073). In all cases, the wind observations refer to 2.4 m (8 ft) above local terrain height.

Wind speed and direction were measured hourly at the project site for an 11-month period starting in October 1974. Data for a total of 260 days were collected. The prevailing wind directions exhibit a pronounced diurnal effect, as illustrated in Figs. 4.2 and 4.3 (Sect. 4.2.3). In this region of frequently cloud-free skies and low humidity, nocturnal heat losses from the ground are quite large. These heat losses result in cooling the air immediately above the earth's surface more rapidly than the air aloft. The cooler, more dense air drains downhill, flowing from the north-northeast as it follows the orientation of Redondo Canyon toward lower elevations. During the day, the flow field is reversed. The sunlit cliffs above the valley floor are heated by the strong solar radiation. The warmer, less dense air rises and is replaced by air flowing up the valley from the south-southwest.

Measured wind speeds are quite low, averaging 1.4 m/sec (3 mph) from 7 PM to 10 AM and 1.7 m/sec (3.8 mph) from 10 AM to 7 PM. The overall average wind speed is 1.5 m/sec (3.3 mph). The recorded wind speeds were less than 2.7 m/sec (6 mph) 87.7% of all hours and exceeded 4.5 m/sec (10 mph) only 1% of the period of record.

At two nearby sites, topographical influences do not produce a dramatic diurnal wind direction variation. At the meadow site, winds from the southwest dominate during the day, but no strong preference is noted at night. Data from the upper forks site show a prevalent wind from the southwest at all hours.

Variations in wind speeds as a function of height were measured for two eight-day periods at the meadow site. These measurements were made by tracking weather baloons six times daily using a double theodolite method. For some of the releases, the baloons carried radiosonde transmitters that made possible the recording of temperature data. During August 1975 the average speed increased from 2.37 m/sec (5.3 mph) at the surface to 4.56 m/sec (10.2 mph) at the 1524-m (5000-ft) level. Corresponding data collected in November 1975 showed an increase from 4.52 m/sec (10.1 mph) at the surface to 9.21 m/sec (20.6 mph) at 1524 m (5000 ft).

3.1.4.1.3 Precipitation

The average annual precipitation in the project area is about 45 cm (18 in.), with monthly averages of 2.5 cm (1 in.) or less from November through April and as high as 7.6 cm (3 in.) in August. Summer precipitation is generally caused by localized convective activity forming over the mountains in the afternoon and producing locally heavy showers. Winter precipitation generally occurs as snow, with average depth accumulations up to 2 m (7 ft) at the higher elevations during the season.

3.1.4.1.4 Temperature

Temperatures at the site are mild. The average daily minimum temperature in January is -11°C (12°F), with a reported minimum of -23°C (9°F), while the average January maximum is 7°C (44°F). In the warmest month, July, the mean minimum temperature is 11°C (52°F) and the mean maximum is 32°C (90°F). Because of topographical influences, large diurnal temperature fluctuations occur.

3.1.4.2 Air quality

Operation of the proposed project will result in releases of gases and particulates into the atmosphere. The gases include carbon dioxide, hydrogen sulfide, nitrogen, hydrogen, and methane. Because of the concentrations involved, the only gas of environmental consequence is hydrogen sulfide. The New Mexico (1-hr) ambient air standard for hydrogen sulfide has recently been revised; it is now 10 ppb at the property boundary. One excursion of up to 35 ppb on a 1-hr average per year is permitted.

Between September 1974 and November 1975, hydrogen sulfide concentrations were measured at 50 sites both at the well field and in surrounding areas. Colortec H_2S detectors (Metronics Associates, Inc.) were employed. High concentrations were measured close to wells and close to natural sources of hydrogen sulfide. High concentrations of H_2S occur close to natural emissions both on and off the Baca property.

Long-term concentrations for naturally occurring emissions averaged as high as 11 ppb, with 24-hr concentrations as high as 65 ppb. Thus at several sites the background concentrations exceed the New Mexico ambient standard for hydrogen sulfide because of natural venting.

Suspended particulate measurements, using a high-volume air sampler, were made at a site on Redondo Creek for thirty 24-hr periods during September-November 1975. The values ranged from 2 to 110 $\mu g/m^3$ with a geometric mean of 40 $\mu g/m^3$. The secondary National Ambient Air Quality Standard (NAAQS) for a 24-hr period is 150 $\mu g/m^3$, while the annual NAAQS is 60 $\mu g/m^3$. These standards are exceeded upon occasion in semiarid regions as a result of naturally occurring wind-blown dust.

3.1.5 Ecology

The following discussion of ecology draws heavily on recent site-specific biological studies performed for the Union Geothermal Division, Union Oil Company of California, and the Public Service Company of New Mexico (Whitford 1974; Whitford Ecological Consultants 1975a, 1975b, 1975c; Public Service Company of New Mexico 1978; Flavill and Whitford 1978). For the sake of brevity, only salient details from these studies and from other information sources will be discussed in the present document. The site-specific studies, in their entirety, were made available for public inspection upon issuance of the draft impact statement.

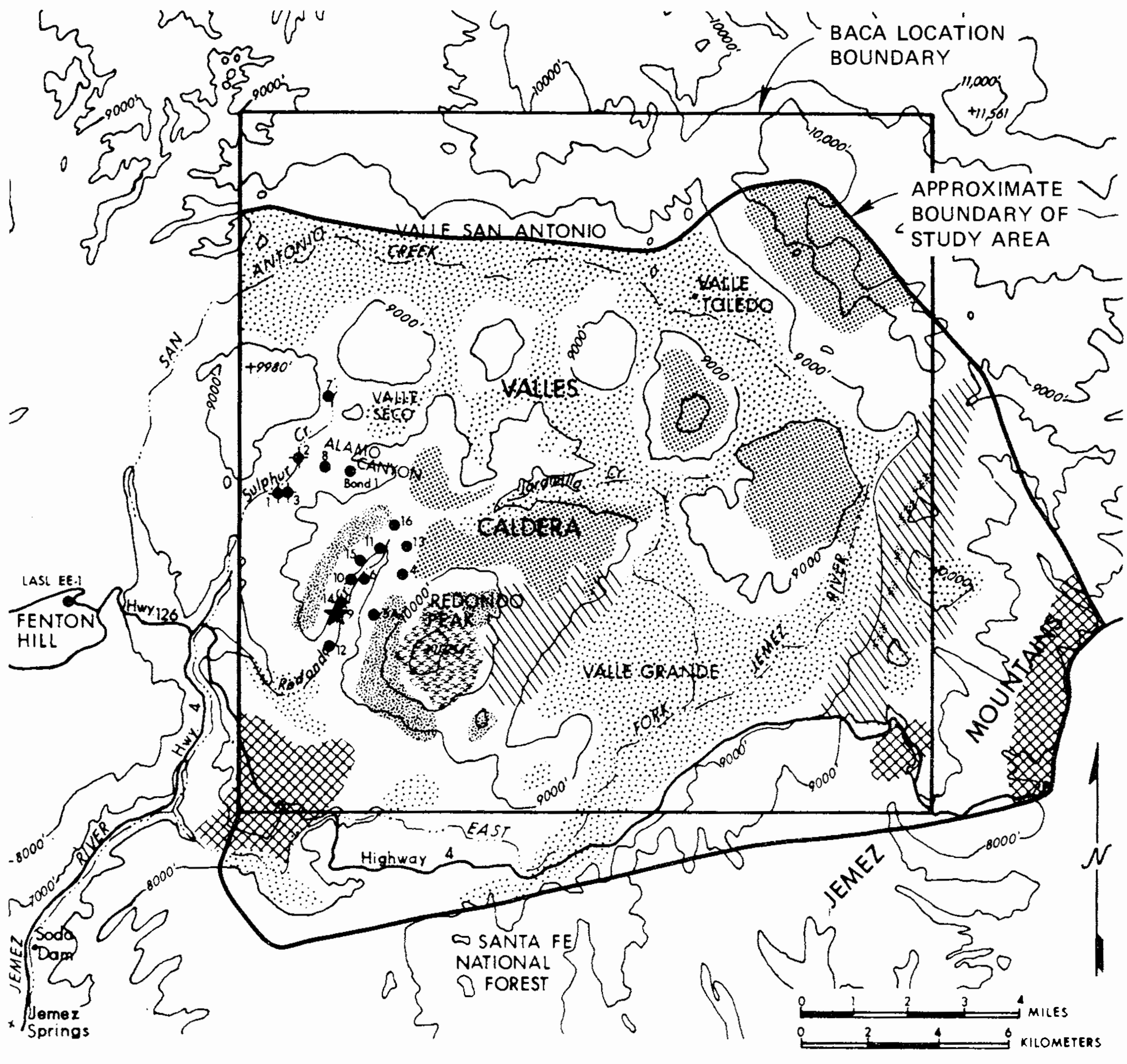
3.1.5.1 Terrestrial ecology

This description of terrestrial ecology considers the general study region outlined in Fig. 3.19, which encompasses the main project area in Redondo Canyon and the proposed transmission corridors. The study region is topographically and ecologically diverse. The varied topography includes open rolling meadows, mountains, and steep narrow-walled canyons. Variations in elevation, slope, and aspect result in a diversity of vegetation types. The diversity of habitats, the remoteness, and the long history of restricted access as a result of private ownership have contributed to making the Baca Location an excellent wildlife habitat.

3.1.5.1.1 Vegetation

This description of vegetation communities is condensed partially from Pilz and Sabo (1979), which contains a large-scale vegetation map of the study region. The map was drawn from aerial photography and helicopter surveys, supplemented by ground collection of plant materials at selected sites throughout the study region. Figure 3.19 is a small-scale map generalized from this large vegetation map. The Los Alamos Scientific Laboratory (LASL) Final Environmental Impact Statement (U.S. Department of Energy 1979) contains a discussion of vegetation communities east of the Baca Location.

The Jemez Mountains (and the nearby Sangre de Cristos) are the southernmost extension of Bailey's Rocky Mountain Forest Province (Bailey 1978). The vegetational communities found in the Jemez Mountains are similar to those found throughout the southern Rockies, as described by Bailey. Vegetational zones are primarily controlled by elevation and slope exposure, which in turn affect moisture, temperature, and insolation. The diversity of vegetational communities in the study region results partly from the large elevational gradient and partly from the abrupt changes in slope and aspect associated with the varied topography. Elevations on the study area range from about 2225 m (7300 ft) at the terminus of the proposed transmission route, near Los Alamos, to over 3430 m (11,250 ft) at the top of Redondo Peak, adjacent to the main



LEGEND

- OPEN MEADOW
- CLEARCUT LOGGED
- SPRUCE-FIR
- MIXED CONIFER, GRADING INTO PONDEROSA PINE AT LOWER ELEVATIONS AND ON SOUTH SLOPES, AND GRADING INTO SPRUCE-FIR AT HIGHER ELEVATIONS AND ON NORTH SLOPES
- HIGH-ELEVATION CONFIERS AND ASPEN INTERSPERSED WITH MEADOWS
- PREDOMINATELY PONDEROSA PINE
- TALUS SLOPES
- WELLS
- PLANT SITE

Fig. 3.19. Vegetation map of Baca study region. Source: Public Service Company of New Mexico, 1978.

project site. Because of the east-west orientation of the drainages and major canyons, there are pronounced north-south slope effects, with corresponding differences in vegetation. The varied topography also results in differences in vegetation along ridges and ravines. The various vegetation zones extend down along ravines to lower elevations, and conversely, lower vegetation zones extend to higher elevations along ridges. These effects produce an interlocking complex of vegetation zones. Edaphic factors and successional stages add another level of diversity.

Eight major vegetation complexes or community types are described for the study region. Detailed descriptions of these communities may be found in Appendix B. Coniferous trees dominate the vegetation in the study region. There are four distinct coniferous communities: spruce-fir, mixed conifer, ponderosa pine, and pinyon-juniper. The mixed-conifer type is the most common community within Baca Location. It occurs generally at locations between 2575 and 2880 m (8500 to 9500 ft). Other forest types do not clearly break from this community. The mixed-conifer type grades into a spruce-fir association at elevations above 2880 m (9500 ft) or at lower elevations on cool north-facing slopes. Extensive stands of the spruce-fir community occur on Redondo Peak and on the Sierra de Los Vallos (see Fig. 3.19). The mixed-conifer community grades into a pure ponderosa pine type at elevations below 2575 m (8500 ft) and at higher elevations on the xeric south-facing slopes. Elevational ranges for the community types are only general, however, since the pronounced north-south slope effects may result in a north slope harboring a mixed-conifer type down to 2286 m (7500 ft) or a south slope at 9000 ft supporting a ponderosa pine community. The pinyon-juniper community (not shown in Fig. 3.19) occurs generally below 2134 m (7000 ft) and occupies large portions of the lower-elevation mesa tops to the south and east of Baca Location.

Succession following logging or fires in the spruce-fir and mixed-conifer communities results in an aspen seral stage. Stands of large mature aspen are common in these two coniferous communities. Secondary succession within the ponderosa habitat results in a brush vegetation of *Cercocarpus*, *Ceanothus*, and oaks.

Large sections of the forest within Baca Location have been disturbed by clear cutting within the last 15 years. Most of the clear cuts are on north slopes. Clear cuts are delineated as a separate vegetation type in Fig. 3.19. This is because the severity of the disturbance and the large amounts of slash left in place have retarded natural succession.

Three types of meadows are encountered on Baca Location. The large open valley meadows, the *valles*, are formed on lacustrine deposits left by an ancient lake that once filled the Valles Caldera. The caldera takes its name from these large meadows. The most extensive of these is the Valle Grande, which covers approximately 41 km^2 (16 square miles). Other *valles* within Baca Location are indicated in Fig. 3.19. Because of their history of grazing use, the large *valles* probably do not support a rare or unique flora. However, the *valles* may be considered a valuable and unique community because such high-elevation meadows are rare within the State. The conditions that created these *valles* occur nowhere else in New Mexico.

The other two types of meadows occurring within the study region are wet meadows and alpine meadows. Wet meadows occur in seep areas or along stream sites. The alpine meadows occur on the summits of the caldera mountain masses and are quite distinct from the other two types of meadows within the Baca Location.

Other vegetation habitats described in the Baca study region have a limited and patchy distribution. A riparian vegetation type is found along streams. Talus slopes occur on most of the mountains and hill-sides in the region. Except for a few deep-rooted shrubs, unstabilized talus slopes are devoid of flowering plants. Stabilized forested talus slopes in various stages of succession are habitat for the State-designated endangered Jemez Mountains salamander, discussed in Sect. 3.1.5.3.

3.1.5.1.2 Fauna

The fauna of the Baca study region consists of species that typically occur in the mountains of northern New Mexico and throughout the southern Rocky Mountains. The Jemez Mountains are relatively remote and undevel-oped and are excellent wildlife habitat. In the Baca study region, the number of vegetation types and their distribution as a complex mosaic reflecting the varied topography has produced a diversity of habitats. The habitat diversity is reflected in the faunal diversity; site-specific biological studies have identified 4 amphibian species, 8 reptilian species, 25 mammal species, and 109 bird species as occurring in the vicinity of the study region (Whitford 1974; Whitford Ecological Consultants 1975a, 1975b, 1975c; Pilz and Sabo 1979). Of these, two species are federally listed as endangered and one is listed by the State of New Mexico as an endangered species (see Sect. 3.1.5.3). Detailed species lists, census data, and habitat affinities are included in the references cited and, except for select species, will not be repeated here.

The diversity of reptiles and amphibians is low, as would be expected at the high elevations. Three species are associated with aquatic habitat on the Baca Location. These include the leopard frog (*Rana pipiens*), the chorus frog (*Pseudacris triseriata*), and the tiger salamander (*Ambystoma tigrinum*). Two species of garter snakes and one horned lizard species have been documented on the Baca Location. The other reptile species occur at lower elevations around Los Alamos (U.S. Department of Energy 1978). Because of its status as a State endangered species, the most important of the herpetofauna of the study region is the Jemez Mountains salamander (*Plethodon neomexicanus*). The distribution and habitat of this species are discussed in Sect. 3.1.5.3.

Of the 109 species of birds observed in the vicinity of the study region (Public Service Company of New Mexico 1978), well over half probably breed on the Baca Location. The rest are transients, migrants, or winter visitors. Twelve species of raptors, including the bald and golden eagles and the peregrine falcon, have been observed in the study region. The bald eagle and peregrine falcon are discussed further in Sect. 3.1.5.3.

Small mammals identified from the study region include 11 species of rodents, cottontail rabbits (*Sylvilagus* sp.), pikas (*Ochotona princeps*), the masked shrew (*Sorex cinereus*), and the short-tailed weasel (*Mustela erminea*) (Whitford 1974; Whitford Ecological Associates 1975a, 1975b, 1975c; Pilz and Sabo 1979). Additionally, the pinyon mouse (*Peromyscus truei*) and the western harvest mouse (*Reithrodontomys megalotis*) are known from the Los Alamos region (U.S. Department of Energy 1978). The commonest and most widely distributed rodents are the deer mouse (*P. maniculatis*) and the red-backed vole (*Clethrionomys gapperi*). Small mammal species with restricted distribution include pikas, which occur on talus slopes at elevations above 2743 m (9,000 ft), and meadow voles (*Microtis pennsylvanicus*), which are restricted to wet meadows. The vegetation types that yielded the greatest diversity of mammals are the mixed-conifer and wet-meadow types. Dry meadows and spruce-fir forests had the least diversity.

Medium and large mammalian predators that have been observed within the Baca Location include bobcats (*Lynx rufus*), mountain lions (*Felis concolor*), black bear (*Ursus americanus*), coyotes (*Canis latrans*), and badgers (*Taxidea taxus*). The commonest predators are coyotes and bobcats. The presence of bears and mountain lions attests to the largely undeveloped nature of the Jemez Mountains. Other medium-sized mammals occurring in the region include beavers (*Castor canadensis*), skunks (*Mephitis mephitis*), and raccoons (*Procyon lotor*).

Two big game species occur in the study region. These are the Rocky Mountain mule deer (*Odocoileus hemionus*) and the Rocky Mountain elk (*Cervus canadensis*, or *C. elaphus* by many authors). Of the two, elk are by far the most abundant on the Baca Location. Deer primarily summer in the high elevations on the Baca Location and in the Santa Fe National Forest and move to lower elevations, especially around the Los Alamos area, during fall and winter (U.S. Department of Energy 1978). During the summer months, deer may be found in Redondo Canyon and on the adjacent slopes of Redondo Peak and Redondo Border (Whitford Ecological Consultants 1975b). The deer are most abundant in logged areas, which provide abundant shrubs and young trees for browse.

The elk population in the Jemez Mountains is apparently healthy and increasing. Table 3.11 summarizes hunter harvest data for the management unit that includes the Jemez Mountains. Relatively good hunter success has been maintained in the face of increasing hunting pressure, indicating a steadily increasing herd.

Apart from the hunter harvest data maintained by the New Mexico Game and Fish Department and their annual winter aerial surveys of the

Table 3.11. Hunter harvest data for elk management unit 9, which includes the entire Jemez Mountains

Year	Number of hunters	Number of elk harvested	Success (% of hunters)
1966	290	29	10
1967	387	52	13.4
1968	425	71	16.7
1969	491	74	15.0
1970	595	113	18.9
1971	845	91	10.7
1972	962	59	6.0
1973	923	65	7.0
1974	661	75	11.3
1975	692	116	16.7
1976	1125	122	10.9
1977[a]	1074	144	13.4

[a]Jemez Mountains changed to elk management unit 6.

area, there have been few studies of the Jemez elk herd. The Game and Fish winter aerial surveys are primarily a tool for determining age and sex ratios of the herd, and are not a census (Sneider 1978). The cow/calf ratios for the last few winter surveys also indicate a healthy and increasing population (Sneider 1978). An accurate estimate of elk numbers for the entire Baca Location does not exist. Whitford and PNM observations and counts of pellet group plots (Whitford Ecological Consultants 1975a, 1975b; Public Service Company of New Mexico 1978) give a valuable indication of elk use patterns and trends, but the limited number of pellet group plots precludes an accurate census. Biologists at the Los Alamos Scientific Laboratory are studying elk movement patterns by the use of radio-collared animals, but their results are as yet unpublished.

The Baca Location is important elk habitat both summer and winter. Elk summer in the high mountain meadows and adjacent slopes within the caldera. Figure 3.20 indicates elk summer and winter use areas in the study region. In the summer, mature bulls stay apart from the cows and are usually found near the small meadows surrounded by conifer forest on the highest peaks; many spend the summer on Redondo Peak and Redondo

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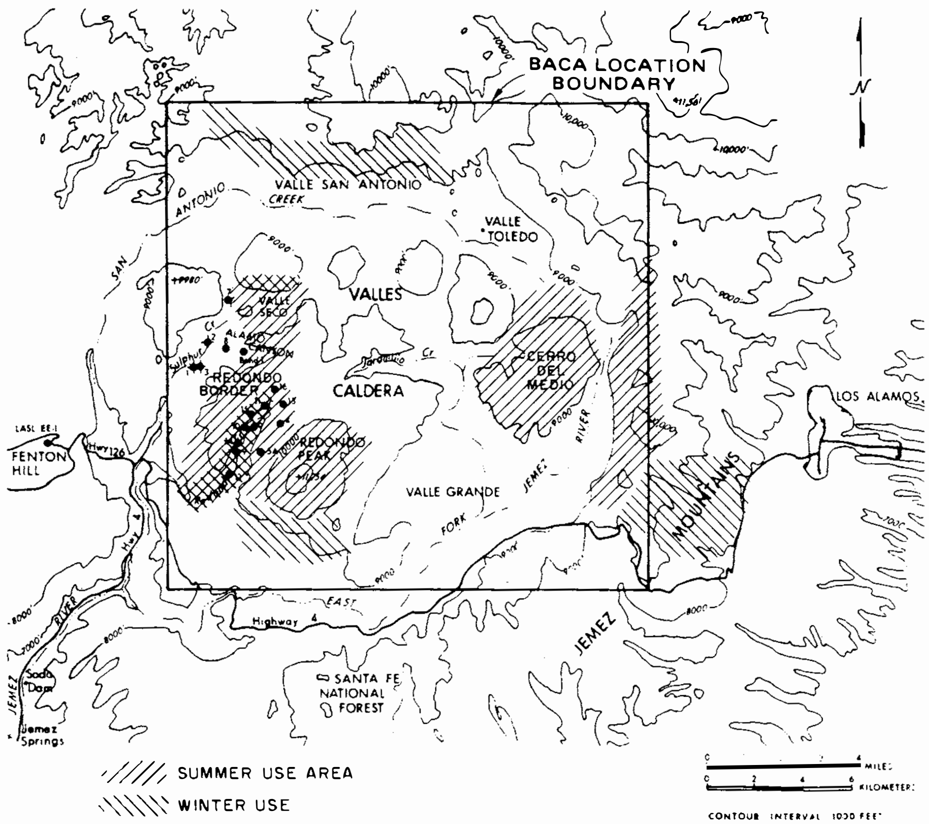

Fig. 3.20. Known elk summer and winter use areas within the Baca study region.

Border (Whitford Ecological Consultants 1975a). After the snow melt, the cows move in small groups to the perimeters of lower-elevation meadows, or *valles*. Calving occurs mid-May to mid-June, primarily on open wooded south-facing slopes adjacent to the lower-elevation meadows (Whitford Ecological Consultants 1975b, Sweeney 1975). The Cerro del Medio, in the east-central portion of the Baca Location, is an important calving area. Most of the LASL radio-collared elk use this area through the summer (White 1979). Other areas of the Baca Location that are heavily used in summer by cow-and-calf groups include the Valle Seco, Alamo Canyon, and San Luis Canyon, just east of Alamo Canyon (Whitford Ecological Consultants 1975b).

Throughout much of their range in the United States, elk move to low-elevation brushlands and woodlands for the winter. In the Baca study region, some elk move east to lower elevations around the LASL area (White 1979), and undoubtedly some also move to lower elevations west of the Baca Location. However, most winters many elk remain on the Baca Location, utilizing the lower meadows and snow-free south-facing slopes below 2896 m (9500 ft) (Whitford Ecological Associates 1975a). Fall and winter habitat in the study region consists of south slopes with well-established stands of gambel's oak, a primary browse species. This habitat is abundant on the south-facing slopes of Redondo Canyon, at the south end of the Redondo Border, and on the south slopes of Redondo Peak. These areas receive heavy use by elk during the winter; Whitford estimates that from 100 to 300 elk winter here. Figure 3.21 shows these prime wintering areas in relation to the main project site in Redondo Canyon. Similar winter habitat on the Baca Location is limited. Elk are known to use the south slopes above the Valle San Antonio (New Mexico Game and Fish Department 1974, 1975, 1977) and limited winter habitat in Alamo Canyon and above the Valle Seco. Since suitable winter habitat appears limited on the Baca Location, the area surrounding Redondo Canyon could be very important winter habitat. It is partly because of the value of this area as elk habitat that Redondo Peak and Redondo Border have been identified as unique ecosystems (New Mexico Heritage Program 1979).

3.1.5.1.3 Well field and plant site

The biota of Redondo Canyon are described in detail in Whitford (1974) and Whitford Ecological Consultants (1975a, 1975b, and 1975c). Although Redondo Creek Canyon is within the mixed conifer major vegetaion type (see Appendix B), the pronounced differences in slope and aspect within the canyon and the influences of Redondo Creek result in a complex of vegetation subtypes or communities. The lower southwest facing slopes of the canyon are relatively dry and support dense stands of gambel's oak. The elk-use areas detailed in Fig. 3.21 coincide with these oak communities. The opposite and more mesic northwest facing slopes of the canyon support predominately conifers such as douglas fir and white fir and some stands of aspen. The riparian communities along Redondo Creek

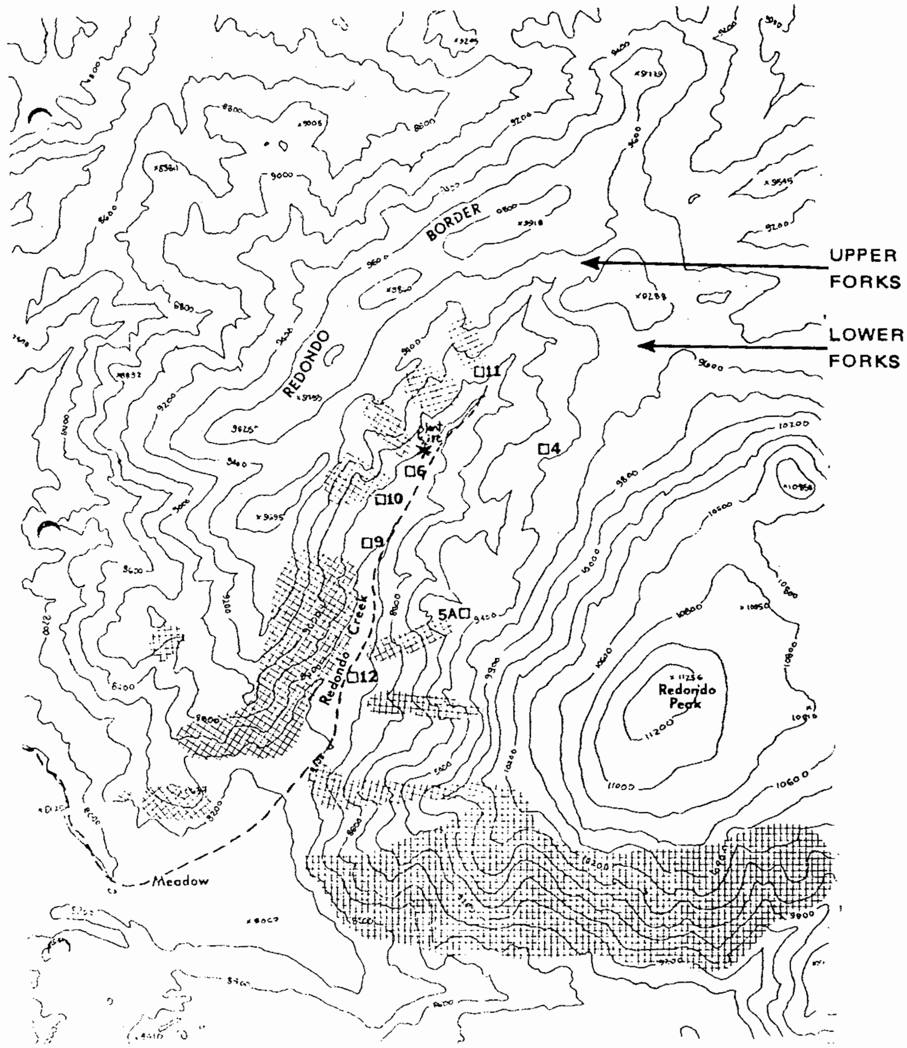

Fig. 3.21. Detail of location of areas used by overwintering herds of elk within the vicinity of the main project site. The dashed line represents the access road for the present well field. The squares are existing geothermal wells. The plant site is also indicated. From Whitford Ecological Consultants. 1975. "Winter Activity and Habitat Use by Elk in the Redondo Creek Area, with Comments on Activities and Relative Abundance of Other Species," prepared for Union Oil Company — Geothermal Division.

consist of stands of alder and boxelder alternating with wet grassy meadows.

Faunal species reported from Redondo Canyon are typical of those reported from most of the Baca study region (Whitford 1974 and Whitford Ecological Consultants 1975a, b, c). Elk utilize all of Redondo Canyon in summer and the portions detailed in Fig. 3.21 during winter. The State-designated endangered Jemez Mountain salamander has been observed in a number of locations within Redondo Canyon, including within the well field area. The salamander habitat is discussed in greater detail in Sect. 3.1.5.3 which addresses endangered species.

3.1.5.2 Aquatic ecology

The biota of Redondo Creek was qualitatively surveyed during July and August of 1978 by Whitford Ecological Consultants (Flavill and Whitford 1978). Algae were sampled by removal of naturally occurring substrate material and glass microscope slides that had been placed in the stream. Benthic macroinvertebrates were collected with a Surber sampler, which sampled a bottom area of 0.093 m^2. One glass slide and one Surber sample were taken at each of 15 and 19 locations, respectively, extending from the headwaters to the mouth of Redondo Creek.

The algal flora of Redondo Creek is characterized by diatoms (Table 6 of Flavill and Whitford 1978), and the species composition of the algal community indicates that the stream is relatively pristine. Thirteen taxa of diatoms were recognized, and three genera of diatoms (*Navicula, Cocconeis,* and *Melosira*) dominated the algal flora along the entire length of Redondo Creek. Several taxa of filamentous blue-green algae (Myxophyceae) and green algae (Chlorophyta) were also noted. Algae were macroscopically visible in only a few places along the stream.

More than 80 taxa of benthic macroinvertebrates were identified in the Surber samples collected at the 25 sampling stations on Redondo, Sulfur, and San Antonio Creeks (Tables 8 and 9 of Flavill and Whitford 1978). These included 5 taxa of molluscs (Mollusca), 6 taxa of water mites (Hydracarina), and 69 taxa of aquatic insects (Insecta). The numbers of macroinvertebrate taxa per Surber sample ranged from 5 to 27, and the Shannon Weaver index of species diversity ranged from 0.57 to 1.14 for individual Surber samples (Table 12 of Flavill and Whitford 1978). The greatest numbers of macroinvertebrate taxa occurred where the substrate ranged from gravel to rubble in size. Two of the more common macroinvertebrates, a midge (Chirondmidae) and a mayfly (*Baetis* sp.), occurred throughout the length of the stream. However, most taxa occurred rarely and were limited in distribution along the stream. Certain species, such as *Hesperoperla pacifica* (a stonefly) and *Heterlimnius corpulenlas* (a riffle beetle), were found only near the headwaters of Redondo Creek, whereas certain other taxa were collected only in the lower sections of Redondo Creek and in Sulfur and San Antonio Creeks. Many aquatic insects have a life cycle that probably precluded their presence as mature larvae during the late summer sampling.

Although the chemical composition of the surface water is relatively uniform along the length of Redondo Creek, the physical characteristics of the stream vary substantially along its length (Sect. 3.1.3.1.1). Consequently, the habitat requirements of many of the macroinvertebrates that occur there are probably met at widely separated stream sites. The species composition of the macroinvertebrate benthos varied considerably, even among adjacent sampling stations (Table 11 of Flavill and Whitford 1978). Some of these apparent differences in community composition among sites are probably a result of inadequate sampling; a single Surber sample is not adequate for definition of the macroinvertebrate community at a site.

There is no evidence of present use of Redondo Creek by fish (Flavill and Whitford 1978), and it is doubtful that fish have occurred there in the last ten years (Moody 1978). The only fish observed in Sulfur Creek during the summer 1978 survey by Whitford Ecological Consultants were some sculpins (*Cottus bairdi*) within 10 m of San Antonio Creek. In contrast, San Antonio Creek and the Jemez River are important trout streams (Sect. 3.1.3.1.2). European brown trout (*Salmo trutta*) have been introduced into the Jemez River system and have maintained self-sustaining populations in these streams for over a decade (Moody 1978). Brown trout spawn in the fall, feed primarily upon aquatic insects, and can withstand considerable fishing pressure (Koster 1957, Eddy and Underhill 1974). The Jemez River system (including San Antonio Creek and the East Fork of the Jemez) are also stocked with hatchery-reared rainbow trout (*Salmo gairdneri*), which are rapidly harvested and do not establish self-sustaining populations in these waters. The native Rio Grande cutthroat trout (*Salmo clarki*) presently occurs in surface waters draining the Jemez Mountains (Moody 1979); however, the status of the species in this area is poorly known. Based on recent collections by the New Mexico Game & Fish Department, few, if any, Rio Grande cutthroat trout are thought to occur in the Jemez River system below the site of the Baca Geothermal Project (Moody 1979). No endangered species of fish are known to occur in the Jemez River and its tributaries north of Jemez Springs.

3.1.5.3 Endangered species

3.1.5.3.1. Plants

Of the 57 species of endangered and threatened plants currently proposed by the Smithsonian Institution (Ayensu and DeFilipps 1978), only one, the blue grama grass cactus (*Pediocactus papyracanthus*), listed as threatened, occurs within the study region. This small cactus occurs near the terminus of the proposed transmission route at Los Alamos (Pilz and Sabo 1979, Spellenberg 1979). The prime habitat is grassland composed of galleta (*Hilaria jamesii*), black grama (*Bouteloua eriopodux*), and blue grama (*B. gracilis*). The altitude range is 5000 to 7500 ft (Pilz and Sabo 1979). The cactus has been collected within Los Alamos city limits and in the Lower Frijoles Canyon in Bandelier National Monument (New Mexico Heritage Program 1978).

There are five species of plants recognized as rare by the New Mexico Heritage Protram which are known to occur in the general study region. These include: *Malaxsis soulei, Viola pedatifida, Cornus canadensis, Lilium philadelohicum* var. *andinum*, and *Epipactus gigantea* (Issacs 1979a, b and c). *Malaxsis* occurs in open ponderosa pine flats; it has been recorded south of the Baca Location on Forest Service land (Issacs 1979c). The *Lilium* and the *Viola* occur in moist situations and could potentially occur in the main project area in Redondo Canyon (Issacs 1979c) — the species has been collected from Water Canyon, southeast of the Baca Location. *Cornus canadensis* occurs on moist, cool north-facing slopes forested with spruce-fir. It has been collected from areas in the eastern portion of the Baca Location, along the East Fork of the Jemez; however, it could also potentially occur in Redondo Canyon, since its preferred habitat is present (Issacs 1979c). *Epipactus gigantea* is known to occur in the vicinity of hot springs (Issacs 1979c). Finally, one other plant species, *Calochortus nuttalii*, recognized as only locally rare, is known from outside of the study region, in the lower elevations near Los Alamos (Issacs 1979a, b, c).

3.1.5.3.2 Animals

The State of New Mexico has provisions for protection of endangered and threatened fauna through the Wildlife Conservation Act of 1974 (New Mexico State Legislature 1974). There are only slight differences between the New Mexico statute and the Federal Endangered Species Act. State protection is accorded to its endangered species as is Federal protection to its designated species. However, there is no provision in the New Mexico statute relating to the concept of critical habitat. Another difference between the State and Federal statutes involves the definition of the term "endangered." While the Federal law considers "endangered" to mean that survival of a species is severely threatened over its entire range, the New Mexico law assigns endangered status to those species whose prospects of survial within the State are in jeopardy or are likely to become so within the foreseeable future (Hubbard et al. 1978). The State definition results in peripheral species, those species occurring in New Mexico which are at the limit of their ranges within the continental United States, being assigned endangered status, even though their survival may not be in jeopardy over the major portion of their range. Additionally, the term "endangered" in the New Mexico statute encompasses both the threatened and endangered categories of the Federal act. New Mexico distinguishes between these categories by assigning species to endangered group I (equivalent to Federal endangered status) and endangered group II (equivalent to Federal threatened status).

Table 3.12 summarizes all species listed as endangered by the State and the Federal government whose ranges include the study region (Hubbard et al. 1978, U.S. Fish and Wildlife Service 1977). Of these species, only three are definitely known to occur in the study region: the bald eagle, the peregrine falcon, and the Jemez Mountains salamander.

Table 3.12. Threatened and endangered species on New Mexico and Federal lists whose ranges possibly extend to the study region

Species	New Mexico classification[a]	Federal endangered	Endangered in New Mexico only
Mammals			
Marten *(Martes americana)*	2		x
Black-footed ferret *(Mustela nigripes)*	1	E	
Mink *(Mustela Vison)*	2		x
Birds			
Zone-tailed hawk *(Buteo albonotatus)*	2		x
Bald eagle[b] *(Haliaeetus leucocephalus)*	1	E	
Osprey *(Pandion haliaetus)*	2		x
Peregrine falcon[b] *(Falco peregrinus)*	1	E	
Blue-throated hummingbird *(Lampornas clemenciae)*	2		x
Broad-billed hummingbird *(Cynanthus latirostris)*	2		x
Red-headed woodpecker *(Melanerpes erythrocephalus)*	2		x
Baird's sparrow *(Ammodramus bairdii)*	2		x
Amphibians			
Jemez Mountains salamander[b] *(Plethodon neomexicanus)*	2		x

[a]State endangered groups: 1, species whose prospects of survival or recruitment in state are in jeopardy; 2, species whose prospects of survival or recruitment in State may become in jeopardy in foreseeable future.

[b]Known to occur in study region.

Source: J. P. Hubbard et al. 1978. "Handbook of Species Endangered in New Mexico," New Mexico Game and Fish.

Four species listed as endangered by the State, the zone-tailed hawk, the blue-throated hummingbird, the broad-billed hummingbird, and the red-headed woodpecker, are peripheral species near the northern limits of their ranges in New Mexico (Hubbard et al. 1978). All four species characteristically occur in low-elevation woodlands and canyons, and sight records for the species in the region have all been from lower elevations around Los Alamos or Bandelier National Monument (Hubbard et al. 1978). None are likely to reach the higher elevations of the Jemez Mountains, which comprise most of the study region.

Three of the species listed occur or are known to have occurred in nearby mountain ranges of northern New Mexico and could also be present in the Jemez Mountains. None have been recorded from the Jemez Mountains recently. Baird's sparrow occurs as an occasional migrant in high mountain meadows in the nearby Sangre de Cristo and San Juan Mountains. Martens inhabit spruce-fir and alpine forests and in New Mexico are at the southern limit of their range in the Rocky Mountains. They are known from the Sangre de Cristo and San Juan Mountains. Mink, usually found near permanent water, may already be extirpated from the State; historic records are from the San Juan, Pecos, and upper Rio Grande river drainages (Hubbard et al. 1978).

The osprey occurs widely in the State as a spring and autumn migrant, especially near streams and larger bodies of water. It nested in the Jemez Mountains historically but is not known to have done so in recent years (Hubbard et al. 1978). The bald eagle, likewise, is widespread and locally common in the State as a winter migrant and visitor, especially along western and northern streams and reservoirs. There have been recent summer records from the Sangre de Cristos, indicating that the species may breed there at present (Hubbard et al. 1978). Within the last few years, adult and immature bald eagles have been observed in the vicinity of the study region, but only during spring and migrations (Pilz and Sabo 1979).

Black-footed ferrets are normally associated with prairie dog colonies. Recent ferret sightings have been recorded for Los Alamos and Sandoval Counties, but they have not been definitely confirmed (Hubbard et al. 1978, Stuart and Christensen 1973). Prairie dog colonies have not been found within the study region. However, Whitford (1975b) observed white-tailed or Gunnison's prairie dogs (*Cynomys gunnisoni*) in the Valle San Antonio, just north of the study region. Although the presence of prairie dogs does not necessarily indicate the presence of ferrets, it does indicate that ferret habitat could be present.

The Jemez Mountains are favorable breeding habitat for the peregrine falcon. Two historic aeries are known in the vicinity of the study region; the nearest is 6.4 km (4 miles) from the Baca Location. There are also two occupied aeries in the Jemez Mountains (Woody 1978). For protection, these locations may not be divulged, but both are well outside of the study region. Since 1975, peregrines have been sighted on a number of occasions within the study region (Whitford 1974; Whitford Ecological Consultants 1975a, 1975b, 1975c; Pilz and Sabo 1979). Most sightings have been from the northern portion, especially around the Valle Seco and Valle San Antonio. The individuals observed were apparently hunting in the area (Whitford Ecological Consultants 1975b, 1975c). A concentrated search for aeries in 1977 failed to locate any on the study region; however, many favorable locations for aeries were identified on the Baca location (Whitford Ecological Consultants 1975c). Since favorable breeding habitat and an abundant prey resource apparently exists on the Baca Location, it is possible that peregrines nested there in the past, and they could conceivably do so in the future.

The Jemez Mountains salamander (listed as endangered only by the State) is the only endangered species known to breed within the study region. The salamander is endemic to the Jemez Mountains, isolated from southeastern plethodontids apparently by the retreat of the Arcto-Tertiary forests (Reagen 1972). The extremely limited range has resulted in its designation as endangered by the State.

Habitat for the species is moist, forested north-facing slopes predominately in the spruce-fir vegetation zone (Reagen 1972). Stabilized talus slopes or slopes with some talus still projecting from the soil surface are a prerequisite (Whitford Ecological Consultants 1975c, Reagen 1972, Williams 1976). The species is active at the surface only when the substrate is dripping wet and ambient temperatures are from 10 to 13°C, usually after spring or summer thundershowers (Whitford Ecological Consultants 1975c, Reagen 1972). Recent studies have determined that the species is apparently abundant in its preferred habitat; however, the habitat is patchily distributed, reflecting the distribution of talus within the spruce-fir forests in the Jemez Mountains (Whitford Ecological Consultants 1975c; Reagen 1972; Williams 1972, 1976).

Figure 3.22 indicates areas within the study region vicinity from which the salamander has been collected. These areas include the tributary canyons to the Rio Cebolla (Pony, Oat, Hay, and Twin Cabins Canyons), which are west of the Baca Location (Williams 1972, 1976), the northfacing slopes above the East Fork of the Jemez River and State Highway 4 (NM-4) in the vicinity of the Los Conchas campground (Reagen 1972), the upper reaches of the Canon del Norte (Reagen 1972), portions of the Sierra de los Valles (Reagen 1972), and the Redondo Peak-Redondo Canyon area (Whitford Ecological Associates 1975b, 1975c). There are also isolated records from some of the canyons on the east side of the Baca Location (New Mexico Heritage Program 1978). Whitford Ecological Associates (1975c) located a large number of suitable salamander habitats within Redondo Canyon and on Redondo Peak. They indicated that dense salamander populations occurred within these habitats. The species had even been collected from relatively unshaded areas on southeast-facing slopes within Redondo Canyon (Whitford Ecological Associates 1975c). The Jemez Mountains salamander apparently occurs throughout the whole of Redondo Canyon, on Redondo Peak, and on portions of Redondo Border.

3.1.6 Historic and archaeological resources

3.1.6.1 Historic sites

A number of sites in Sandoval and Los Alamos Counties are listed in the National Register of Historic Places. Those nearest to the site include the Jemez State Monument and the Bandelier National Monument.

The Jemez State Monument consists of a 17th-century Franciscan mission and convent (San Jose de los Jemez Mission) and the remains of the prehistoric Guisewa Indian pueblo. The site includes a museum and educational trails and is in the vicinity of the Santa Fe National Forest. The Jemez State Monument was included in the National Register of Historic Places in 1973 (U.S. Department of the Interior 1979,

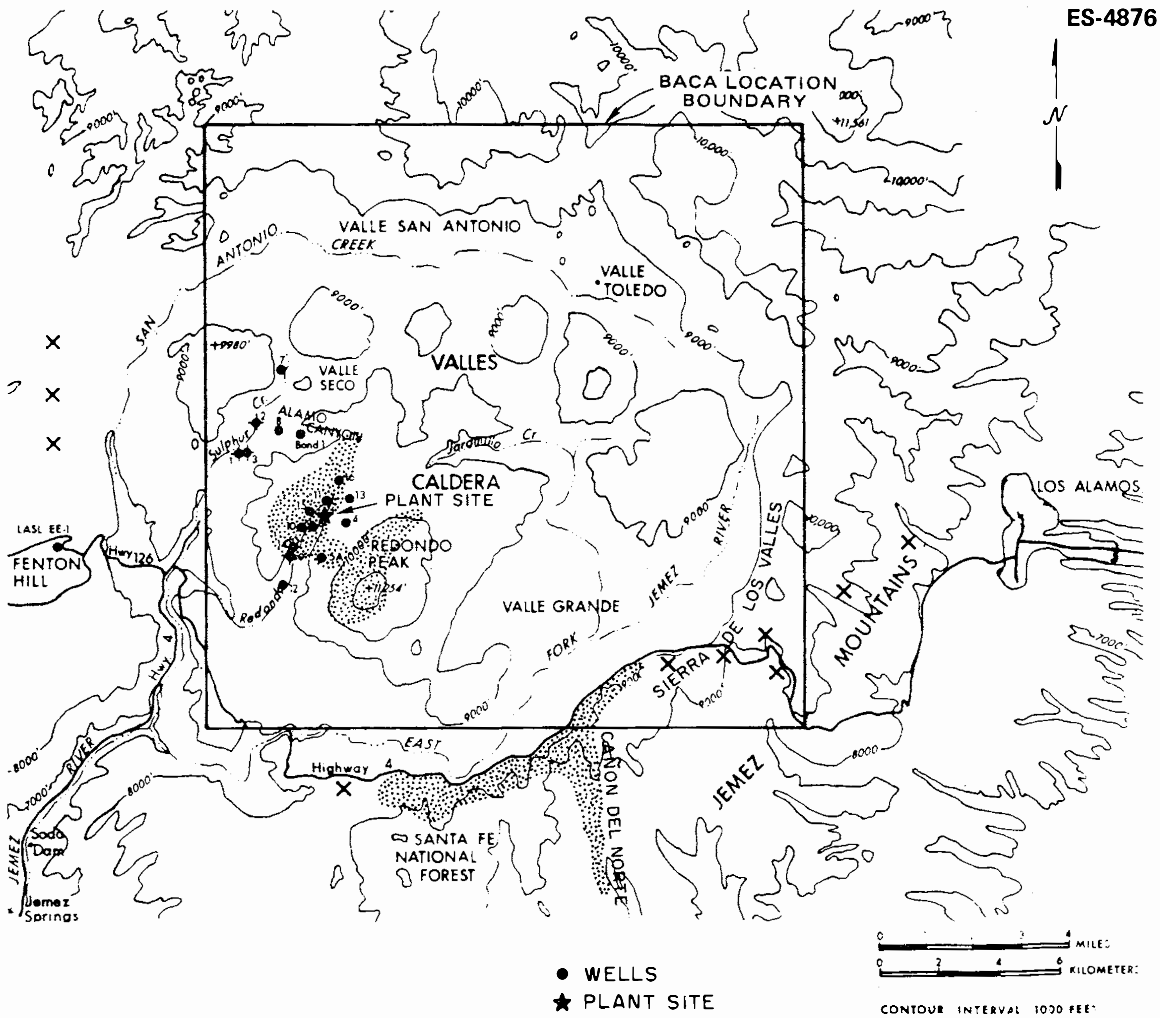

Fig. 3.22. Locations of known Jemez Mountains salamander habitat within the vicinity of the Baca study region. The stippled areas are habitats from which many salamanders have been observed or collected. The X's are isolated collection sites.

Mountain West Research, Inc. 1979, Broilla et al. 1978). The Jemez State Monument is located at Jemez Springs on NM-4.

The Bandelier National Monument was set aside in 1916 to preserve its prehistoric, scientific, and scenic values (U.S. Department of the Interior 1979, Mountain West Research, Inc. 1979). Currently, one proposed route for the 115 kV transmission line would pass through the northern boundary area of the National Monument (see Sect. 3.1.1.2).

Several sites listed in the National Register of Historic Places (U.S. Department of Interior 1979) are located in a region surrounding the Baca Location that could be affected by future transmission corridors in the event of further geothermal development (see Sect. 4.5). These include:

Rio Arriba County
  Santa Clara Pueblo
  San Juan Pueblo

Sandoval County
  Jemez Pueblo
  Zia Pueblo
  San Juan Mesa Ruin
  Jemez State Monument

Santa Fe County
  Pueblo of Nambe
  Pueblo of Tesuque (U.S. Department of the Interior 1979).

3.1.6.2 Archaeological resources

An archaeological survey has been carried out for the Baca land areas where the PNM generating plant and the Union Oil wells and pipelines will be located (Broilla et al. 1978). A 803-ha (1984-acre) tract was surveyed and 29 archaeological sites and 1 locality were identified and recorded.

The archaeological and cultural resources encountered during the survey were difficult to assess. Additionally, all of the identified prehistoric sites have suffered disturbance as a result of activities sanctioned by the various owners of the Baca Grant (Broilla et al. 1978). Even though previously disturbed, "all of the sites recorded by the survey possess scientific significance, albeit to varying degrees" (Broilla et al. 1978). These sites do not appear to have religious significance.

A request for determination of eligibility for inclusion in the National Register of Historic Places was made for the 29 sites identified in the archaeological survey. On August 6, 1979, the archaeological sites were determined to be eligible for inclusion in the National Register (U.S. Heritage Conservation and Recreation Service 1979) and a notice of their eligibility was published in the *Federal Register* on Sept. 4, 1979 (*Federal Register* 44: 51708, Sept. 4, 1978).

3.1.6.3 Other areas

Although not specifically identified as archaeological or historical sites, features related to the geothermal and volcanic activity of the area have long been important. For example: "A series of explorations of the surrounding territories were begun at once and in the first week of August, 1598, Oñate visited the Jemez Province. He reports 'marvelous hot baths which spring up in many places and are singular marvels of nature' and 'mines of sulfur and rock alum'" (Reiter 1938:27 cited in Broilla et al. 1978). "Historically, springs in the vicinity of Jemez Springs have attracted visitors since early days of Spanish exploration" (Broilla et al. 1978).

Another area of importance is Redondo Peak, which is within the Baca geothermal lease area. Redondo Peak, as well as other areas of local prominance, is considered sacred to a number of Puebloan groups (Sect. 3.1.10). Additionally, Navajo groups have used this area for ceremonial purposes. It is reported that there are numerous active shrines in the area and that the area "possesses exceptional significance and sensitivity" (Broilla et al. 1978). For these reasons, the religious significance of the area will be carefully considered in all future plans. If agreed to by the native American population of the area, possible nomination of the Redondo Peak area to the National Register of Historic Places should also be given attention.

3.1.7 Social and community profile and demography

3.1.7.1 Introduction

The proposed Baca geothermal demonstration project, if built and operated, would become the largest commercial activity in a relatively isolated, undeveloped, and highly scenic area. In order to identify and evaluate socioeconomic effects of the project, an independent consultant, Mountain West Research, Inc., of Tempe, Arizona, prepared a detailed socioeconomic analysis for PNM and Union Oil Company.

3.1.7.2 Construction schedule and manpower requirements

Union Oil Company is presently engaged in continuing exploratory work to locate producing wells. Construction of the power plant by PNM is expected to start in the spring of 1980 and continue for one and one-half years. Operation of the plant is scheduled to begin in 1982.

A peak labor force of about 240 is expected for a short time during the second quarter of 1981, with an average of 210 workers needed during the summer and about 80 workers during the winter. About 55 people will operate and maintain the plant and well field. The detailed employment schedule is presented in Table 4.1.

The size of the work force will be small compared to other construction projects in the urban areas of Albuquerque or Santa Fe (both of which are within commuting distance of the site) but is large for the rural areas nearer the site. This work-force size is very small when compared to energy projects associated with "boom towns," where the total work-force may number in the thousands.

3.1.7.3 Demography and impact area identification

Mountain West Research identified two impact areas that might be affected by construction and operation of the project. Figure 3.23 shows the regional impact study area, chosen to include communities within a two-hour commuting time of the site. This commuting time is considered to be a reasonable commuting time for construction workers, so this region would include the primary labor pool for the Baca project. Table 3.13 lists the communities within the regional impact study area, 1976 populations, and driving times to the site. Table 3.14 lists recent population changes for selected communities within this region.

Even though construction workers often commute long distances to a job site, some workers may choose to move closer to the site, possibly resulting in localized impacts. Figure 3.24 shows the local impact study area identified by Mountain West Research. Indian pueblos were not included in the local impact study area because their lands are not normally open to residential development by non-Indians. Also, facilities on Indian reservations were not included because they are not normally

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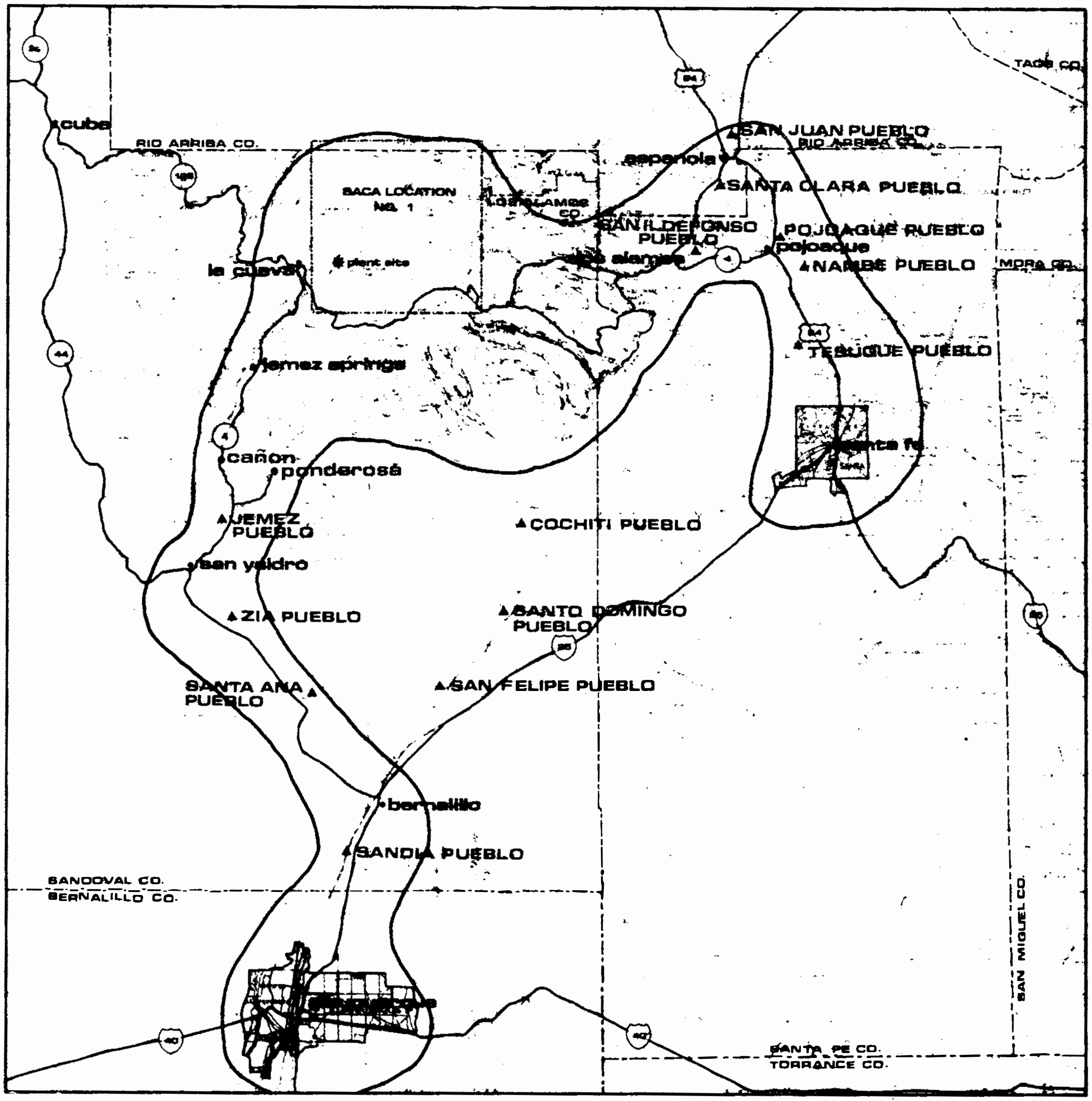

Fig. 3.23. Regional impact study area. From: "Proposed Baca Geothermal Demonstration Project — Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

open to use by non-Indians. Also, Indian users of facilities located off the reservations were not singled out as Indian users. Rather, they were included in the total group of users. Therefore, impacts on the total group of users would affect Indians as well as non-Indians. Also cities

Table 3.13. Commuting times to Baca geothermal plant site from communities in the regional impact area

From	Driving time[a]	Population, 1976[b]
	Communities	
Santa Fe	1 hr 45 min	45,900
Albuquerque	1 hr 30 min	284,600
Espanola	1 hr 30 min	7,560
Bernalillo	1 hr 15 min	2,510
Los Alamos	50 min	16,500
San Ysidro	40 min	210
Ponderosa	35 min	390[c]
Canon	25 min	n.a.
Jemez Springs	15 min	460
La Cueva	5 min	n.a.
	Indian pueblos	
Cochiti	1 hr 55 min	851[d]
Santo Domingo	1 hr 40 min	2,946
Tesuque	1 hr 35 min	289
Nambe	1 hr 35 min	337
San Felipe	1 hr 30 min	2,568
Pojoaque	1 hr 25 min	78
Santa Clara	1 hr 25 min	1,796
Sandia	1 hr 20 min	309
Santa Ana	1 hr 20 min	525
San Ildefonso	1 hr 15 min	329
Zia	50 min	632
Jemez	30 min	2,093

[a]Actual driving time at 55 mph as estimated by State Department of Highways and confirmed by Mountain West.

[b]Based on Federal Revenue Sharing entitlement period records, July 1, 1976, as supplied by the New Mexico Bureau of Business and Economic Research, unless otherwise noted.

[c]1977 estimate based on present water system service to 100 units in the town, at 3.9 persons per unit. According to the 1970 census, Sandoval County had an average of 4.1 persons per occupied housing unit. The Pueblo Indian average per unit was about 4.4, and the Indian population of Sandoval County was 38.9% of the total. Thus the implied household size for the nonreservation population is approximately 3.9 persons.

[d]"Bureau of Indian Affairs Office of Administration: Labor Force Report," U. S. Department of the Interior, March 1978.

From: "Proposed Baca Geothermal Demonstration Project – Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

Table 3.14. Recent population growth in the area surrounding the Baca project

Area	Population 1970	Population 1975	Population 1977[a]	Percent change, 1970–1977	Annual percent change
New Mexico	1,017,055	1,144,000	1,190,000	17.0	2.3
Counties					
Bernalillo	315,774	362,600	377,900	19.7	2.6
Los Alamos	15,198	16,100	17,100	12.7	1.7
Rio Arriba	25,170	27,800	27,600	9.8	1.3
Sandoval	17,492	22,800	24,000	37.5	4.7
Santa Fe	54,774	62,000	65,200	19.0	2.5

Area	Population 1970	Population 1975	Percent change, 1970–1975	Annual percent change
Towns				
Albuquerque	243,751	279,400	14.6	2.8
Bernalillo	2,016	2,775	37.6	6.6
Espanola	4,528	7,380	63.0	10.3
Jemez Pueblo	1,197	n.a.		
Jemez Springs	356	439	23.3	4.3
Santa Fe	41,167	44,937	9.2	1.8
San Ysidro	182	208	14.3	2.7

[a]Provisional estimate, Bureau of the Census.

Sources: U.S. Bureau of the Census, "Provisional Estimates of the Resident Population of the States, July 1, 1977," Department of Commerce, 1977. *New Mexico Statistical Abstract, 1977,* Bureau of Business and Economic Research, University of New Mexico, Albuquerque, 1977. *Municipal Wages and Salaries, 1978,* New Mexico Municipal League, April, 1978.

From: "Proposed Baca Geothermal Demonstration Project – Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

such as Albuquerque, Santa Fe, and Espanola were not included because of their distance from the site and, Albuquerque and Santa Fe, because of their large populations. The local area includes Bernalillo (including Rio Rancho), San Ysidro, Ponderosa (unincorporated), Jemez Springs, Canon and La Cueva (both unincorporated), and Los Alamos.

3.1.7.4 Local communities

3.1.7.4.1 Housing

Even though single family housing is the predominant area housing type, the use of mobile homes and multiple-dwelling units is increasing.

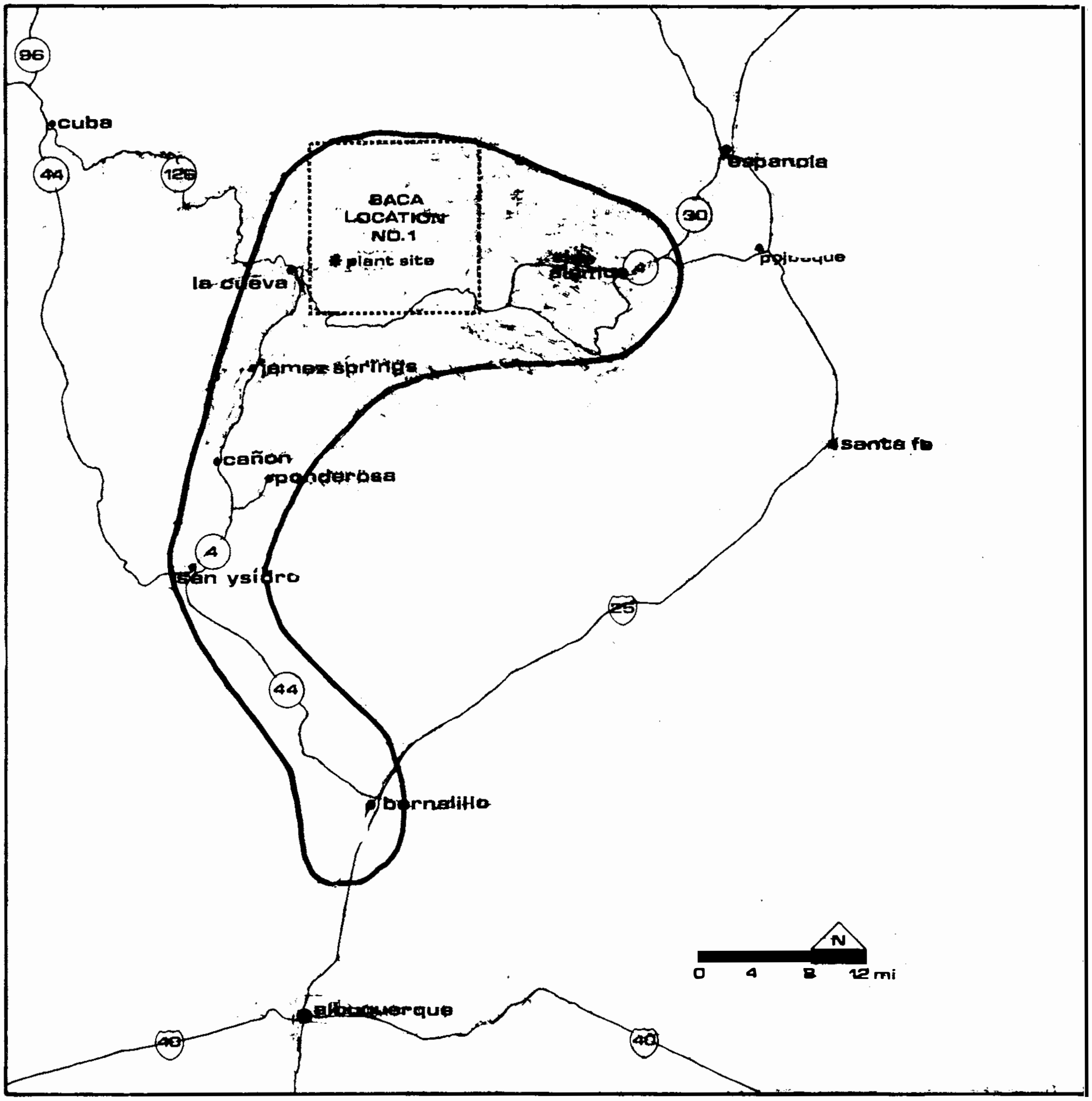

Fig. 3.24. Local impact study area. From: "Proposed Baca Geothermal Demonstration Project — Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

In Sandoval County, most residential building is taking place in the southern part of the county. In 1976, about 86% of the 368 county building permits were for the towns of Bernalillo, Corrales, and Rio Rancho. Little published data on housing is available for other communities in the county: records of only one building permit in 1976 for San Ysidro, four for Cochiti Lake, and seven others dispersed throughout the county (Mountain West Research 1979) were found.

Los Alamos currently has high occupancy rates, little available land, and higher housing prices than in the Albuquerque area. For these reasons, Los Alamos would not be as attractive to migrating construction workers as would other areas near the site (Mountain West Research 1979).

The Jemez Valley also has little land remaining for residential development. Mountain West Research reported that the 12 to 15 Union Oil drill crewmen from outside the local area have already strained the local area's supply of temporary housing.

Indian Pueblos should not be affected because they are not open to development by persons other than members of the Pueblo.

3.1.7.4.2 Public services

Bernalillo water is supplied by three wells with a combined capacity of 8.14 million liters/day [2.15 million gallons/day (gpd)]. Current average and peak consumption rates are 1.3 million liters/day (347,000 gpd) and 3.8 million liters/day (1 million gpd). Additional capacity is planned, along with a 3.78 million liter (one-million-gallon) storage tank scheduled for 1981; this increased water supply should be adequate for about 10,000 people. Bernalillo's sewer system is currently overloaded, but improvements in capacity scheduled for completion by 1981 will give the system a capacity to serve approximately 8,000 people (Mountain West Research 1979).

San Ysidro offers water and sewer facilities, but the system cannot meet current demands, and the water supply from current sources is not of good quality. Ponderosa water supply is now at capacity, although additional water allocation has been applied for. Canon and La Cueva presently use wells and septic tanks, but both face problems in expanding to meet any new needs. La Cueva, the community closest to the site, would need to acquire existing water rights to offset increased water appropriation for new population growth. Also, sewage system or septic tank permits from the New Mexico Environmental Improvement Division (EID) would be needed in an area where the geological conditions make such uses for sewage disposal questionable (Mountain West Research 1979).

Jemez Springs has excess water and sewer capacity and, like Los Alamos and Bernalillo, offers a wide variety of other community services such as fire and police protection. Table 3.15 summarizes these services for Jemez Springs and Los Alamos, the two towns capable of hosting short-term residents associated with the Baca project and also closest to the project site. Because of Bernalillo's proximity to Albuquerque, workers making the choice to move nearer the site rather than commute long distances are not likely to move to Bernalillo. For these reasons, only Jemez Springs and Los Alamos represent currently feasible locations to accommodate an influx of workers (Mountain West Research 1979).

3.1.7.5 Labor supply

The larger labor supply region, including the urban areas of Albuquerque (Bernalillo County) and Santa Fe, should be able to supply the relatively small construction manpower needs of the project. Interviews and data gathered for the PNM all confirm an adequate supply of construction labor within the region (Mountain West Research, Inc. 1978a, 1978b, 1979) (see Table 3.16).

3.1.7.6 Transportation

The site is located in the Redondo Creek area, 4.8 km (3 miles) northeast of NM-4, the principal access route for the project. Project-related traffic may also use New Mexico Highways 44, 30, and 285 on the way to NM-4 and the site.

Both NM-44 and NM-4 have unfavorable ratings from the New Mexico Department of Highways. Most of NM-44 from U.S. 85 in Bernalillo to NM-4 is deficient in capacity. Additionally, a 6.4-km (4-mile) section before San Ysidro that was rated deficient on surface, capacity, and safety is presently being upgraded. NM-4 is ruled as unsafe principally for hazardous conditions such as inadequate sight distances, sharp curves, narrow bridges, and sharp dips. Currently, the bridge north of San Ysidro on NM-4 is being replaced.

Table 3.15. Services and facilities in the Jemez Springs and Los Alamos communities

Public service	Jemez Springs	Los Alamos
Water supply	Spring fed (3 wells); 96 acre-ft/year; 210,000-gal storage	Supplied by DOE; 5 wells, 11.3-mgd capacity; 26 mg storage
Wastewater treatment	600-user capacity; 45,000 gal/day	3 treatment plants; 1–2 mgd, approximate capacity for 20,000 users
Solid waste disposal	U.S. Forest Service landfill	County-operated landfill; owned by DOE but separate from LASL-use contaminated waste
Utilities		
Electricity	Jemez Electric Co-op	PNM; 5,200 units
Gas	Delivered LP gas	DOE supplied county with gas purchased from the Gas Co. of New Mexico
Telephone	Continental Telephone	Mountain Bell
Fire protection	Volunteer; 2 trucks and 1 emergency vehicle	Operated by DOE; 5 stations, 110 employees
Police service	1 village marshal; one state patrol route, patrolman lives in Jemez Springs	County force, 32 officers; DOE security force
Health care	Jemez Clinic, with 1 part-time doctor and 1 full-time nurse-practitioner	Denomination-operated hospital; 102 beds, 24 doctors, ratio of 1 doctor per 600 patients
Education	K-12 system, located in Cañon. 500 students; about 50% of capacity	K-12 system, 4,740 students
Library	State-affiliated branch; 1 librarian	County-administered; 14 full-time staff; 85,700 books
Government	Mayor, town council (4 members), municipal judge	County administrator (nonelective); county council (7 members)

Source: Mountain West Research, Inc.

From: "Proposed Baca Geothermal Demonstration Project — Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

NM-4 passes through Jemez Pueblo, whereas NM-44 passes through the Zia and Santa Ana Reservations. Within the past two years, traffic accidents along NM-44 resulted in the death of approximately 2% of the population of Zia Pueblo. All fatal accidents involved semitrucks (Pueblo of Zia 1979).

Table 3.16. Skilled labor in north central New Mexico, April 1978

O C No.[a]	Craft employment category	Alb.[b] unemp.[c]	Esp.[d] unemp.	L. A.[e] unemp.	S. F.[f] unemp.	Total unemp.
801–805 809	Iron workers	19	16	4	19	58
810	Welders and welders' helpers	19	5	2	6	32
828–829	Electricians	12	5	3	13	33
859	Operating engineers	28	44	3	16	91
860	Carpenters	87	116	10	123	336
862	Pipe fitters	34	26	8	42	110
900–909	Teamsters	133	63	10	105	311
930	Drill crewmen Derrickmen and roughnecks Laborers Other crafts	7	9	1	2	19
Total		339	284	41	326	990

[a] Department of Labor occupation category number.
[b] Signifies data from the Albuquerque—North Valley Employment Security Office.
[c] The number of workers registered as currently unemployed in a job category as of Mar. 31, 1978.
[d] Signifies data from the Espanola Employment Security Office.
[e] Signifies data from the Los Alamos Employment Security Office.
[f] Signifies data from the Santa Fe Employment Security Office.
Source: Employment Security Commission of New Mexico, Applicant Listing for period ending Mar. 31, 1978.
From: "Proposed Baca Geothermal Demonstration Project — Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

3.1.8 Noise

Noise is any undesirable sound; for analytical purposes it is assumed to decrease in desirability as intensity increases. The ear's response to sound intensity is logarithmic rather than linear. Therefore perceived loudness is measured in decibels (dB), which represent the logarithms of sound power ratios. Normally, decibels are stated with respect to the threshold of hearing, which is at a level of 10^{-6} $\mu W/m^2$, or 0.0002 microbar. The least perceptible increase in sound level is about 1 dB, and a 10-dB increase roughly corresponds to a doubling of loudness.

The human ear does not respond uniformly over the entire frequency range of audible sound, however. It is most sensitive to frequencies from 1000 to 4000 Hz and significantly less sensitive to frequencies at the low and high ends of the spectrum. A sound of 100 Hz, for example, must be at a level of about 32 dB above threshold 0 to be perceived at all by a person with normal hearing. Because of this variable sensitivity of the ear, noise sources of equal intensity in decibels but different frequency characteristics will differ in audibility and acceptability. Noise measurements taken for the purpose of assessing human acceptability are usually done with sound level meters equipped with an A-weighted network, which approximates the frequency response of the human ear and yields readings in dBA. This network modifies the linear decibel readings taken at various frequencies so that any two sounds of the same dBA level should be perceived as equally loud, regardless of their frequency spectra. Table 3.17 gives some common sound levels in dBA.

Sound levels decrease, or attenuate, with distance according to physical laws of wave propagation. Roughly, there is a 6-dB decrease with doubling of distance from a source. Thus a noise that is measured at 90 dBA at 15 m (50 ft) will be about 84 dBA at 30 m (100 ft), about 60 dBA at 400 m (1/4 mile), about 54 dBA at 800 m (1/2 mile), and about 48 dBA at 1.6 km (1 mile). This 6-dB decrease is a conservative estimate based on simple spreading of energy; it does not take into consideration absorption of sound by the atmosphere or by vegetation. These additional factors are difficult to assess, however, without setting up detailed models. Therefore, for the purposes of this assessment, attenuation estimates will be based on a 6-dB decrease with doubling of distance and a 35-dB decrease at 800 m (1/2 mile) from a noise source.

3.1.8.1 Noise characteristics of the site

No noise surveys have been made for the Redondo Canyon area of the Baca Location. However, the undeveloped nature of the area coupled with its remoteness from intensive human activity indicate that ambient noise levels are those characteristic of woods and open meadows with little, if any, intrusion of vehicular or industrial types of noises except from

Table 3.17. Typical "A"-weighted sound levels and human response

Sound source	dBA[a]	Response criteria	Intensity ($\mu W/m^2$)
Carrier deck jet operation	150		10^9
	140	Painfully loud, limited amplified speech	10^8
	130		10^7
Jet takeoff [60 m (200 ft)]		Maximum vocal effort	
Discotheque			
	110		10^5
Jet takeoff [610 m (2000 ft)]			
Shout [0.2 m (0.5 ft)]			
	100		10^4
Heavy truck [15 m (50 ft)]		Very annoying, hearing damage (8 hr)	
Pneumatic drill [15 m (50 ft)]		Annoying	
	80		10^2
Freight train [15 m (50 ft)]			
Freeway traffic [15 m (50 ft)]		Telephone use difficult	
		Intrusive	
	70		10^1
Air conditioning unit [6 m (20 ft)]			
	60		1
Light auto traffic [15 m(50 ft)]		Quiet	
	50		10^{-1}
Living room			
Bedroom			
	40		10^{-2}
Library			
Soft whisper [5 m (15 ft)]		Very quiet	
	30		10^{-3}
	20		10^{-4}
Broadcasting studio		Just audible	
	10		10^{-5}
	0	Threshold of hearing	10^{-6}

[a]Typical A-weighted sound levels taken with a sound-level meter and expressed as decibels on the scale. The "A" scale approximates the frequency response of the human ear.

Source: Council on Environmental Quality. *Environmental Quality – The First Annual Report of the Council on Environmental Quality,* transmitted to Congress, August 1970.

previous project activities and infrequent off-the-road vehicle use. Background noise levels would therefore be expected to be in the 40-dBA range, perhaps slightly lower at night. The character of the ambient sound is that typified by the wind, insects, birds, and flowing water.

3.1.8.2 Noise regulations

State of New Mexico noise regulations are aimed at occupational exposure. This environmental analysis is directed at community noise, for which the State has only a prohibition of public nuisance noise. However, there are some generally accepted guidelines for community noise. The U.S. Department of Housing and Urban Development, for example, sets criteria for a "clearly acceptable" noise level as one that does not exceed 45 dBA for more than 30 min in a 24-hr time span. The Environmental Protection Agency also recommends this level for nighttime hours in residential areas. These criteria or recommendations are not regulations, however.

3.1.9 Visual resources of the region

The Jemez Mountains are noted in northern New Mexico for their scenic quality. The region surrounding the Baca Location contains many excellent visual resources, including one of the world's largest calderas. The Valles Caldera is characterized by large, open meadows dotted with forested domes and set against a background of some of the highest peaks in the Jemez Mountains. Because the area is near two large population centers (Los Alamos/Santa Fe and Albuquerque), it receives heavy recreation and sight-seeing use. Impacts on the visual quality of the area are of special concern. Figure 3.2 delineates areas within the Santa Fe National Forest that have high recreation use and scenic value and have been recommended for exception from geothermal development for those reasons (U.S. Forest Service 1977). Public Service Company of New Mexico (Cantu 1979) has prepared a comprehensive inventory of the visual resources of the study region (see Fig. 3.25), based on the Forest Service's Visual Management System (1974). Appendix D contains a description of the methods and definitions of some of the terms used below. The following discussion of visual resources is condensed from Cantu (1979).

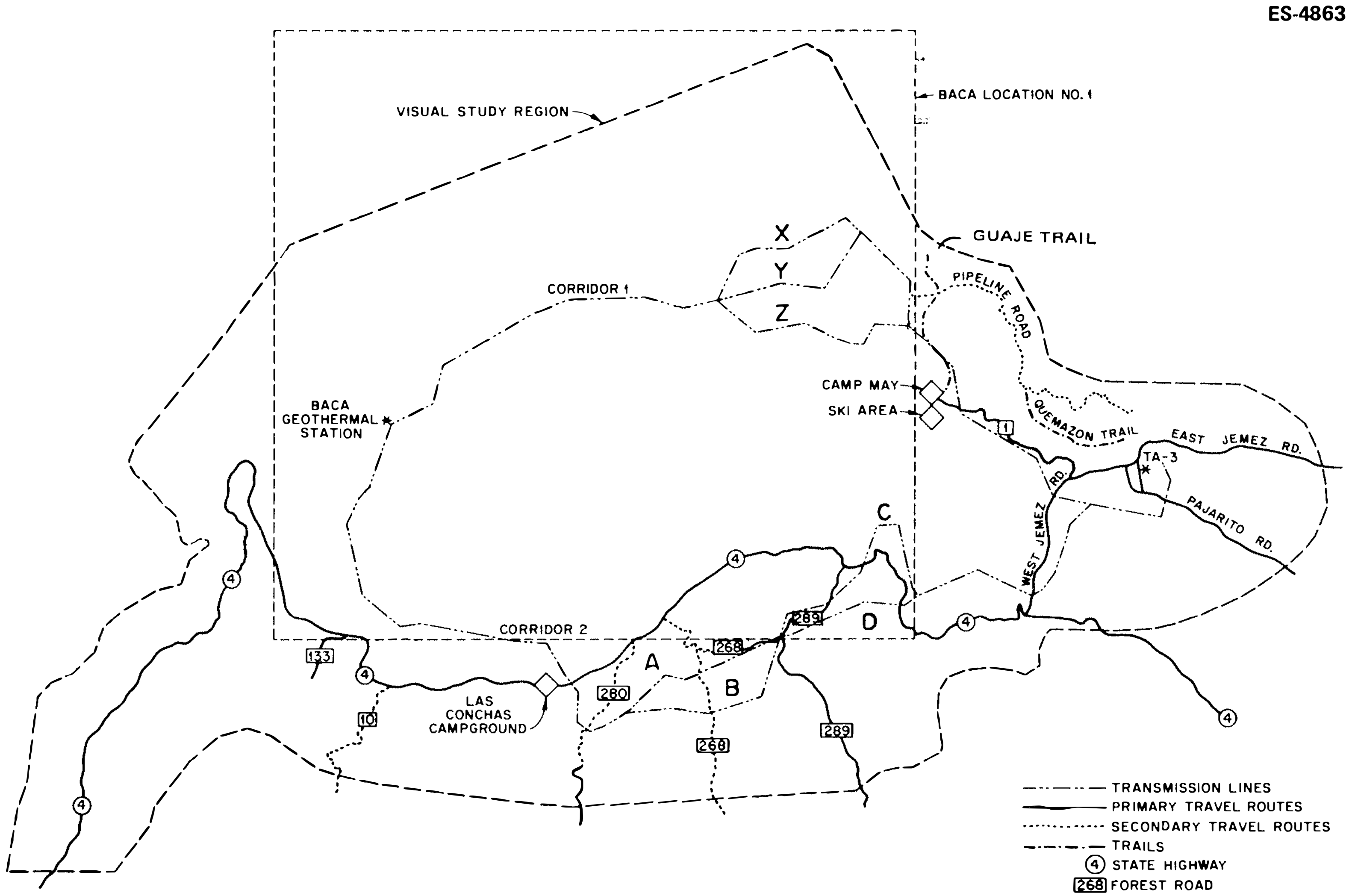

Fig. 3.25. Visual resources surrounding the Baca Location.

Figure 3.25 indicates the locations of sensitivity level one and two travel routes and use areas of concern within the visual study region (see Appendix D for explanation of sensitivity levels). The two proposed transmission corridors (of which only one will be chosen) are also indicated in Fig. 3.25. Sensitivity one travel routes of concern are State Highway 4 (or NM-4), Forest Route 289 (Dome Road), part of FR-268 (Bland Canyon Road), FR-1 (Camp May Road), and FR-133 (Banco Bonito Road). Sensitivity one use areas in the vicinity of the transmission corridors include the East Fork of the Jemez River (see Fig. 3.2) and the nearby Las Conchas Campground, Camp May, the Pajarito Ski Area, Guaje Canyon Trail, and the Quemazon Trail. Sensitivity level two travel routes include FR-10 (Ponderosa Road), FR-280 (Peralta Road), part of FR-268 (Bland Canyon Road), and the Pipeline Road. Sensitivity two use areas include the summer home areas indicated on Fig. 3.3 (e.g. Horseshoe Springs, La Cueva, Vallecitos de Los Indios, and Thompson Ridge). The roads that serve the LASL technical areas, the East Jemez Roads, and the Pajarito Road are indicated in Fig. 3.25 but are not assigned sensitivity levels. The West Jemez Road as a part of NM-4 has sensitivity level one.

In the interest of legibility, the characterizations of all seen areas and their visual quality management objectives (see Appendix D) were not included in Fig. 3.25. The reader is referred to Cantu (1979), which includes a large map illustrating these areas. The visual management categories of select areas are described below (refer to Appendix D for an explanation of visual quality management objectives).

Preservation areas

Four areas are categorized as preservation and are illustrated in Fig. 3.2: Bandelier Wilderness area, Monument Canyon Natural Research area, and the two Forest Service designated roadless areas, Dome and Caballo.

Retention areas

The entire length of the Cãnon de San Diego, located southwest of the Baca Location, is a retention area. The canyon, occupied by the Jemez River, includes NM-4 and a large number of recreational use areas and scenic overlooks (refer to Fig. 3.2). Other retention areas include the East Fork of the Jemez River from the Valle Grande to the confluence with the Jemez River, Redondo Peak, Cerro Grande, a peak in the southeast corner of the Baca Location, portions of Los Alamos Canyon, and the forested knolls in the Valle Grande. The quality of the views in these retention areas are described in detail in Cantu (1979).

Partial retention areas

Partial retention areas include the forested slopes within the Valles Caldera and on the mountainous caldera ring. All but one of the *valles* of the Valles Caldera fall into this category. The *valles* are characterized by gently concave grassy meadows. The Valle Grande is the most extensive and impressive of the *valles*. According to Cantu (1979), the *valles* were assigned to the partial retention category because they represent homogeneous landscapes with little visual variety. However, views of the Valle Grande with the backdrop of forested mountain are impressive and certainly merit protection.

Modification and maximum modification areas

Modification areas include many areas of the Baca Location seldom seen, or not seen at all, from identified travel routes and use areas. Many of the forested domes within the Baca Location are categorized as modification, as are the forested slopes of Redondo Border, Redondo Peak, and the headwaters of Frijoles Canyon. Remaining modification areas are the restricted entry areas associated with the LASL technical areas.

Maximum modification areas include the logged areas of the Baca Location (see Fig. 3.19) which are seldom seen from travel routes. Mesa tops along Virgin, Holiday Cebollita, and Cat Mesas are also classifed as areas of maximum modification.

3.1.10 Pueblo Indian culture and religion

The following discussion is based on a background study of the Pueblo religion commissioned by DOE (Singley, et al 1979).

3.1.10.1 Geographical setting

Northern New Mexico is the home of the eastern group of Pueblo Indians. There are 19 independent Pueblo tribes, 18 of which occupy reservation lands in the Rio Grande Valley. The political, cultural, and social focal point of each tribe is its primary village or pueblo (Fig. 3.26).

Those Pueblo tribes owning lands within a 20-mile radius of the project site are the Santa Clara, Cochiti, Santo Domingo, Zia, and Jemez. The Santa Clara and the Jemez tribes are closest to the site; their lands are about 12 miles away. Highway commuting times to the project site from each of the nearest pueblos are given in Table 3.13.

The Pueblo Indians derive their livelihood primarily from farming, which has been practiced for many generations and has become a cultural tradition for the Pueblos. In any agricultural community, water assumes a major role as the giver of bountiful harvests. Accordingly, most of the pueblos are located on or near flowing streams, and the farmlands are situated on adjacent floodplains. Water is used by the Indians for domestic consumption, crop irrigation, medicinal applications, and ceremonial purposes (T. Sando 1979). In the semiarid land of the Pueblos, water is essential to the Indian way of life.

The project site is drained by Redondo Creek, a tributary of the Jemez River. The Jemez, Zia, and Santa Ana Pueblo tribes derive the majority of their water supply from the Jemez River Basin and its associated aquifer.

3.1.10.2 Way of life

The Pueblo way of life is inextricably tied to the environment, which the Indians usually refer to as "Mother Earth." The Pueblos pride themselves on having always lived in harmony with the environment, a concept that has only recently become accepted among non-Indians

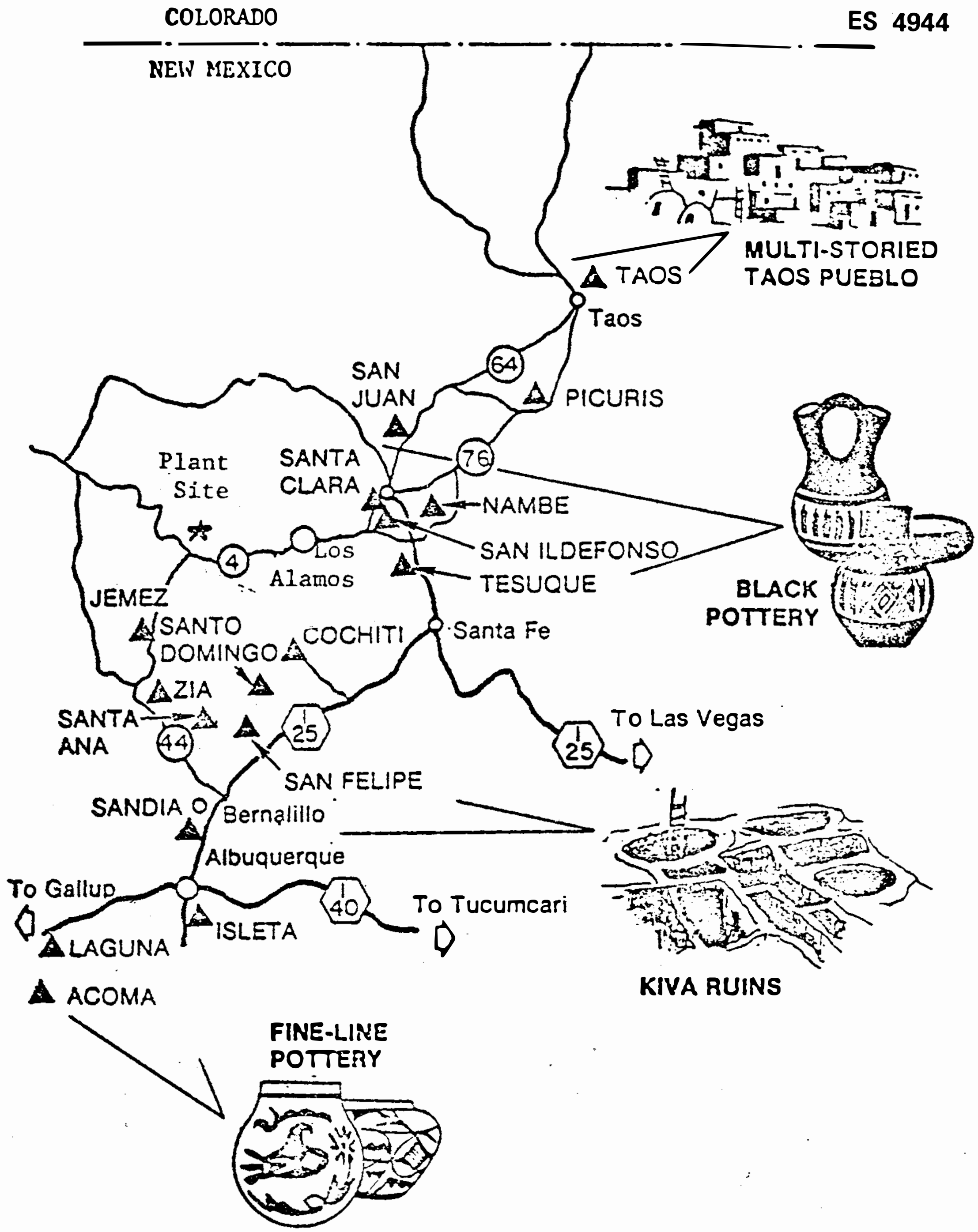

Fig. 3.26. Present-day Rio Grande Pueblos. Source: U.S. Department of Energy 1979.

(Weahkee 1979). As members of an agricultural-based society living in a water-poor land with a delicate ecological balance, the Pueblo Indians have developed a profound appreciation for the importance of Mother Earth. This appreciation forms the basis of the beliefs and practices that constitute the Pueblo religion.

For the Rio Grande Pueblos, religious beliefs and practices permeate every aspect of daily living. Religious belief prescribes relationships with the natural world and among the Pueblos themselves. Assurance of a harmonious relationship among the natural and social worlds is a basic concern. Religious societies in each tribe have particular responsibilities for maintaining a harmonious relationship between the people and the spiritual world in control of weather, fertility, curing, hunting, and pleasure. Today, as in the past, most Pueblos belong to a religious society, and a calendar of ritual is observed. Their religion is an essential means by which the Pueblos assert their cultural identify.

3.1.10.3 Concept of reality

The doctrine on which any religion is founded generally derives from the adherents' concept of reality. To understand the Pueblos' perceptions and uses of the natural environment in relation to their religious beliefs, it is necessary to understand the Pueblos' world view.

The Pueblo world is based on the precept that space is sacred. Space is seen in terms of horizontal zones and vertical levels (Table 3.18). Each pueblo sets precise limits to its world. Boundaries differ from tribe to tribe, but all tribes adhere to the same principle for setting the boundaries.

The horizontal world is bounded in each of the cardinal directions by sacred mountains. The mountains are sometimes associated with bodies of water where spirits are thought to reside. Within these boundaries are other points of division and places of worship, including both natural and man-made shrines. At the center of the horizontal dimension of the world is the Pueblo village itself.

Table 3.18. Dimensions and associated natural phenomena of the Pueblo world

	Levels/zones and natural phenomena				
Vertical	Underworld (lower level)		Earth (middle level)		Sky (upper level)
Horizontal		*Inner zone*	*Between zone*	*Outer zone*	
		Village	Springs Streams Animals Plants	Mountains	

[a]It is not reported which group uses these sites.

Source: Singley, et al 1979.

The vertical order consists of three levels: the sky, the earth, and the underworld. Of these, the underworld is considered most significant; it is the place of origin of Pueblo human life and the home of spirits of the highest order. The Pueblos believe that they came to live in the natural world from under a lake to the north. Before leaving the underworld they lived in harmony and equality with the animals and spirits there. Worship of the spirits of the underworld is considered essential to maintain the balance of elements in the other two levels, the sky and the earth. Events and conditions within these levels affect life-giving processes and the general well-being of the people.

The sky and those spirits associated with celestial bodies, clouds, rain, and other features of weather are looked to for cyclical signs indicating the initiation of various agricultural and other subsistence activities. To ensure the continuation of favorable conditions, the spirits are worshipped in ceremonies conducted either by responsible religious societies or the pueblo as a whole at shrines throughout the Pueblo world.

The middle level, Mother Earth, includes all flora, fauna, and natural features such as lakes, ponds, streams, springs, mountains, hills, caves, and fissures. The Pueblos ascribe symbolic significance to natural features and products of the earth. Various natural products and items fashioned from them are used in rituals and ceremonies to venerate the spirits in control of their supply and quality. Waste of these products is not tolerated because the Pueblos understand that man is to live in harmony with his environment. All animate and inanimate objects are important and have a proper place in the universe. Harmonious actions ensure that the spirits will answer requests for life's necessities. The gifts Mother Earth provides in the form of crops and other products are seen as fulfillment of these requests. On the other hand, nonharmonious actions upset the natural balance of the environment and product negative repercussions such as drought (Hecker letter to Rogowsky, Appendix J).

3.1.10.4 Religious beliefs and practices

Although there are some differences among the various Pueblo tribes, there exists a basic commonality of religious symbols and meanings. Variations are in matters of detail. Despite contact with other cultures since the sixteenth century, notably the Spanish, Mexican, and American cultures, the Pueblo culture has not changed greatly. The Pueblos retain many of their traditional ways. For instance, the Spaniards tried to convert them to Catholicism and other Spanish ways of life. However, assimilation of Spanish social structure and Catholic doctrine occurred only when those concepts were compatible with Pueblo beliefs and practices.

The preeminent importance of water to the Pueblos is expressed in their religion. Lakes, ponds, and springs are considered especially sacred because spirits of the underworld use them for access to and from the natural world. Accordingly, the Pueblos go to these waters to communicate with the spirits. Although communication with the underworld can take place elsewhere, the number of entry points to the underworld are limited.

Flowing bodies of water are not considered portals between the underworld and the natural world. However, the Pueblo Water Serpent, the deity of terrestrial waters, is sometimes manifested through flowing waters. Among other responsibilities, this spirit has control over the flow of water and plays an important role in the agricultural cycle. The day before water is ushered through irrigation ditches, a ceremony is held in his honor to ensure adequate flow for a bountiful harvest.

When rain is needed and does not come, the responsible religious society must go to the mountains to ask for it. The high peaks are considered the places where the clouds gather and rain forms. During pilgrimages to the peaks, offerings fashioned from materials of the natural world are left at shrines along the way and at the summit. This activity appeases the spirits, who are then expected to send rain.

Besides water, a number of other natural objects, animate and inanimate, have religious significance to the Pueblos. A variety of plants, herbs, and roots, such as yucca, pinon, jimsonweed, bear root, mountain tobacco, and various conifers, including the Douglas fir, are collected for religious purposes. Those plants growing in the farthest and highest zones are collected during the course of pilgrimages. Once collected, the plants may be used to construct fetishes, cure disease, overcome witchcraft, or venerate spirits through rituals.

Many animals of the region are associated with the spirits, and materials from these animals are used in rituals. Eagles particularly, but also turkey, hawk, and other fowl, are considered important. Most of the Pueblos have a specific society responsible for catching and killing eagles and distributing the feathers to the rest of the village for use in the adornment of shrines.

Mountain lion, bear, snake, badger, antelope, elk, and deer are a few of the species whose products are used in ritual as adornments. Usually an offering is made at a shrine before a hunt. The remains of the kill are subsequently offered to the spirits to ensure an abundance of the species in the future.

Many Pueblo ceremonies include prescribed dances and costumes. Masks impersonating spirits are common. These ritual costumes are made from antelope or deer leather and are decorated with pigments collected from the surrounding ecological zones. A black mud used as ceremonial body paint comes from the banks of nearby streams. Pottery used in ritual is glazed with mineral pigments obtained from the area. From the high mountains, obsidian and other stones are collected. A type of black stone is valued as an excellent heat conductor and cooking surface, especially for cooking a food called paper bread, which may have religious significance.

Deities associated with the sky and its features are revered at the distant peaks as well as at sites near to and within the village. The Pueblos look to the sky for indications of a productive or nonproductive year. Responsible Pueblo religious groups or leaders watch the sky carefully for constellations and celestial signs indicating changes in the seasons. Particularly sacred times of the year occur during the solstice and equinox; ceremonies are conducted then for the good of both the spirits and man.

3.1.10.5 Sacred sites

As the meeting place of earth and sky, mountains hold a special religious significance for the Pueblo. Some mountain peaks are the sites of major rituals and ceremonies; others mark the boundaries of the Pueblo world.

A number of peaks and locations within the mountains are considered sacred to various Pueblo groups. The sacred sites of different pueblos are often the same, but there is no conflict over their use for religious purposes. Because of the inherent secrecy surrounding the Pueblo religion, an exhaustive list of these sites cannot be compiled; however, some of the locations that are reported as sacred to different tribes are listed in Table 3.19.

Of all the known sacred sites, the Redondo Peak is the area closest the project area (Fig. 2.1). The Jemez Pueblo owns a 4- by 4-ft plot of land on the top of Redondo Peak. This site is used for religious purposes by several Jemez religious societies. At or near the summit there are a number of religious shrines. A secondary peak just north of Redondo Peak may also be a religious site.

Several Jemez religious societies are known to use Redondo Peak. Each summer the Underworld Chiefs' Society makes a pilgrimage to the peak; the nature of the associated ritual is considered secret. Other Jemez societies that use the peak are the Arrow, Eagle, and Mountain Lion societies. Although the Eagle Catchers once used Redondo Peak regularly, they reportedly have been going to a peak in the Sierra de Los Valles adjacent to Turkey Run in recent years. As

Table 3.19. Illustrative list of Pueblo sacred sites

Jemez	Santa Clara	San Juan	Tesuque	Cochiti	San Felipe	Zia
Redondo Peak	Redondo Peak	Redondo Peak	Redondo Peak	Redondo Peak	Redondo Peak	Redondo Peak
Mt. Taylor	Mt. Taylor	Mt. Taylor	Mt. Taylor	Mt. Taylor	Mt. Taylor	Mt. Taylor
Church Canyon	Chicoma	Chicoma	Sandia Mountains	Stone Lions and "Cave Of The Ancestors"		
Soda Dam	Sandia Mountains	Santa Clara Peak	Lake Peak	Tetilla Peak		
Jemez Falls	San Antonio	Conjilon	San Antonio			
Pajarito Peak	Lake Peak	Sandia Crest				
Cerro Toledo[a]	Cerro Toledo[a]	Truchas Peak				
2nd peak north of Redondo[a]	2nd peak north of Redondo[a]	Lake Peak				
		San Antonio				
Peak adjacent to Turkey Run		Area of Bartolome Sanchez Grant				
		Santa Cruz Grant				
		Sebastian Martin Grant				

[a]It is not reported which group uses these sites.

Source: Singley, et al 1979.

indicated in Table 3.19, other Pueblo tribes recognize Redondo Peak as sacred. In the recent past, visits have been made by groups from the Zia, Santa Ana, San Filipe, Santa Domingo, Cochiti, some Pueblos north of Santa Fe, and the Jemez. The specific time, place, and nature of such visits are not known to outsiders, and the frequency of current visitation is not documented. Some of the tribes, but not all, claim Redondo Peak as a boundary marker.

All springs in the Jemez Mountains are regarded as sacred sites by the pueblos (Hecker letter to Rogowsky, Appendix J). There are two known sacred water bodies within 8 miles of the project area.

There are numerous other known sacred sites throughout the Rio Grande Valley, but they are well removed from the project area.

3.2 TRANSMISSION CORRIDORS

Two routes have been proposed for a 115-kV transmission line from the Baca Power Plant to the TA-3 substation (see Sect. 2.2.4). A major consideration in selection of the routes was the minimization of potential visual impacts, particularly the avoidance of crossing the Valle Grande — a valuable scenic resource. Only one route will ultimately be chosen for the construction of the transmission line. Corridors approximately 1.6 km wide (1 mile) have been chosen along both proposed transmission routes for consideration of potential environmental consequences of transmission line construction. Figures 2.9 and 3.25 illustrate the two proposed transmission corridors, labelled corridor 1 (the Baca corridor) and corridor 2 (the southern corridor). Alternative links within each corridor are labelled by letters (X, Y, Z, for corridor 1 and A, B, C, D for corridor 2).

The following synopsis of the existing environment along both corridors makes frequent reference to regional environmental information presented in Sect. 3.1. Also Table 3.20 summarizes salient environmental characteristics for both corridors. Certain detailed environmental information is lacking at the present stage of corridor selection. After

Table 3.20. Environmental characteristics for the two proposed transmission corridors from the Baca plant to the TA-3 substation. Corridor 1 is the Baca corridors, corridor 2 is the southern corridor (refer to Figs. 3.25 and 2.9)

	Corridor 1 (Baca)	Corridor 2 (southern)
Right-of-way characteristics		
Total length, km	32–35[a]	37–41.5[a]
Land ownership along corridor, km		
Private – Baca	20–23	10.5
Private – Other	0	~1
DOE	5	8
USFS	7	14.5–15[a]
NPS	0	3.5–6.5
Land use characteristics		
Perennial streams crossed	1	2
Intermittent "and/or canyons crossed"	5	9–11[a]
Number of residential areas traversed	0	1
State highway (NM-4) crossings	1[b]	3[b]
Forest Route crossing	1	4
Trails/unimproved road crossings	1	1[c]
LASL area roads	3[d]	3[d]
Ecological characteristics[e]		
% right-of-way within		
Forests	70–75	100
Clearcuts	15–25	0
Meadows	4.5–8.5	0
Elk use areas, km	4–8[f]	Up to 9.5
Salamander habitat, km	2.5[g]	8
Visual considerations		
% right-of-way within		
Retention areas	4.5	13
Partial areas	21.5	53.5
Modification areas	52	22
Maximum areas	26	11.5
Number of crossings of travel routes:		
Sensitivity one	2	5
Sensitivity two	0	2
Number of sensitivity one use areas potentially affected by right-of-way	2	2

[a]Varies according to alternative link chosen.

[b]Includes 1 crossing of West Jemez Road which is an alternate of NM-4.

[c]May cross 1 or more – depends upon exact placement of right-of-way in vicinity of Los Conchos campground and the East Fork of the Jemez River.

[d]Not including the West Jemez Road (corridor 2 parallels an access road through TA-16 for about 2 km, both corridors parallel an access road north of TA-22 and TA-40 for about 1.6 km).

[e]Because exact placement of right-of-way not determined, these are rough estimates.

[f]Two links cross calving areas on the Cerro del Medio.

[g]These 2.5 km are known habitat. An unknown portion of an additional 5 km on the eastern rim of the caldera could be potentially habitat.

one of the proposed corridors has been selected, detailed engineering, environmental, and archaeologic surveys will be made. Final centerline placement of the 30-m (100-ft) right-of-way within the chosen corridor will be determined by the results of these studies and by negotiation with landowners or land management agencies involved.

Route description

Corridor 1 — Baca corridor

Corridor 1, or the Baca corridor, is about 32 to 35 km in length, depending upon which alternate link is selected, and crosses the Baca Location to the east en route to the TA-3 station (see Figs. 2.9 and 3.25). The corridor exits the plant site and crosses Redondo Creek, trending northeast to leave Redondo Canyon at the saddle about 3.2 km up-canyon from the proposed plant site. The Baca corridor then trends east-northeast, remaining for about 3.2 km within a clear-cut area on the lower slopes of Redondo Border. After leaving the clear-cut area, the corridor stays within stands of mixed-conifer forest on the northwestern slopes of the Jaramillo Creek at the point along the creek where the marshy meadow habitat is narrowest. The corridor then traverses the lower south slopes of the Cerro del Abrigo, many of which have been clear-cut. After exiting the clear-cut areas near the Puerta del Abrigo, corridor 1 divides into three links.

The northern link, X, crosses almost 3.2 km of meadow within the Valle Toledo and ascends the Cerros de los Posos at a saddle. Link X then trends southeast within the mixed-conifer forest on the north slopes of these hills. The link then turns almost due south along the Sierra de los Vallos leaving the Baca Location near the exit of the natural gas pipeline, just southeast of the Valle de los Posos.

The middle link, Y, remains south of the Valle Toledo, on the north slopes of the Cerro del Medio which have been clear-cut. Link Y then crosses a narrow portion of the Valle Toledo, crossing San Antonio Creek, and ascends the Cerros de los Posos to join the northern link X at the saddle.

The southern link, Z, of the corridor also remains south of the Valle Toledo, traversing more of the clear-cut lower north slopes of the Cerro del Medio than the other two links. Link Z then crosses the narrow neck of marshy grassland along the East Fork of the Jemez River south of the Valle de los Posos and ascends the spruce-fir forested slopes of the Sierra de los Valles to join the other two links and leave the Baca Location as a single corridor.

After the Baca corridor exits the Baca Location, it enters the Santa Fe National Forest and descends the steep slopes of the eastern rim of the Valles Caldera. Almost immediately, the corridor crosses the Guaje Trail. It also crosses an upper arm of Los Alamos Canyon to follow a route north of the Pajarito ski area and south of Los Alamos Canyon. The corridor parallels FR-1 (Camp May road) for about 4 km.

The Baca corridor then crosses the West Jemez road and enters the Department of Energy lands that comprise the Los Alamos Scientific Laboratory Technical Sites. Within the LASL reservation the corridor trends southeast across Two-Mile Mesa, between Technical Areas 2 and 3. It then turns due north between Technical Areas 2 and 23 to parallel an existing transmission line, crossing the Pajarito road before entering the TA-3 substation.

Corridor 2 — southern corridor

Corridor 2, or the southern corridor, leaves the plant and crosses south across the Baca Location (see Figs. 2.9 and 3.25). The corridor is from 37 to 41.5 km in length, depending upon which alternative link is followed. The southern corridor leaves the plant site, crosses Redondo Creek, and turns to the south-southwest along the lower northwest-facing slopes of Redondo Peak. The line skirts the Banco Bonito, a large meadow south of Redondo Peak, and turns southeast, crossing El Cajete Canyon, through which an intermittent stream flows. The southern corridor then parallels the southern boundary of the Baca Location for approximately 1.6 km before crossing into the Santa Fe National Forest into which it extends for 8 km.

Upon entering the forest, the southern corridor turns southeast and crosses the East Fork of the Jemez River and NM-4 in the vicinity of the Los Conchas Campground. The corridor turns south for about 1 km and crosses FR-280 (Peralta Road). The route then turns east and almost immediately divides into two links.

The northern link A turns northeast and crosses the southern part of FR-268 (Bland Canyon road). Link A then trends parallel to FR-268 and FR-289 (the Dome road) for about 1 km before reentering a small corner of the Baca Ranch where it is joined by link B from the south.

Link B traverses a section of the Santa Fe forest about 1.5 km south of link A. Like A, link B also crosses the southern section of FR-268. However, link B traverses a portion of the Primos Hermanos private inholding, which is partially subdivided for second home development. Link B then trends northeast to join link A.

After links A and B rejoin, the corridor crosses a corner of the private Baca Ranch for less than 1 km, parallelling FR-289. The corridor then enters a portion of Bandelier National Monument which was acquired in 1976 from the private owners of the Baca Ranch (with all geothermal leases and easements intact). Within the monument the corridor divides into two links again.

Link C trends northeast, paralleling FR-289 and then NM-4 for just over 3 km. Link C then crosses NM-4 and ascends the lower slopes of the Cerro Grande, to avoid crossing Frijoles Canyon. Link C then joins link D and exits to National Forest Land.

Link D does not avoid upper Frijoles Canyon, but crosses both its east and west arms. Link D crosses NM-4 east of Frijoles Canyon within the Monument and joins link C to leave NPS land and reenter the Santa Fe National Forest as one corridor.

Within the forest the southern corridor trends northeast for about 1.5 km to cross Water Canyon, then trends southeast for about 2 km and enters the DOE LASL reservation. The corridor crosses the West Jemez road just south of Technical Area 9. Within the LASL reservation the corridor traverses the west portion of TA-9 and parallels an access road for about 2 km. The southern corridor then turns north, away from the access road, and follows the same route as the Baca corridor for the remainder of the route to the TA-3 substation.

3.2.1 Land ownership and use

The following summarizes land ownership and present land use along the two proposed corridors. The reader is referred to Sect. 3.1.1 for land use information and maps for the general study region which includes the transmission corridors. Table 3.18 presents salient land use characteristics for both corridors.

Corridor 1 — Baca corridor

The Baca corridor crosses from 20 to 23 km of the privately owned Baca Ranch. Present land use along the corridor is for cattle grazing and some private recreation. Clear-cut logging practices have severely altered some portions of the Baca Ranch. However, logging is no longer practiced on the ranch. Much of corridor 1 within the Baca Ranch utilizes these clear-cut areas (see Table 3.18). Sections of the corridor also cross meadow grazing areas.

The Baca corridor crosses about 7 km of the Santa Fe National Forest as the route descends the steep eastern slopes of the Valles Caldera. This portion of the forest is extensively used by Los Alamos residents for day-use recreational activities such as hiking, picnicking, cross-country skiing, horseback riding, and ORV use. The Baca corridor will be adjacent to and visible from the Pajarito Ski area and FR-1 (Camp May road), the road to the ski area. The Forest Service lands are also used for timber production. Almost the entire Santa Fe Forest portion of this Baca corridor passes through large mature timber of commercial size.

The Baca corridor crosses about 5 km of DOE-owned land that comprises the LASL Technical Sites. The land is used exclusively for a variety of research and support activities and as open land for security around the technical areas.

Corridor 2 — southern corridor

The initial 9.5 km of the southern corridor cross the private Baca Ranch; an additional 1 km of the ranch is crossed again by the corridor as it leaves USFS land and enters the Bandelier Monument. This southern section of the Baca Ranch has not been extensively logged.

The southern corridor traverses about 11 km of the Santa Fe Forest south of the Baca Ranch and then another 3-4 km of USFS land between Bandelier National Monument and the LASL reservation. Activities occurring in the USFS land include selective logging, grazing, and heavy recreational use, especially in the section south of the Baca Ranch. Some of the Santa Fe Forest south of the Baca has been leased for geothermal exploration and development.

The southern corridor crosses about 3.5 to 6.5 km of the Bandelier National Monument administered by the National Park Service. This parcel of the Monument was acquired (with geothermal rights intact) from the private owners of the Baca Ranch to protect the Upper Frijoles watershed and the cultural resources located in the parcel (Wirth Associates 1979). Current use of this land is restricted to recreation.

After leaving the Bandelier Monument, the southern corridor traverses 3-4 km of the Santa Fe National Forest and enters DOE land on the LASL reservation. For the final 8 km, the south corridor remains on DOE land to its terminus at the TA-3 substation.

3.2.2 Ecology

The ecological communities of the study region including the transmission corridors are discussed in Sect. 3.1.5, which includes a vegetation map. The final statement for the LASL reservation (DOE 1979) also includes a vegetation map of the LASL area and a discussion of ecology of the LASL reservation. Table 3.18 summarizes environmental characteristics for both corridors. Detailed vegetation and faunal studies have not been done along either corridor.

Corridor 1 — Baca corridor

The Baca corridor crosses a total of approximately 1-3 km of *valles* meadow habitat on the Baca Location. About 6.5 km of the corridor utilizes portions of the Baca Ranch which have been previously clearcut. The remainder of the Baca corridor is within heavily forested areas. Because of the indistinct boundaries between the mixed conifer and spruce-fir vegetation types, it is difficult to determine exactly how much of the corridor traverses each type. Generally the steep eastern slopes of the caldera east of the Baca Location are forested by the spruce-fir type. Therefore, approximately 7 km of the Baca corridor may be in spruce-fir forests. About 5.5-6 km of the Baca route (mostly on the LASL reservation), is in ponderosa pine forest. The remainer of the forested land on the Baca Ranch and on the Santa Fe Forest crossed by the Baca corridor is within the mixed conifer vegetation type. Almost all the forested land crossed by the corridor, except for the logged areas on the Baca Ranch, has timber of commercial size. The forests on the eastern side of the caldera consist of large mature trees.

The Baca corridor crosses elk year-round habitat within Redondo Canyon. Also links Y and Z cross identified elk calving areas on the Cerro del Medio (see Sect. 3.1.5) in the eastern half of the Baca Ranch. The eastern slopes of the caldera are a summer use area for elk (DOE 1978), but the Baca corridor crosses north of the heavy use identified by LASL.

Because the Baca corridor utilizes mostly south-facing slopes and clear-cuts on the Baca Ranch, except for Redondo Canyon little potential salamander habitat is crossed. Only the initial 3-4 km of the corridor crosses identified salamander habitat in Redondo Canyon. No salamanders have been collected from the Santa Fe Forest land east of the Baca traversed by corridor 1. However, it is possible that the habitat is present since much of this area is heavily forested with spruce fir.

Both corridors cross areas within Redondo Canyon where five species of plants identified as rare in the State of New Mexico may be found (see Sect. 3.1.5.3.1). Also a species of plant on the Federal list (threatened)

Pediocatus papyracanthus, is found in the Los Alamos vicinity, where the corridors terminate.

Corridor 2 — southern corridor

The south corridor crosses less than 1 km of meadow habitat, just south of Redondo Canyon. It crosses the East Fork of the Jemez River in a forested area between meadows. Because this corridor utilizes, for the most part, south slopes below 2745 m (9000 ft), it crosses little spruce-fir forest. Only about 1.5 km of the corridor just east of Bandelier Monument is within this vegetation type. Almost the entire portion of the corridor within the LASL reservation is in ponderosa pine forest. The remainder of the corridor is within mixed conifer forest. About 3.2 km of the corridor traverses portions of the Santa Fe Forest that have been selectively logged. The major portion of the southern corridor is within forests of commercial-size timber.

The southern corridor crosses known elk summer and winter habitat in Redondo Canyon and crosses about 1.5-2.5 km of the Banco Bonito, an identified elk wintering area (U.S. Forest Service 1977). The southern corridor crosses about 4 km of an area of heavy elk summer use identifed in the LASL statement (DOE 1979).

The southern corridor traverses some known habitats of the Jemez Mountains salamander including approximately 3.2 km of north-facing lower slopes within Redondo Canyon (see Sect. 3.1.5.3.2). After crossing the East Fork of the Jemez River, the corridor turns south to avoid the main concentration of salamander habitat described by Reagen (1967, 1972) on the north-facing slopes of the Sierra de Los Valles (see Fig. 3.22). Both link A and link B, however, cross the Canyon del Norte, where Reagen lists a number of collection sites (see Fig. 3.22). Link B traverses the head of Pines Canyon, where Reagen (1967) collected the species from south-facing slopes. Sections of the corridor within Bandelier National Monument and east of the Baca Location in the Santa Fe National Forest cross areas where, according to isolated records, the salamander also exists (New Mexico Heritage Program 1978). A total of 8 km of the southern corridor crosses salamander habitat.

3.2.3 Soils

The following is a description of soil types along both corridors. Refer to the maps of soil types for the study region in Sect. 3.1.2. Characteristics of the soil types and maps of soils along the corridors may be found in Table 3.2.

Northern

Corridor 1 — Baca corridor

There are 30 soil mapping units identified exclusively along the Baca corridor outside of the project site. Of this number, two (6.6%) have severe erodibilities; seven (23%) of the units have overall (general sensitivity to transmission line construction) ratings of severe. The majority (18, or 60%) are characterized by moderate erodibility; 9 units (30%) have general sensitivity ratings of slight to moderate or moderate.

Southern

Corridor 2 — southern corridor

There are 33 soil mapping units coincident with the southern transmission line corridor. Six percent (2 units) of these soils have severe erosion potential; the majority (60% or 20 units) are characterized by moderate erodibility. The general sensitivity to transmission line construction category ranges from slight to moderate hazard potential to severe. Nineteen (57%) of the soil mapping units have severe sensitivity ratings; six (18%) are rated moderate.

3.2.4 Archaeology

Detailed archaeology surveys have not been done for either corridor. Normally such surveys are done in conjunction with other environmental and engineering surveys when the route selection process has narrowed the right-of-way selection. This project has not yet progressed to this point. However, an archaeological analysis and predictive study has been conducted for a broad corridor of land to the east and south of the Baca site (Camilli 1979). The Camilli study considers the archaeologial potential of various types of habitat based on current archaeologic findings in the surrounding vicinity. The purpose of the study was to provide baseline data for further archaeological investigation when a definite transmission line alignment is made. The methodology used in the study utilizes LANDSAT satellite imagery to stratify environmental zones, along with archival research, to obtain existing archaeological data and to predict archaeological site type and density in presently unknown corridors of the transmission study areas. This study provides a base of quantifiable analysis for alternative transmission corridors in the route selection process as well as background data for the inventory field survey which will be conducted after a specific transmission line alignment is made.

Utilizing the Camilli study, PNM has determined (Public Service Company of New Mexico 1979) that the southern corridor (corridor 2) has a 22% greater probability for encountering archaeologic resources than the Baca corridor (corridor 1). This determination is based partly on the southern corridor's greater length and partly on the fact that it traverses a portion of the Bandelier Monument where cultural resources are known to exist. Additionally Bandelier National Monument in its entirety is currently listed in the National Register of Historic Places (U.S. Department of the Interior 1979a).

3.2.5 Visual resources

Section 3.1.9 contains a discussion of visual resources of the study region including the two proposed corridors. Figure 3.25 is a map showing sensitivity one and two travel routes and use areas and indicating the proposed corridors. Table 3.18 indicates the percentage of each corridor within each of four Visual Quality Management Objective Classes (there are no Preservation areas) crossed. Appendix D contains a discussion of the Management Objective classes.

Corridor 1 — Baca corridor

The Baca corridor remains out of view of public use areas and travel routes for almost its entire length on the Baca Location. As it descends the slopes of the eastern caldera rim, it crosses near the Pajarito Ski area and Camp May and parallels FR-1 (Camp May road). It crosses the West Jemez road (NM-4 alt.) and the Pajarito road within the LASL Technical Sites. All these travel routes and use areas are sensitivity one. About 7 km of the Baca route is within an area (Fig. 3.2) identified by the Forest Service as having high scenic value and heavy recreation use and recommended as being excepted from geothermal development (U.S. Forest Service 1977).

Corridor 2 — southern corridor

About 4 km of this corridor crosses an area designated as scenic and having heavy recreation use by the U.S. Forest Service (1977). In addition, the U.S. Forest Service (1977) recommended that the land in this proposed corridor be excepted from geothermal leasing because of its recreational and scenic value. The corridor crosses the East Fork of the Jemez and NM-4 near the Los Conchas Campground; all are sensitivity one areas. It crosses FR-280 (Peralta Canyon road) and the southern section of FR-268 (the Bland Canyon road), which are sensitivity two travel routes. The southern corridor crosses FR-268 and FR-289 (Dome road) where they are sensitivity one. The corridor then parallels FR-289 for about 2 km. Additionally it crosses NM-4 and West Jemez road (NM-4 alt.) and the Pajarito road — all sensitivity one.

REFERENCES FOR SECTION 3

Albright, J. N., et al. 1978. "Environmental Studies," pp. 249-267 in *Hot Dry Rock Geothermal Energy Development Project, Annual Progress Report for FY-1977,* LA-7109-PR, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Ayensu, E. S., and R. A. DeFilipps. 1978. *Endangered and Threatened Plants of the United States*, Smithsonian Institution and World Wildlife Fund, Washington, D.C.

Bachman, G. O., and H. H. Mehnert. 1978. "New K-Ar Dates and the Late Pliocene to Holocene Geomorphic History of the Central Rio-Grande Region, New Mexico," *Geol. Soc. Am. Bull.,* Vol. 89, pp. 283-292.

Bailey, R. G., 1978. *Description of the Ecoregions of the United States*, U.S. Dept. of Agriculture, Forest Service, Ogden, Utah.

Broilla, Frank J., et al. 1978. *An Investigation into High Altitude Adaptations — the Baca Geothermal Project*, Office of Contract Archaeology, Univ. of New Mexico, October 1978.

Budding, A. J. 1978. *Gravity Survey of the Pajarito Plateau, Los Alamos and Santa Fe Counties, New Mexico,* Informal Report No. LA-7419-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Camilli, E. 1979. *Regional Cultural Resource Predictive Study for the Baca Geothermal Project*, Public Service Company of New Mexico.

Cantu, J. M. 1979. *Visual Resource Inventory for the Proposed Baca Geothermal Project.* Public Service Company of New Mexico.

Conover, C. S., C. V. Theis, and R. L. Griggs. 1963. *Geology and Hydrology of Valle Grande and Valle Toledo, Sandoval County, New Mexico,* U.S. Geological Survey Water-Supply Paper No. 1619-Y.

Cordell, L. 1978. "Regional Geophysical Setting of the Rio Grande Rift," *Geol. Soc. Am. Bull.,* Vol. 89, pp. 1073-1090.

Cushman, R. L., and W. D. Purtymun. 1975. *Evaluation of Yield and Water-Level Relations,* Informal Report No. LA-6086-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Cushman, R. L., S. G. Hildebrand, R. H. Strand, and R. M. Anderson. 1977. *The Toxicity of 39 Trace Elements in Coal to Freshwater Biota: A Data Base with Automated Retrieval Capabilities,* ORNL/TM-5793. Oak Ridge National Laboratory, Oak Ridge, Tenn.

Daugherty, L. A., and B. A. Buchanan. 1979. *Soil Inventory for the Proposed Baca Geothermal Project.* Public Service Company of New Mexico.

Dondanville, R. F. 1978. "Geologic Characteristics of the Valles Caldera Geothermal System, New Mexico," *Geothermal Resources Council Trans.,* Vol. 2, pp. 157-159.

Eddy, S., and J. C. Underhill. 1974. *Northern Fishes,* Univ. Minnesota Press, Minneapolis.

Edwards, C. L., M. Reiter, C. Shearer, and W. Young. 1978. "Terrestrial Heat Flow and Crustal Radioactivity in Northeastern New Mexico and Southeastern Colorado," *Geol. Soc. Am. Bull.,* Vol. 89, pp. 1341-1350.

Fitzsimmons, J. P. 1975a. "Evaluation of the Valles Caldera, New Mexico." Unpublished report for the National Park Service, National Natural Landmark Program.

Fitzsimmons, J. P. 1975b. "Natural Landmark Brief — Valles Caldera." Unpublished report for the National Park Service, National Natural Landmark Program.

Flavill, P., and W. G. Whitford. 1978. *The Biota of Redondo Creek — Union Baca Geothermal Exploration Site — Sandoval Co., New Mexico,* Whitford Ecological Consultants, Las Cruces, N.M.

Griggs, R. L., and J. D. Hem. 1964. *Geology and Groundwater Resources of the Los Alamos Area, New Mexico,* U.S. Geological Survey Water-Supply Paper 1753.

Hubbard, J. B., et al. 1978. *Handbook of Species Endangered in New Mexico*, New Mexico Dept. Game and Fish.

Issacs, W., Director, New Mexico Heritage Program. 1979a. Personal communication (telephone conversation) with K. M. Oakes, Oak Ridge National Laboratory, Jan. 12, 1979.

Issacs, B. F. 1979a. Letter to D. Sabo, Public Service Company of New Mexico, Feb. 13, 1979.

Issacs, B. F. 1979b. Letter to D. Sabo, Public Service Company of New Mexico, Feb. 15, 1979.

Issacs, B. F. 1979c. Telephone conversation with K. M. Oakes, Oak Ridge National Laboratory, June 5, 1979.

Keller, M. D., compiler. 1968. *Geologic Studies and Material Properties Investigations of Mesita de Los Alamos,* Report No. LA-3728, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Kintzinger, P. R., C. B. Reynolds, F. G. West, and G. Suhr. 1978. *Seismic Reflection Surveys Near LASL Geothermal Site,* Informal Report No. LA-7228-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Kirkpatrick, T. O. 1965. *The Economic and Social Values of Hunting and Fishing in New Mexico,* Bureau of Business Res., Univ. New Mexico, Albuquerque, N.M.

Koster, W. J. 1957. *Guide to the Fishes of New Mexico,* Univ. New Mexico Press, Albuquerque, N.M.

Koster, W. J., Univ. of New Mexico. 1978. Personal communication.

Laughlin, A. W., and A. Eddy. 1977. *Petrography and Geochemistry of Precambrian Rocks from GT-2 and EE-1,* Informal Report No. LA-6930-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Moody, T. M., New Mexico Department of Fish and Game. 1978. Personal communication — meeting with J. G. Wiener, Oak Ridge National Laboratory, Oak Ridge Tenn., November 1978.

Moody, T. M. 1979. Telephone conservation with J. G. Wiener at Oak Ridge National Laboratory, Oak Ridge, Tenn., June 13, 1979.

Mountain West Research, Inc. 1978a. Private conversation with business manager of Building Trades Council, Nov. 6, 1978.

Mountain West Research, Inc. 1978b. Private discussion with the Director of Construction Industries Division, State of New Mexico, Nov. 8, 1978.

Mountain West Research, Inc. 1979. *Proposed Baca Geothermal Demonstration Project — Socioeconomic Analysis,* prepared for the Public Service Company of New Mexico (in preparation).

National Park Service. 1975. "Additions to the National Registry of Natural Landmarks," *Fed. Regist.* 40(169): 39911, Aug. 29, 1975.

New Mexico Game and Fish Department. 1974, 1975, 1977. Winter aerial census data for Jemez Mountains.

New Mexico Heritage Program. 1978. Search of computerized data files, December 1978.

New Mexico Heritage Program. 1979. *Baca Ranch: Unique Wildlife Ecosystem Study Site,* report to U.S. Fish and Wildlife Service.

New Mexico State Legislature. 1974. "Wildlife Conservation Act," (Sects. 53-2-50 through 53-2-29, *New Mexico Statutes Annotated*), Feb. 20, 1974.

Nyhan, J. W., L. W. Hacker, T. E. Calhoun, and D. L. Young. 1978. *Soil Survey of Los Alamos County, New Mexico,* Informal Report No. LA-6779-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Patterson, R. R. 1977. "Postal Survey to Determine Angler Use and Harvest," New Mexico Dept. of Fish and Game, Santa Fe, N.M.

Pettitt, R. A. 1976. "Environmental Monitoring for the Hot Dry Rock Geothermal Energy Development Project, Annual Report for the Period July 1975–June 1976," LA-6504-SR, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Pilz, W. R., and D. G. Sabo. 1979. *Biotic Inventory Baseline Studies for the Transmission System for the Proposed Baca Geothermal Project*, Public Service Company of New Mexico, Albuquerque, N.M.

Public Service Company of New Mexico. 1979. *Environmental Assessment of Alternative Transmission Line Routes for the Baca Geothermal Project*, 22 pp.

Purtymun, W. D. 1973. *Geology of the Jemez Plateau West of Valles Caldera*, Informal Report No. LA-5124-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Purtymun, W. D. 1977. *Hydrologic Characteristics of the Los Alamos Well Field, with Reference to the Occurrence of Arsenic in Well LA-6*, Informal Report No. LA-7102-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Purtymun, W. D. 1978. *Water Supply at Los Alamos During 1977*, Informal Report No. LA-7436-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Purtymun, W. D., and J. B. Cooper. 1969. *Development of Ground-Water Supplies on the Pajarito Plateau, Los Alamos County, New Mexico*, U.S. Geological Survey Prof. Paper 650-B, pp. B149-B153.

Purtymun, W. D., and S. Johansen. 1974. *General Geohydrology of the Pajarito Plateau*, New Mexico Geological Society Guidebook, 25th Field Conference, pp. 347-349.

Purtymun, W. D., W. H. Adams, and A. K. Stoker. 1978. *Water Quality in Vicinity of Fenton Hill Site, 1976,* Informal Report No. LA-7307-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Purtymun, W.D., F. G. West, and W. H. Adams. 1974. *Preliminary Study of the Quality of Water in the Drainage Area of the Jemez River and Rio Guadalupe,* Informal Report No. LA-5595-MS, Los Alamos Scientific Laboratory, Los Alamos, N. M.

Ramberg, I. V., F. A. Cook, and S. B. Smithson. 1978. "Structure of the Rio Grande Rift in Southern New Mexico and West Texas Based on Gravity Interpretation," *Geol. Soc. Am. Bull.*, Vol. 89, pp. 107-123.

Rea, K. H. 1977. *Environmental Investigations Associated with the LASL Hot Dry Rock Geothermal Energy Development Project,* Report No. LA-6972, Los Alamos Scientific Laboratory, Los Alamos, N.M.

Reagen, D. P. 1967. *Aspects of Life History and Distribution of the Jemez Mountains Salamander,* Plethodon neomexicanus, M.S. thesis, Univ. of New Mexico, Albuquerque, N.M.

Reagen, D. P. 1972. *Ecology and Distribution of the Jemez Mountains Salamander,* Plethodon Neomexicanus, *Copeia* 1972(3): 486-492.

Sando, T. 1979. *Hearing on the Draft Environmental Impact Statement Geothermal Demonstration Program - Before the All Indian Pueblo Council,* Aug. 16, 1979.

Savage, W. U., R. W. Ely, and D. Tocher. 1977. *Review of the Los Alamos Seismic Monitoring Program in Relation to the Hot Dry Rock Geothermal Project,* prepared for Los Alamos Scientific Laboratory by Woodward-Clyde Consultants, San Francisco, Calif.

Siebertson, H., Santa Fe National Forest. 1979. Personal communication (telephone conversation) with K. M. Oakes, Oak Ridge National Laboratory, Jan. 18, 1979.

Singley, J., T. McDowell, and M. McNamara-Pastor. 1979. *Baca Ranch Geothermal Demonstration Program - A Background Study of Pueblo Indian Religious Freedom,* prepared for the Assistant Secretary for Environment, U.S. Department of Energy, November 1979.

Sneider, Walt, New Mexico Game and Fish Department. 1978. Personal communication (meeting) with K. M. Oakes, Oak Ridge National Laboratory, October 1978.

Spellenberg, R. W., New Mexico State Univ. at Las Cruces. 1979. Personal communication (telephone conversation) with K. M. Oakes, Oak Ridge National Laboratory, Feb. 9, 1979.

Stuart, J. E. B., and A. G. Christensen. 1973. "The Status of the Black-Footed Ferret in New Mexico," in "The Black-Footed Ferret and Prairie Dog Workshop," South Dakota State Univ., Brookings, S.D.

Sweeney, J. M. 1975. *Elk Movements and Calving as Related to Snow Cover,* Ph.D. dissertation, Colorado State Univ., Fort Collins, Col.

Trainer, F. W. 1974. *Ground Water in the Southwestern Part of the Jemez Mountains Volcanic Region, New Mexico,* New Mexico Geological Society Guidebook, 25th Field Conference.

Trainer, F. W. 1975. *Mixing of Thermal and Nonthermal Waters in the Margin of the Rio Grande Rift, Jemez Mountains, New Mexico,* New Mexico Geological Society Guidebook, 26th Field Conference.

Trainer, F. W. 1978. *Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico,* U.S. Geol. Survey Water Resources Investigation 77-131.

Union Oil Company of California, *Technical Memoranda 1974-1976,* Research Department, Union Research Center, Brea, Calif.

Union Oil Company of California and Public Service Company of New Mexico. 1978. *Baca Geothermal Demonstration Plant Project Proposal.*

U.S. Department of Energy. 1979. *Final Environmental Impact Statement — Los Alamos Scientific Laboratory Site,* DOE/EIS-0018, Los Alamos Scientific Laboratory, Los Alamos, N.M., December 1979.

U.S. Department of the Interior. 1979a. "National Register of Historic Places," *Fed. Regist.* 44(26) (Tuesday, Feb. 6, 1979).

U.S. Fish and Wildlife Service, Department of the Interior. 1977. "List of Endangered Fauna," *Fed. Regist.* 42(135).

U.S. Forest Service, Dept. of Agriculture. 1974. "National Forest Landscape Management," in *The Visual Management System, Agriculture Handbook 462,* vol. 2, ch. 1, U.S. Government Printing Office, Washington, D.C.

U.S. Forest Service. 1977. *Environmental Statement — Geothermal Leasing — for Santa Fe National Forest,* U.S. Forest Service, S.W. Region, Albuquerque, N.M.

U.S. Forest Service. 1979. *Summary — Final Environmental Impact Statement for the Roadless Area Review and Evaluation — RARE II,* U.S. Forest Service, Department of the Interior.

U.S. Forest Service and Earth Environmental Consultants, *Soils Information for the Proposed Baca Geothermal Project,* Public Service Company of New Mexico, 1979.

U.S. Department of the Interior. 1979b. *A Study of Alternatives for the Valles Caldera,* National Park Service, Denver Service Center.

U.S. Geological Survey. 1965. "Mineral and Water Resources of New Mexico," *N.M. Bur. Mines Miner. Resour. Bull.* No. 87.

U.S. Heritage Conservation and Recreation Service. 1978. *Fed. Regist.* 43(82): 18049-18055 (Apr. 27, 1978).

U.S. Senate. 1970. "Pueblo de Taos Indian Cultural and Ceremonial Shrine Act of 1970," *Congressional Record,* pp. 39586-39607, Washington, D.C.

Water Resources Associates, Inc. 1977. *Hydrology, Jemez Mountains, New Mexico,* Scottsdale, Ariz.

Weahkee, C. J. 1979. *Hearing on the Draft Environmental Impact Statement — Geothermal Demonstration Program — Before the All Indian Pueblo Council,* Aug. 16, 1979.

West, F. G. 1973. *Regional Geology and Geophysics of the Jemez Mountains,* Informal Report No. LA-5362-MS, Los Alamos Scientific Laboratory, Los Alamos, N.M.

White, Gary C., Los Alamos Scientific Laboratory. 1979. Computer-generated plottings of fixes on radio-collared elk.

Whitford, W. G. 1974. *The Biota of Redondo Creek Canyon, Sandoval County, NM: with Emphasis on Big-Game Species and Rare and Endangered or Threatened Species,* Southwest Environmental Research and Development Corporation report to Union Oil.

Whitford Ecological Consultants. 1975a. *Winter Activity and Habitat Use by Elk in the Redondo Creek Area with Comments on Activities and Relative Abundance of Other Species,* prepared for Union Oil — Geothermal Division.

Whitford Ecological Consultants. 1975b. *The Biota of the Baca Geothermal Site,* report to Union Oil — Geothermal Division.

Whitford Ecological Consultants. 1975c. *Studies of Rare and/or Endangered Species of the Union-Baca Geothermal Lease and Surrounding Area (with Discussion of Other Species)*, prepared for Union Oil Geothermal Division.

Wilbur, A. 1979. Memorandum to William Manning, San Francisco Operations Office, U.S. Department of Energy, Sept. 5, 1979.

Williams, S. R. 1972. *Reproduction and Ecology of the Jemez Mountains Salamander,* Plethodon neomexicanus, M.S. thesis, Univ. of New Mexico, Albuquerque, N.M.

Williams, S. R. 1976. *Comparative Ecology and Reproduction of the Endemic New Mexico Plethodontid Salamanders,* Plethodon neomexicanus *and* Aneides hardii, Ph.D. dissertation, Univ. of New Mexico, Albuquerque, N.M.

Wirth Associates. 1979. *Land-Use Inventory for the Proposed Baca Geothermal Project,* prepared for Public Service Company of New Mexico and Union Geothermal Company.

Woody, Jack, U.S. Fish and Wildlife Service. 1978. Personal communication (meeting) with K. M. Oakes, Oak Ridge National Laboratory, October 1978.

4. IMPACTS OF THE PROPOSED PROJECT

SUMMARY OF CHANGES

This section contains expanded analyses of the impact on future public ownership of the Baca Ranch (4.1.1); archaeological, cultural, and religious issues (4.1.7); water quality (4.2.2); air quality (4.2.3); the effects of accidents (4.3.3); transmission lines (4.4.1); and potential full-scale development (4.5).

4.1 IMPACTS OF CONSTRUCTION OF WELL FIELD AND POWER PLANT

4.1.1 Impacts on land use

Construction of the proposed project will result in a total of approximately 300 ha (740 acres) of land within Redondo Canyon being devoted over the 30-year life of the project to the production of electricity from geothermal resources. This area includes the plant site and all production and injection wells estimated to be required over the 30-year lifetime of the power plant. Well spacing in the reservoir of 8-ha (20-acre) is assumed. The entire well field and plant site are confined to privately owned land. Presently, no private use of the land within Redondo Canyon should be affected by construction and operation of the proposed power plant.

Potential effects on surrounding land uses are possible during both construction and operation of the proposed power plant and well field. Section 3.1.1.3 details the location of residential areas, predominantly second-home developments, with respect to project activities. The nearest residence is 3 km from the main project site. At the nearest residence, noise from drilling and well testing should not be detectable above background noise levels (see Sect. 4.1.6). Emissions of hydrogen sulfide from well testing should not raise the ambient levels sufficiently to cause detectable odor at the nearby residences (see Sect. 4.1.3). The only potential source of conflict of project construction with the nearby residences would be increased traffic. Diesel trucks and heavy construction machinery enroute to the project site will pass less than 300 m from some residences in the Deer Canyon–Thompson Ridge area, which is near the entrance to the project site off NM-4. The increased noise and activity from the traffic could be a source of annoyance to the residents. Increased traffic may also adversely impact the Jemez and Santa Ana Reservations and the Zia Pueblo. As stated previously (Sect. 3.1.7.6), approximately 2% of the population of Zia Pueblo was killed in accidents involving semitrucks in the past two years. The increased traffic resulting from construction may increase the chances for accidents. However, the magnitude of this potential increase is not known. Also, the noise and activity resulting from the increased traffic may be a source of annoyance to members of Jemez, Santa Ana, and Zia Pueblos. Mitigation may best be achieved by limiting construction traffic to the daytime hours and by consultation with the residents most affected.

The scenic values of the Jemez Mountains and the relatively heavy recreational use of the public lands surrounding the Baca Location have been described elsewhere in this document (Sects. 3.1.1.2 and 3.1.9). Construction and later operation of the proposed demonstration power plant and well field could be a source of conflict with some recreational uses, both directly and indirectly. During construction, direct effects on visitors to the Santa Fe National Forest recreation areas near the project would accrue mainly from the increase in truck traffic and its attendant noise. Because of their location within a canyon, the main project site and well field are not visible from any recreational use areas. Additionally, the project site is sufficiently far from NM-4 and campgrounds that noise from construction and well testing will not be detectable at these areas. Effects on recreational users from construction-related traffic will be short-term and should not be significant.

Potential indirect conflicts with recreational users would be related to the fact that some of these users will perceive the proposed demonstration power plant as an essentially industrial development that is incompatible with the surrounding natural values of the area. To some recreational users, just the knowledge that a power plant is nearby could reduce their enjoyment of the natural setting. This type of impact is, of course, very subjective and almost impossible to mitigate completely. However, a public view of geothermal energy as a desirable alternative could serve to ameliorate the potential conflict, to some extent. An appropriate public information campaign would aid the development of a positive public view of the proposed project.

Impacts on the Natural Landmark status

The entire Baca Location and Valles Caldera is a national natural landmark (see Sect. 3.1.1.2). Designation as a landmark does not confer any legal protection on private land from private uses that could change the character of the landmark. However, all Federal agencies are required to take cognizance of the sites listed on the National Registry of Natural Landmarks in contemplating any Federal action that would affect a landmark (U.S. Heritage, Conservation, and Recreation Service, 1978). Should the natural integrity of an eligible site deteriorate from either natural or man-induced causes, to the extent that national significance is lost, the site will be removed from the registry. Landmarks are recognized as "nationally significant" areas that are "a true, accurate and essentially unspoiled example of nature" (U.S. National Park Service 1971). The Baca Location/Valles Caldera is largely undeveloped. Although some parts of the Baca Location have been altered by past geothermal drilling, clear-cutting of timber (Appendix B), and construction of ranch buildings, a ski area, and a natural gas pipeline, large portions of the Baca Location/Valles Caldera remain in their natural state. The general impression of the area from public use areas along NM-4 is one of unspoiled natural beauty. Because of its industrial nature, the proposed demonstration power plant and transmission lines will change the present nature of the Baca Location/Valles Caldera that led to its designation as a landmark. Future geothermal development beyond the demonstration plant, encouraged by success of the proposed project, would further reduce the integrity of the area. The Heritage Conservation and Recreation Service (HCRS), which administers the Landmark Program, has been consulted regarding possible conflicts of the proposed project with the landmark status of the Baca Location/Valles Caldera. The Service has determined that the potential for this project constitutes a threat to the integrity of the landmark (U.S. Heritage, Conservation, and Recreation Service 1979).

Impacts on potential future public acquisition

Relationships of the proposed project with plans for possible future public acquisition of the Baca Location/Valles Caldera are difficult to predict. Since the proposed project site is confined to Redondo Canyon in the southwest portion of the caldera, conflicts with public use of most of the caldera would be expected to be minimal.

Redondo Peak offers the best vantage point for a full view of the caldera (U. S. Department of the Interior (1979). The entire proposed 50-MW(e) plant and well field would be visible from the Redondo Peak area. How much of the facility would be visible from the summit of Redondo Peak is not known. However, the plume and portions of the transmission line will be visible from the summit (Paulson 1978). Furthermore, if the Baca transmission corridor is utilized for construction of the 115-kV transmission line, the line would probably be visible from other public use areas within the caldera. It is possible that future plans for public use of the caldera might include the proposed plant as a visitor area to display the country's first use of a liquid-dominated geothermal resource to generate electricity.

However, the Department of the Interior has recommended delaying the project or moving the project to an alternative location so as not to jeopardize public acquisition plans. (See Appendix I, Comments and Responses, pp. I-14 and 15).

A detailed discussion of the extent to which geothermal activities could affect the visitor experience would require information about the future type and level of public use and the location of roads, trail, campgrounds, and interpretive sites. At the present stage of study of public acquisition alternatives for the Valles Caldera, this information is not available (U.S. Department of Interior 1979). The Department of Interior study of alternatives for the caldera adknowledges that geothermal development is a potential threat to the area's natural and cultural resources. Potential conflicts are mentioned in the categories of air quality, water quality, visual impacts, noise, quality of wildlife habitat, and cultural resources. Expanded geothermal development in the caldera, which could be encouraged by the success of the proposed project, could prove, by its industrial nature, to be incompatible with future use of the Valles Caldera as a public preservation or recreation area.

4.1.2 Impacts on water quality and use

Construction activities in Redondo Canyon could accelerate erosion, which would increase suspended sediment loads and turbidity of surface waters and sedimentation of stream bottoms in Redondo Creek and in other downstream aquatic systems. In addition to activities associated with previous exploration and well field development at the Baca Project, current sources of sedimentation in the Redondo Creek and Jemez watershed also include erosion from recent forest fires, clear-cutting, and road construction. During normal flow, water in Redondo Creek is clear (Flavill and Whitford 1978) and undoubtedly does not exceed the State turbidity standard (normal flow) for the Jemez River and its tributaries above Jemez Springs of 25 Formazin turbidity units (FTU). However, the proximity of road and well pad construction activities to the creek provide a potential for erosion and resultant sedimentation. More than one-fourth of the length of Redondo Creek is adjacent to the geothermal development (Sect. 3.1.3.1.1). Although the well pad construction is almost complete, disturbances related to road, pipeline, and plant construction may accelerate erosion in the Redondo Creek watershed throughout the construction period. The applicant plans to use erosion control procedures during and after construction; however, considerable erosion and stream sedimentation may result from roadbuilding and other activities, even when good erosion control procedures are carefully implemented (Beschta 1978; Reed 1978).

The two most probable means of soil transport to Redondo Creek are overland flow (water flowing unchanneled over the soil surface because the infiltration capacity of the soil has been exceeded by rainfall intensity) and mass soil movement (rapid movement of soil down an incline) from adjacent road and well pads. The pumice soils of the area are highly erodible (U.S. Forest Service 1977), and the intense thunderstorms that occur during summer can produce large amounts of overload flow carrying large quantities of sediment to streams (U.S. Geological Survey 1965).

Such storms may also trigger soil movement into Redondo Creek from adjacent roadsides and well pads even though these are carefully constructed and maintained (Beschta 1978). During a visit to the site in August 1978, sedimentation of the streambed of Redondo Creek was apparent at certain areas where an unpaved access road ran adjacent to the creek. Similar observations were recorded during the baseline aquatic ecology survey (Flavill and Whitford 1978).

Suspended silt entering Redondo Creek could be transported considerable distances downstream, even during normal flow. For example, excavation of a pool in San Antonio Creek, immediately above its confluence with Sulfur Creek, caused the stream to be turbid for 3 km (2 miles) downstream during normal flow (Flavill and Whitford 1978). Suspended loads in streams in this region are highest during and immediately after intense rainstorms (U.S. Forest Service 1977). In some circumstances, most likely as a result of severe storms, sediment entering Redondo Creek could reach San Antonio Creek and the Jemez River. Effects of downstream sedimentation on aquatic biota are addressed in Sect. 4.1.4.2.

4.1.3 Air quality

Air quality impacts during construction and well field development will result from fugitive dust and engine emissions and from venting of geothermal wells during flow testing. The dust and emissions will be at a relatively minor level and will be localized to the immediate construction areas and roadways of occurrence. The main road to the project area will be paved. Dust control measures will be utilized where appropriate to minimize releases.

Geothermal fluids contain gases and dissolved solids as discussed in Sects. 2 and 3. During well testing, a period of a few days, these gases will be vented through a submerged discharge tube in the well catchment basin.

There will also be relatively short periods of venting to the atmosphere. Hydrogen sulfide will be the only emission of concern during this period and will be released at an estimated rate of 25 to 50 lb/hr per venting well. When a well is flow tested the operator must measure the release of hydrogen sulfide to the atmosphere; if it is less than 10 lb/hr then a permit is not required and that release rate is interpreted by the State as meeting the air quality standard for hydrogen sulfide at the project boundary for flow testing.

A permit is required for a release greater than 10 lb/hr, but the State makes a determination for each well as to whether the air quality standard will be exceeded at the project boundary and takes appropriate action at such times (New Mexico Air Quality Section 1979). If more than one well is vented at a time, some periods of concentrations in excess of State limits may be experienced, but after testing the wells will be shut back to approximately 10% of full flow so that multiple releases at full flow should not occur often.

4.1.4 Impacts on biota

Impacts of the construction plant and well field only are discussed below. The impacts of construction and operation of the transmission lines are discussed in Sect. 4.4.

4.1.4.1 Impacts on terrestrial biota

Impacts on terrestrial biota will include removal of vegetation from land cleared for construction sites and drill pads and both direct and indirect loss of wildlife habitat. Direct habitat loss will be related to loss of land committed to the plant roads, pipelines, and well pads. Indirect habitat loss will occur for those species of wildlife that will vacate the vicinity of the project site as a result of disturbance from increased noise and activity. Both types of habitat loss can be held to a minimum with proper mitigation.

The total area of the well field within Redondo Canyon is approximately 300 ha (740 acres); from 10 to 20% of the 300 ha will ultimately be disturbed in connection with construction of well pads, access roads, pipelines, and the power plant. The majority of this disturbance has already taken place. Almost all of the well pads and access roads have already been constructed, and the site for the proposed power plant has been cleared in connection with earlier exploration activities. Future disturbance related to the proposed project will be primarily limited to clearing for pipeline rights-of-way and a few additional well pads. Up to 16 ha (40 acres) could be cleared for these purposes. However, most of the area cleared for pipeline construction will be reseeded immediately once pipeline construction has ceased.

There are a variety of vegetation sub-types or communities within Redondo Canyon (see Sect. 3.1.5.1), including riparian communities along the creek, scrub oak on the south-facing slopes, and conifer on the north-facing slopes. The locations of all future pipelines and well pads depend upon results of well tests during well field development. Therefore, it is not possible to accurately estimate how much clearing will take place in each vegetational community. Three species of plants considered rare in New Mexico could potentially occur in the well field area. Impacts on these species are addressed in Sect. 4.1.4.3 dealing with rare and endangered species.

The removal of vegetation from land cleared for construction will result in direct habitat loss for wildlife species that presently inhabit the areas in question. Loss of individuals of many of these species is inevitable. Some individuals, particularly burrowing animals, will be destroyed during the clearing operations; others will be lost as a result of increased competition in adjacent habitats as displaced individuals move into these territories. These losses will involve, for the most part, small wildlife species such as rodents, rabbits, and passerine birds. Most of these species are common and widely distributed throughout the region, and the loss of some individuals and their habitat will not be significant. However, for two wildlife species, habitat loss is of some concern. These species are elk and Jemez Mountains salamander. Impacts on the salamander are discussed in Sect. 4.1.4.3 dealing with rare and endangered species.

Habitat loss for elk could accrue directly from destruction of vegetational cover and indirectly from disturbance as a result of increased human presence and activity. The majority of vegetation clearing has already been accomplished; direct habitat loss from additional clearing should be minimal. However, indirect habitat loss resulting from elk avoidance of areas of human intrusion could be more significant. Avoidance by elk of areas of human activity is well documented in the literature (Sundstrom and Norberg 1972; Luge and Hickey 1977; Pengelley 1972; Schultz and Bailey 1978; Forest, Wildlife, and Range Experiment Station 1976). Elk reaction to human disturbance depends upon a number of factors: the season, the amount of vegetational cover, the predictability and the severity of disturbance, and whether the elk are from a regularly hunted population. Generally, elk display some avoidance of roads; the extent of the avoidance depends upon the frequency of traffic and the amount of screening afforded by forest cover adjacent to the roads (Forest, Wildlife, and Range Experiment Station 1976).

Recent studies have documented that elk utilize almost all of Redondo Canyon during the summer months and that, in most years, significant numbers of elk overwinter on the lower south-facing slopes of the canyon (Whitford 1974 and Whitford 1975c, and Public Service Company of New Mexico 1978). Figures 3.20 and 3.21 indicate major elk wintering areas in the vicinity of Redondo Canyon. Because winter habitat is limited, loss of such habitat resulting from human presence is of some concern. Recent studies indicate that exploratory drilling activities apparently have not precluded elk winter use of Redondo Canyon; however, full-scale well field development and power plant construction will result in a sharp increase in human presence, noise, and activity within the canyon over those associated with earlier exploration. It is probably inevitable that the increased level of human activity will result in elk avoiding some formerly used wintering areas within the canyon. The extent to which this will occur is not possible to predict. Even if the amount of winter habitat loss resulting from the proposed project could be quantified, it would be difficult to determine whether the loss would significantly affect the Jemez elk herd without some indication of the amount of alternate habitat available. Currently, there is not sufficient knowledge regarding the size of the Jemez elk population and the quantity and quality of other winter habitat in the Baca vicinity to make such a determination. The significance of the elk and elk winter habitat in Indian religious customs is not known at this time. It is possible that the projected loss of elk winter habitat could affect Indian religious practices. A further discussion of impacts on Indian religious practices is presented in Sect. 4.1.7.2.

Mitigation of effects of elk may best be achieved by avoidance of areas within Redondo Canyon that have been identified as heavy elk winter use areas. Maintenance of sufficient forest cover for screening of roads and drill pads will also reduce disturbance to elk. Close coordination with the New Mexico Department of Game and Fish and Forest Service big-game biologists familiar with the Jemez elk herd will be used to minimize effects on this species.

4.1.4.2 Impacts on aquatic biota

New Mexico Department of Fish and Game and University of New Mexico personnel were contacted independently. Each expressed the opinion that possible sedimentation of streambeds was the main concern regarding impacts on aquatic biota from the proposed project. Suspended sediment in Redondo Creek and downstream aquatic systems should have little impact on aquatic biota, because the tolerance of fishes and other aquatic organisms to sediment in suspension is quite high (Iwamoto et al. 1978), and the suspended load in these streams decreases rapidly after runoff ends (U.S. Forest Service 1977). However, potential impacts on aquatic biota from the deposition of sediment on stream bottoms are much greater.

The effects of sedimentation on stream-dwelling organisms have been comprehensively reviewed by Iwamoto et al. (1978). Sedimentation of Redondo Creek and downstream systems would probably reduce both the diversity and density of aquatic insects and the quantity of insect drift produced in these streams. Insect drift may be an important food source for downstream trout population. Reductions in production and downstream drift of aquatic insects from Redondo Creek could indirectly adversely affect both brown trout and stocked rainbow trout inhabiting San Antonio Creek and the Jemez River by reduction of their food resources. Reduced macroinvertebrate drift from Redondo Creek could also diminish the recolonization potential of the macroinvertebrate community in downstream systems (Müller 1974). If sedimentation of streambeds in San Antonio Creek and the Jemez River were to result from sediment transport from Redondo Creek, self-sustaining populations of brown trout and other fishes that spawn in the gravel stream bottoms would be adversely affected. Decreased survival of both eggs and fry would result. Declines in downstream populations of brown trout from direct or indirect effects of stream sedimentation would diminish the quality of San Antonio Creek and the Jemez River as sport fisheries (Sect. 3.1.3.1.2).

During previous well-field development, the applicant has withdrawn water from Redondo Creek for drilling purposes. During future well-field development, water will be withdrawn from Redondo Creek only when such a withdrawal will not substantially reduce the flow in Redondo Creek, thus ensuring protection of aquatic biota.

4.1.4.3 Impacts on rare and endangered species

Section 3.1.5.3 details the three species of rare plants that could occur in Redondo Canyon. *Viola pedatifida* and *Lilium philadelphicum* occur in moist situations, especially in riparian areas; *Cornus canandensis* occurs on north-facing spruce-fir forested slopes (Issacs 1979c). Future vegetation clearing, especially in areas of the canyon where the species are most likely to occur, could destroy small populations of the plants. PNM and Union have consulted with the New Mexico Heritage Program and have prepared a mitigation plan indicating that the well field and transmission line right-of-way will be surveyed to determine the location of any rare plants. These areas will be avoided during future clearing and construction activities (Sabo 1979). The State Heritage Program Director has agreed with this arrangement (Issacs 1979a and b).

Of the rare and endangered animal species listed in Sect. 3.1.5.3 whose range includes the Baca study region, only one, the Jemez Mountains salamander, is known to occur within Redondo Canyon. Biological studies of Redondo Canyon have demonstrated a number of localities with dense salamander populations. Habitat for this species is apparently abundant but patchily distributed throughout the canyon. Disturbance of some salamander habitat during construction of the plant roads, pipelines, and well pads is inevitable. Recent studies dealing with the species have indicated that the salamander is fairly abundant within the proper habitat and that the habitat is more widely distributed within the species' range than was originally thought (Whitford Ecological Consultants 1975a, Public Service Company of New Mexico 1978, Williams 1972 and 1976). Therefore disturbance of small amounts of the habitat should not significantly threaten the species' survival. However, the fact remains that the species' range is extremely limited, and the State accords the species protection because of its official endangered status. Disturbance of large areas of salamander habitat could be a serious impact.

Because the species is apparently limited by the occurrence of proper habitat, the only way to effectively mitigate effects on the species is to avoid the habitat. Inasmuch as salamander habitat is patchily distributed within Redondo Canyon, it should be possible in most cases to avoid large areas of prime habitat during future placement of roads, pipelines, and drill pads. In the past, Union Oil has contracted biologists familiar with the species' habits to conduct surveys of proposed roads and drill pads for the salamander. Areas of habitat thus identified were avoided where possible. This type of mitigation will continue during construction and operation of the proposed project. The New Mexico State Game and Fish Department has agreed with the mitigation plan (Pilz 1979, Olson 1979).

4.1.5 Socioeconomic and cultural impacts

4.1.5.1 Regional historic and archaeological sites

The project will not directly affect the Jemez State Monument. However, hot springs in the Jemez Springs area and the Indian Spring on the Jemez Pueblo will be affected by flow depletion as a result of geothermal reservoir production (see Sects. 3.1.3.2.1, 3.1.3.2.2, 4.2.2.2., 4.5.1.2, 4.5.2.2). Because of lack of specific knowledge about current use of these springs and because of uncertainty about the consequences of flow depletion on their use, we are unable to assess the impact of flow depletion at this time resulting from geothermal reservoir production on these springs.

A copy of the report *An Investigation Into High Altitude Adaptations — The Baca Geothermal Project* has been reviewed by the New Mexico State Historic Preservation Offices (Broilla et al. 1978, Carroll 1978). In accordance with his recommendations, a request for determination of eligibility for inclusion in the National Register of Historic Places was made for the Baca Geothermal Lease Archaeological District. On August 6, 1979, the archaeological sites were determined to be eligible for inclusion in the National Register (U.S. Heritage Conservation and Recreation Service 1979). The proposed PNM generating station, along with the access road, has no foreseeable effect on the eligible archaeological sites. Some possible conflicts with the originally planned Union Geothermal activities and specific archaeological sites have been identified. A specific plan for mitigation with preservation of the archaeological resources as a prime objective has been prepared in cooperation with the New Mexico State Historic Preservation Offices (Carroll 1978).

The State of New Mexico has determined that the proposed project will have no adverse effect on the eligible archaeological sites, provided that the mitigation program proposed by the Office of Contract Archaeology, University of New Mexico to Union Geothermal Company (June 1979) is carried out (U.S. Department of Energy 1979, New Mexico State Historic Preservation Office 1979). In accord with "36 CFR Part 800" (Advisory Council on Historic Preservation regulations), DOE has made a determination of "no adverse effect" on the archaeological sites (U.S. Department of Energy 1979a). This determination has received the concurrence of the Advisory Council on Historic Preservation (Advisory Council on Historic Preservation 1979). The notice of eligibility was published in the *Federal Register* on Sept. 4, 1979.

Appendix E includes copies of documents concerning eligibility of the 29 sites and 1 locality for inclusion in the National Register of Historic Places, along with documents related to the determination of "no adverse effect" on the archaeological sites providing that the mitigation program is carried out.

4.1.5.2 Cultural impacts

Contact with representatives of area Indian groups has been made by both the commercial partners and DOE. Concerns expressed in initial meetings include items such as water rights, water pollution, possible reduced flow of hot springs, reduced surface water runoff, air pollution (principally concern over odors), multiple use of the geothermal resources, earthquakes and subsidence, and possible infringement on religion because of changed access to important religious areas or to impacts on areas of religious importance.

In addition to direct contact with representatives of Indian groups, a meeting was held at the request of the All Indian Peublo Council on August 16, 1979. Indian groups were also represented at the DOE public hearing on the DES on August 30, 1979. Among the issues of concern, water issues and impacts on religious sites were deemed of major importance (Department of Energy — All Indian Pueblo Council Meeting, August 16, 1979; Department of Energy Public Hearing, August 30, 1979).

"Numerous religious sites are located within the project site... . The Pueblo of Zia and other Indian tribes have for centuries, even before the first Europeans arrived, maintained that the area had religious significance. These sites are presently active and need the protection of the Federal government" (Pueblo of Zia, September 6, 1979).

The issue of Indian religious freedom is discussed more thoroughly in Sect. 4.1.7.

4.1.5.3 Community impacts

Detailed analysis of possible community impacts has been conducted for PNM by Mountain West Research (1979). Two scenarios were developed that represent the range of possible community impacts, given uncertainties in specific locational patterns of moving construction workers and possible advance planning activities by the area communities, PNM, or Union. As stated previously (Sect. 3.1.7.3), Indian users of facilities located off the reservations were not considered separately. Rather, they were included in the total group of users. Impacts on the total group of users of a facility will similarly affect Indian users.

Facilities on Pueblos were not considered because they are normally not open to use by non-Indians. The following is a summary of the two scenarios:

> "Scenario 1 — No Additional Facilities. This scenario assumes that no new facilities for mobile homes, trailers or other recreational vehicles are provided for weekly commuters or for non-local workers who wish to relocate to the Jemez Valley while they are working on the project. Under this scenario, in-migrating workers use accommodations wherever they can be found. The number of persons relocating to the Jemez Valley area is minimized under this scenario because of the shortage of facilities.
>
> Scenario 2 — New Recreational Vehicle (RV)/Trailer Park Provided in the Jemez Valley. Scenario 2 assumes that a new RV/trailer park is established in the Jemez Valley. The number of persons relocating to the Jemez Valley area under this assumption is maximized because accommodations are assumed to be readily available.

The intent of scenario 2 is not to suggest that new facilities will be provided or even that they are likely to be provided. Its purpose is to serve as a point of comparison so that the implications of a maximum number of in-migrants can be studied." (Mountain West Research, Inc. 1979).

Within the local impact area, only two communities represent feasible locations for the accommodation of in-moving workers: Los Alamos and Jemez Springs. Other communities in the area were felt to be much less likely to attract workers for a variety of reasons, including distance to the site and lack of adequate water supplies. Additionally, possible use of Forest Service land for the development of a temporary housing facility, with permanent use as a campground after the completion of construction, has been discussed, although no firm plans exist for this type of development.

Under scenario 1, detailed study predicted that a minimum of 31 people (20 workers and 11 dependents) would move to the local area and seek sites for campers, trailers, and recreational vehicles wherever they could be found. About 50% would be dispersed and about 50% would eventually reside in Jemez Springs.

Scenario 2 results predicted that a maximum of 60 people (40 workers and 20 dependents) would move to the new park for recreational vehicles and trailers near the site.

Under either scenario, public services and facilities would not be taxed by the new population. The only foreseeable increases in public service might be in additional police services to handle increased traffic and after-hours activity. Also, some staff may be added to the volunteer fire department or to the central administration at the mayor's office, but these additions would be small, if needed at all.

4.1.5.4 Economics

Total payroll for the two-year construction period is expected to be $4.2 million. Only about 10% of the $15.1 million for building materials will be purchased in New Mexico, principally for structural materials and transportation of materials (Mountain West Research, Inc. 1979).

4.1.5.5 Labor

Table 4.1 lists the work-force schedule for the geothermal plant and transmission line construction. The 1981 peak of about 250 workers (second quarter 1981) is for a short time only, with an average of 210 workers needed during the summer and about 80 workers during the winter. About 55 people will operate and maintain the plant and well field.

Because of the good availability of construction labor (see Sect. 3.1.7.5) within commuting distance of the plant, no difficulty is anticipated in getting either the construction or operation work forces. About half of the 55 permanent operating jobs are expected to be filled by existing Jemez Valley residents, with the other half coming from the larger Bernalillo, San Ysidro, and Los Alamos areas (Mountain West Research, Inc. 1979).

4.1.5.6 Transportation

Construction of the project will result in an average of approximately 80 additional trips daily on the roads leading to the site. Additionally, heavy materials and equipment will be transported to the site by truck, principally from Albuquerque on NM-44 and NM-4. NM-4 has an average daily

Table 4.1. Baca geothermal demonstration plant employment schedule

O C No.[a]	Craft employment category	Quarterly requirements									
		1980				1981				1982 and Future	
		1	2	3	4	1	2	3	4	1	1
801-805, 809	Iron workers (PNM)		1	2	12	7	18	6	4	1	1
810	Welders and welders' helpers (Union)						7	7			7
828-829	Electricians (PNM)				1	1	17	30	22	7	
859	Operating engineers (PNM)			2	2	2	4	5	4	2	
859	Operating engineers (Union)						4	4			
860	Carpenters (PNM)		1	8	15	16	40	15	9	3	3
862	Pipe fitters (PNM)			1	1	1	14	32	26	8	8
	Pipe fitters (Union)						4	4			
900-909	Teamsters (Union)	5	5	5	5	5	8	8	5	5	3
930	Drill crewman (Union)	20	20	20	20	20	20	20	20	20	20
930	Derrickmen and roughnecks (Union)	5	5	5	5	5	5	5	5	5	5
930	Laborers (PNM)		2	6	17	9	17	6	4	2	2
	Laborers (Union)						6	6			
	Other crafts (PNM)		1	3	1	3	16	24	16	4	6
	Other crafts (Union)						1	1			
Total craft		30	35	52	79	69	181	173	115	57	55
Supervisory (Union Geothermal offices located at Rio Rancho)		12	12	12	12	12	12	12	12	12	12
Transmission-line contractor[b]											
Operating engineers							5	5			
Linemen							5	5			
Laborers							25	25			
Foremen							5	5			
Total Baca employment		42	47	64	91	81	233	225	127	69	67

[a]Department of Labor occupation category number.

[b]Preliminary estimates.

Sources: Bechtel Power Corporation memorandum to PNM, 29 September 1978; personal communication with J. Robinson, Union Geothermal Company, October, 1978; personal communication with R. Jackson, PNM, December 1978.

From: "Proposed Baca Geothermal Demonstration Project – Socioeconomic Analysis," prepared for the Public Service Company of New Mexico by Mountain West Research, Inc. (in preparation).

traffic (ADT) count of 894 vehicles north of Jemez Springs and an ADT of 699 vehicles at La Cueva. Maximum capacity of NM-4 is approximately 1100 vehicles per hour at Jemez Springs and 1500 vehicles per hour at La Cueva. Clearly, NM-4 has adequate excess capacity to accommodate the construction traffic without serious traffic congestion; however, since NM-44 and NM-4 already have unfavorable or unsafe ratings (see Sect. 3.1.7.6), the current safety deficiencies of the roads could be exacerbated by the increased traffic.

Because NM-4 passes through Jemez Pueblo and NM-44 passes through Zia and Santa Ana Reservations, increases in traffic volumes on these routes and the resulting increase in noise and activity may also adversely affect members of these pueblos by creating an annoyance for some individuals. Also, accidents involving semitrucks have resulted in the death of approximately 2% of the population of Zia Pueblo (Pueblo of Zia, September 6, 1979). The projected increase in traffic volumes may result in an increase in the number of accidents.

Since portions of the route are currently insufficient to reliably carry heavy loads, some special route planning may be necessary for heavy material or heavy equipment transportation. This planning could appropriately take place in conjunction with present Department of Transportation permit requirements for oversized vehicles or loads (Mountain West Research, Inc. 1979).

Increased inconvenience and delays to traffic on Highway 4 can be expected as a result of the large, slow truck-traffic to the site during construction, especially since the road conditions would result in slow speeds for large trucks and in few safe places for passing.

4.1.6 Noise impacts

Noise production during exploration falls into three phases: site preparation, well drilling, and well testing. Site preparation may take up to a week per site and will involve grading and surfacing or drilling pads; no road grading operations are anticipated, since existing roads will be used for access. Noise levels during site preparation will probably reach 85 to 95 dBA at 15 m (50 ft) from the source and will be attenuated to be about 50 to 60 dBA at 800 m (1/2 mile).

All drilling machinery equipment is equipped with mufflers. Noise levels during drilling are typically about 85 to 90 dBA at 15 m (50 ft) and 50 to 55 dBA at 800 m (1/2 mile). Figure 4.1 shows typical noise levels for geothermal drilling and testing. The loudest operations — air drilling and steam testing — will not occur at Baca. Measurements taken by Union in the Imperial Valley recorded 70 to 90 dBA 45 m (150 ft) from the source and 46 to 51 dBA 800 m (1/2 mile) away. In the case of

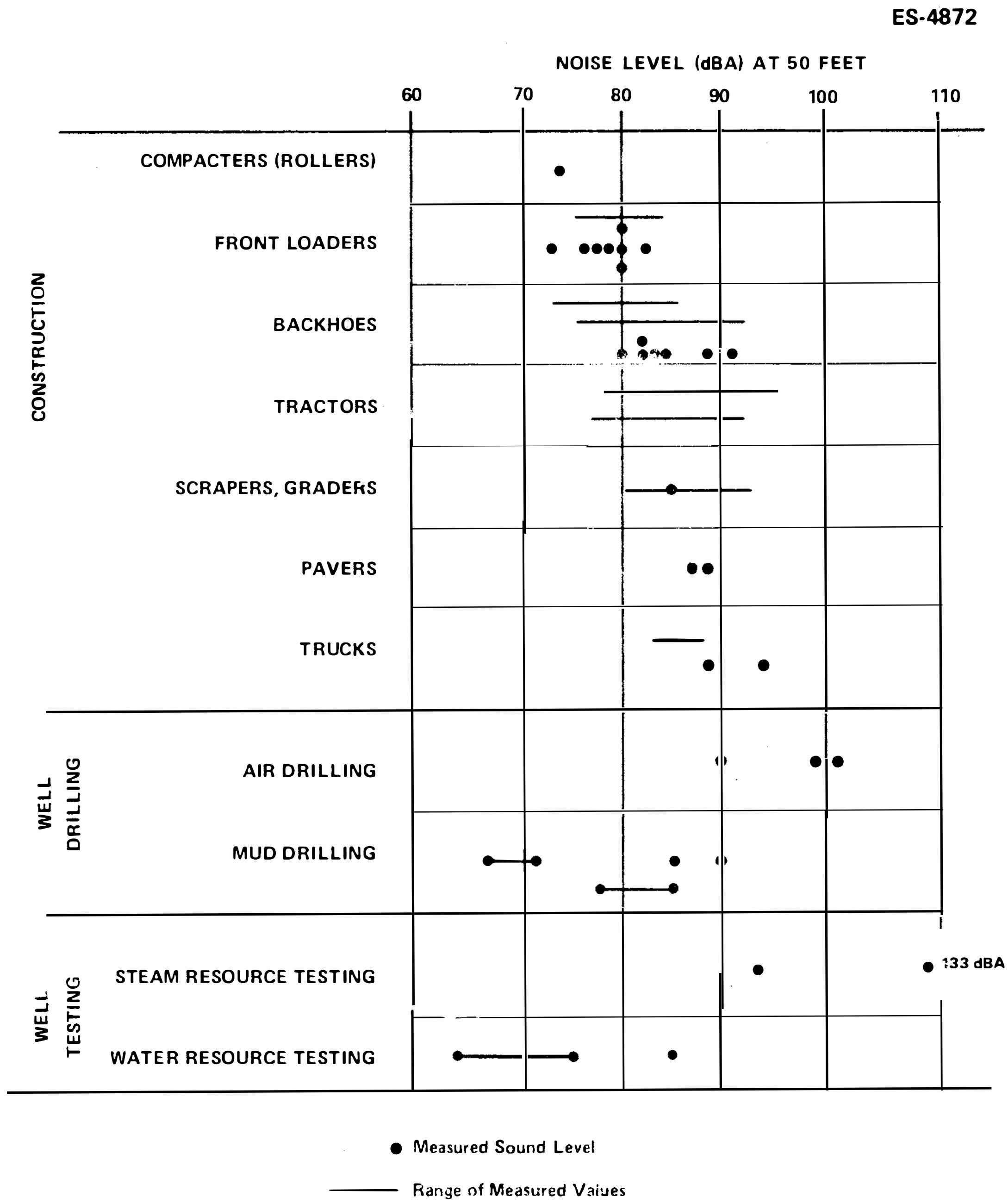

Fig. 4.1. Noise levels from geothermal operations. Source: Modified after VTN Consolidated, Inc., *Environmental Analysis Record, Proposed Geothermal Exploration, South Brawley Prospect, California*, CUl Venture, Irvine, Calif., 1977; including data obtained from Dwight Carey (Republic Geothermal, Inc.) and Philip Leitner (St. Mary's College, Calif. — consultant, Lawrence Livermore Laboratory).

multiple drilling operations, noise levels would be greater, although sound levels are not simply additive. The total noise level of two sounds of equal intensity is 3 dB higher than that of either individual sound. Addition of unequal sound levels involves an increment of less than 3 dB (according to a scale of values) above the level of the louder sound. The worst case for two wells being drilled simultaneously would thus be about 88 to 93 dBA at 15 m (50 ft) from both wells and about 53 to 58 dBA at 800 m (1/2 mile).

At the geothermal field in East Mesa, California, venting of geothermal fluids typically produces noise levels of about 85 dBA at 15 m (50 ft), which will attenuate to about 50 dBA at 800 m (1/2 mile). Union has recorded levels of 81 dBA at 15 m (50 ft) from the well but only 37 to 40 dBA 53 m (175 ft) away when the well vented into a submerged discharge structure such as that proposed for this project.

It is likely that standard construction equipment such as diesel trucks and earth movers used in the project area will produce levels up to 90 and 95 dBA at 15 m (50 ft) and 84 and 89 dBA at 30 m (100 ft).

Redondo Peak, identified as being sensitive to noise because of its religious significance, is approximately 2500 m (8300 ft) from the plant site and 1300 m (4500 ft) from the nearest geothermal well. Table 4.2 shows the calculated noise levels that would result from simple attenuation with distance between Redondo Peak and the plant and well field. These levels are representative of the actual levels expected, although exact noise levels are difficult to predict because of terrain, vegatation, and atmospheric variations.

Activities relating to wells constructed, drilled, and tested nearest to Redondo Peak would not occur continuously. Thus, the noise levels ranging from 51 to 60 dBA would occur only infrequently and last for a period of approximately 3 months for each well. A more or less continual noise level ranging from 46 to 55 dBA would be expected at Redondo Peak as a result of development of the remainder of the well field and plant construction.

Plant operation would result in a continuous noise level of 41 dBA on the peak, whereas an abnormal release of steam during operation would result in a short duration noise level of up to 47 dBA.

Table 4.2. Estimated noise levels at Redondo Peak[a]

Noise source	Maximum expected level (dBA)	Reference distance [ft. (m)]	Distance to peak [ft (m)]	Noise level on peak (dBA)
Construction	95	50 (15)	4,500 (1,300)	56
			8,300 (2,500)	51
Well testing	90	150	4,500	60
			8,300	55
Well drilling	90	50	4,500	51
			8,300	46
Plant operation	65	500	8,300	41
Plant accident	90	50	8,300	46

[a]Based on attenuation with distance. Absorption, vegetation, or intervening masses will reduce levels; reflection and refraction from the canyon and atmospheric inversion will increase the levels.

The nearest permanent residence is approximately 3 km (1.8 miles) from the project area. Normal noise attenuation would reduce the loudest noises (95 dBA from accelerating diesel trucks) to approximately 55 dBA at that distance. Heavy equipment traveling near a residence would have greater impact, but it would not be continuous. Other project construction and well field development activities would produce significantly lower noise levels; however, the low frequencies of the sound would be of a different character and would likely be audible over ambient noises at some residences near the highway or in the campsites even though the levels are acceptably low. Workers may be exposed to noise levels that constitute a health hazard. However, exposures will be controlled and workers safety and health protected by implementing the appropriate OSHA regulation(s).

Noise from construction-related traffic will be noticed in communities through which NM-4 or NM-44 pass. However, because the incremental automobile traffic of 80 trips per day is but a small percentage of the 700 to 900 vehicles on these roads daily and because light vehicles produce a noise level of about 55 dBA at 15 m (50 ft), attenuating to less than 40 dBA within 60 m (200 ft), no significant impact is expected. Heavy equipment and vehicles using these highways will produce some impact, however, creating noise levels of about 95 dBA at 15 m (50 ft). It is not known how this type of vehicular noise compares to existing vehicle noise patterns, but it is quite likely that there will be a substantial increase in heavy equipment noise in the communities along NM-4 and NM-44. All noise increases resulting from vehicles associated with the project are expected to occur during daytime hours.

4.1.7 Impacts on Indian religious values

In accordance with the American Indian Religious Freedom Act (P.L. 95-341), the consultation process with representatives of Indian groups has been initiated to determine whether tribal rights may be adversely affected by the project (Wilbur 1979). Furthermore, at the request of the All Indian Pueblo Council, a formal meeting was held on August 16, 1979, to enable the member tribes to express their concerns about the project. Indian groups also gave testimony at the public hearing on the DEIS.

At these meetings the Indians consistently cited infringement of religious freedom by the project as a matter of grave concern to them. The infringement, as expressed by various Indian spokesmen, would take the form of:

1. destruction of religious sites;
2. destruction of sacred areas, plants, animals, birds, trees, etc.;
3. invasion of privacy;
4. interference from transmission lines;
5. contamination and/or loss of water for sacred practices;
6. depletion of sacred springs; and
7. interference with access to religious sites.

The representatives of Indian religious leaders have had the opportunity to comment on the following analysis of impact (see Appendix J).

4.1.7.1 Destruction of religious sites

The Pueblo Indians have taken the position that he whole Jemez Mountains, including Baca Location, are sacred and thereby constitute a religious site. This position is consistent with their system of beliefs and practices (Sect. 3.10.4). They have been unwilling to identify the location of specific religious sites either within Baca Location or the area impacted by the proposed power plant. This unwillingness reflects their concern for maintaining the privacy and integrity of the sites. The sole exception is the summit of Redondo Peak, which is generally acknowledged to be a sacred spot (DOE Public Hearing, August 30, 1979). Reliable non-Indian sources have identified two other sacred spots within Baca Location. Both are well outside the project area but within view of an alternate transmission corridor. (In accordance with the concerns of the Pueblos for privacy, the exact locations of these sacred sites will not be revealed.)

The Zia, Cochiti, and Santa Clara Pueblos have stated that there are sacred sites on the proposed project area (DOE Public Hearing, August 30, 1979; Hecker letter to Rogowsky, Appendix J). However, the Pueblos decline to identify the exact nature and location of those sites. An archaeological survey of the 746 acres devoted to the project area failed to reveal any indications of active or abandoned religious shrines (Harlan 1979). The religious sites referred to by the Pueblos may well be collection grounds for sacred objects (plants, animals, and so forth). They may be temporary shrines built during pilgrimages to Redondo Peak. Or they may be natural objects considered as shrines by the Pueblos.

Six years of private drilling activity within Redondo Canyon leading up to the proposed project, as well as prior lumbering operations, have altered the physical character of the valley. The plant site and many of the well pads have been cleared and graded. As a result, some or all of the possible religious sites located within the project area may have already been affected. The continued religious significance of such sites is unknown.

The extent of adverse impacts on specific religious sites cannot be fully assessed because of lack of information. However, because the Pueblos regard the Jemez Mountains as a religious site, they consider the very presence of the project to be a significant infringement (Appendix J).

4.1.7.2 Destruction of sacred objects

In order to perform the rituals of the Pueblo religion, various sacred objects or materials are required. As in the case of religious sites, the Indians have been reluctant to provide specific information about these objects or materials. Certain plants, animals, and inanimate objects are used (Sect. 3.1.10.4). The collection areas for these sacred items may be of religious importance because the objects must be collected in a special setting in order to be effective and do not necessarily have an equivalent value for purposes of the religious ritual if collected at another site (Hecker letter to Rogowsky, Appendix J). On the other hand, Sando (1979) indicates that in order not to destroy the natural appearance of a collection area for a particular sacred object, a number of collection areas may be used. DOE has no information on whether the project area has been used to collect sacred objects. Any potential sacred objects within the project area may not be suitable for religious purposes because the natural setting of the area has been altered by private drilling activity.

4.1.7.3 Invasion of privacy

A great deal of secrecy is associated with the Pueblo religion. This secrecy evolved partly in response to religious harassment and persecution since the time of Spanish conquest (Tenorio 1979). As a rule, non-Indians are forbidden from viewing most Pueblo religious ceremonies, especially those taking place in the Jemez Mountains. Apparently certain ceremonies are even forbidden to some tribal members.

The Pueblos believe the increased presence of non-Indians brought about by the project will eventually cause violation of their ceremonials and desecration of their sacred sites. Such an invasion of privacy would probably occur if secret religious ceremonies are conducted within the project area. The Santa Clara Pueblo is known to observe religious ceremonies within the project area (Hecker letter to Rogowsky, Appendix J). (As in the cases of religious sites and sacred objects, the Indians are reluctant to reveal details about their ceremonies.) After more than six years of private drilling activity in Redondo and Sulfur Creek canyons, DOE is not aware of any violation of religious ceremonies by non-Indians.

Redondo Peak is a known sacred site. Since the summit of this mountain is outside the project area, no project personnel would have reason to visit there. Accidental or unauthorized visits to the shrine by project personnel cannot be precluded. However, the strategic location of the project at the base of the mountain may help to discourage trespassers and curiosity-seekers from trying to reach the summit.

Sensory factors that could constitute an invasion of privacy if violated are sight, sound, and smell. Impacts on the aesthetic values of Redondo Canyon and its surroundings have been addressed elsewhere (Sect. 4.1.1). Those values are important to the Pueblos because they reflect the harmonious beauty of Mother Earth. The Pueblos consider the depletion of aesthetic values to be an infringement of their right to practice religion.

Redondo Peak and its environs are likely to be affected aesthetically. A visual survey from the summit has not been made, but some project facilities on the northwest face of Redondo Canyon would probably be visible. Under certain meteorological conditions the cooling tower plume would also be visible. The noise reaching Redondo Peak from the nearest project facilities is computed to be 50 to 60 dBA during drilling and construction and 40 to 50 dBA during operation. The former noise level should be audible, whereas the latter may not be discernible from ambient (see Sects. 4.1.6 and 4.2.6). Upper air turbulence should effectively disperse any pollutants carried to the top of Redondo Peak. Under normal operating conditions, hydrogen sulfide is not likely to be present in sufficient quantities to create an odor problem. However, it is possible under certain operating and meteorological conditions that concentrations at the summit could reach an odor threshold. Any project-related noises or odors reaching the shrine would disrupt Indian religious ceremonies (Hecker letter to Rogowsky, Appendix J).

4.1.7.4 Interference from transmission lines

The Indians' concerns about transmission lines are the same as those regarding the power plant. The primary ones are: (1) destruction of religious sites and sacred objects and (2) invasion of privacy. The two alternative transmission routes will avoid crossing all known religious sites.

The Pueblos' view that the entire Baca Location is sacred certainly implies there will be an impact on religious practices from the transmission lines. Although the total amount of land taken up by the transmission route would be small, the visible intrusion from manmade structures crossing the Baca would affect religious sites (Hecker letter to Rogowsky, Appendix J).

4.1.7.5 Contamination and/or loss of water

The expected changes in water quality and quantity due to the project should have minor environmental consequences (Sect. 4.2.2). Flow depletion in the Jemez River will be compensated by the withdrawal of irrigated lands. Possible contamination of surface waters from accidental spills of geothermal fluids of toxic material should be of short duration (Sect. 4.3.3).

Details of the many and varied uses of water in Pueblo religious practices are unknown. The Pueblos object to any change affecting their water supply. This position is consistent with the importance of water to the Pueblo culture and religion (Sect. 3.1.10).

4.1.7.6 Depletion of sacred springs

All springs of the Jemez Mountains are considered sacred (Hecker letter to Rogowsky, Appendix J). If any springs are supplied at least in part by geothermal waters, there is a possibility their flows would be affected. The depletion is expected to be small, however (Sect. 4.2.2). All known major springs should flow for the lifetime of the project, barring some unforeseen natural impact such as drought. In general, minor springs derive their waters from the shallow aquifer; their flows would depend more on abundance of rainfall than reservoir drawdown. Depletion of most springs in the region is more likely to result from natural causes than power plant operations.

In view of the importance attached to springs as portals to the underworld (Sect. 3.1.10.4), even the small amount of depletion could be a substantial infringement.

4.1.7.7 Interference with access to religious sites

Since the Baca Location is under private ownership, the general issue of access must be settled between the landowner and the Pueblos. Public access to the immediate project area will be controlled by the project operators. The operators have no authority to restrict access by anyone with a legal right to visit the project area. If arrangements for access to religious sites cannot be worked out, those sites located in controlled areas could be unavailable to the Indians. Any denial of access to the project area for religious purposes would be considered an infringement.

4.2 IMPACTS OF OPERATION

4.2.1 Impacts on land use

Noise and odor from hydrogen sulfide resulting from operation of the proposed power plant should not be detectable at the nearest residence (see Sects. 4.2.3 and 4.2.6). During project operation, traffic will be much reduced from that of the construction phase and should not affect surrounding land uses. Potential direct conflicts with recreational uses of the surrounding public lands could accrue from visual impacts of the cooling tower plume and transmission lines on visitors to the area. Visual impacts of the transmission lines are discussed in Sect. 4.4.

PNM has contracted a computer-generated study of the potential visibility of the cooling tower plume from surrounding recreational use areas (Paulson 1978). On all but three days of the year, the plume is predicted to be less than 245 m (800 ft) high. The visibility analysis indicates that a 245-m plume will be visible from NM-4 along approximately a 1/2-km section near the southwest corner of the Baca Location. The plume will also be visible at a distance of over 16 km from the high peaks within the Santa Fe National Forest to the northeast and at a distance of 6.5 km from a small portion of the forest to the southwest of the Baca Location. Because of the few places from which the plume will be visible, visual impacts resulting from operation of the plant itself should be minimal.

Indirect conflicts of the power plant and well field with recreational uses have been addressed in Sect. 4.1.1. Conflicts with potential public use of the Baca Ranch, if the land is acquired by the government, are addressed in Sect. 4.1.1.

Plant operation will result in withdrawal of a total of approximately 5.6 ha (14 acres) of irrigated crop land from irrigation and production over the 30-year life of the plant (Sect. 2.2.5.3). This land will be located near the Jemez River in San Diego Canyon. The crop presently grown on this land has not been specified.

4.2.2 Water quality and use

4.2.2.1 Surface water

During normal plant operation, geothermal fluids will be disposed of by reinjection (Sect. 1.2.4 of proposal), and no wastes from plant operation will be directly discharged into surface waters. Surface water quality should therefore not be adversely affected by normal plant operation.

The predicted total reduction in flow of the Jemez River, caused by withdrawal from the geothermal reservoir by one 50-MW unit after 30 years of operation, could be as much as 0.78 liter/sec (0.03 cfs) (Sect. 4.2.2.2). The minimum and maximum discharges for the period 1960 to 1975 were 93 liters/sec (3.3 cfs) and 29,200 liters/sec (1030 cfs), respectively. The mean annual flow averaged 850 liters/sec (30 cfs) and ranged from 450 to 1850 liters/sec (16 to 65 cfs) during 1960 to 1975. This reduction is approximately 1% of the lowest flow recorded [94.5 liters/sec (3.3 cfs)] during a 16-year period at Battleship Rock (Sect. 3.1.3.1). This minor reduction in base flow may affect water quality and use in the Jemez River. Although withdrawal or diversion of geothermal outflow could result in higher quality water, several Pueblos have expressed the concern that their uses would be impacted with any type of change in water quality. Use by native Americans would also be adversely impacted by any reduction in streamflow attributable to the project. Reduction in quantities of water available for irrigation may adversely affect farming practices and the productivity of Indian farms. However, these impacts will be mitigated by the purchase of water rights to lands that are currently irrigated in the La Cueva area. These lands will be withdrawn from irrigation in order to make up for reductions in stream flow caused by the project. As stated previously (Sect. 2.2.5.3), Bureau of Indian Affairs has filed a protest concerning several aspects of the water issue with the State Engineer on behalf of several pueblos. The effect of this protest on mitagation plans is not known. Reductions in flow from mineralized springs in San Diego Canyon may diminish the suitability of these springs for bathing (see Sect. 4.2.2.2 and Table 3.7).

Effects of accidental releases of geothermal fluids into Redondo Creek on surface water quality are discussed in Sect. 4.3.

4.2.2.2 Groundwater

The primary impact to groundwater resulting from plant operation will be to the deep (geothermal) circulation system (refer to Sect. 3.1.3.2.1). The shallow groundwater system should not be impacted directly, since (1) fluids will neither be withdrawn nor injected into shallow aquifers and (2) shallow aquifers will be protected from surface infiltration by the use of impermeable pits (sumps) with high freeboard to contain vented and/or drilling fluids.

The operation of the Baca demonstration plant will result in a total mass loss of approximately 362,872 kg (800,000 lb) per hour (Fig. 2.11), or 101.35 liters/sec (1,606.43 gal/min), from the geothermal reservoir (Union Oil Company 1978). Provided that the plant operates 100% of the time, 3.2×10^6 m^3 (2593 acre-ft) of fluid will be lost from the reservoir annually. If the plant operates 80% of the time (as expected), the fluid loss will be correspondingly less. For the purposes of this environmental statement, however, a "worst case" of 100% operation time will be assumed.

Known geothermal fluid discharges occur along the Jemez River in San Diego Canyon (refer to Sect. 3.1.3.2.1); the amount of geothermal outflow reaching the river is estimated to be 10.35 liters/sec (164 gal/min) using arsenic dilution ratios (Water Resources Associates, Inc. 1977) and at least 13.7 liters/sec (217 gal/min) using dilution ratios of chloride, bromide, boron, and lithium (Trainer 1975). These should be regarded as minimal figures, because geothermal discharge of unknown (but small) quantities occur at localities other than those for which geothermal discharge component calculations were made (Trainer 1974). For instance, using chloride, bromide, boron, and lithium concentrations, one-third of the flow of Indian Spring owned by Jemez

Pueblo is geothermal outflow. The source of these fluids has not been definitely determined. Although they are assumed to be derived from the geothermal reservoir underlying the project site, the possibility exists that their source is a separate, deep geothermal reservoir.

The maximum geothermal reservoir drawdown during the 30-year life of the 50-MW(e) power plant, at proposed fluid withdrawal rates, will total 9.6×10^7 m^3 (7.8×10^4 acre-ft). This amount of drawdown is not expected to result in an adverse impact on any natural geothermal discharges. It is assumed that the source of geothermal fluids ultimately reaching the Jemez River is the liquid-dominated geothermal reservoir described in Sect. 3.1.2.3. The total reduction in groundwater outflow (well and stream depletion) resulting from reservoir drawdown is not known at this time. Induced recharge from shallow aquifers (ultimately surface water) may result. "Best fit" streamflow depletion analyses conducted at the applicant's request indicate total losses of about 0.15, 0.26, and 0.45 liters/sec (2.4, 4.8, and 7.2 gal/min) from the Jemez River at 10, 20, and 30 years of 50-MW(e) plant operation (Water Resources Associates, Inc. 1977). The actual proposed withdrawals of 8761.12 m^3 (3.09×10^5 ft^3) per day exceed the withdrawal used in the calculation model [6242.98 m^3 (2.206×10^5 ft^3) per day] by a factor of 1.40. Therefore Jemez River depletion alone can be expected to amount to perhaps 0.21, 0.36, and 0.63 liters/sec (3.36, 6.72, and 10.08 gal/min) at 10, 20, and 30 years of plant operation, based on dilution effects of arsenic. The instability of arsenic in area waters implies that the calculated quantities of geothermal reservoir leakage in San Diego Canyon are probably lower than actual leakage for the assumed conditions. For instance, studies conducted by Trainer (1975) using the more stable chloride, bromide, boron, and lithium constituents indicate that 24% more stream flow diversion could be expected. Depletion of the Jemez River could then amount to 0.26, 0.45, and 0.78 liters/sec (4.12, 7.13, and 12.36 gal/min) at 10, 20, and 30 years of plant operation. The effects of reservoir drawdown might be felt in extremely small amounts almost from the beginning of plant operation (Water Resources Associates, Inc. 1977).

Two major thermal springs areas at Jemez Springs and Soda Dam (Fig. 3.2 and Table 3.7) contribute geothermal discharge to the Jemez River. It is estimated that 20% [2.45 liters/sec (39 gal/min)] of the discharge of Jemez Springs and 27% [5.17 liters/sec (82 gal/min)] of the spring discharge at Soda Dam is comprised of geothermal reservoir fluid using arsenic dilution ratios (Water Resources Associates, Inc. 1977). Provided that they are derived from the subject reservoir, spring flows at Jemez Springs could possibly be reduced by 0.08, 0.13, and 0.23 liters/sec (1.20, 2.39, and 3.58 gal/min) and those at Soda Dam by 0.08, 0.14, and 0.24 liters/sec (1.29, 2.58, and 3.88 gal/min) at 10, 20, and 30 years of plant life.

Using Trainer's (1975) dilution ratio, the more stable constituents — chloride, bromide, boron, and lithium, 33 1/3% [4.2 liters/sec (67 gal/min)] of the flow at Jemez Springs and 50% [9.5 liters/sec (150 gal/min)] of the spring discharge at Soda Dam is comprised of geothermal fluid. With the use of this method, springflows at Jemez Springs could possibly be reduced by 0.08, 0.14, and 0.24 liters/sec (1.28, 2.22, and 3.80 gal/min) and those at Soda Dam by 0.18, 0.39, and 0.54 liters/sec (2.85, 4.91, and 8.56 gal/min) at 10, 20, and 30 years of plant life.

Cold mineral springs between the caldera rim and San Ysidro and a flowing warm well at the western foot of the Sierra Nacimiento are discharging some geothermal water (Trainer 1974) (refer to Sect. 3.1.3.2.1). If their source is the project's geothermal reservoir, it is to be expected that drawdown would result in some very minor flow depletion; however, the quantities are not known at this time. Indian Spring, owned by Jemez Pueblo, is used occasionally for bathing (Trainer 1978). Because one-third of the springflow is reportedly comprised of geothermal fluid (Trainer 1975), there may be some impact on the use of the spring.

Reservoir fluid quality will decrease during the 30-year life of the demonstration power plant, assuming (1) that the existing reservoir fluid contains an average total dissolved solids concentration of 6093 ppm (refer to Sect. 3.1.3.2.1) and (2) that the proposed production-injection scheme is adhered to. Fluids injected back to the reservoir would be more concentrated in dissolved solids than those withdrawn, because of evaporative losses. A rough estimate — based on reservoir mass in place, depletion rates, and dissolved solids concentration — indicates that the reservoir will be degraded by 12% of the existing average total dissolved solids in 30 years. The reservoir will also be degraded to an unknown (but apparently slight) extent because of the injection of 0.0095 liter/sec (0.15 gal/min) of waste from the hydrogen sulfide abatement system. The chemical components of the waste stream and their percent by weight of each are as follows: ADA (anthraquinone disulphonic acid), 0.16; $NaVO_3$, 0.75; Na_2CO_3 (equivalent), 1.18; Na_2SO_4, 7.10; $Na_2S_2O_3$, 15.81; and water, 75.00 (Union Oil 1978).

Temperature degradation of the geothermal reservoir will occur as a result of the mixing of the relatively cool [134°C (273°F)] injection water with the hot [329°C (624°F)] reservoir water. By assuming a porosity of 0.10 and extrapolating the applicant's reservoir temperature performance data, a reservoir temperature decline to approximately 302°C (575°F) can be expected after 30 years of production.

The reservoir pressure of 13,780 kPa (2000 psia) can also be expected to decline with reservoir fluid withdrawal. This is estimated to result in a reservoir pressure of 10,630 kPa (1543 psia) after approximately 30 years of production (Union Oil Company 1978).

One of the thermal springs (H-15 of Table 3.7) at Jemez Springs is used commercially for public bathing (Sect. 3.1.3.2.2). Provided that its geothermal flow component is derived from the production reservoir, as is thought to be the case (Trainer 1974), reservoir pressure and temperature decline will adversely impact the value of the spring by reducing its discharge rate and water temperature.

Mitigation of groundwater impacts resulting from geothermal fluid withdrawal will be accomplished in part by the implementation of a groundwater monitoring program (Sect. 11.1.2.2 and 11.2.2.2).

4.2.3 Air quality impacts

The atmospheric pollutant of most concern in the case of the proposed facility is hydrogen sulfide (H_2S). To a great extent the hydrogen sulfide contained in the geothermal fluid will be removed by a Stretford process. However, the cooling tower makeup water will contain some remaining H_2S and the cooling tower effluents constitute a release of H_2S to the atmosphere.

The operation of the cooling towers at the site will result in an increase in ground level concentrations of hydrogen sulfide. Calculations have been performed for typical conditions obtained from the meteorological data available. The data are insufficient to permit estimates of more severe conditions with any certainty. However, a severe condition could be postulated in which all of the hydrogen sulfide would be trapped in a nocturnal drainage layer. This condition has also been addressed. The threshold of odor detection is generally acknowledged to be about 25-30 ppb but can be as low as 10 ppb (Rosen and Molenkamp 1978).

The proposed plant is to be located in Redondo Canyon at the Baca well field site, which has an elevation of 2600 m (8800 ft) above sea level. The cooling tower will be a mechanical-draft tower containing a row of eight cells essentially aligned along the wind vector. Wind information for the Baca well field site (Figs. 4.2 and 4.3) shows up-valley winds during the day and down-valley winds at night (drainage winds). Average daytime wind speed is 1.69 m/sec and average nocturnal wind speed is 1.37 m/sec.

4.2.3.1 Daytime dispersion conditions

Calculations are shown for daytime dispersion condition C in Fig. 4.4. The Baca Location boundary is located about 14 km (9 miles) from the proposed plant in the direction of the up-canyon winds. Dispersion condition D gives similar values outside the property whereas for A and B conditions, the values are lower. The following parameters were assumed for the cooling tower, which is the source of the hydrogen sulfide:

Eight cells of 9.14 m (diameter)
Volume flow, 690 m^3/sec
Temperature of effluent, 26.6°C
Height to tower, 18.3 m
Emission rate of H_2S, 42 lb/hr.

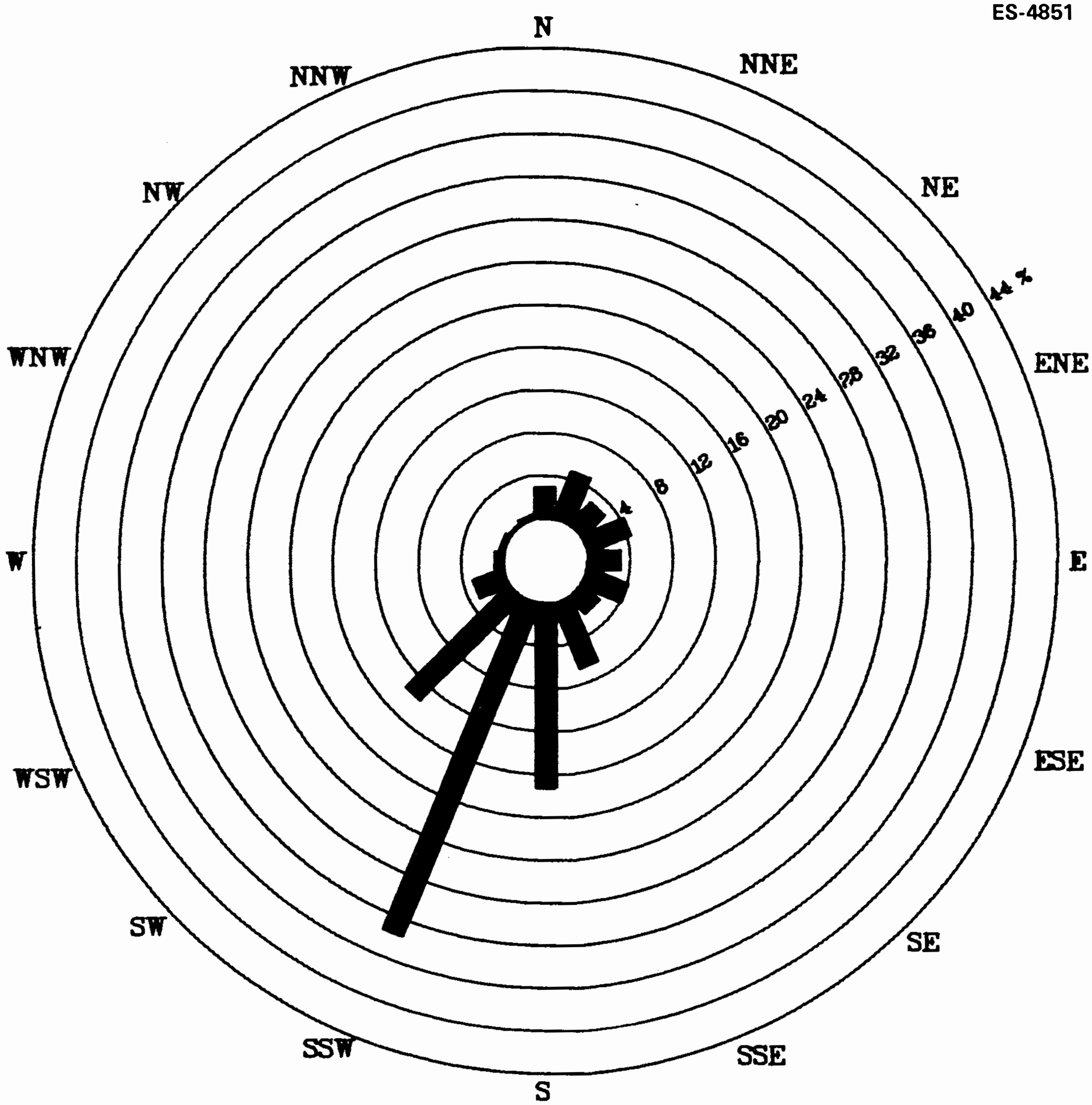

Fig. 4.2. Baca wells annual wind rose, 10 AM–7 PM.

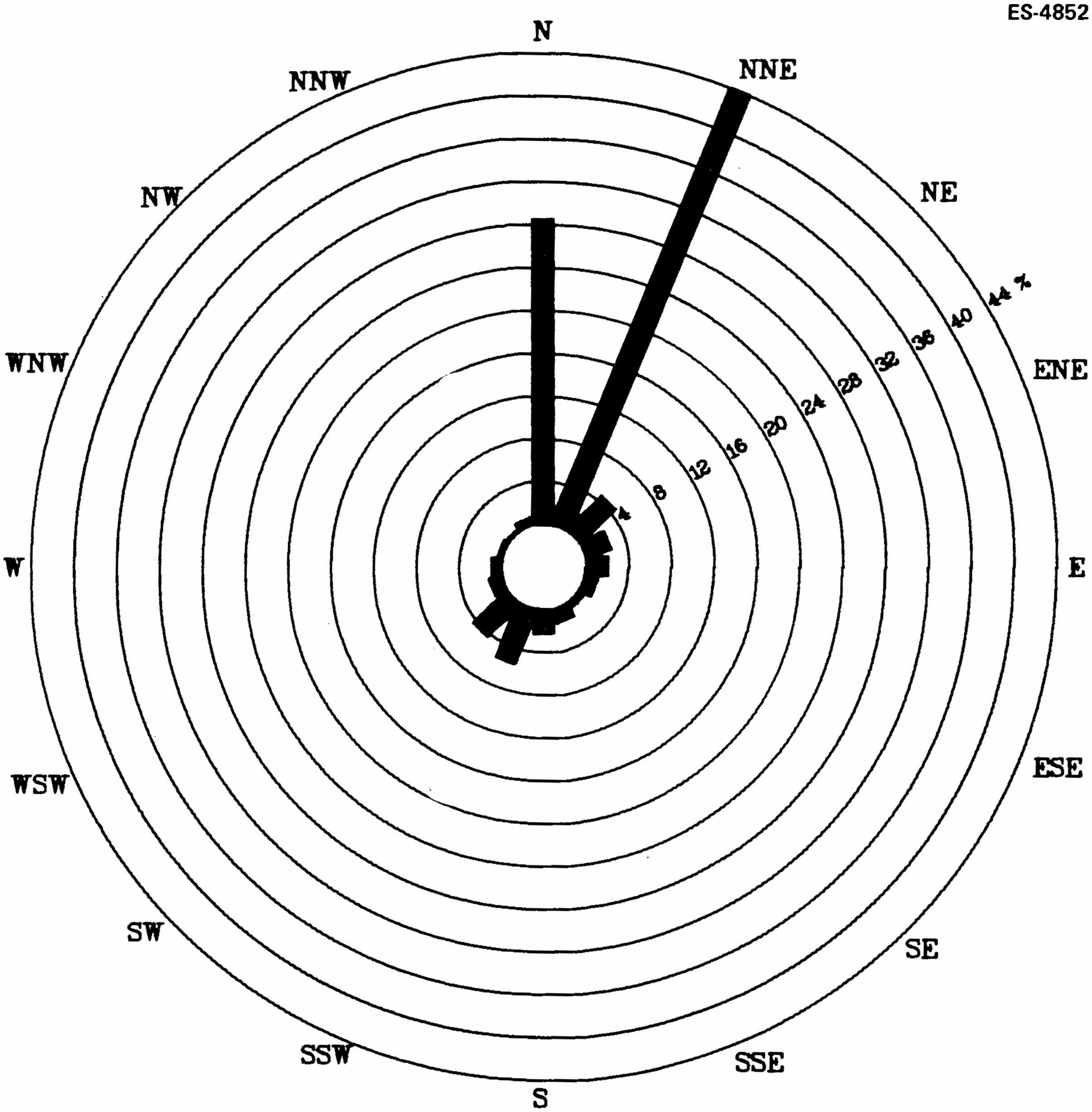

Fig. 4.3. Baca wells annual wind rose, 7 PM–10 AM.

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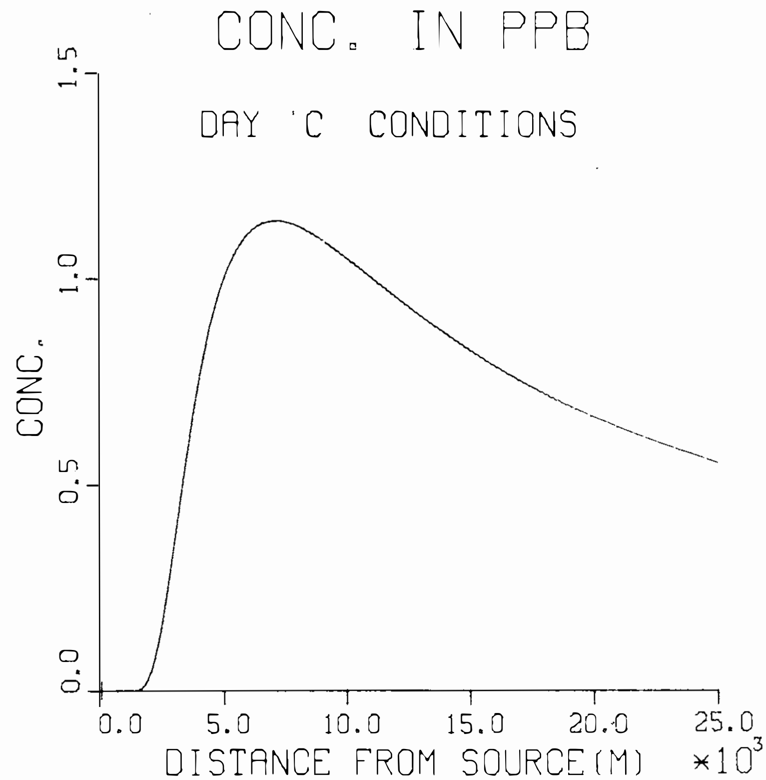

Fig. 4.4. Calculated hydrogen sulfide concentrations at ground level during daytime C conditions.

The dispersion calculations depicted in Fig. 4.4 were based on the Gaussian plume formula. The diffusion parameters employed were those of Smith (for vertical diffusion) and those of Briggs (for horizontal diffusion). These diffusion coefficients are discussed by Hosker (1973) and Culkowski and Patterson (1976). They are similar to the Pasquill-Gifford parameters at short distances, but they show less diffusion at greater distances. The plume rise calculations used the formulation outlined in the cooling tower model ORFAD (LaVerne 1977), which is based on the work of Briggs (1969) and Hanna (1971). In calculating ground-level concentrations, the diffusion parameters typically give values representative of 10- to 15-min time periods. Hourly values have been estimated using the conversion technique recommended by Turner (1970).

The daytime pattern of atmospheric dispersion will be initiated by up-valley winds as the cooling tower effluent first enters the atmosphere.

The resulting advection will cause this effluent to move towards the saddle to the northeast of the plant site (i.e., roughly towards the Upper Forks site). The Upper Forks wind data do not show the same persistent northeasterly flow as do the canyon floor data. Therefore it is quite likely that there will be a change in the direction of plume travel as it leaves Redondo Canyon. From the upper end of Redondo Canyon, the shortest travel length to the property boundary would be about 7.5 km, assuming advection of the plume to the west from the Upper Forks region. Referring to the Gaussian plume calculation above, daytime dispersion conditions would therefore predict concentrations at the reservation boundary which are on the order of 1 ppb.

Conventional dispersion calculations that apply to flat open country are known to be less than adequate for complex terrain environments. Nevertheless, they are useful in making a first approximation. In an effort to obtain a better approximation to the daytime situation, we have made some estimates along the lines proposed by Egan (1975) employing potential flow concepts to the plume as it moves over terrain of varying height. Figure 4.5 shows the kind of variation predicted along a transect as the plume moves to the northeast under "C" stability conditions. (A and B conditions give lower concentrations, except close to the source, whereas D conditions produce a maximum of about 2 ppb near the boundary.) Figure 4.5 represents a situation similar to that shown in Fig. 4.4 but with topographic perturbations added. The detailed variation in concentration shown in Fig. 4.5 depends very much on the transect chosen. However, as the plume traverses the high elevations near the northern boundaries of the property, it can be seen that the predicted concentration is about 1.3 ppb. Assuming a change in wind direction when the plume reaches the Upper Forks area, we have calculated the ground level concentration which would occur over some high peaks just outside the western boundary of the Baca property. The highest value calculated was about 2 ppb, employing the complex terrain modeling approach of Egan (1975). In summary, therefore, offsite maximum concentrations of roughly 2 ppb of hydrogen sulfide are predicted during daylight hours.

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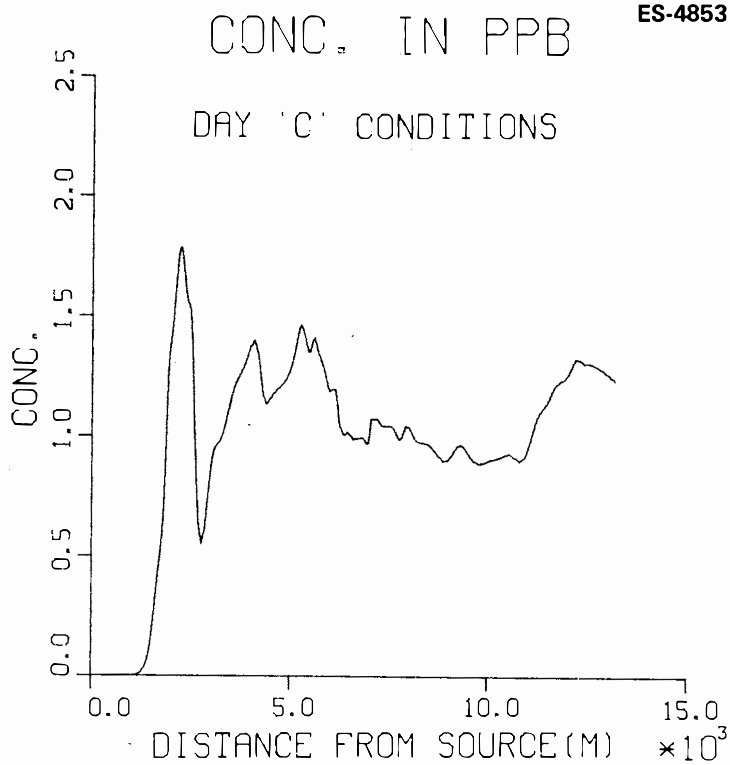

Fig. 4.5. Topographical influences on ground level concentration along a transect going roughly northeast from the proposed plant site.

4.2.3.2 Nocturnal dispersion conditions

During nighttime hours, a drainage wind blows down the canyon. The drainage layer will probably be fairly well mixed and will be capped by a stable layer. One can assume that the top of the drainage layer acts as a lid. The dispersion of hydrogen sulfide in this drainage layer was calculated as a function of drainage layer depth. It is assumed that any parts of the plume that do not initially rise above the top of the drainage layer are trapped within the layer. Any part of the plume that penetrates into the stable layer aloft is assumed to remain aloft. In calculating penetration of the top of the drainage layer, the following is assumed: Plume rise Δh is calculated as in ORFAD (LaVerne 1977). The total plume is assumed to be contained between 0.5 Δh and 1.5 Δh and for simplicity is assumed to have a uniform concentration. Thus, if the height of the drainage layer is known, the fraction between 0.5 Δh and 1.5 Δh that is below it should be used as the source strength in calculating ground-level concentration. This approach is from Briggs (1979).

The following assumptions were also employed in doing these calculations: The drainage layer is parallel to the ground surface; that is, it slopes with the terrain. Mixing within the drainage layer is fairly good and representative of a D condition. For the purposes of plume rise, the drainage layer was assumed to have an isothermal lapse rate. Furthermore, all material diffusing upward to the top of the drainage layer was treated as diffusing back downward, since it is assumed that it is trapped below the stable layer aloft. This conventional approach for a trapped plume was used for the calculations (Turner 1970).

The nocturnal dispersion situation was studied as a function of two important variables — wind speed and drainage layer depth. As wind speed increases, it reduces plume rise and consequently will tend to increase the ground-level concentration of pollutant. On the other hand, increased wind speed causes increased plume dilution. If the drainage layer depth is small, it will reduce the dilution of the trapped pollutant. However, given that the pollutant has buoyancy and/or upward momentum, a larger fraction of it is likely to penetrate the top of a shallow drainage layer.

Wind data from the Baca wells site show nocturnal down-valley winds whose average speed is 1.37 m/sec. The data show that the wind speed covers a range from a minimum of 1.17 m/sec to a maximum of 1.49 m/sec.

In calculating nocturnal dispersion in the drainage layer, we have assumed neutral stability (D conditions). In other words, we expect the drainage layer to be fairly well mixed. It is possible that when this drainage layer reaches the "meadow" area to the southwest, it will spread laterally and hence dilute somewhat more than D conditions would indicate. This would have the effect of further reducing the ground-level concentration.

An estimate of drainage layer depth can be made from an analysis of wind data. Figure 4.6 is a plot of the nocturnal wind frequency and direction for the Upper Forks location. One can see that at this location, which is at 2895 m (9500 ft) elevation, there is no evidence of the drainage flow. The Upper Forks location is about 215 m above the

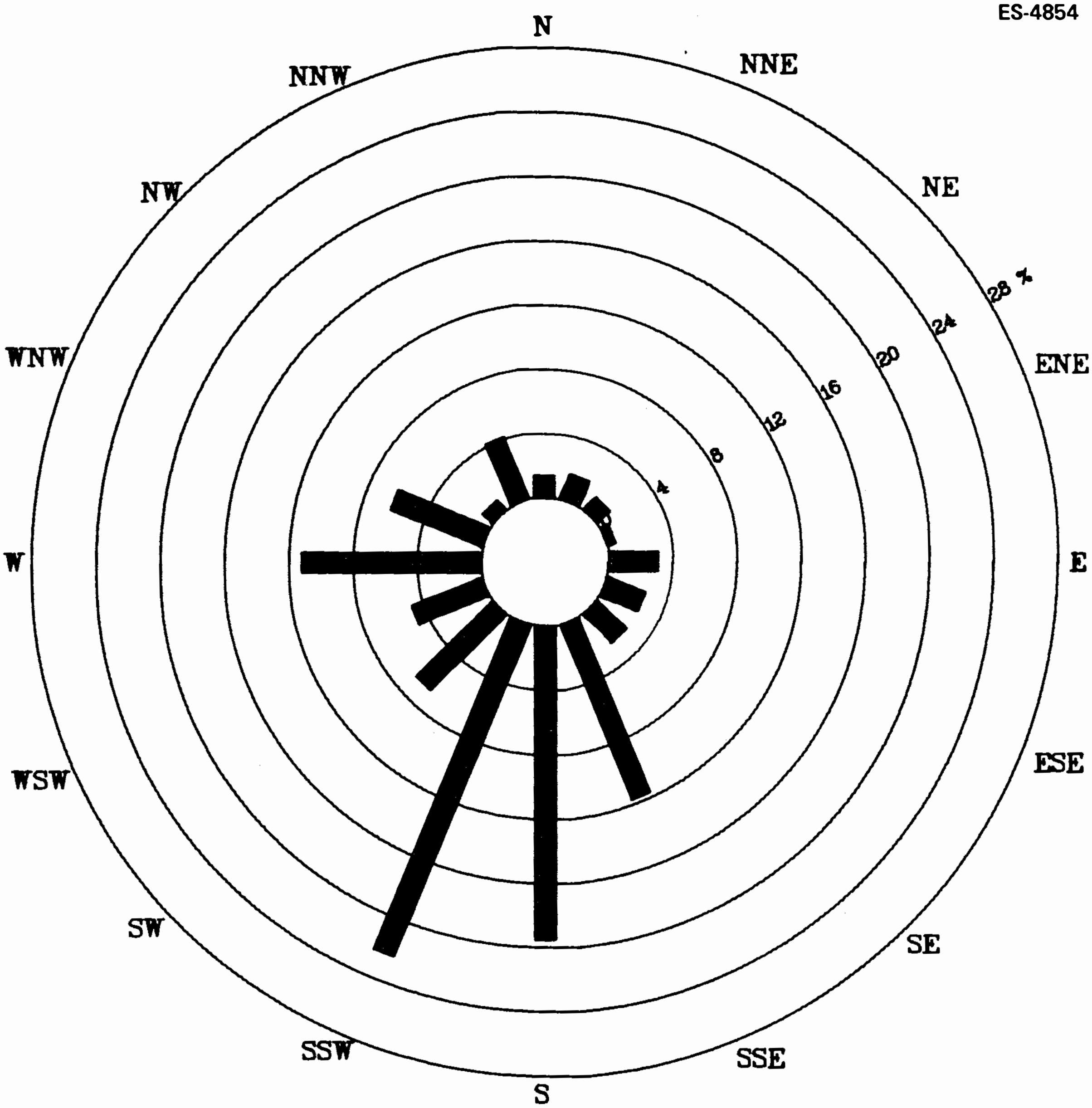

Fig. 4.6. Upper forks annual wind rose, 7 PM–10 AM.

canyon floor, and one can therefore assume that the drainage layer is at most about 215 m in depth. Figure 4.7 shows the concentration of hydrogen sulfide vs distance from the source for the case of a 215-m-deep drainage layer with an isothermal lapse rate. The concentration at the reservation boundary would be on the order of 0.6 ppb.

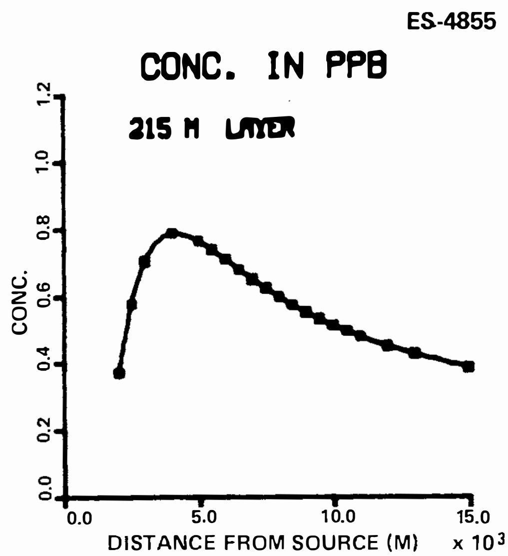

Fig. 4.7. Calculated hydrogen sulfide concentrations at ground level for drainage layer depth of 215 m.

These calculations are intended to produce numbers to outline what might happen under typical conditions, not extreme conditions. The calculations have been limited for two important reasons: (a) there is only a small amount of data available and (b) the problem of dispersion in complex terrain is poorly understood.

The results depend critically on the initial plume rise from the cooling tower, the height of the drainage layer, and the atmospheric dispersion parameters. There are no data on the drainage layer to permit an estimate of plume rise. The approach has therefore been to assume an isothermal lapse rate. This lapse rate is enough to allow partial penetration by the bouyant plume into the stable layer aloft. However, if it is assumed that the drainage layer allows very little plume rise causing the entire cooling tower plume to be trapped within the layer, the hourly concentrations at the boundary of the reservation could go as high as 22 ppb. Atmospheric dispersion is probably greater in complex terrain than over flat terrain. Flat terrain values were used because the complex terrain situation is not well understood. As a result of the terrain effects the dispersion is likely to be greater, tending to decrease ground level concentrations.

The dispersion of H_2S has been modeled for maximum, minimum, and average wind speed as observed at the Baca well field. Recall that the wind speed data refer to 2.5 m (8 ft) above the canyon floor. It is likely that there are higher wind speeds at greater heights above the canyon floor. However, for the nocturnal drainage winds, which cause the greatest concentrations offsite, the wind profile in the canyon is not well understood. Because a drainage wind is driven by pressures which are hydrostatic in nature, the wind speed is likely to be greater in the lower depths of the drainage layer. Thus, wind speed should be a decreasing function of height above the ground. However, the ground itself is likely to reduce wind speed because of frictional forces, so that the net effect may be a wind speed maximum at some intermediate height within the drainage layer. It would be purely speculative to make any estimates of such wind profiles. Therefore, we have chosen the available measured ground-level wind speeds in doing our calculations.

In summary, therefore, the maximum nocturnal hydrogen sulfide concentration at the reservation boundary would be less than 1 ppb, if an isothermal drainage layer is assumed. However, if the plume becomes trapped entirely within the drainage layer, the maximum concentration would be on the order of 20-25 ppb.

Workers may be exposed to H_2S levels that constitute a health hazard. However, exposures will be controlled and worker safety and health protected by implementing the appropriate OSHA regulation(s).

4.2.3.3 Cooling tower drift

During the operation of the cooling towers, some of the water vapor released to the atmosphere is in the form of droplets, called drift.

These droplets will contain the same impurities as the circulating water. It is estimated that 0.027 kg/hr (0.06 lb/hr) of total dissolved solids in the stream condensate will be lost from the towers, based on a drift rate of 0.005% of the circulating water and makeup water having a TDS (total dissolved solids) concentration of 30 mg/liter. Experience at operating facilities having similar cooling towers indicates that most of the drift is deposited within 1 mile of the towers (Carson 1976). Based on the wind information at the site as depicted in Figs. 4.2 and 4.3, deposition of drift will be confined to Redondo Canyon. If it is conservatively assumed that all of the drift will deposit within an 800-m (1/2-mile) semicircle downwind of the plant, total solids deposited will average less than 2.2 kg/ha (2 lb/acre) per year.

4.2.4 Impacts on ecological systems

4.2.4.1 Terrestrial

After construction has ceased and after adequate reclamation, some of the initially disturbed areas will again be available for wildlife habitation. Effects of disturbances from both construction and operation on sensitive wildlife species have been discussed in Sect. 4.1.5.

During project operation, the only additional effects on the surrounding terrestrial biota could result from power plant emissions. Of the noncondensable gases, only hydrogen sulfide (H_2S) is present in sufficient quantities to be of concern at the Baca Location. The concern is primarily one of nuisance odor (hydrogen sulfide is detectable at concentrations of about 25-30 ppb but possibly as low as 10 ppb) rather than with potential damage to vegetation or animals. Effects of long-term exposure of vegetation to hydrogen sulfide have been documented only at concentrations above 100 ppb (Subcommittee on Hydrogen Sulfide 1979). Thompson demonstrated no effects on ponderosa pine (*Pinus ponderosa*) at 30 ppb, but he did observe tip burn on some individuals after eight weeks of exposure to 300 ppb. Short-term exposure to hydrogen sulfide requires concentrations in the parts-per-million range before vegetation damage occurs (Subcommittee on Hydrogen Sulfide 1979). Results of predictions of atmospheric hydrogen sulfide levels resulting from normal power plant operation indicate that ambient hydrogen sulfide levels should not exceed approximately 2 ppb (Sect. 4.2.3). These concentrations are two orders of magnitude below levels at which vegetation effects might occur. Exposure to higher levels of hydrogen sulfide for short periods of time (a few days) could be expected if the hydrogen sulfide abatement system fails. However, in such an instance, atmospheric hydrogen sulfide levels would not reach the parts-per-million concentration required to produce damage to vegetation for short-duration exposure.

Drift from the cooling towers is another potential source of polluted emissions at the proposed project. An analysis of potential cooling tower drift has indicated that most drift will fall within an area approximated by a 800-m-radius semicircle downwind from the plant (Sect. 4.2.3). The geothermal fluid from the Baca reservoir is of relatively good quality, with a total dissolved solids content averaging 6000 ppm (Union Oil Company 1978). The drift analysis indicates that the deposition rate of total dissolved solids resulting from cooling tower drifts will be less than 2.2 kg/ha/year (2 lb/acre/year within the approximate 800-m-radius semicircle around the cooling tower (Sect. 4.2.3). The natural deposition of atmospheric salts from precipitation may be estimated for the Jemez Mountains using the data of Junge and Werby (1953), which characterize the concentration of airborne salts per unit volume of rainwater. Assuming an annual average precipitation of 45 cm (18 in.), the natural deposition of salts in the region of the project site should be about 33 kg/ha annually (30 lb/acre annually). The added salt from cooling tower drift of 2.2 kg/ha per year (2 lb/acre per year) would not be detectable over the natural background salt deposition and would have no significant adverse effects.

Experience at The Geysers, the only operating geothermal power plant in the United States, has indicated that boron, dissolved in the cooling tower drift, has caused vegetation damage around some power plant units (Rosen and Molenkamp 1978, Leitner 1978). This damage is primarily limited to one sensitive plant species, big-leaf maple, within 300 m of two older power plant units. Newer units with more efficient drift eliminators on the cooling towers have not demonstrated this effect. Measured boron concentrations in condensate at the Baca reservoir average 1 ppm — over an order of magnitude below concentrations at The Geysers (Rosen and Molenkamp 1978, Leitner 1978). It is not known if the plant species that occur in the Redondo Creek area will show the same or greater sensitivity to boron damage as the maple at The Geysers. However, the drift eliminators on the unit at the Baca plant should be more efficient than the older units at The Geysers; also, the concentration of boron in the drift at Baca is much lower than that at The Geysers. While vegetation damage from boron is not expected to occur at the Baca project, it is difficult to predict this with certainty. If vegetation damage from boron does occur at Baca, however, it should be limited to the approximate 800-m-radius semicircle around the cooling towers where the drift is predicted to fall. Therefore only a few individual plants should be involved, and the impacts should not be significant.

4.2.4.2 Aquatic ecology

Normal plant operations are not expected to adversely affect the aquatic biota, because geothermal fluids will be reinjected and there should be no direct discharges of wastes into surface waters. Reduction of base flow from the geothermal reservoir to the Jemez River, caused by withdrawal of fluids from the reservoir, should have very little effect on the discharge of the Jemez River (Sect. 4.2.2.1) and should therefore not adversely effect the aquatic biota in the river. Potential impacts on the aquatic biota from accidental releases of geothermal fluids or drilling muds and/or fluids are discussed in Sect. 4.3.

4.2.4.3 Impacts on rare and endangered species

Potential impacts of construction on the Jemez Mountains salamander are discussed in Sect. 4.1.4.3. These impacts include all proposed future well drilling. Operation of the power plant will not further affect the species, nor will operation affect any other endangered species (see Sect. 4.1.4.3).

4.2.5 Seismic and geologic-related impacts

Seismic and geologic-related impacts resulting from geothermal plant operation include land subsidence and induced seismicity. These environmental impacts are expected to be minimal, if detectable at all, in the project area.

The potential for subsidence is generally considered to be a definite hazard in liquid-dominated geothermal systems. Subsidence is a direct result of reservoir compaction accompanying pressure decline caused by fluid withdrawal; however, land subsidence at the project site as a consequence of fluid production is not expected to be significant. This conclusion is reached by considering several factors. First of all, about 73% of the fluids withdrawn will be injected back into the geothermal reservoir, mitigating some of the potential impact. Second, most of the rock units associated with the geothermal system (Bandelier Tuff, Paliza Canyon Volcanics, Abo Formation, Magdalena Group, and basement granite) are competent. Because of this, any compaction occurring within them would probably be caused by fracture closing and would most likely be undetectable. The Tertiary sands, on the other hand, are poorly consolidated; compaction would therefore be expected within this unit. The great overlying thickness of competent rocks, however, would prevent the translation to the surface of compaction within the Tertiary sands. Natural subsidence caused by withdrawal of the underlying magma body may still be taking place (Union Oil Company 1978). If so, natural subsidence could be more significant than any induced by geothermal fluid production.

Seismicity at the project site could possibly be induced by the release of tectonic stress triggered by stress or fluid pressure changes on preexisting faults. Earthquakes of this origin can have the magnitude of naturally occurring ones. Additional, nontectonic earthquakes may result from increased fluid pressures or thermal stresses within the reservoir injection zone. The project site is located within an active first-order tectonic feature, the Rio Grande rift, as well as a major Quaternary volcanic center, Valles Caldera.

Injection pressures of approximately 1033.5 kPag (150 psig) above hydrostatic at a fluid temperature of 134°C (273°F) are proposed for the demonstration plant. It is at this point difficult to predict what will happen with respect to fluid injection and induced seismicity at the project site. The injection pressures are most likely not high enough and the injection temperatures too high to initiate any significant earthquake activity caused by hydraulic fracturing or thermal stress cracking. Also, the high rock temperatures existing at shallow depths might be conducive to creep rather than fracture as a release of tectonic stresses (Savage, Ely, and Tocher 1977). Seismic events resulting from hydraulic fracturing at the LASL Hot Dry Rock geothermal site about 8 km (5 miles) west of the Redondo Creek field were detectable only down-hole (Savage, Ely, and Tocher 1977). It can be expected that any induced seismic activity at the project site will be obscured by natural seismicity.

The overall stability and engineering ratings for project site soils are given in Table 3.2 (refer to Sect. 3.1.2.2). The erosion potential for all but one of the soils is slight, indicating that gullies are uncommon, rills are shallow [less than 1.27 cm (0.5 in.) deep], and more than 3.05 m (10 ft) apart. The rock outcrop, steep, unit has severe erosion potential (deep, numerous rills and exposure of subsoil). The depths to hard bedrock are mostly slight, which indicates a soil cover of at least 152.4 cm (60 in.). Stability, in terms of shrink and swell, is primarily moderate to severe, indicating an expansion and contracting of 3 to more than 6%. The soils are all well drained. Corrosivities vary from slight to moderate in the project site area. Moderate runoff problems are typical, however, with soils showing some evidence of flow patterns. Topsoil ranges from poor to fair, exhibiting sandy or clayey textures and steep to moderate slopes.

A history of landslides exists for the project area, so the possibility of future rock falls and landslides cannot be eliminated. Structural or other soil-related problems at the site are not known to have occurred; therefore, soil impacts to future facilities in Redondo Creek Canyon may be expected to be slight, at most.

Upper Frijoles Canyon is underlain primarily by Tschicoma volcanics. Downstream, the Bandelier Tuff crops out. Soils occurring along the steep canyon slopes are probably moderately to highly erodible and poorly to moderately drained, with a severe runoff potential.

4.2.6 Noise impacts

The noise of plant operation consists of many of the construction-related noises discussed earlier, because well drilling and testing will continue at intervals during the life of the plant. In addition, some venting of fluid as a result of abnormal operation or equipment failure may occur at infrequent intervals during plant operation. In most instances of these, however, such venting will be muffled by submerged discharge or quickly shut back to a minimal flow.

Other noises of plant operation are those associated with turbo-generators, steam flow, and cooling towers.

Table 4.3 presents noise measurements made at The Geysers at generating units 5 through 11 by Pacific Gas and Electric Company. Noise levels are high at the plant site (70 to 94 dBA) as a result of the operation of turbines and gas ejectors, but the noise measurements farther than 60 m (200 ft) from the plant [60 dBA at 150 m (500 ft)] are dominated by the cooling towers. The overall plant noise is 40 to 50 dBA at 1000 m (0.6 mile) (Bush 1977) and is virtually inaudible at distances over 1 mile (1.6 km). As stated in Sect. 4.1.7, Redondo Peak is a noise sensitive area because of its religious significance. Continuous noise levels of 41 DBA at the peak are anticipated during normal operation. Abnormal release of steam during operation would result in a short duration noise level of up to 47 dBA (see Table 4.2).

Workers may be exposed to noise levels which constitute a health hazard. However, exposures will be controlled and worker safety and health protected by implementing the appropriate OSHA regulation(s).

4.2.7 Socioeconomic and cultural impacts

During the longer-term plant operation, the plant would produce stable, relatively high-paying jobs. This should result in some new

Table 4.3. A-weighted sound levels from various noise sources at The Geysers at a typical power plant operating at full load

Noise source description	Distance from noise source (m)	Distance from noise source (ft)	Sound level (dBA re. 20 micropascals)
Cooling tower	1.5–3	5–10	81–85
Outside turbine-generator building	7.5	25	70–75
Steam jet gas ejector	1–3	3–10	88–93
Around turbine-generator unit inside building	1–1.5	3–5	92–94
Random locations on turbine-generator floor			90–94
Total plant noise at plant fence line	6–20	20–70	67–83
Total plant noise[a]	150	500	60 ± 5

[a]Total noise from plant at distances greater than 60 m (200 ft) is primarily from cooling tower only. The noise from steam jet gas ejector falls off rapidly as a function of distance from source because of small radiating surface area and high frequency content.

Source: R. C. Bush, "An Overview of PG&E's Audible Noise Measurements Program at The Geysers," pp. 169–73 in *Proc. Geothermal Environmental Seminar 1976,* Lake County, Calif., October 1976.

permanent housing construction and a gradual movement of operations workers to single-family units in the Jemez Valley.

The addition of the plant to Sandoval County's tax rolls will result in a very substantial increase in the tax base. Current estimates of the plant's value ($78.8 million), when assessed at the usual rate of one-third of market value, would result in a 24% increase in Sandoval County's tax base. Traditionally, communities receiving large tax-base increases without a similar increase in population or demand for services have lowered or stabilized tax rates while increasing service levels. Also, Sandoval County's Jemez school district could expect an increase of $174,000 in annual revenues because of the project; however, this increased revenue locally would be substantially offset by a reduction in State school funding, and only $8,700 (5% of $174,000) would be a net increase in school funding.

Annual PNM payroll during operation will be about $488,000 (not including fringe benefits), and Union's annual operating payroll is expected to be at least $1,000,000. These payrolls as well as the construction payroll, represent a significant source of income to the local population, especially since this income is "basic sector" income and will generate additional indirect activity for goods and services sectors of the area economy. However, this increased private-sector income is not likely to significantly benefit local communities such as Jemez Springs, since present expenditure patterns indicate that income flows rapidly to the major market centers of Albuquerque and Santa Fe (Mountain West Research, Inc. 1979).

Impacts of plant operation on Indian cultural and religious practices are discussed in Sect. 4.1.7.

4.3 POTENTIAL ACCIDENTS

The potential accidents resulting from construction or operation of the proposed project that would produce greater environmental impact than that estimated for normal construction and operation activities are discussed here. These events can result from abnormal conditions of plant operation and from equipment malfunction in the steam supply and return systems. The environmental consequences of abnormal operation are treated separately from the legal interpretation of the State ambient air quality standard because conformance of hydrogen sulfide concentrations resulting from abnormal operation to State standards are subject to prediction and interpretation by the State.

4.3.1 Abnormal plant operation

The environmental impacts of plant operation are based on normal operating conditions in which all systems function. Abnormal operation results (1) when an auxiliary system fails but the plant is able to continue electrical power generation or (2) when the plant shuts down unexpectedly.

The two most important systems for the mitigation of environmental impacts are the hydrogen sulfide abatement system and the injection plant for spent geothermal fluid. A total loss of either system for an extended period of time would result in plant shutdown; however, loss of the injection system is highly unlikely. A short-duration outage of less than 12 to 24 hr, once detected, might occasionally result in plant operation without one of the systems. Similarly, the plant might operate for a few hours without the failed system until the extent of the outage was determined. Thus, to predict several hours of operation during the course of a year (perhaps five to ten days a year) without hydrogen sulfide abatement or fluid injection is reasonable.

4.3.1.1 Loss of hydrogen sulfide abatement system

Loss of the hydrogen sulfide abatement system would result in the release of approximately 108 kg/hr (240 lb/hr) of hydrogen sulfide to the atmosphere from the cooling towers. The resultant concentration of hydrogen sulfide at the Baca boundary would be less than 11 ppb, or 5.6 times that estimated for normal operation for the worst-case atmospheric conditions. Except for the increased chances of odor in areas of existing high ambient hydrogen sulfide levels, no environmental damage or health effects would be expected from these infrequent, short-duration events.

4.3.1.2 Loss of fluid injection system

Loss of the injection capability as a result of pump failure is unlikely because two of the injection wells do not require pumps; the injection pump can be bypassed to these wells. Hydrogen sulfide emissions from injection plant bypass would be about the same as for normal operation; however, the concentration in the atmosphere would be quite different and higher near the plant, because of the ground-level release height.

4.3.2 Turbine trip

There are several types of equipment failure in the plant and in the electrical distribution system that require immediate shutdown of the power plant on an unplanned basis as opposed to a previously scheduled shutdown for maintenance or a shutdown in which several hours' notice is given. Such a shutdown is referred to as turbine trip, or loss of load, and usually requires the immediate venting of steam to prevent damage to the turbine. These events are infrequent, and when they are added to the scheduled downtime, the total outage of the plant is less than 20% of the year. One or two such events per year for a single geothermal turbine would be unusually frequent.

When a turbine trip occurs, it is necessary to vent steam from the main steam line to the atmosphere until orderly shutback of the geothermal supply wells is possible. It is unlikely that venting will occur for a period of up to 48 hr. For longer outages, the flow will be shut back to the satellite separaters; then to the wells; eventually the wells will be shut back to about 10% of full flow until the plant comes back on line. The reduced flow will be vented through the various bypass pits.

Hydrogen sulfide and hot fluids will be released to the atmosphere until the wells are shut back, but the short duration and infrequent occurrence will result in only minimal environmental impact. The ambient hydrogen sulfide limits are a legal matter for interpretation by the state for the upset condition of operation.

4.3.3 Geothermal fluid system failure

The geothermal fluid supply and disposal systems are subject to failure by rupture in the well casing, at the wellhead, and in the aboveground piping. Rupture in the well casing is called a blowout and has potential impacts on the hydrological regime as well as on the surface. The other piping system ruptures would have predominantly surface effects. Experience with geothermal systems shows that well blowouts are preventable and usually occur during drilling rather than during plant operation. Other pipe ruptures are highly unlikely, the predominant historical instances being related to vandalism of unguarded wellheads.

4.3.3.1 Blowouts

Blowouts can occur during exploratory drilling, field development, or full-scale production. Blowout-prevention equipment will be used on both the exploration and production wells; nevertheless, malfunctioning equipment, human error, or negligence occasionally leads to blowouts. Blowouts can occur at any time during exploratory drilling or field development when geopressured fluids or the potential for steam flashing is encountered. Blowouts can also occur if casings rupture at a shallow depth. Blowouts that occur below ground are controlled by several techniques, depending on the nature of the blowout.

Geothermal blowouts do not carry the risk of fire that oil field blowouts do. Nevertheless, they are difficult to handle because of the presence of heated fluids. Blowouts may result in surface cratering; destruction of vegetation, wildlife habitat, and wildlife; contamination of the surface, water, and atmosphere; excessive noise; waste of geothermal energy; and injury to personnel. The land area affected by a blowout is difficult to estimate and is dependent on location, flow rate, and duration. It is estimated that the largest probable area of direct impact from any single excursion would be on the order of 5 ha (10 acres).

Well casing may also rupture during the production stage as a result of natural subsidence, earthquakes, or landslides. Because of the geologic setting for the proposed project, the most likely causes of casing failure are natural subsidence and landslides. Cement packing around the casing is intended to contain the fluids in the event of a casing failure. However, large displacement caused by landslides or subsidence may rupture the cement packing as well. If the casing ruptures in a groundwater aquifer and if the reservoir fluids are geopressured or steam-flashed, groundwater contamination and waste of geothermal energy will occur. Shallow aquifers in the immediate vicinity of the project site with the potential for contamination are small in volume and are currently unused. If rupture takes place in the cap rock or reservoir, little or no damage to the environment or waste of energy will result, but the well would have to be recompleted. It may be possible for escaping fluids to reach the surface along a fault or joint, but this should only occur in the case of a prolonged blowout and is not likely.

4.3.3.2 Pipe rupture

Ruptured geothermal pipelines may cause intense but short-duration surface spills and possible release of geothermal fluids to surface waters. Whereas blowouts and ruptured well casings may be difficult to bring under control, pipelines can be isolated within less than an hour or so by shutting back the appropriate wells and, if necessary, closing down the generating plant.

The total mass flow of geothermal fluid from geothermal wells to the four satellite steam separators will be about 1,360,500 kg/hr (3,000,000 lb/hr) (Sect. 2.2.5.1). Consequently, the mass flow of geothermal fluid to and from each satellite steam separator will be about 340,130 kg/hr (750,000 lb/hr). The approximate temperature of the fluid under pressure is 166°C (330°F) (Sect. 2.2.5.1). Union has a spill prevention plan and emergency containment procedures for accidential releases (see Appendix G). Discharge of geothermal fluid until mitigated from a broken pipe would be about 340,130 kg/hr (750,000 lb/hr), or 93 liters/sec (3.3 cfs). Considering the spill mitigation measures that would be initiated in the event of a rupture, the maximum duration of this flow would be less than one hour. In some cases of surface pipe rupture, the flow could be diverted into a reserve pit until shut back.

A pipe rupture discharging the maximum rate (93 liters/sec) near Redondo Creek could have severe adverse effects on the stream ecosystem. Most of the fluid discharged would reach the creek channel. The estimated release of 93 liters/sec (3.3 cfs) from a ruptured pipe ranges from about 4 to 17 times the mean monthly discharge recorded in Redondo Creek (Sect. 3.1.3.1). Consequently, the temperature of Redondo Creek at the point of mixing with hot geothermal fluid would be near the boiling point of water (100°C). This is well above the maximum temperature tolerances of cold-water fishes and other stream organisms, which generally range from 20 to 30°C (McKee and Wolf 1963). Consequently, such a release would result in substantial mortality of organisms in

Redondo Creek downstream of the discharge, primarily because of thermal shock. The distance downstream over which thermal shock would occur would depend upon the temperature and volume of fluids released and the flow of Redondo Creek at the time of release.

Effects of a spill on portions of the Jemez River downstream of Redondo Creek will depend upon flow conditions in the streams and the magnitude of the spill. Except during very high stream flows, a large slug of geothermal fluid would move rapidly down Redondo Creek and possibly down San Antonio Creek virtually undiluted, and subsequently enter the Jemez River at the confluence of San Antonio Creek and the East Fork of the Jemez River, near Battleship Rock. Low flows of the Jemez River at this point would be expected to be on the same order as the flow of geothermal fluid from a pipe rupture. The record low flow of the Jemez River recorded at Battleship Rock was 93 liters/sec, equal to the flow from a pipe rupture. The annual average flow of the Jemez River (850 liters/sec) at this point is less than an order of magnitude greater than the flow from a pipe rupture. Concentrations of trace elements in the geothermal fluid, which are well above toxic levels and drinking water standards, would probably remain above these criteria at the point of mixing with the Jemez River. These trace element concentrations would peak at the point of mixing and the peak concentrations would be expected to last just over one hour for a spill of maximum duration. As the slug of geothermal fluid moves down the river, dilution will occur and the concentration curve will flatten such that the peak values will be lower but will last longer. How rapidly this dilution occurs and the distance downstream over which the peak concentrations will exceed criteria will depend upon the flow of the Jemez River at the time of the spill.

Downstream aquatic ecosystems could be adversely affected by toxic trace elements in the geothermal fluids (Cushman, Hildebrand, and Brocksen 1977). The extent of the impact will depend upon the resultant concentrations of these elements in stream water and the duration of exposure. Downstream water users could also be adversely affected by high trace element concentrations. Table 4.4 details maximum concentrations of trace elements recorded from the geothermal fluid and compares

Table 4.4. Maximum concentrations of trace contaminants in geothermal fluids at the Baca site in relation to concentrations that are known to be toxic to aquatic biota

Constituent	Maximum concentration in geothermal fluid (mg/liter)	Known toxic concentration (mg/liter)	Ratio of geothermal fluid concentration to known toxic concentration	Drinking water standard where applicable (mg/liter)	Ratio of fluid concentration to drinking standard
Al	1.0	0.07[a]	14		
As	10	0.022[a]	450	0.05[b]	200
B	40.2	0.69[a]	58		
Ba	0.3	5.3[a]	0.06	1.0[b]	0.3
Be	0.021	0.15[a]	0.1		
Br	9.0	0.18[a]	50		
Cr	0.004	0.005[a]	0.8	0.05[b]	0.08
Fe	18	0.2[a]	90	0.3[c]	60
Hg	0.0009	0.0001[a]	9	0.002[b]	0.45
Mg	5.3	17.0[a]	0.3		
Mn	0.11	0.35[a]	0.3	0.05[b]	2.2
Mo	0.1	70[d]	0.001		
Pb	0.1	0.007[a]	14	0.05[b]	2.0
Rb	4.3	14.0[a]	0.3		
Zn	0.1	0.01[a]	10	5.0[c]	0.02
Fluoride	21.2	95[d]	0.2	0.4–2.4[e]	53–8.8
T.D.S.	6000			500[c]	12

[a] Cushman, Hildebrand, Strand, and Anderson (1977).
[b] National Interim Primary Drinking Water Standards, FR40(24B): 59566–59577, December 24, 1975.
[c] Proposed National Secondary Drinking Water Standards, FR42(62): 17143–17147, March 31, 1977.
[d] McKee and Wolf (1963).
[e] Depending upon average maximum daily air temperature, lower standard for warm climates.

these to the minimum toxic concentrations for aquatic biota and to drinking water standards. Comparisons of the concentrations of 16 trace elements in the fluid with toxic concentrations for aquatic biota indicate that arsenic, boron, bromine, and iron are the constituents of greatest concern for effects on downstream ecosystems. Arsenic, iron, fluoride, and total dissolved solids considerably exceed drinking water standards. Estimated peak concentrations of the constituents of concern have been calculated at the point of mixing with the Jemez River for the record low flow (93 liters/sec) and for the annual average flow (850 liters/sec) and are presented in Table 4.5. To facilitate calculation, complete mixing with the river water at this point has been assumed. Estimates of resultant concentrations at the low flow of 93 liters/sec may be considered worst case.

Estimated concentrations of arsenic, boron, bromine, and iron in the Jemez River from Table 4.5 may be compared with known toxic concentrations for aquatic biota from Table 4.4 and from Cushman, Hildebrand, and Brocksen (1977). Predicted arsenic concentrations in the river after a spill are above 24-hr and 48-hr LC_{50}s (dosage at which 50 percent of the individuals exposed die within the time period) for bluegill (*Lepomis macrochirus*) in static bioassays. Arsenic concentrations of 1.1 mg/liter and above are lethal to mayflies. Information on the toxicity of bromine is sparse; however, the predicted concentrations in the Jemez River at both low and average flows are well above the toxic level for *Chlorella*, a green alga. Predicted concentrations of iron at both low and average flow are acutely toxic to many species of fish, including trout (Cushman, Hildebrand, and Brocksen 1977). However, effects on downstream biota from exposure to the concentrations in Table 4.5 are difficult to predict because the exposures at which toxicity levels are determined are generally of a longer duration than the one or possibly two hour exposure resulting from a hypothetical maximum duration spill. Generally, higher concentrations are required to produce adverse effects on biota for a very short duration exposure. For example, predicted concentrations of boron in the Jemez River after a spill (from Table 4.5) are above the mimimum toxic concentration (from Table 4.4) but well below the concentrations of 100 mg/liter

Table 4.5. Predicted concentrations of arsenic, boron, bromine, and iron in surface water of the Jemez River at Battleship Rock during 16-year low and mean flows, following hypothetical rupture of a pipeline adjacent to Redondo Creek

Estimated rate of discharge of geothermal fluid into Redondo Creek is 3.3 cfs, or 93 liters/sec

Constituent	Baseline concentration in Jemez River (mg/liter)	Concentration in geothermal fluid[a] (mg/liter)	Predicted concentration in Jemez River (mg/liter)	
			Low flow (3.3 cfs)[b]	Mean annual flow (30 cfs)[c]
As	0.006	10	5.0	1.0
B	0.04	40	20	4.0
Br	0.0001	9.0	4.5	0.9
Fe	0.06	18	9.0	1.8
Fluoride	0.6	21.2	10.0	2.0
T.D.S.	150	6000	3150	790

[a] Data from Table (3.3.1-4).

[b] Equivalent to 93 liters/sec.

[c] Equivalent to 850 liters/sec.

of boron which is generally required to cause short-term toxic effects on aquatic biota (Cushman, Hildebrand, and Brocksen 1977).

Drinking water standards from Table 4.4 for arsenic, iron, fluoride, and total dissolved solids may be compared with the estimated concentrations of these constituents in the Jemez River after a spill (from Table 4.5). At low flows, worst-case peak concentrations of all these constituents at Battleship Rock would be above drinking water standards; at average flows, peak concentrations of only arsenic, iron, and total dissolved solids would be above drinking water standards. These peak concentrations would last just over an hour at Battleship Rock for a maximum duration spill. As the slug of geothermal fluid moves downstream, the peak concentrations will decline below the levels in Table 4.5 and the duration of these peaks will lengthen to a few hours. It is possible that some downstream users of the Jemez River will be exposed for a few hours to concentrations of these constituents that are above standards for drinking water. However, drinking water standards are set at levels safe for long-term exposures, while a spill will result in only a short-term exposure. Short-term exposures of a few hours to concentrations as indicated by Table 4.5 should cause no adverse effects on downstream users. For example, the standard for arsenic is to protect users from chronic arsenic poisoning (U.S. EPA 1976). The estimated worst-case concentrations of arsenic in the Jemez River (Table 4.5) are well below an order of magnitude less than the concentrations of arsenic required for acute poisoning (U.S. EPA 1976). The standards for iron and total dissolved solids are set for palatability rather than health reasons. The standard for fluoride is set to protect against dental mottling from long-term consumption of the element. Exposures of downstream users to fluoride as a result of a spill would be short-term and at levels at or just above drinking water standards. Therefore, a spill of geothermal fluid which reaches the Jemez River should not adversely affect downstream users relative to any of the above constituents.

4.3.3.3 Failure of a drilling sump

Sumps will be constructed at each well site to serve as catchments for drilling muds and fluids (Sect. 2.2.3.1). Oil and grease may also be contained in the sump. Failure of a wall of a sump at a well pad adjacent to Redondo Creek would likely result in a release of drilling muds and fluids from the sump to the creek. The probability of such a release is impossible to estimate. Drilling muds and fluids used at the Baca project are noncaustic and have near-neutral pH and as such are not likely to be severely toxic to aquatic biota. However, bioassay data on toxicity of several of the constituents of the muds used at the Baca project are not available; therefore, the impacts of an accidental release of drilling muds and fluids cannot be precisely evaluated.

4.4 IMPACTS OF TRANSMISSION LINES

4.4.1 Construction

The following discussion of impacts considers separately impacts of construction of the 115-kV transmission line and impacts of operation. Two proposed transmission line corridors are treated, of which only one will be chosen. Details of construction and maintenance practices may be found in Sect. 2.2.4. Section 3.2 discusses the environment along the two proposed corridors. Exact centerline placement of the right-of-way along the corridors is not known presently and detailed vegetation, archaeology, and engineering studies along the right-of-way have not been completed. Therefore, quantification of many impacts is not possible; in such cases impacts are discussed in general terms only.

Impacts of construction on land use, the biotic environment, soils, archaeologic and cultural resources, and visual resources are discussed separately for each corridor, followed by a comparison of overall impacts. Figures 2.9 and 3.25 illustrate the two proposed corridors.

4.4.1.1 Land use

Construction of the 115-kV transmission line along either corridor will result in impacts to grazing, timber production, and to recreational uses via visual impacts. Impacts to future timber production will only be considered for private and Forest Service lands because timbering is not allowed on LASL land or in Bandelier National Monument. The extent of these land use impacts are different for each corridor according to the land ownership along the corridor.

Corridor 1 — Baca corridor

Approximately two-thirds of the Baca corridor is within the privately owned Baca Ranch, where current land uses are restricted to grazing and timber production. Seven kilometers of the corridor crosses the Santa Fe National Forest where land uses include grazing, timber production, and recreation. The remaining 5 km of the corridor is within the DOE lands on the LASL reservation, which are devoted to research and support services. The Baca corridor does not traverse any residential areas.

Impacts to grazing on the Baca Ranch and the USFS land will be minimal. The impacts will be temporary for the season of construction and until revegetation of any cleared areas is accomplished. Approximately 1-3 km of the Baca route crosses meadow grazing areas. The remainder of grazing lands crossed on the Baca and USFS land are wooded.

Construction of the line along the Baca corridor will necessitate clearing of forest from about 15 km of the right-of-way within the private Baca Ranch; about 8 km of this forest consists of timber of commercial size (7" dbh or greater). The remainder of the right-of-way is within meadows (1 to 3 km) and recent clearcuts (6 km). Considering that the clearcuts will eventually be reforested, construction of the line along this corridor will remove about 21 km of the right-of-way on private land from future timber production for the life of the line. Assuming a 30-m right-of-way, this will result in about 65 ha (166 acres) of private timber land removed from production. On the Forest Service land, the entire 7-km length of the right-of-way is within heavy timber, which will be cleared. A total of 21 ha (94 acres) of Forest Service land will therefore be removed from future timber production for the life of the line.

The USFS lands crossed by the Baca route are managed for recreation, as well as other uses. Because of their close proximity to Los Alamos, these eastern slopes of the caldera are heavily used by local area residents for a variety of recreational activities. Impacts to recreational uses caused by transmission line construction are primarily visual impacts. People's enjoyment of outdoor recreation is greatly affected by the quality of the visual resources. The Baca corridor crosses the Guaje trail and passes in close proximity to the Pajarito Ski Area and Camp May, and the FR-1 road to these use areas. Visual impacts are discussed in greater detail in Sect. 4.4.1.5.

Approximately 5 km of the corridor crosses the LASL reservation. Impacts in terms of present or planned land use on the reservation are not anticipated as a result of transmission line construction. In terms of interference with land use, final alignment of the right-of-way will be closely coordinated with the Laboratory Environmental Review Committee and with other Laboratory personnel.

Corridor 2 — southern corridor

The southern corridor crosses 10.5 km of the private Baca Ranch, 15 km of Forest Service land, 3.5 to 6.5 km of Bandelier National Monument, and 8 km of DOE land on the LASL reservation. Timbering and grazing are not allowed on the LASL lands or on the monument, but both land use practices may occur on the Baca Ranch and Forest Service land. Impacts to grazing from line construction along this southern corridor will be similar to those along the previously discussed Baca corridor. Construction of the line will necessitate clearing of forests from about 8.5 km of the right-of-way on the Baca Ranch; the remainder of the corridor on the private land is within meadow and scrub oak stands. Almost all of the timber to be removed from the Baca Ranch is of commercial size and some of the stands are of virgin timber. Approximately 25.5 ha (65 acres) of private land will therefore be removed from timber production. Much of the Forest Service land south of the Baca has been selectively logged; the amount of commercial timber to be removed from this portion of the national forest by line construction will depend upon final right-of-way placement. The section of Santa Fe forestland east of Bandelier Monument, however, has not been recently logged, and all of the right-of-way is within dense forests of commercial timber. In all, 15 km of the right-of-way on Forest Service lands, a total of 45 ha (115 acres), will be removed from timber production for the life of the line.

One link of the southern corridor crosses about 1 km of private inholding in the Santa Fe National Forest south of the Baca Location. This land, the Primos Hermanos Subdivision, is slated for development for second homes (Wirth Associates 1979). Construction of the transmission corridor along the southern link would undoubtedly create a conflict with residential use of this land.

Approximately 18.5 to 21.5 km of the southern corridor crosses public recreation lands (15 km in the Santa Fe National Forest and 3.5 to 6.5 km of the Bandelier National Monument). Construction of the line will result in conflicts with recreational use as a result of visual impacts. The southern corridor passes in close proximity to the Los Conchas campground and the use area along East Fork of the Jemez River. Visual impacts are discussed in more detail in Sect. 4.4.1.5.

The southern transmission corridor crosses a portion of Bandelier National Monument recently acquired from the private owners of the Baca Ranch. Almost the entire Bandelier National Monument south of this recent acquisition is a designated wilderness. The new acquisition is under consideration for addition to the Bandelier Wilderness Area (Wirth Associates 1979); only the portion of the acquisition south of NM-4 would qualify as wilderness. Link C of the proposed corridor avoids this southern section; however, link D bisects the area. Construction of the transmission link along link D could disqualify this section as wilderness. This conflict could be avoided by choosing link C or otherwise routing the line north of the highway.

Land use conflicts for the southern corridor within DOE lands are discussed for the Baca corridor.

4.4.1.2 Ecological impacts

Impacts to vegetation will result from clearing of the right-of-way and for access roads and structure placement sites. Wherever possible, clearing of the right-of-way will be limited to topping or removal of large trees. Even limited clearing in densely forested areas will open the canopy and result in the establishment of an earlier successional community, primarily shrubs, grasses and forbs, in the right-of-way. Along the corridors where rare or threatened plant species might occur, clearing and other construction activities could result in the destruction of small populations unless they can be avoided. Both corridors cross areas within Redondo Canyon where three species of plants considered rare in the State of New Mexico could occur (see Sect. 3.1.5.3). The southern corridor crosses ponderosa pine areas south of Redondo Canyon where one other rare plant species, *Malaxsis soulei* could occur (Issacs 1979c). Both corridors cross an area around Los Alamos that could be habitat for the Federally listed and threatened *Pediocactus papyracanthus*. Mitigation measures for possible effects on these plant species include surveys and subsequent avoidance of areas where populations are located. The State Heritage Program has approved these mitigation plans (Issacs 1979a, 1979b; Sabo 1979).

Impacts to wildlife species could occur from habitat alteration as a result of right-of-way clearing. The major portions of both corridors are within densely forested areas. Clearing along the right-of-way will result in habitat loss for wildlife species that depend upon closed-canopy forest. Forested habitat is abundant in the region and most closed-canopy species are likewise abundant and widely distributed in the vicinity of the corridors. Loss of some individuals of most of these species as a result of habitat alteration will not be significant. However, the Jemez Mountains salamander, a State-designated endangered species, requires moist, densely forested areas. Impacts to the salamander will be considered separately for each corridor in subsequent discussion.

Creation of an earlier successional community along the right-of-way will benefit a variety of important wildlife species. The narrow, lineal nature of the right-of-way will result in an increase in habitat for "edge" species such as wild turkey and mule deer. Both the abundance and diversity of plant species that are valuable wildlife forage are greater in open-canopy situations such as that created along the right-of-way. Transmission line construction will probably result in increased forage for elk and deer in areas frequented by these species.

The noise and human activity associated with transmission line construction will probably cause wildlife species sensitive to human presence to avoid the adjacent areas during construction and clearing. Some of these sensitive species include black bears, bobcats, mountain lions, and elk. Disturbance to these species should be limited to the season of construction; it is likely that the species will return to the area once the disturbance along the corridor ceases.

Impacts on aquatic biota could occur as a result of increased sedimentation caused from erosion from line construction. Erosion potential along both corridors is discussed in Sect. 4.4.1.3 on soil-related impacts. Sedimentation potential is increased where the corridors cross perennial streams. Both corridors cross Redondo Creek. Additionally, the southern corridor crosses the East Fork of the Jemez River and one link crosses Frijoles Canyon in which a perennial stream flows. Crossings of these streams are discussed in further detail in subsequent sections devoted to each of the corridors specifically.

Corridor 1 — Baca corridor

The only perennial stream crossed by this corridor is Redondo Creek. Line construction could incrementally increase erosion, resulting in sedimentation in the creek. Downstream consequences of erosion and siltation in the Redondo Creek/Jemez River watershed are discussed in detail in Sect. 4.1.4.2.

Corridor 1 crosses approximately 26 km of densely forested habitat, which will be altered by clearing. From 1.5 to 2.5 km of known habitat for the Jemez Mountains salamander within Redondo Creek is crossed. Portions of the 7-km section of the corridor in spruce-fir forest that descend the eastern slopes of the caldera (see Sect. 3.2.2) could also be potential salamander habitat. The salamander is extremely dependent upon moisture and rarely occurs in unshaded areas (Reagen 1967, 1972; Whitford Ecological Consultants 1975a, 1975b; Williams 1972). Construction of the transmission line could result in a loss of habitat by actual disturbance of the surface during clearing for tower placements or by removal of the closed canopy within the right-of-way. Recent studies have determined that the species is more abundant and widely distributed within its range than was thought earlier. However, the fact remains that its range is extremely limited. Because of the concentration of salamander habitat within Redondo Creek, some loss of habitat will be inevitable as a result of construction of the right-of-way. Disturbance of large areas of salamander habitat would be undesirable. Mitigation measures include surveys along the right-of-way to delineate areas of salamander concentration and subsequent avoidance of these areas. These measures have been approved by the New Mexico Game and Fish Department.

Corridor 1 crosses elk winter habitat in Redondo Canyon. It also crosses elk summer use areas on the Cerro del Medio and on the eastern rim of the caldera. The Cerro del Medio is an identified elk calving area. Construction of the line will result in disturbance to elk in these areas during the season of construction.

Corridor 2 — southern corridor

In addition to crossing Redondo Creek, the southern corridor crosses the East Fork of the Jemez River, creating a potential for siltation in this watershed. Use of a long span to cross these streams, which will remove the tower construction sites as far as possible from the stream banks, should reduce this potential. Siltation potential will be further reduced by the fact that there will be no clearing of stream-bank vegetation. Potential impacts of sedimentation in the East Fork of the Jemez River are discussed in more detail in Sect. 4.1. With use of sound practices outlined in USDOI, USDA (1970), siltation resulting from transmission line construction should be minimal and should not significantly affect the aquatic biota in the Jemez River.

Link D, an alternative link of the southern corridor, crosses both arms of the upper Frijoles Canyon within the recent addition to Bandelier National Monument. Potential erosion and subsequent increased sediment loads in the Frijoles River would be of special concern to the National Park Service because this section of the monument was acquired to protect the upper Frijoles watershed (Wirth Associates 1979). By crossing the canyon, especially the eastern arm of it, some towers could be placed on relatively steep slopes, increasing the potential for erosion. The southern corridor crosses about 35-38 km of forested habitat, which will be altered by right-of-way clearing.

The southern corridor crosses about 3.5 km of forested north-facing slopes in Redondo Canyon that have been identified as excellent habitat for the Jemez Mountains salamander. The corridor avoids the type locality for the species occurring south of the Baca Location, where Reagen collected a number of individuals (Reagen 1967, 1972), but it does cross other areas of potential salamander habitat as described in Sect. 3.2.2. Impacts to the species and mitigation measures already have been discussed for the Baca corridor. In all, from 4 to 8 km of salamander habitat is crossed by the southern corridor.

The southern corridor traverses both elk winter and summer habitat in Redondo Canyon and crosses elk winter habitat in the Banco Bonito area, south of the canyon. Additionally, the corridor crosses a heavy elk summer use area in the Santa Fe Forest, east of Bandelier Monument. In all, about 4 to 8 km of elk habitat is crossed. Elk will undoubtedly avoid this area during construction but may be attracted to the increased forage once construction ceases.

Impacts to rare and endangered species

As discussed earlier, both corridors cross areas where three species of plants considered rare in New Mexico could occur. These species are: *Viola pedatifida*, *Cornus canadensis*, and *Lilium Philadelphieum*, var. *andiinum*. The southern corridor crosses an area where another New Mexico rare plant species, *Malaxsis soulei*, could occur. Both corridors also cross an area around Los Alamos where the federally listed (as threatened) *Pediocactus papyracanthus* might occur. Mitigation of effects on these species include surveys along the proposed right-of-way and subsequent avoidance where possible of areas in which these species occur. These mitigation measures have been approved by the New Mexico Heritage Program (Issacs 1979a, 1979b; Sabo 1979).

Sections of both corridors cross known and potential habitat for the state-designated endangered Jemez Mountains salamander (*Plethodon neomexicanus*). The details of potential impacts on this species have been discussed above for each corridor specifically. Mitigation measures, including surveys of salamander presence along the right-of-way and subsequent avoidance of salamander habitat, have been approved by the New Mexico State Game and Fish Department (Olson 1979, Pilz 1979).

Both corridors are sufficiently distant from identified peregrine falcon eyries to preclude impacts on these birds (see Sect. 3.1.5.3); however, neither corridor has been surveyed for presence of peregrine eyries. Because the Jemez Mountains are favorable breeding habitat for the peregrine, such a survey should be conducted before a route is selected to ensure that impacts to this federally designated endangered species do not occur.

4.4.1.3 Soil-related impacts

The major soil-related impact of concern is erosion. The following is a general discussion of erosion potential along both transmission corridors based on the general information available regarding soil types along the corridors (see Sect. 3.2.3). Before actual construction commences, a detailed engineering and soil stability survey will be conducted along the right-of-way to identify soils that would be unsuitable for construction. Such soils would be avoided in transmission line construction. Mitigation of erosion-related impacts is best achieved by such avoidance wherever possible. Also appropriate are erosion control methods outlined in the U.S. Department of Agriculture and U.S. Department of the Interior (1970) criteria.

Corridor 1 — Baca corridor

The erosion potential of the various soil mapping units along the Baca transmission line corridor can be described best as moderate. Although erodibilities range from slight to severe, 60% of the soils show moderate erosion potential and slight to moderate general sensitivities. The soils are typically deeper and slopes more gradual than along the southern corridor.

Corridor 2 — southern corridor

The erosion potential of soils along the southern transmission corridor ranges from slight to severe. The majority of the soil units (60%) are characterized by moderate erodibility. The overall sensitivities of these soils to transmission line construction, however, are not restricted to erosion potential. Depth to bedrock is often very slight, with numerous rock outcrops, and shrink-swell potential exceeds desirable limits for a number of soils. Fifty-seven percent of the soils along the southern route have general sensitivity ratings of severe, indicating a reduced suitability for line construction.

4.4.1.4 Impacts on archaeological and cultural resources

Because neither corridor has been surveyed for archaeologic resources, impacts on these resources cannot be predicted. Both corridors have potential for encountering archaeologic remains; the potential is greater along the southern corridor because it is longer and because it crosses more potentially archaeologically rich areas, including a portion of Bandelier Monument. Mitigation of impacts on archaeological and cultural resources by avoidance is almost always possible, except in cases of extraordinary site density. Before the transmission line is constructed, PNM will conduct a detailed archaeologic field survey and will route the transmission line to avoid sites located by the survey. The mitigation plan will be approved by the State Historic Preservation Officer.

Construction of the line along the southern corridor will involve a National Register site — Bandelier National Monument, listed in the National Register of Historic Places. A determination of no adverse effect would be required by the National Advisory Council before an easement to utilize the southern corridor could be granted. Such an easement, if granted, would undoubtedly carry strong stipulations regarding avoidance of cultural and archaeologic resources.

Also, construction of the line along either corridor will impact property registered on the National Registry of Natural Landmarks -- the Baca Location/Valles Caldera. The Baca corridor will cross from 20-23 km of the landmark; the southern corridor will cross 10.5 km.

The transmission line will add further to the alteration of the largely undeveloped natural state of the landmark, as discussed in Sect. 4.1.1.

4.4.1.5 Visual impacts

The visual resources of the study region surrounding the corridors is described in Sect. 3.1.9 and 3.2.5. Determination of potential visual impacts takes into consideration two factors: the quality of the view to be affected and the sensitivity and number of people enjoying the view. The Baca Location and the surrounding public lands contain many excellent visual resources, including one of the world's largest calderas. The contrast of the open rolling *valles*, forested mountains, and often snowcapped peaks provide superior views. Although portions of the Santa Fe National Forest and the Baca Location have had a long history of logging, the general impression of the view from the main travel routes and recreational use areas is one of an undeveloped natural area. The great majority of the people who come to the Jemez Mountains come for recreation and sightseeing and are likely to be sensitive to visual intrusions of the cleared right-of-way, lines, and towers into the natural setting.

Some indication of potential visual impact is possible from a consideration of the proportions of the corridors within each of the four visual quality management objective classes. Table 3.20 summarizes the percentages of each corridor within the four management objective classes. Generally, a corridor located with a major portion of its length in areas that fall within the two highest classes of retention and partial retention, is likely to have greater visual impact than a corridor that crosses primarily modification or maximum modification areas. Over 66% of the southern corridor crosses retention and partial retention areas; 26% of the Baca corridor crosses retention and partial retention areas. However, in some cases, an area having a greater variety of features (and thus having a higher visual management objective classification) would be better able to absorb disturbance, such as that related to a transmission line, without as noticeable a visual intrusion as a homogeneous landscape.

A better quantification of visual impact is consideration of the number of travel routes and use areas from which portions of the transmission line would be visible. Also important is a determination of the length of the line that will be visible and from what viewing distance. The following is a discussion of visual impacts for each of the proposed corridors. Table 4.6 summarizes visual considerations for both corridors and provides average daily traffic estimates for affected travel routes.

Mitigation of visual impacts is best achieved by routing the right-of-way through the least-visible sections of the corridors. PNM and Union have contracted a computer-generated visual analysis of the region surrounding both corridors to identify areas visible to the least number of locations in sensitive use areas (Paulson 1978). Further mitigation of visual impacts will be achieved by adhering to the construction practices and techniques of right-of-way screening outlined in the U.S. Department of the Interior and U.S. Department of Agriculture (1970) criteria for transmission facilities.

Corridor 1 — Baca corridor

Almost the entire section of the Baca corridor across the private Baca Ranch is screened from views from public use areas and NM-4 to the south by the forested domes within the caldera. A portion of the corridor (about 0.5 km) crossing Jaramillo Creek will be visible from the NM-4 scenic overlook of the Valle Grande at a distance of about 6.5 km. Much of the Baca corridor on the private land would be visible from Pueblo religious sites on Redondo Peak (the mountain) and may be visible from other sacred sites on the Baca Ranch.

Visual impacts of the 7-km section of the Baca corridor within the Santa Fe National Forest east of the Baca Ranch will be moderate to severe. This section of the forest was designated by the USFS to be a scenic area of heavy recreational use (Forest Service 1977). All routes descending the densely forested slopes of the eastern caldera rim are visible from the Pajarito Ski area and from portions of Los Alamos. The Baca corridor will be visible from both the ski area and the day-use area at Camp May (see Table 4.6). The corridor crosses the Guaje Trail, which

Table 4.6. Visual consideration of the two proposed transmission corridors

Corridor 1 — Baca corridor

Travel routes crossed	Average daily traffic
FR-1 Camp May Road (1)[a]	747
NM-4 alt., W. Jemez Rd. (1)	1156
Total	1903

Travel routes paralleled	Length (km)	View distance (km)	Average daily traffic
FR-1 Camp May Road (1)	5.0	0.5	747
NM-4 alt., W. Jemez Rd. (1)	2.5	1.0	1156

Visibility from use areas	Length of line (km)	View distance (km)
NM-4 overlook to Valle Grande	0.5	6.5
Gauje Trail	2.5	0.5
Camp May	3.0	1.0
Ski Area	3.0	1.0

Corridor 2 — southern corridor

Travel routes crossed	Average daily traffic
NM-4 near Las Conchas (1)	561
FR-280 Peralta (2)	*b*
FR-268 Bland (2)	30
FR-289 (Dome) (1)	102
NM-4 near FR-289 (1)	665
NM-4 alt., W. Jemez Rd. (1)	1045
Total	2302

Travel routes paralleled	Length (km)	View distance (km)	Average daily traffic
FR-289 (1)	6.5	1.0	102
LASL access	5.0	0.5	*b*

Visibility from use areas	Length of line (km)	View distance (km)
East Fork Jemez	0.3	0.5
Las Conchas Camp	0.3	1.0
Pinic area at FR-289 & FR-287	0.5–1.0	0.5

[a]Sensitivity rating of road crossed indicated within parentheses.
[b]Not available.
Source: Public Service Company of New Mexico, 1979. *Environmental Assessment of Alternative Transmission Line Routes for the Baca Geothermal Project.*

receives considerable use by hikers. The corridor also crosses FR-1 (Camp May road), which accesses the ski area, and parallels the road for a distance of about 5 km. However, because heavy timber encloses the road and trail for much of their distance, the crossings of both the trail and the road will only be visible briefly. Over much of the distance along which the corridor parallels the Camp May road, it should be possible to hide the corridor from view of the road by maintaining a screen of timber between the road and the line.

As the Baca corridor crosses into the LASL reservation it crosses NM-4 alt. (West Jemez Road), the entire length of which has been proposed as a state scenic highway. The road is crossed in a high use area (average daily traffic of 1156). However, the immediate area surrounding the crossing has already been altered by activities associated with the LASL reservation. The Baca corridor will cross at least two access roads within the LASL reservation. The visual impact of these crossings are considered less severe.

Corridor 2 — southern corridor

From 26 to 29.9 km of the southern corridor crosses public lands where visual impacts on recreational use of these lands are likely. About 4 km of the corridor is within a portion of the Santa Fe Forest which the USFS has designated as a highly scenic area of heavy recreational use and recommended that it be excepted from geothermal development (United States Forest Service 1977). That portion of the corridor that extends along Redondo Canyon and exits the canyon across Banco Benito will be visible from Redondo Peak (the mountain). How much, if any, of the corridor will be visible after it crosses Banco Benito or how much of the corridor will be visible from the summit of Redondo Peak is not clear. The southern corridor will be visible from public use areas along the East Fork of the Jemez River, at the Las Conchas Campground, and at an informal picnic area near the junction of FR-289 and FR-287 (see Table 4.6). Views at the river and campground are partially enclosed by timber, and the line should be seen only briefly.

The southern corridor crosses NM-4 twice: once near Las Conchas Campground and once near the junction with FR-289 (Dome Canyon Road) within Bandelier Monument. All of NM-4 has been proposed as a state scenic highway. At the Las Conchas crossing, the line will cross above the viewer and, at most, only two structures and the conductor will be noticeable. If the drainage is followed south of the road, structures will be in sight to eastbound travelers but will probably go unnoticed because dense timber will background them and because the area will be cleared only minimally. The drainage alignment would go virtually unnoticed by westbound travelers. At the NM-4 crossing near FR-289, however, structures will be more at viewer level, surrounding trees are less dense, open meadows occur in the area, and more of the line will be visible for a longer period of time.

The southern corridor crosses a southern leg of FR-268, at a sensitivity two travel route location. The corridor also crosses FR-268 near its junction with FR-289, a sensitivity one location. Both crossings will be in dense timber; the line will emerge from the forest and reenter quickly. This, combined with the twisting nature of the roads, will result in only brief visibility of the line at the crossings. The corridor also parallels about 6.5 km of FR-289 (Dome Road) within Bandelier Monument. Along this road, the forest is dense in some areas and sparse in others. In many places along the road, the viewer looks through a thin curtain of trees at the landscape beyond. In this situation, a transmission line with adequate backgrounding will be significantly less visible.

After leaving the Bandelier Monument, the southern corridor crosses NM-4 alt. (West Jemez Road). Unlike the crossing of this road by the Baca corridor, this corridor crosses in an undeveloped area. The trees on both sides of the road will hide the structures, but because the road is straight, the conductors and possibly the structures will be visible from about 0.5 km away.

Within the LASL reservation, the southern corridor parallels an access road for about 5 km. The corridor also crosses at least three other access roads within the reservation before reaching the TA-3 substation.

4.4.2 Impacts of operation

Other than continuing visual impacts, operation of the transmission line should have no significant effect on land use. Recent studies concerning the effects of corona discharge, electrostatic and electromagnetic coupling effects, audible noise, ozone generation, and radio and television interference from high-voltage lines indicate little cause for concern at voltages as low as 115 kV (U.S. Rural Electrification Administration 1976, Power Technologies, Inc. 1978).

The Public Service Company plans to close and restore any access roads immediately upon completion of construction. No access road will be maintained for routine line inspections; these incursions will be accomplished by helicopter. Any access that may be opened for maintenance purposes will be closed and restored immediately after repair is accomplished. However, because of the recreational popularity of the region surrounding the corridors, some unauthorized use of the right-of-way is inevitable. Inasmuch as no road will be maintained along the right-of-way, most of the unauthorized use probably will be by hikers, cross-country skiers, and, possibly, snowmobile users.

The southern corridor holds the greatest potential for such unauthorized use because it provides the greatest access to the transmission corridor from NM-4. Access to the Baca corridor, in contrast, is limited because of Baca landowner's constraints. The greatest impact from unauthorized entry would be on archaeological resources from illegal collecting or "pot-hunting." Because of the high site density along the southern corridor, as well as access via NM-4, impacts would be expected to be greatest along this route.

No herbicides will be used for right-of-way maintenance. The conductors are sufficiently far apart on 115-kV lines to preclude the possibility of raptor electrocution deaths (Miller, Boeker, Thursell, and Olendorff 1975; U.S. Department of Agriculture 1972). The primary impacts to wildlife resulting from operation of the transmission line would be those connected with unauthorized use of the right-of-way. Harassment of wildlife, especially by loud snowmobiles, and illegal hunting could be encouraged by the increased access provided by the line.

4.4.3 Comparison of corridors

Table 3.20 provides a summary of environmental considerations for both corridors. The southern corridor is 20% longer than the Baca corridor. Land use impacts for both corridors are of a similar type, however, overall land use impacts will be greater along the longer southern corridor. The Baca corridor affects more private land; the southern, more public land. Both corridors cross similar lengths of grazing and timber production lands (27-30 km for the Baca; 25 km for the southern). The southern corridor crosses 18.5 to 21.5 km of public recreation lands, including a 3.5- to 6.5-km track of the Bandelier National Monument under consideration for an addition to a wilderness area. The Baca corridor crosses only 7 km of public recreation lands. The southern corridor also crosses a planned residential area.

Both corridors cross forested areas for a major portion of their lengths; however, because the Baca corridor utilizes some meadows and clear-cut areas on the Baca Ranch, the corridor is within densely forested areas for only about 75% of its length (approximately 25 km of forested area). The southern corridor is almost completely within dense forests. The timber stands crossed by the southern corridor are, for the most part, more dense and more mature and will require more clearing than the timberlands crossed by the Baca corridor. Both corridors cross areas where rare plants could occur.

The two corridors will cross elk-use areas of similar dimensions; the Baca corridor crosses an identified elk calving area. Both corridors cross identified and potential habitat for the Jemez Mountains salamander. The Baca corridor crosses about 2.5 km of identified habitat and an additional 5 km of possible habitat. The southern corridor crosses about 8 km of identified salamander habitat.

The erosion potential along the southern corridor is greater than along the Baca corridor. Certain areas of volcanic-ash soil along the southern corridor have high erosion potential. The southern corridor crosses more canyons and, thus, more sensitive side slopes than the Baca corridor. The sedimentation potential is also greater along the southern corridor, both because of the greater erosion potential and because the southern corridor crosses three perennial streams, whereas the Baca corridor crosses only one.

The southern route has a greater potential for encountering archaeologic resources. Also, the southern corridor crosses Bandelier National Monument, a national historic site. The southern corridor was found to be unacceptable by the U.S. Forest Service (comment letter Sept. 6, 1979, p. I-42). Both corridors cross portions of the Valles Caldera National Landmark (Baca corridor, 20 to 23 km; southern corridor, 10.5 km).

Finally, the impact on visual resources is greater along the southern corridor. The southern corridor crosses more travel routes than does the Baca corridor. Even though the Baca corridor crosses the more heavily used roads, the total average daily traffic for all roads crossed by the Baca corridor is 1903, whereas that for all roads crossed by the southern corridor is 2302. Although both corridors will be visible from the same number of recreational use areas, the Baca corridor is in a more developed area, in the sense that the ski area is, itself, a man-made alteration of the landscape. A transmission line near the ski area will repeat much the same linear features as the cleared slopes and tow-lines.

Overall, the southern corridor is much more environmentally sensitive than the Baca corridor. All other things being equal, the southern corridor would represent greater environmental impact simply because it is 20% longer. However, this analysis indicates that for all categories of impact, those associated with the southern corridor are greater to an extent out of proportion to its greater length.

4.5 IMPACTS OF FUTURE EXPANSION BEYOND 50 MW

In the event that generating capacity on the Baca Ranch is expanded beyond the proposed 50-MW plant, the expansion would likely occur in intervals of 50 MW. The initial 150 MW of capacity will probably be sited in Redondo Canyon. The location of subsequent power plants beyond 150 MW may be anywhere within the western portion of the Baca Ranch, but has been assumed to be concentrated in Sulfur and Alamo Canyons for this analysis. The impacts of a potential expansion of generating capacity are addressed below separately as they relate to 150 MW in Redondo Canyon and an additional 250 MW in Sulfur and Alamo Canyons.

4.5.1 150 MW

Impacts of a total of 150 MW of generating capacity are discussed in the following sections as they relate to land use, air quality, groundwater hydrology, water quality, biological resources, socio-economic considerations, and cultural resources. In most cases, the impacts of 150 MW will be similar to those discussed for the initial 50 MW (Sects. 4.1 through 4.3), but will be increased threefold. An exception is transmission line impacts; no added transmission facilities will be necessary up to 150 MW.

4.5.1.1 Land use

An additional 100 MW of generating power in Redondo Canyon will require two additional well fields of about 300 ha (740 acres) each, for a total area of 900 ha (2220 acres) in Redondo Canyon devoted to the well fields for 150 MW. Of this area, from 10 to 20% will be actually disturbed in connection with construction of additional roads, well pads, pipeline rights-of-ways, and sites for two more power plants and related facilities. Therefore, a maximum of 180 ha (440 acres) in Redondo Canyon could be disturbed by development to 150 MW.

If the Baca Ranch remains in private ownership, it is assumed that this land commitment for geothermal development will not conflict with the private owner's use of the land because of the leasing agreement reached between the owner and the commercial partners. Considering the location of the new power plants in Redondo Canyon, the impacts of the additional 100 MW on surrounding public lands should be similar to those discussed for the initial 50 MW also in Redondo Canyon. The new plants and well fields, cooling towers, and plumes should not be visible from existing public recreation areas. The impacts on recreational users of public lands and surrounding residential areas from construction related traffic and noise will be similar to those discussed for the initial

50 MW (Sect. 4.1.1), but will be extended over more seasons as the additional 100-MW plants are constructed. Development of the proposed 50-MW plant already represents a change in character of a portion of the Valles Caldera/Baca Location National Natural Landmark from that of a relatively natural setting to that of an industrial use. The additional 100 MW in Redondo Canyon would increase the possibility of altering the status of the landmark.

Noise from operation of the additional two power plants and cooling towers should not be detectable at the nearest residence (see Sect. 4.1.1). The increased emission of hydrogen sulfide from two additional 50-MW units in Redondo Canyon should not result in H_2S detectable odor at the nearest residence or at public recreation areas (see Sects. 4.1.1 and 4.5.1.3).

4.5.1.2 Hydrologic

Field development to 150 MW will increase the expected hydrogeologic impacts, but to an unknown degree. Additional production to this stage of development will be contained within Redondo Canyon; therefore, it is assumed that reservoir properties identical to those known will be encountered. The additional impacts will be dependent upon reservoir and fracture geometry and the direct relationship (linear or otherwise) existing between geothermal reservoir pressure decline and subsequent effects on regional shallow groundwater systems. The simplest way to estimate anticipated hydrogeologic impacts is to assume that a linear relationship exists between the deep and shallow systems, the previously determined flow depletion in the Jemez River system as a result of geothermal production are reasonable estimates, and all of the estimated fluid in place in the reservoir is recoverable (it is not).

By multiplying the impacts of 50-MW development by a factor of 3, with plants coming on line at five-year intervals, it is possible to derive flow depletion based on arsenic dilution ratios along the Jemez River of 0.32, 0.89, and 1.46 liters/sec (5.07, 14.11, and 23.14 gal/min) at 10, 20, and 30 years of plant operation. Other factors remaining constant and using chloride, bromide, boron, and lithium ratios, the Jemez River discharge could be reduced by as much as 0.40, 1.10, and 1.81 liters/sec (6.34, 17.44, and 28.69 gal/min) at 10, 20, and 30 years of plant operation. For the period 1960-1975, the minimum flow of the Jemez River was 93 liters/sec (3.3 cfs), the maximum flow was 29,200 liters/sec (1030 cfs), and the mean annual flow averaged 850 liters/sec (30 cfs). The mean annual flow ranged from 450 to 1850 liters/sec (16 to 65 cfs) for the period 1960-1975. Development to 150 MW is expected to further reduce the flow from Jemez and Indian Springs; however, the magnitude of the reduction is unknown. This reduction will affect the use of these springs for bathing. Refer to Sect. 4.2.2.2. for impacts related to 50-MW(e) development.

The geothermal reservoir would not be depleted for approximately 220 years with expansion to 150 MW, assuming that production is limited to 150 MW and the three 50-MW plants come on line at five-year intervals. Reservoir temperature and fluid quality will be degraded by the additional plant production. Preliminary calculations are that the total dissolved solids in the reservoir fluid could be increased from 6093 ppm to perhaps 7920 ppm, and the temperature could decrease to 262°C (503°F) within 30 years of the beginning of operation of the first 50-MW plant. Geothermal reservoir pressure can be expected to decrease from 13,780 kPa (2000 psia) to 5,900 kPa (856 psia) over the 30 years following the first 50-MW plant production startup.

4.5.1.3 Air quality

The location of three 50-MW units in Redondo Canyon would increase the air quality impacts on the order of three times that of a single unit. Because the units will probably be spread apart, the combined impact may be somewhat less than additive. However, without knowing the probable positioning of the units, the estimate for hourly daytime concentrations over the peaks on the western edge of the reservation is approximately 6 ppb. Assuming an isothermal lapse rate within the nocturnal drainage layer, the hourly concentration occurring at NM-4 to the southwest as a result of the 150-MW plant located in Redondo Canyon should be approximately 2 ppb. If, however, the plumes become trapped within the drainage layer, hourly concentrations at this location might reach 60 to 70 ppb. As stated previously, the revised state standards for hydrogen sulfide are 10 ppb at the property line on a 1-hr. averaged sample with one excursion per year permitted of up to 35 ppb on a 1-hr averaged sample.

4.5.1.4 Impacts to biota

Terrestrial

Disturbance to vegetation for a total of 150 MW will be increased threefold over that for 50 MW. The locations of future well pads, roads, pipelines, and power plants are not yet known, so that a determination of disturbance to specific vegetation types is not possible. The extent of adverse biological impact will depend upon which habitat types are affected. As discussed in Sect. 3.1.5 and 4.1.5, north-facing spruce-fir talus slopes are habitat for the Jemez Mountains salamander, south-facing scrub-oak slopes are winter elk habitat, and riparian areas could include habitat for rare plants. The increase in disturbances for additional well fields and power plants will necessarily increase the likelihood for some disturbance of these important habitats. Even with mitigation measures (outlined in Sect. 4.1.5), some additional disturbance will inevitably occur to salamander habitat because of the abundance and wide distribution of this habitat type throughout Redondo Canyon. The potential impacts on elk use of Redondo Canyon resulting from disturbance and human presence were discussed for 50 MW (Sect. 4.1.5). The additional vegetation disturbance, noise, and human presence at 150 MW may totally preclude elk use of the south-facing slopes of Redondo Canyon, resulting in loss of this area of winter habitat to the Jemez elk herd.

The increase in hydrogen sulfide emissions from expansion to 150 MW should result in ambient hydrogen sulfide concentrations well below the levels that would affect biota. Similarly, salt drift from two additional cooling towers should have negligible effects on surrounding biota (see Sect. 4.1.5).

Aquatic ecology

The impacts of erosion and sedimentation on Redondo Creek and the Jemez River system have been discussed in Sect. 4.1.5. For an additional 100 MW in Redondo Canyon, the potential for erosion and resultant sedimentation of the creek will be increased threefold from that at 50 MW. If water for drilling the additional 100-MW well is taken from Redondo Creek, the reduction in surface flow could severely impact the creek's aquatic system. Normal operation of 150 MW of power in Redondo Canyon will not impact surface water quality because all geothermal fluid will be reinjected. However, the potential for accidents during drilling and operation of the power plants is necessarily increased threefold at 150 MW. Impacts of an accidental release to surface water are discussed in Sect. 4.3.

4.5.1.5 Socioeconomic

The expansion to 150 MW, assuming sequential construction, would result in essentially the same level of impact as the original 50-MW plant to the region around the plant, but over a longer period. Because the 150-MW facility will be constructed in 50-MW increments, workforce sizes, payrolls, materials delivery, etc., would all be similar to those for the 50-MW plant needs.

The impacts on the site itself could be greater because of the increased land areas involved. The actual increased size of the plant would result in greater chances of conflict with archaeological sites or Indian religious sites.

4.5.1.6 Religious values

Expansion to 150-MW generating capacity would probably be confined to Redondo Canyon. No new transmission line would be required. The most likely impact would be the possible loss of religious sites as the geothermal well field expands. However, the Redondo Peak shrine would remain remote from geothermal operations. Larger numbers of non-Indians would be continously present in the area, making the practice of secret aspects of their religion increasingly difficult for the Indians. Some sacred springs and other water sources fed by geothermal fluids may be depleted to a greater extent by the additional geothermal development.

4.5.2 Expansion beyond 150 MW (up to 400 MW)

Expansion beyond 150 MW will involve additional areas of the Baca Ranch. Probably, the additional 250 MW will be placed somewhere within Sulfur Canyon, Alamo Canyon, San Luis Canyon, Valles Seco, and, possibly, portions of the Valles San Antonio. Because development to this capacity is still merely speculative, the location of future facilities cannot be predicted. The following is a very general discussion of potential environmental considerations relating to expansion in this western portion of the Baca Ranch. For expansion beyond 150 MW, additional transmission facilities will be required, probably in the form of one 345-kV line. Environmental considerations of the added transmission facilities are discussed in Sect. 4.5.3.

4.5.2.1 Land use

Expansion of future generating capacity to 400 MW could involve 2400 ha (9.2 square miles) for the well fields (based on a similar land commitment as that for the initial 50 MW). This land commitment does not include that devoted to a second transmission line right-of-way for a 345-kV line (described in Sect. 4.5.3). From 10 to 20% of the land devoted to well fields could be disturbed by well field development and power plant construction for a maximum of 240 ha (1 square mile) disturbed. It is assumed that much of the land initially disturbed during well field development would subsequently be revegetated.

Development to 400 MW could affect portions of Sulfur, Alamo, and San Luis Canyons and Valles Seco and Valle San Antonio. Some of these areas are currently used for grazing; therefore, the vegetation disturbances and activities associated with well-field development could preclude some grazing land. If the Baca Ranch is still under present private ownership, it is assumed that future development would proceed with the knowledge of and consultation with the private landowner. Because of this, conflicts with the private uses are assumed to be minimal.

Conflicts with use of surrounding public recreational areas could sharply increase beyond 150 MW. The location of new well fields and power plants with the attendant cooling tower plumes and new transmission facilities could be such that they are visible to users of the adjacent Santa Fe National Forest or to residents of second home developments on private inholdings within the forest. Noise, traffic, and increased hydrogen sulfide emissions, possibly beyond the odor threshold at nearby residences and public recreation areas, would be additional sources of adverse effects on these land uses. Expansion to 400 MW would in all probability degrade the character of the present Valles Caldera/Baca Location Natural Landmark such that its status could be revoked or new boundaries redrawn to exclude the western portion under development. Similarly, if the Baca Ranch should enter the public domain, geothermal developments up to 400 MW could be incompatible with use of the western portion of the Valles Caldera as a national or state park or recreation area.

4.5.2.2 Hydrologic

Field development to 400 MW would increase the anticipated hydrogeologic impacts and severity in affected areas. However, the nature and degree of these impacts cannot be assessed with existing data.

Expansion beyond 150 MW would entail development and fluid production in Sulfur and Alamo Canyons. It has been stated (Sect. 3.1.2.3) that a steam-dominated reservoir exists in these areas. The size and nature of this reservoir is not known. Furthermore, the relationship or interconnection (if any) between this reservoir, the fluid-dominated geothermal reservoir underlying Redondo Canyon, and shallow groundwater systems and discharge points (Jemez River) is not known at this time. Provided that such connections exist, previously determined adverse impacts to other hydrologic systems could be substantially increased by additional development to 400 MW. Withdrawal of additional lands from irrigation may be required to offset the impacts of expanded development on the Jemez River.

Reservoir fluid quality, temperature, and pressure will be adversely affected by development to 400 MW, but the degree to which this will occur is as yet undetermined.

4.5.2.3 Air quality

If another 250 MW of capacity (the remainder of the 400 MW) were to be located in Sulfur Canyon, the resulting concentrations would be approximately 250/150 times the concentrations from 150 MW of capacity, that is, hourly daytime concentrations of approximately 10 ppb, hourly nighttime concentrations of approximately 3 ppb (assuming an isothermal lapse rate within the drainage layer) and hourly nighttime concentrations of 100 to 120 ppb, if the plumes become trapped in the drainage layer. This estimate assumes that what is known about wind regions in Redondo Canyon will apply also to Sulfur Canyon. The possibility that the plumes from Sulfur Canyon and from Redondo Canyon could merge should be kept in mind, although not enough is known about the local wind field to speculate on this possibility. However, if the plumes in both canyons were to be trapped in nocturnal drainage layers, they would be quite likely to merge. In this event hourly concentrations of approximately 180 ppb in the region of NM-4 to the southwest of the reservation could occur.

4.5.2.4 Impacts on ecological systems

Expansion beyond 150 MW will involve portions of the western Baca Location that have not been extensively inventoried for their biological resources. The following discussion is based on limited knowledge of these areas from earlier biological studies (summarized in Sect. 3.1.5). Without detailed information regarding vegetation and wildlife habitat and location of future well fields and generating facilities, biological impacts of expansion to 400 MW can only be discussed very generally.

Terrestrial

Expansion to 400 MW could involve a total of 2400 ha (9.2 square miles) for the well fields. From 10 to 20% of the vegetation of the well fields will be disturbed in connection with well-field development and power plant construction. Therefore, a maximum of about 240 ha (1 square mile) could be disturbed on well fields scattered throughout the western portion of the Baca Location. The extent of adverse impacts will depend upon sensitivity of the vegetation disturbed, successive revegetation, and the extent of disturbance to important wildlife habitat.

Well-field development and power plant construction to 400 MW could affect consideraly greater portions of Jemez Mountains salamander habitat that may exist outside of Redondo Canyon but is yet to be identified. Whether the amount of habitat disturbed could cause significant adverse effects on the species cannot be determined without additional information concerning both the location and abundance of the habitat and siting of geothermal development in the particular areas. However, even with mitigating measures, destruction of salamander habitat could conceivably reach a threshold that would result in extirpation of the species from certain regions of the Baca Ranch that it presently inhabits.

Expansion into the Valles San Antonio could involve a Federally designated endangered species. Potential nesting habitat has been identified for the peregrine falcon in the northern portion of the Valles San Antonio (see Sect. 3.1.5 and Whitford 1974, 1975a and b). Disturbance related to development in this area could preclude the species use of this habitat.

Expansion into the Valles Seco and Alamo Canyon areas would affect identified elk calving grounds in these areas. Expansion north and east of Redondo Canyon will involve greater portions of identified year round and winter habitat for the Jemez elk herd. Winter habitat is a limiting factor for elk populations. The Jemez elk herd is currently expanding rapidly and could exceed carrying capacity in 10 to 15 years without increased hunting pressure. Loss of proportionally greater amounts of winter habitat through geothermal development will reduce carrying capacity and, without increased hunting pressures, could conceivably accelerate the deterioration of remaining winter range.

If the chemistry of the geothermal reservoir in other portions of the Baca is similar to that in the Redondo Canyon area, operation of additional generating facilities and cooling towers should cause minimal adverse effects to nearby vegetation. Increased hydrogen sulfide releases over the initial 50 MW will, in all likelihood, cause ambient concentrations of hydrogen sulfide to exceed the odor threshold in localized areas, especially near NM-4. However, atmospheric hydrogen sulfide should still remain well below the concentrations that would affect biota (see Sect. 4.1.5). Again, if fluid chemistry is similar to that for Redondo Canyon, the effect, if any, from cooling tower drift should be localized. If, however, the geothermal reservoir in other sections of the Baca has appreciably higher concentrations of hydrogen sulfide, trace metals, and dissolved solids, significant impacts potentially could accrue from power plant operation. Early sampling of the reservoir in these areas will be imperative for the design of proper mitigation plans to ensure protection of surrounding biota.

Aquatic ecology

Development beyond 150 MW (up to 400 MW) will involve impacts to aquatic systems similar to those discussed for Redondo Creek in Sects. 4.1 and 4.3. These will include degradation of water quality from increased erosion and sedimentation and attendant effects upon aquatic biota. Development will occur in the Sulfur Creek watershed and possibly in the upper San Antonio Creek watershed. Sulfur Creek is a small stream, however, physically similar to Redondo Creek, and it does not support a fishery. The entire length of San Antonio Creek downstream of the Baca Ranch is on Forest Service land, and San Antonio Creek is an important trout stream (see Sect. 3.1.3.1.2). Deterioration of water quality in San Antonio Creek could adversely affect a very important recreational resource through degradation of the stream as trout habitat.

Since all watersheds on which future development could take place drain into the Jemez River, the potential effects on the Jemez River of increased sedimentation could be increased eightfold over the effects from the initial 50-MW plant. Similarly, at 400 MW the possibility of accidential release of toxic materials to surface water must necessarily increase eightfold over those of 50 MW. An accidental release of geothermal fluid could have potentially adverse effects on the Jemez River system. Effects of hypothetical release of geothermal fluids are discussed in Sect. 4.3.

4.5.2.5 Socioeconomic

Expansion to 400 MW at several distinct locations would generally have greater impact on surrounding communities than would 50-MW or 150-MW plants because of larger workforce sizes, increased traffic, increased materials delivery, increased economic activity, and the associated increases in public and private sector goods and services such as housing, water, etc. The specific impacts are discussed in the section dealing with the 50-MW facility. It is also feasible that a more continuous workforce would be on the site and that plant construction schedules would overlap, thereby increasing the level of impact as well as the length of time.

4.5.2.6 Religious values

Expansion to 400 MW would affect the entire southwest quadrant of the Baca Location. One or more additional valleys would be developed; at least one additional transmission route would probably be required. The area would assume a more marked industrial character and the chances of direct conflicts with the Pueblo religion would increase substantially. The immediate impacts would be confined largely to the valleys; mountain peaks, such as Redondo Peak, would remain largely unaffected. However, the overall appearance of this part of the Jemez Mountains would be greatly changed. The resulting impact on the practice of the Pueblo religion is impossible to assess, but the increased activity by non-Indians in the area would be disruptive to the current Indian lifestyle.

4.5.3 Additional transmission facilities

Development beyond 150 MW (up to 400 MW) will necessitate construction of an additional transmission line. The new line would be of a 345-kV capacity and would follow one of five feasible routes of egress from the Baca site as outlined on Fig. 4.8. Route 1 connects the Baca site with a 345-kV line exiting west from Ojo and would require a new substation at the connection. Route 2 ties Baca with the existing Ojo substation to the northwest. Route 3 follows the Baca corridor to Los Alamos (described in Sects. 3.2 and 4.4) and would require upgrading the existing 115-kV line to Los Alamos and construction of a 345-kV leg from Los Alamos to the Norton switching station. Route 4 follows a route to San Ysidro that has been discussed as an alternative route for the 115-kV line from the initial 50-MW plant (see Sect. 9.7). If the alternative route were chosen for the 115-kV line from the initial 50-MW plant, it would have to be upgraded to handle 345 kV. Choice of the route 4 alternative would also necessitate construction of a 345-kV leg from San Ysidro to Rio Puerco. Route 5 ties Baca to an existing substation at Star Lake, to the west of Baca.

At this early stage in route identification for generation beyond 150 MW, environmental considerations relating to these five routes can only be discussed in general terms. Considerations are discussed separately for each route in the following sections. The discussions are based on an outline of considerations prepared by PNM. Impacts along the route from Baca to Los Alamos and from Baca to San Ysidro have been treated in some detail in Sects. 4.4 and 9.7, respectively, and will not be repeated here.

Construction of a 345-kV line will differ in some respects from that for a 115-kV line (described in Sect. 2.2.4). Structures utilized will be either wooden K-frame construction or tubular steel or lattice steel towers. The structures will be about 24.5 m (80 ft) tall. Structures will be placed at ∿245-m (800-ft) intervals resulting in about four structures per kilometer (6.6 per mile). As for the 115-kV line, the structures will be assembled at each structure erection site. Since the towers for 345 kV are larger than for the 115-kV line, the amount of land disturbed at each assembly site will be greater than that for

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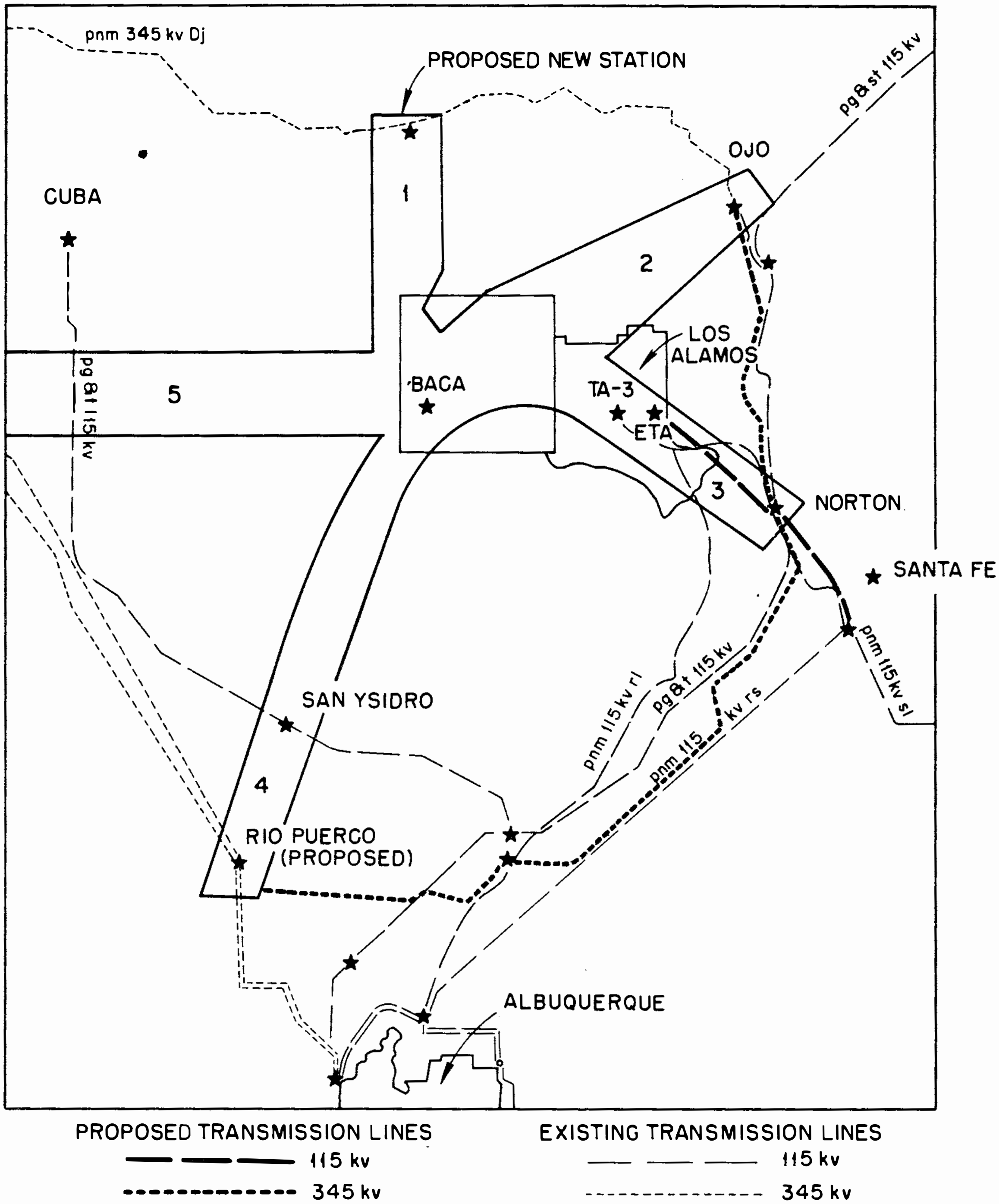

Fig. 4.8. Five feasible egress routes for 345-kV capacity from Baca to the existing and present planned 115 and 345-kV grid.

115 kV. Otherwise, the construction and maintenance details for a 345-kV line will not significantly differ from those described for the proposed 115-kV line (see Sect. 2.2.4). This includes the same width of right-of-way of 30 m (100 ft).

Unlike a 115-kV line, operation of a 345-kV line might have potential audible noise and electromagnetic radiation effects. Audible noise from transmission lines greater than 230-kV capacity consists of two components: line hum and random crackling noise associated with corona discharge (usually occurring in moist weather). Audible noise levels beneath a 345-kV line have been recorded in the 50- to 55-dBA range (Bonneville Power 1977). Electromagnetic effects include radio noise, television interference, and effects on pacemaker devices. These are considerations for line placement near residential areas. Induced voltages on linear features located parallel to the transmission lines, such as buried pipelines or fences, constitute another potential electromagnetic effect for the 345-kV line. These potential effects should be taken into consideration during transmission line placement.

Route 1

This route is from Baca north to a 345-kV line coming west from Ojo (see Fig. 4.8). This routing would necessitate construction of a new substation to tie into the Ojo 345-kV line. The route is approximately 41.5 km (26 miles) in length and crosses the private Baca Ranch, Forest Service land, some state land, and other private land near the community of Coyote. The route crosses grazing leases on the Santa Fe National Forest and on state lands. The route also passes in the vicinity of a number of residential areas associated with NM-96, including Coyote, Youngsville, Rito de las Sillas, Arroyo de la Agua, and Thompson Ridge. Road crossings include NM-96, FR-316, FR-376, and FR-144. The route traverses a number of recreation and geothermal lease areas on the Santa Fe National Forest, including the YCC camp and several small streams that are extensively used for recreation and the Rio Puerco, which harbors a native cutthroat trout population, the Rite de las Sillas, Coyote Creek, and San Antonio Creek. These are all excellent trout fisheries. Visual impacts could accrue at the residental areas, the road crossings, and at public recreation sites.

Route 1 traverses forested areas for almost its entire length, primarily mixed conifer and ponderosa pine forests, but also some spruce-fir forest, riparian habitat, and a number of wet meadows along seeps. The route traverses excellent habitat for elk, deer, black bear, and turkey, all important game species. The Jemez Mountains salamander has been collected from the canyons on the caldera rim, northwest of the Baca Location (Williams 1972, 1976). Much of the area traversed by route 1 in this region could be good salamander habitat. The route also traverses potential peregrine nesting habitat north of the Baca Location and possible habitat for the zone-tailed hawk (listed as Endangered Group II by the state). The potential for occurrence of rare plants along this route is unknown.

The southern two-thirds of the route would likely encounter archaeologic resources similar to those identified for the 50-MW site in Redondo Canyon. Along the northern one-third of the route, there is an increased probability for encountering structural sites of Anasazi, Navajo, and possibly Ute origin. Mitigation by avoidance would be necessary.

Route 2

This route connects the Baca plant sites with an existing substation at Ojo, northeast of the Baca Location (see Fig. 4.8). A line along this route would be about 53.5 km (33.5 miles) long. The route crosses the Baca Ranch and other private lands, Forest Service land, and some state-owned land. Grazing leases are held on the state and Federal lands. The route also crosses a number of recreation areas and geothermal lease areas. Spotty residential and commercial development exists along NM-84-285. Road crossings include FR-131, FR-144, and NM-84-285. The route does not cross any campgrounds, but does traverse a number of trout streams, including San Antonio Creek, the Rito de los Indios, Rio del Oso, and Santa Clara Creek. The route also passes in close proximity to the Polvadera Peaks Roadless Area 102 and Roadless

Area 103 on the Santa Fe National Forest. Visibility considerations would pertain to the roads and recreational streams crossed and to visibility from the flanks and hills of the Jemez Mountains, including the roadless areas.

The route is totally within forest consisting primarily of mixed conifer, spruce-fir, and ponderosa-pine forests. Approximately 25% of the route is at 3050 m (10,000 ft) or higher altitudes. Soils are of a low erodibility potential for most of the route. The route crosses habitat for elk, deer, black bear, and turkey. Additionally, it crosses potential Jemez Mountains salamander habitat, peregrine falcon habitat, and zone-tailed hawk habitat. Ospreys (state Endangered Group II) have been sighted in this area. The potential for rare plants along the route is unknown.

Archaeological resources would be similar to those described for route 1, with proportional increase in potential occurrence with corridor length. The route also traverses a part of the Santa Clara Indian Reservation. These portions of the route have a high potential for infringement on native American religious sites. The broad route corridor includes the Santa Clara and San Juan Pueblos, which are currently listed on the National Register of Historic Places (U.S. Heritage Conservation and Recreation Service 1979).

Route 3

This route follows the Baca corridor to Los Alamos, the same corridor described as proposed corridor 1 to handle 115 kV from the original 50-MW plant. Upgrading to 345 kV would necessitate construction of a 345-kV line to the Norton substation from Los Alamos (see Fig. 4.8). Environmental considerations have been discussed previously for the Baca corridor (see Sects. 3.2 and 4.4) and will not be repeated here. The remainder of the discussion refers to the Los Alamos-to-Norton leg, which is about 29 km (18 miles) long.

The route traverses land under ownership by the U.S. Forest Service, National Park Service, Department of Energy, Bureau of Land Management, and private landowners. Grazing leases are held on the BLM land. The route would affect the communities of Los Alamos and White Rock. The route crosses NM-4 and main drives of Los Alamos. The route crosses the Rio Grande at White Rock Canyon, an important recreation area, and a portion of the river proposed as an addition to the scenic river system. Other land-use considerations included along the route are the maximum flood pool for Cochiti Dam, the Otowi Historic District, and an Indian sacred area currently under ownership dispute. The potential for severe visual impacts exists for the White Rock and Los Alamos communities at crossings of NM-4 and drives surrounding Los Alamos, at the White Rock Canyon crossing, and from recreation areas on the flanks of the Jemez Mountains.

The route is primarily within ponderosa-pine and pinon-juniper forests. Soils from the Rio Grande east to Norton are highly erodible and possess poor revegetation capabilities. The route traverses excellent winter habitat for elk and habitat for black bear, deer, and turkey. The potential for conflicts with both Federal and state-designated endangered species is high. As for Federal-endangered species, the route includes potential peregrine habitat, potential bald eagle habitat, crosses the Whooping Crane migratory route along the Rio Grande, and traverses habitat for the blunt-nose shiner in the Rio Grande. The route includes potential habitat for the zone-tailed hawk and the osprey, both state Endangered Group II. The route also includes habitat for the threatened plant species *Pediocactus papyracanthus*.

The route includes a probability for high-density Anasazi sites, including substantial pueblos. White Rock Canyon also contains a high density of sites. Avoidance of all sites could prove difficult. Three archaeologic sites on the LASL Reservations have been proposed by LASL for nomination to the Historic Register; these are the Otowi and Little Otowi Ruins, Cavate Ruins, and Tshirege Ruin (U.S. DOE, 1979). This route also traverses a disjointed piece of Bandelier National Monument which contains the Tsankowi Ruins.

Route 4

Route 4 connects the Baca station to the switching station at Rio Puerco through the San Ysidro substation (see Fig. 4.8). The route from Baca to San Ysidro is described as an alternative route for the proposed 115-kV line (see Sects. 9.7 and 10.4), and the discussion of impacts will not be repeated here. The remainder of the discussion of route 4 is for the San Ysidro to Rio Puerco leg, a distance of about 24 km (15 miles).

The route crosses land under the ownership of the Bureau of Land Management, the state, the Zia Indian Reservation, and private ownership. There are grazing leases on BLM land and state land. Farming is practiced along the Rio Salado river bottom, which the route crosses. At White Mesa, pumice is mined. The route passes near the community of San Ysidro, the Zia Pueblo, and several small communities along the Rio Salado. The route crosses NM-44. Visual considerations along the route will include the residential areas at Zia Pueblo and San Ysidro, the NM-44 crossing and visibility of the line from nearby open mesa areas, and, potentially, from the flanks of the Jemez Mountains.

The route is primarily within desert grassland with highly erodible soils and very poor revegetation capability. The route has potential for encountering habitat for only one endangered species, the black hawk (state Endangered Group I). The Rio Salado is not an important fishery.

The route has a strong probability of encountering a high density of Archaic and Anasazi sites. The portion of the route north of San Ysidro to Baca has a very high density of large pueblos and Anasazi communities. The size of the sites will make avoidance along the entire route difficult. Finally, the northern section of the route has a potential for conflict with modern Indian religious sites. The Jemez and Zia Pueblos, the San Juan Mesa Ruins, and the Jemez State Monument are all listed on the National Register of Historic Places (U.S. Heritage Conservation and Recreation Service, 1979) and are all located within the Route 4 corridor.

Route 5

Route 5 connects the Baca site with a station at Star Lake, west of the Baca Location (see Fig. 4.8). The route is 72 km (45 miles) in length and crosses private, state, BLM, U.S. Forest Service, and Indian land. There are grazing leases on the Forest Service, BLM, and state lands. The route will cross near the communities of La Cueva, Thompson Ridge, Horseshoe Spring, Porter, and La Ventana. The route crosses a number of roads including NM-197, NM-44, NM-4, FR-105, FR-106, FR-132, FR-144, FR-126, FR-176, and FR-378. Recreational uses are intense in the La Cueva area and between La Cueva and Fenton Lake, including campgrounds, trails, and sightseeing areas. The route also crosses a number of recreational trout streams and lakes including San Antonio Creek, the Rio Cebolla, Rio Las Vaca, Rio Puerco, Guadeloupe Creek, and Fenton Lake. Impacts to visual resources would be high at the communities, road crossings, and recreation areas listed above. Additionally, the route will be visible from the flanks of the Jemez Mountains and from the Sierra Naciemento Mountains.

The eastern portion of the route is predominately within mixed conifer and ponderosa-pine forests; the western portion is within desert grassland. Soils in the forested portion of the route are generally of low erodibility. From the Sierra Naciemento to Star Lake, however, the desert soils are moderately erodible with potentially poor revegetation capability. The route traverses deer, elk, black bear, and turkey habitat as well as potential habitat for the Jemez Mountains salamander and the peregrine falcon. The potential for rare plants is unknown.

The eastern portion of the route from Baca to NM-4 would have potential for archaeologic resources similar to that of the Baca site. The western portion enters the San Juan Basin archaeologic province that has a relatively high site density. Mitigation by avoidance should nevertheless be relatively easy.

REFERENCES FOR SECTION 4

Advisory Council on Historic Preservation. 1979. Letter to U.S. Department of Energy, Sept. 25, 1979.

Beschta, R. L. 1978. "Long-Term Patterns of Sediment Production Following Road Construction and Logging in the Oregon Coast Range," *Water Resources Res.* 14(6): 1011-1016.

Bonneville Power Administration. 1977. *Audible Noise and Radio Noise Measurements on the McNary-Ross 345-kV Line for the IEEE Worldwide Survey of Audible Noise from EHV/UHV Lines,* Laboratory Report No. ERJ-77-50.

Briggs, G. A. 1969a. *Plume Rise,* AEC Critical Review Series, TID-25075.

Briggs, G. A. 1979b. To be published in *Atmospheric Science and Power Production.*

Broilla, F. J. et al. 1978. *An Investigation into High Altitude Adaptations — the Baca Geothermal Project,* Office of Contract Archaeology, Univ. of New Mexico (October 1978).

Bush, Ronald C. (Pacific Gas and Electric Company). 1977. Data presented at the LLL/GRIPS Geothermal Noise Workshop, Univ. of California at Davis, Nov. 14-15, 1977.

Carroll, C. H., PNM. 1978. Letter to H. G. Arnold, ORNL, Dec. 1, 1978.

Carson, J. E. 1976. *Atmospheric Impacts of Evaporative Cooling Towers,* ANL/ES-53, Argonne National Laboratory, Argonne, Ill., October 1976.

Culkowski, W. M., and M. R. Patterson. 1976. *A Comprehensive Atmospheric Transport and Diffusion Model,* ORNL/NSF/EATC-17, Oak Ridge National Laboratory, Oak Ridge, Tenn., April 1976.

Cushman, R. M., S. G. Hildebrand, and R. W. Brocksen. 1977. *The Potential Impacts on Aquatic Ecosystems from the Release of Trace Elements in Geothermal Fluids*, ORNL/TM-6057, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Cushman, R. M., S. G. Hildebrand, R. H. Strand, and R. M. Anderson. 1977. *The Toxicity of 35 Trace Elements in Coal to Freshwater Biota: A Data Base with Automated Retrieval Capabilities*, ORNL/TM-5793, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Egan, B. A. 1975. "Turbulent Diffusion in Complex Terrain" in *Lectures on Air Pollution and Environmental Impact Analyses*, American Meteorological Society, Boston, Mass.

Flavill, P., and W. G. Whitford. 1978. *The Biota of Redondo Creek — Union Baca Geothermal Exploration Site — Sandoval Co., New Mexico*, Whitford Ecological Consultants, Las Cruces, N.M.

Forest, Wildlife and Range Experimental Station. 1976. *Proceedings of the Elk-Logging-Roads Symposium, Moscow, Idaho, Dec. 16-17, 1975*, Univ. of Idaho, Moscow.

Hanna, S. R. 1971. *Meteorological Effects at Cooling Tower Plumes*, NOAA-ATDL Report, ATDL Contribution No. 48.

Harlan, M. E. 1979. Personal communication.

Hosker, R. P., Jr. 1973. "Estimates of Dry Deposition and Plume Depletion over Forests and Grassland," *Proceedings of the IAEA Synposium on the Physical Behavior of Radioactive Contaminants in the Atmosphere*, Vienna, Austria (November 1973).

Issacs, B. F. 1979a. Letter to D. Sabo of PNM, Feb. 13, 1979.

Issacs, B. F. 1979b. Letter to D. Sabo of PNM, Feb. 19, 1979.

Iwamoto, R. N., et al. 1978. *Sediment and Water Quality: A Review of the Literature, Including a Suggested Approach for a Water Quality Criterion,* EPA-910/9-78-048, U.S. Environmental Protection Agency, Seattle, Wash.

Junge, C. E. and R. T. Werby. 1953. "The Concentration of Chloride, Sodium, Potassium, Calcium and Sulfate in Rainwater over the United States," *J. Meteorol.* 15(6): 417-423.

LaVerne, M. E. 1977. *The Oak Ridge Fog and Drift Code (ORFAD) User's Manual,* ORNL/TM-5201, Oak Ridge National Laboratory, Oak Ridge, Tenn. (January 1977).

Leitner, P. 1978. *An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA.* Vol. 5. *Ecosystem Quality,* UCRL-52496, Lawrence Livermore Laboratory, 1978.

Luge, T. A., and W. O. Hickey. 1977. "Elk Low Habitat Relationships in the Pete King Drainage, Idaho," *Idaho Dept. of Fish and Game Wildlife Bull. No. 6.*

McKee, J. E., and H. W. Wolf. 1963. *Water Quality Criteria,* 2nd ed., Publ. No. 3-A, State Water Quality Control Board, The Resources Agency of California.

Merlan, T. W. 1979. Letter to Mr. Art Wilbur (DOE), March 19, 1979.

Miller, D., E. L. Boeker, R. S. Thursell, and R. R. Olendorff. 1975. *Suggested Practices for Raptor Protection on Powerlines,* Edison Electric Institute.

Mountain West Research, Inc. 1979. *Proposed Baca Geothermal Demonstration Project — Socioeconomic Analysis,* prepared for the Public Service Company of New Mexico (in preparation).

Müller, K. 1974. "Stream Drift as A Chronobiological Phenomenon in Running Water Ecosystems," *Annual Rev. Ecol. Syst.* 5: 309-323.

New Mexico Heritage Program. 1978. Search of computerized data files, December 1978.

New Mexico Air Quality Section. 1979. Personal communication to A. C. Wilbur of DOE. June 11, 1979.

New Mexico State Historic Preservation Office. 1979. Letter to A. Wilbur, September 11, 1979.

Olson, H. 1979. Letter to Mr. Wayne Pilz, Public Service Company of New Mexico. March 1979.

Paulson, M. J. 1978. *Baca Visual Analysis Overlay Maps*, prepared for PNM.

Paulson, M. 1978. *Visual Analysis, Baca Geothermal Project*, prepared for Public Service Company of New Mexico.

Pengelly, W. L. 1972. "Clearcutting: Detrimental Aspects for Wildlife Resources," *J. Soil Water Conserv.* 27(6): 255.

Pilz, W. 1979. Letter to Dr. John Hubbard, Endangered Species Program, New Mexico/Feb. 20, 1979.

Power Technologies, Inc. 1978. *Transmission Line Reference Book, 115-138 kV Compact Line Design*, Electric Power Research Institute, Palo Alto, Calif.

Public Service Company of New Mexico. 1978. *Baca Baseline Studies*.

Pueblo of Zia, Office of the Governor. 1979. Letter to U.S. DOE, Sept. 6, 1979.

Reagen, D. P. 1967. *Aspects of the Life History and Distribution of the Jemez Mountains Salamander,* Plethodon neomexicanus," M.S. thesis, Univ. of New Mexico, Albuquerque.

Reagen, D. P. 1972. "Ecology and Distribution of the Jemez Mountains Salamander, *Plethodon neomexicanus,*" *Copeia* 1972(3): 486-492.

Reed, L. A. 1978. *Effectiveness of Sediment-Control Techniques Used During Highway Construction in Central Pennsylvania,* U.S. Geol. Survey Water Supply Paper 2054.

Rosen, L. C., and C. R. Molenkamp. 1978. *An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA.* vol. 2. *Air Quality,* UCRL-52496, Lawrence Livermore Laboratory, July 7, 1978.

Sabo, D. 1979. Letter to B. F. Issacs, Director, New Mexico State Heritage Program, Jan. 22, 1979.

Sando, J. S. 1979. *Discussion of Pueblo Indians*, unpublished report to the U.S. Department of Energy.

Savage, W. U., R. W. Ely, and D. Tocher. 1977. *Review of the Los Alamos Seismic Monitoring Program in Relation to the Hot Dry Rock Geothermal Project,* prepared for Los Alamos Scientific Laboratory by Woodward-Clyde Consultants, San Francisco, Calif.

Schultz, R. D., and J. A. Bailey. 1978. "Responses of National Park Elk to Human Activity," *J. Wild. Mgmt.* 42(1): 91-100.

Subcommittee on Hydrogen Sulfide, Committee on Medical and Biological Effects of Environmental Pollutants, National Research Council. 1979. *Hydrogen Sulfide,* University Park Press, Baltimore.

Sundstrom, C., and E. Norberg. 1972. *A Brief Summary of the Influence of Roads on Elk Populations*. Unpublished report.

Suter, G. W., II. 1978. *Effects of Geothermal Energy Development on Fish and Wildlife*, FWS/OBS-76/20.6, Fish and Wildlife Service, Biological Services Program.

Tenorio, F. 1979. *Hearing on the Draft Environmental Impact Statement — Geothermal Demonstration Program — Before the All Indian Pueblo Council, August 16, 1979.*

Trainer, F. W. 1974. *Ground Water in the Southwestern Part of the Jemez Mountains Volcanic Region, New Mexico*, New Mexico Geological Society Guidebook, 25th Field Conference.

Trainer, F. W. 1975. *Mixing of Thermal and Nonthermal Waters in the Margin of the Rio Grande Rift, Jemez Mountains, New Mexico, New Mexico*, Geological Survey Guidebook, 26th Field Conference.

Turner, D. B. 1970. *Workbook of Atmospheric Dispersion Estimates*, U.S. E.P.A. Publication No. AP-26 (revised).

Union Oil Company of California and Public Service Company of New Mexico. 1978. *Baca Geothermal Demonstration Plant Project Proposal.*

U.S. Dept. of Agriculture. 1972. "Powerline Contacts by Eagles and Other Large Birds," *REA Bull.* 61-10.

U.S. Department of Energy. 1979. *Final Environmental Impact Statement for the Los Alamos Scientific Laboratory*, DOE/EIS-0018, December 1979.

U.S. Department of Energy. 1979. Letter to Western Division of Project Review, Advisory Council on Historic Preservation, Sept. 17, 1979.

U.S. Department of Energy. 1979. Transcript of hearing on the Draft Environmental Impact Statement before the All Indian Pueblo Council, Aug. 16, 1979.

U.S. Department of Energy. 1979. Transcript of public hearing on Draft Environmental Impact Statement, Aug. 30, 1979.

U.S. Department of the Interior and U.S. Department of Agriculture. 1970. *Environmental Criteria for Electric Transmission Systems*.

U.S. Environmental Protection Agency. 1976. *Quality Criteria for Water*, EPA-440/9-76-023, Washington, D.C.

U.S. Forest Service. 1974. "The Visual Management System," in *National Forest Landscape Management*, vol. 2, Agriculture Handbook No. 462, Department of Agriculture, U.S. Government Printing Office, Washington, D.C.

U.S. Forest Service. 1977. *Environmental Statement — Geothermal Leasing — for Santa Fe National Forest*, U.S. Forest Service, S.W. Region, Albuquerque, N. M.

U.S. Geological Survey. 1965. "Mineral and Water Resources of New Mexico," *N. M. Bur. Mines Miner. Resour. Bull.* No. 87.

U.S. Heritage Conservation and Recreation Service. 1978. "Revision of List of National Registry of Natural Landmarks," *Fed. Regist.* 43(82): 18049-18055. April 27, 1978.

U.S. Heritage Conservation and Recreation Service. 1979. "National Registery of Historic Places Annual Listing," *Fed. Regist.* 44(26): 7533 (Feb. 6, 1979).

U.S. Heritage Conservation and Recreation Service. 1979. Letter and document to A. Wilbur, Aug. 6, 1979.

U.S. Heritage Conservation and Recreation Service, Southwestern Regional Office. 1979. Letter to R. Brechbill of DOE. May 31, 1979.

U.S. National Park Service. 1971. *The Natural Landmarks Program*, Brochure 483-417/10, Department of the Interior, U.S. Government Printing Office, Washington, D.C.

U.S. Rural Electricification Administration. 1976. "Electrostatic and Electromagnetic Effects of Overhead Transmission Lines," *REA Bull.* 62-4, Department of Agriculture, Washington, D.C.

U.S. Senate. 1970. "Pueblo de Taos Indian Cultural and Ceremonial Shrine Act of 1970," *Congressional Record*, pp. 39586-39607, Washington, D.C.

Valdez, R. A., W. T. Helm, and J. M. Neuhold. 1977. "Aquatic Ecology," pp. 287-313 in *The Environment of Amchitka Island, Alaska*, ed. M. L. Merritt and R. G. Fuller, U.S. Energy Research and Development Administration.

Water Resources Associates, Inc., 1977. *Hydrology, Jemez Mountains, New Mexico*, Scottsdale, Ariz.

White, Gary C., Los Alamos Scientific Laboratory. 1979. Computer-generated plottings of fixes on radio-collared elk.

Whitford, W. G. 1974. *The Biota of Redondo Creek Canyon, Sandoval County, NM, with Emphasis on Big-Game Species and Rare and Endangered or Threatened Species*, Southwest Environmental Research and Development Corporation report to Union Oil.

Whitford Ecological Consultants. 1975a. *The Biota of the Baca Geothermal Site*, report to Union Oil — Geothermal Division.

Whitford Ecological Consultants. 1975b. *Studies of Rare and/or Endangered Species of the Union-Baca Geothermal Lease and Surrounding Area (with Discussion of Other Species)*, prepared for Union Oil Geothermal Division.

Whitford Ecological Consultants. 1975c. *Winter Activity and Habitat Use by Elk in the Redondo Creek Area with Comments on Activities and Relative Abundance of Other Species*, prepared for Union Geothermal Division.

Wilbur, A. 1979. Memorandum to William Manning, San Francisco Operations Office, U.S. Department of Energy, Sept. 5, 1979.

Williams, S. R. 1972. *Reproduction and Ecology of the Jemez Mountains Salamander*, Plethodon neomexicanus," M.S. thesis, Univ. of New Mexico, Albuquerque.

Williams, S. R. 1976. *Comparative Ecology and Reproduction of the Endemic New Mexico Plethodontid Salamanders*, Plethodon neomexicanus and Aneides hardii," Ph.D. dissertation, Univ. of New Mexico, Albuquerque.

Wirth Associates. 1979. *Land-Use Inventory for the Proposed Baca Geothermal Project*, prepared for the Public Service Company of New Mexico and Union Geothermal Division.

5. UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts of the proposed project include loss of wildlife habitat, some decrease in water quality in Redondo Creek and the Jemez River, and visual-related land-use and recreational conflicts.

Even with mitigation, construction activities in Redondo Canyon and along the transmission route will cause some increase in sedimentation and turbidity in Redondo Creek and the East Fork of the Jemez River. Construction of the transmission line and well field development will result in an unquantified loss of habitat for the Jemez Mountains salamander, listed by the State of New Mexico as endangered. Human presence and increased activity in Redondo Canyon will result in an unquantifiable loss of elk winter habitat. Construction of the transmission line will cause aesthetic impacts and related conflicts with recreational uses in a heavily used section of the Santa Fe National Forest and in a portion of the Bandelier National Monument. The proposed project will represent an unavoidable intrusion of an essentially industrial development into an area known for its scenic and unique natural resources. There is a possibility that the status of the Baca Location/Valles Caldera National Natural Landmark could be affected by the proposed activity.

If the source of the known geothermal fluid discharges from springs along the Jemez River southwest of the project site (Sect. 3.3.2) is the production reservoir, spring and streamflow depletion will occur as a result of reservoir drawdown. The Jemez Springs and Soda Dam thermal spring areas are the primary ones to be adversely impacted by this possibility; as much as 27% of the spring flows may consist of geothermal fluids. The loss of any portion of this hot, mineralized contribution to discharge will reduce the temperature and mineral content of the springs correspondingly.

The proposed project may infringe on American Indian religious freedom by destroying religious sites and objects, invading the privacy of the Indians during religious ceremonies and rituals, contaminating or reducing the availability of water for sacred practices, depleting sacred springs, and interfering with access to religious sites. The extent of this potential infringement cannot be predicted at this time (Sect. 4.1.7).

The impacts predicted for development of the 50-MW plant will be likely to occur for expansion of the facility to 150 MW and 400 MW; however, the magnitude of these impacts cannot be predicted at this time.

6. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The only resources committed irreversibly and irretrievably to this project are the fuels and materials used in construction, which will be negligible amounts. No environmental effects are expected to be permanent if the plant is abandoned and the site is restored according to procedures described in Sect. 2.3.

The consumptive use of geothermal fluid is "consumptive" by definition in that estimated recharge of the geothermal reservoir is much slower than the rate of consumption. Although the data are not complete for the total hydrologic regime (refer to Sect. 4.2.2), the geothermal fluid lost to the atmosphere during 30 years of plant operation would be recharged within approximately 240 years after operation ceased. There is no estimate of how long heating of the recharged fluid would take, but it is assumed that reheating to average reservoir temperatures would occur, based on known geologic conditions. Fluid losses from expansion to 150 MW and 400 MW will probably be greater than those from a 50-MW plant; however, the magnitude of this impact cannot be determined at this time.

The heat withdrawn from the earth (as opposed to the water) and released at the surface is an irreversible and irretrievable resource use, based on current knowledge of geology; but the amount withdrawn by this project is totally negligible with respect to the total heat reservoir from which it is withdrawn.

7. RELATIONSHIP OF LAND-USE PLANS, POLICIES, AND CONTROLS

7.1 PERMITS AND REGULATIONS

The commercial partners and the Department of Energy have coordinated project plans with several State, local, and regional planning and regulatory agencies. The following permits are required and are part of the planned permitting process for this project and for any actual expansion beyond 50 MW:

1. Permit to drill, deepen, or plug back geothermal resource well. These are routinely issued by the New Mexico Oil Conservation Commission (NMOCC). Union has received these in the past and has the next three well permits on hand now. An application is the only documentation required. It takes two to four weeks for the commission to process an application and grant the approval. No hearings are held.

2. Certificate to produce fluids. This will be issued by the NMOCC prior to commercial production. A certificate is not required for testing of geothermal wells. An application is the only documentation required, and it is estimated to take four to six weeks to process the application. No hearings are held.

3. Permit to inject fluids. These are issued by the NMOCC in about two to four weeks from the time of application. The commercial partners have three injection permits and may need only one more for this project. No hearings are held. Also, the Underground Injection Control Program will be complied with when it becomes effective.

4. Permit to appropriate underground waters. This permit will be issued by the New Mexico State Engineer's Office (NMSEO) to Union. The commercial partners have reached tentative agreement with the NMSEO regarding the potential for surface stream flow impairment caused by steam withdrawals from the reservoir. This agreement will be reflected in the application for a permit, which is planned for this year. Less than one year should be needed to acquire this permit. A public hearing will be required before granting the permit. The permit is valid for five years, and at that time it will be converted to a license, which will be valid until the project is over. Prior to receiving the permit,

Union must demonstrate to the NMSEO that Union controls sufficient irrigated land to retire water rights equal to the amount of impairment detected by monitoring of streams.

5. Certificate of Public Convenience and Necessity. This permit will be issued by the New Mexico Public Service Commission upon finding that the proposed power plant is necessary and within the commission's rules and regulations.

6. Permit to Emit Air Pollutants. This permit is issued by the New Mexico Environmental Improvement Department.

7. Right of Way Permit. Permits are required from the United States Forest Service for all rights-of-way crossing Forest Service Lands and from the National Park Service for rights-of-way across Bandelier National Monument.

8. Archaeological Clearance for Steam Production Facilities. This clearance is given by the State Historic Preservation Officer upon examination of archaeological survey records and mitigation plans related to steam production.

9. Archaeological Clearance for Electrical Production and Transmission Facilities. Similar clearance will be given for the power plant and transmission lines upon examination of archaeological surveys and mitigation plans.

10. Prevention of Significant Deterioration (PSD) Review. This review of the air quality impacts is performed by EPA Region IV for regulated effluents from the proposed plant.

7.2 POTENTIAL LAND USE PLANS AND CONFLICTS

Potential conflicts with future land use plans are discussed in detail in Sect. 4.1.1. These conflicts arise from the possibility that the Baca Ranch may become public land.

7.3 OTHER INTERESTED PARTIES

In response to the NOI, three letters were received from individuals, groups, or state agencies expressing interest or concern about various aspects of the proposed project. The letters identified the following issues and concerns:

1. the impact on recreation and scenic values,
2. the impact of atmospheric releases of toxic substances,
3. the impacts of effluents on surface waters,
4. the impact of noise,
5. the potential for subsidence and increased seismicity,
6. the potential socio-economic effects of the project,
7. the energy requirements of this project versus energy savings resulting from increased funding of conservation activities, and
8. identification of the agency responsible for enforcement of mitigation measures.

These letters are on file in DOE Public Document rooms as listed in the NOI (DOE 1979).

DOE consulted with U.S. Forest Service and National Park Service on the development of alternate transmission corridors. The U.S. Forest Service has requested that it be identified as a cooperating agency in the Final Environmental Impact Statement (U.S. Forest Service comment letter dated Sept. 6, 1979, page I-47). DOE also consulted with Pueblo tribal governors and other spokesmen about possible socio-economic, cultural, and religious impacts of the project on the Indians.

Written comments on the Draft Environmental Impact Statement (DEIS) were received from 23 interested parties (Appendix I). Twenty-eight persons gave testimony at the public hearing on the DEIS.

REFERENCE FOR SECTION 7

Department of Energy. 1979. "Notice of Intent." *Fed. Regist.* 44(29), Feb. 9, 1979.

8. THE RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE OF LONG-TERM PRODUCTIVITY

The proposed 30-year life of this project is an economic life based on the guaranteed supply of geothermal energy for that period of time. Actual plant operation could be of longer duration, especially with respect to the transmission lines, which can form redundant circuits for the entire PNM service system, with or without the power plant. Successful resource confirmation could result in the construction and operation of significantly more electrical plants within the same general hydrologic and land use area; therefore there is potential for much more than 50 MW of resource withdrawal and effluent release as well as for more than 30 years of plant life. Any reasonable plant life is basically short-term with respect to the capacity for the environment to reestablish itself under the conditions predicted for this project. However, no allowance has been made for the additive or multiplicative effects of several years of construction, well drilling, and fluid consumption at increasing rates for additional development in the general area of the proposed plant.

It is expected that the proposed 50-MW power plant operating for 30 or more years would not significantly alter the long-term productivity of the surface or subsurface environment. It is not known at this time how many more 50-MW plants can be built before long-term productivity is affected. Further, whether long-term productivity will be affected by development of plants to produce 400 MW is not known.

9. ALTERNATIVES

The reasonably available alternatives to the proposed action consist of alternative Federal actions and of alternative project designs and locations. The rationale of each alternative and the ability of the Department of Energy to carry out some alternatives under the current project contract are not the same for each alternative discussed. The action alternatives are no action, delayed action, and funding of a nonelectric use. The design alternatives include alternative cooling systems, hydrogen sulfide abatement systems, power cycles, and steam separator locations. The location alternatives include sites within the immediate area and sites at other geothermal resource areas.

9.1 NO FEDERAL ACTION

The no-action alternatives will result in withdrawal of approximately 50% of the total project funding for the Baca Geothermal Demonstration Plant. The power generation economics for PNM are such that it is unlikely that a wholly utility-funded project would be economically competitive with alternative fuels, particularly coal, for approximately ten years (Union Oil Company 1978); thus, no DOE action would postpone development of liquid-dominated, geothermal, electric power plants in the Valles Caldera KGRA for a length of time approximately within that economic time frame. According to reports, the current status of commercially funded development of hydrothermal liquid-dominated resources includes plans for completion of construction of at least one 50-MW power plant in the Imperial Valley by the year 1982, with smaller plants in the 10-MW range at five other locations in the Imperial Valley by approximately the same time (Wilson 1978). Plans for other 50-MW electrical plants are not firm. With Federal cost-sharing participation, development of liquid-dominated hydrothermal resources is expected to proceed at a faster rate than with totally private funding. If the no action alternative is implemented, commercial scale information and data on flash-steam systems that would have been obtained with Federal support of the project will not be available. This information would have been an additional inducement to geothermal development by the industrial or financial community. Entry into geothermal development will be less risky technically and economically to the initial participants and initiation of participation would be easier. Therefore, the effect of DOE cessation of support for this demonstration project will be to increase the risk for developers of liquid-dominated hydrothermal resources as a whole and slow the rate of its development.

Implementation of the no action alternative by DOE would not assure retention of the Baca property in its existing condition, elimination of the threat to the status of the national natural landmark, or elimination of the potential for infringement on Indian religious practices, because the property could be developed by private interests without Federal involvement. The no action alternative would not constrain the option of public ownership of the property.

9.2 DELAY OF FEDERAL ACTION

Delay of the proposed action would have much the same effect on the development of hydrothermal resources for electricity production as denial of funding, but the length of time until utility development could proceed would be shorter. The demonstration plans for the project might still be met, but the uncertainty for the industry that proceeds to develop other sites will be greater because of the delay of knowledge of this part of the geothermal resources. Also, the costs for developing this demonstration project will be increased.

Delay of funding may provide sufficient time to resolve the issue of potential Federal acquisition of the Baca lands. However, since no date has been established for the decision on whether or not to acquire these lands, it is not certain that delay of funding would resolve this issue. Delay of funding may provide sufficient time for resolution of outstanding procedural issues such as U.S. Forest Service's evaluation and approval of a transmission corridor. Also, delay of funding may provide sufficient time to develop improved pollution control equipment which will lessen the impacts of the proposed project.

9.3 FUNDING OF A NONELECTRIC USE OF THE RESOURCE

The Federal Geothermal Program is responsible for promoting commercial development of geothermal energy. To date, commercial development has focused on electricity production from vapor-dominated resources and nonelectric uses of liquid-dominated resources. The objective of the program opportunity notice issued by DOE on Sept. 30, 1977, is to provide the stimulus for the development of a plant that will demonstrate the viability of utilizing liquid-dominated resources for the production of electricity. Funding a nonelectric use of the resource for this project is inconsistent with the goals of the Federal Geothermal Program to develop the full potential of a given geothermal resource.

9.4 FUNDING OF ALTERNATIVE SITES WITHIN THE BACA LOCATION

9.4.1 Redondo Canyon

At least two viable alternative power plant locations are assumed to exist in Redondo Canyon, one on either side of the proposed plant site. The environmental impacts of the proposed plant on either alternative site would be very similar to the proposed site with the exception of hydrogen sulfide concentrations at the Baca boundary. The ecological setting would not change significantly with respect to terrestrial, aquatic, or endangered species, and the hydrogeological environment would be the same for any of the three sites in the canyon. Impacts on cultural and archaeological resources and Indian religious sites will be the same for any of the three sites. The primary difference is that prior disturbance is greater for the proposed site.

Because the alternative sites are 1 or 2 miles closer or farther away from the Baca boundary than the proposed site, depending on the alternative selected, the hydrogen sulfide concentrations at the Baca boundary would be higher or lower, depending upon whether the site is closer to the boundary or farther away. Although it is possible that the site nearest the boundary would result in hydrogen sulfide concentrations greater than at the other two sites, a specific analysis for this site was not performed, and there may be offsetting parameters resulting from elevation and terrain differences.

9.4.2 Sulfur Creek area

Limited exploration has been pursued in the Sulfur Creek area of the Valles Caldera. A total of seven exploration wells have been drilled, revealing a potentially vapor-dominated resource. The Sulfur Creek area is considered highly prospective, however, and little is actually known about the reservoir. Most impacts resulting from a demonstration plant located in Sulfur Creek would be similar to those expected from the demonstration plant in Redondo Creek. (See Sect. 4.5 for additional discussion.)

Sulfur Canyon is smaller than Redondo Canyon and has a history of human presence and disturbance at the hot springs. Sulfur Canyon is not likely to be as good a habitat for elk as Redondo. It is not known whether the Jemez Mountains salamander occurs in Sulfur Canyon. Impacts on these species resulting from power plant construction and operation might be less in Sulfur Canyon than in Redondo. However, the extensive exploration and reservoir development required for the Sulfur Creek area will result in a greater surface disturbance than in Redondo Canyon. Downstream effects on the biota in San Antonio Creek and the Jemez River as a result of increased sediment load could thus be greater with disturbance in the Sulfur Creek locality.

9.5 FUNDING OF ALTERNATIVE SITES AT OTHER LOCATIONS IN THE UNITED STATES

The ability of DOE to consider alternative sites outside the Redondo Creek portion of the Baca was limited by the small number of responses to the PON. The only other demonstration plant proposal that was received qualifies as an alternative with respect to the site, although that proposal was eliminated for reasons not related to the site.

The San Diego Gas and Electric Company (SDG&E) submitted the other proposal in response to the PON (PON EG-77-N-03-1717). It was for a binary-cycle power plant at Heber in the Imperial Valley of California. The SDG&E proposal was found by the DOE review panel to be technically unacceptable in all areas except for the environmental aspects (Myers 1978). A major weakness was that some components of the SDG&E proposal, such as the downhole pumps and binary-fluid turbine, would be developmental, whereas the PNM proposal utilizes a geothermal technology proven at the pilot level. DOE found other weaknesses or ambiguities concerning the resource supply, capabilities of the offeror's team, information dissemination, and business factors. The SDG&E proposal was not selected because of problems related to technical and business issues. Because the proposal was unacceptable for the above reasons, the selection process was not contingent upon location or environmental issues.

The reissuance of a similar program opportunity notice (PON) might produce responses not received under the original PON. The goal of the previous PON, "design, construction and operation of a geothermal electric power plant which utilizes a liquid-dominated hydrothermal reservoir in the U.S.," is very general. Therefore the number of responses is potentially large. This section will briefly discuss some known geothermal resource areas (KGRAs) that have resource characteristics and near-term development potential consistent with the PON.

9.5.1 Imperial Valley sites

Six KGRAs are identified in the Imperial Valley: Salton Sea, Brawley, East Mesa, Glamis, Dunes, and Heber (Fig. 9.1). Development is sufficiently advanced at the Heber, Brawley, Salton Sea, and East Mesa KGRAs for them to serve as possible alternative project sites. Because these areas have common climatic, geologic, socioeconomic, and hydrologic characteristics, the following information on these environmental factors presented for the Heber KGRA will not be repeated for the other three KGRAs. Other environmental characteristics (i.e., land use, ecological, and archaeological characteristics) are discussed for each of the four site alternative KGRAs.

The primary land use in the Heber KGRA is irrigated agriculture but urban (Heber and Calexico) and transportation uses are also important. The major potential impact on land use is the loss of agriculture production. The effect of agriculture on the socioeconomics of the Imperial Valley is evident in Heber where a large public housing project has

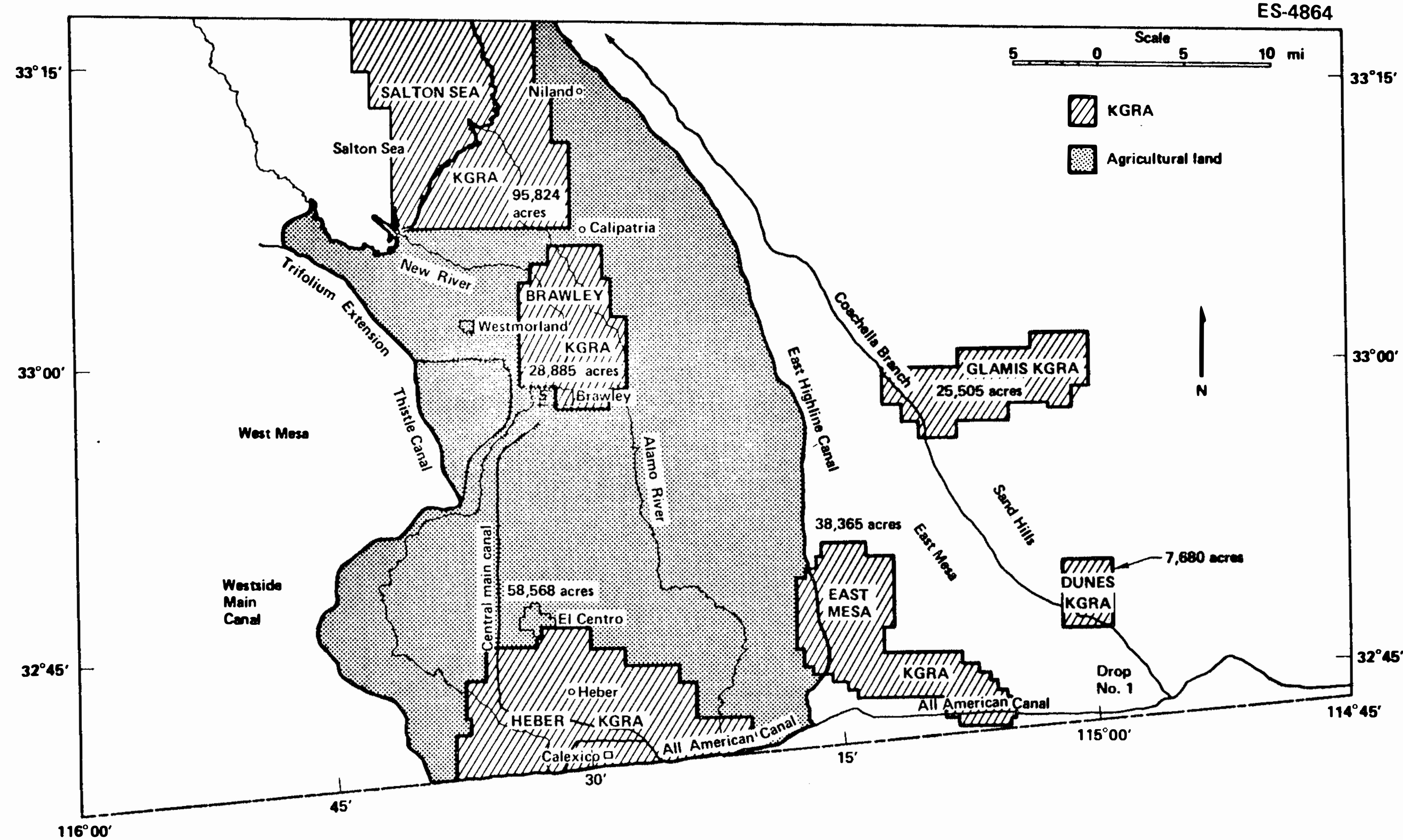

Fig. 9.1. Map of Imperial Valley. The six KGRAS are outlined on this map. Irrigated, agricultural lands are shown as the shaded areas.

attracted farm workers. Over 80% of the town's population is Spanish-speaking and only 10% of heads of households have completed high school (Meidav and Meidav 1977). Development of the Heber KGRA would increase state and county revenues. Because the demand for skilled workers is already high (Layton and Ermak 1976), some skilled workers may have to be imported to the area.

Agricultural, domestic, and industrial water needs in the Imperial Valley are met by Colorado River water, which is delivered to the southern border of the valley in the All-American Canal and flows northward through an elaborate system of canals, laterals, ditches, and drains to the New and Alamo Rivers and then to the Salton Sea. Although the Imperial Irrigation District (IID) has an adequate supply to meet expanding domestic and industrial needs, completion of the Central Arizona Project is expected to result in the loss of 1.55×10^9 m^3 (1.25×10^6 acre-ft) of water per year (U.S. Department of Energy 1979). This loss is expected to result in increased competition for water.

The IID makes irrigation water available only to pilot plants or other plants operating on a precommercial basis (Wilson 1979). Adequate drain water is available for the operation of a commercial plant. The irrigation (Colorado River) water is of relatively good quality (Table 9.1) and is suitable for condenser cooling and other needs. The drain water is available in abundance but is of lower quality because of the minimal sewage treatment afforded by Mexicali and because of the salts, biocides, and other materials flushed from the fields (Table 9.1). It may require pretreatment for use in geothermal power plants.

Evaporative losses of cooling water may diminish the Salton Sea's value as recreational and wildlife resource by reducing flows to the sea (the amount of dilution water) without reducing the total salt input. Unless some method is devised to remove the accumulating salts, geothermal water use will slightly hasten the demise of the Salton Sea fishery (Goldsmith 1976).

The native desert vegetation of the Heber KGRA is now reduced to small remnant stands along the New River. No rare, threatened, or endangered plant species were found during a survey of the area (San

Table 9.1. Water quality in New and Colorado Rivers

Water quality indicator	Unit	New River at DWR station 57 – international boundary, 96.48 km (60.3 miles) upstream of Salton Sea	Colorado River at Imperial Dam
pH		7.3	8.0
Electrical conductivity X 10^6	Micromhos	7,354	1,306
Total dissolved solids	mg/liter	4,865	856
Coliform	MPN/ml	160,000	
Total hardness	mg/liter	1,111	360
Dissolved oxygen	mg/liter	6.3	
Turbidity	mg/liter	128	
Boron (B)	mg/liter	1.79	0.18
Calcium (Ca)	mg/liter	242	88.0
Magnesium (Mg)	mg/liter	123	34.0
Sodium (Na)	mg/liter	1,209	145.0
Chloride (Cl)	mg/liter	2,001	128.0
Sulfate (SO_4)	mg/liter	732	336.0
Nitrate (NO_3)	mg/liter	14.4	1.6
Bicarbonate (HCO_3)	mg/liter	291	174.0
Fluoride (F)	mg/liter	1.03	0.5

Source: Layton and Ermak 1976.

Diego Gas and Electric Company 1977). The terrestrial fauna consists primarily of those species, such as the house mouse, deer mouse, raccoon, mourning dove, and red-winged blackbird, that commonly utilize agricultural habitats (San Diego Gas and Electric Company 1977). Migratory and resident waterfowl also forage in agricultural fields. The Yuma clapper rail, California black rail, and yellow-billed cuckoo may be found along the New River within the KGRA. However, the area constitutes poor habitat, and none of these species was observed during a formal survey (San Diego Gas and Electric Company 1977, VTN Consolidated, Inc. 1978). The Yuma clapper rail is listed as endangered by the Federal Government (U.S. Department of the Interior 1977); the other two species are listed as rare by the State of California (California Department of Fish and Game 1976). The aquatic biota of the New River and drainage canals in the KGRA is depauperate because of poor water and substrate quality. Irrigation canals support a diverse warm-water biota.

The Imperial Valley is an area of intensive crustal deformation with high heat flow, seismicity, and subsidence. It is one of the most seismically active areas in the United States. These characteristics result from the rifting and associated fault movement that has formed the valley. The Imperial Valley is undergoing natural subsidence at a maximum rate of 1.5 cm (0.6 in.) per year relative to the surrounding mountains (Geonomics, Inc. 1976). Although geothermal developers are required to inject a volume of fluid equal to that withdrawn, net subsidence from differences in the pressure between the withdrawal wells could result in a pattern of ground movement. Significant differential subsidence could disrupt water flow in the irrigation and drainage canal system. The liklihood of any induced seismicity is believed to be low (VTN Consolidated, Inc. 1978 and Geonomics, Inc. 1976).

The Imperial Valley is an area of high air-pollution potential. Neutral to stable atmospheric conditions have an annual average occurrence of 68% and an average occurrence during the winter months of 76%. Because of high agricultural activity, the atmospheric particulate levels regularly exceed the national primary and secondary air-quality standards of 75 $\mu g/m^3$ and 60 $\mu g/m^3$ and the California standard of 60 $\mu g/m^3$. The annual geometric mean of suspended particulate concentrations at Brawley (120 miles to the north) was 211 $\mu g/m^3$ in 1975. Because the area is basically nonindustrial and vehicular traffic density is low, other air-quality standards are rarely exceeded (San Diego Gas and Electric Company 1977).

The California standard for hydrogen sulfide is 0.03 mg/liter (42 $\mu g/m^3$) averaged over a one-hour period. The highest recorded 1-hr averaged hydrogen sulfide concentration is 0.07 mg/liter (98 $\mu g/m^3$); however, hydrogen sulfide concentrations are normally below 0.005 mg/liter (7 $\mu g/m^3$) (VTN Consolidated, Inc. 1979).

Particulate emissions from drilling and construction activities will probably increase slightly (a localized impact). Because the resource has a low non-condensable gas content and a very low hydrogen sulfide content, emissions during drilling and testing are not expected to be serious.

Noise levels at the site boundary are regulated by Imperial County's frequency and land use specific geothermal noise standards, which, when integrated to the A-scale, range from 47 to 76 dBA (Imperial County Department of Public Works 1971).

No archaeological sites in the Heber area are recorded, and a search of the area revealed no archaeological resources (San Diego Gas and Electric Company 1977). No historic sites or natural landmarks are found in the Heber area.

The Brawley KGRA lies in an agricultural area near the center of the valley. Its environmental setting is nearly identical to that of Heber KGRA. The Salton Sea KGRA is also primarily agricultural, but it contains important wildlife habitat in the deltas of the New and Alamo Rivers, the Salton Sea National Wildlife Refuge, and the Imperial Wildlife Management Area. The natural marshes of the deltas and shoreline and the planted fields of the refuge and management area support hundreds of thousands of wintering waterfowl and shorebirds as well as hundreds of resident animal species. The Federal Government lists as endangered the Yuma clapper rail, which is common in these marshes (U.S. Department of the Interior 1977). The endangered bald eagle, California least tern, brown pelican, and peregrine falcon occasionally visit the Salton Sea area during the nonbreeding season (U.S. Department of the Interior 1977). The State of California lists the California black rail and yellow-billed cuckoo as rare (California Department of Fish and Game 1976). These species may also use the Salton Sea KGRA.

The East Mesa KGRA, which lies on the east side of the Valley, contains 10% agricultural land, 50% creosote shrublands, and 40% dunes (U.S. Department of the Interior 1973). The area is ecologically unremarkable, and the dunes are less active and dramatic than those nearby in the Glamis area. The area has received significant disturbance, and use is largely confined to occasional off-road-vehicle events. The area contains identified archaeological resources consisting of Yuman camp sites (U.S. Department of the Interior 1973).

The effects of geothermal development at the Brawley or Salton Sea KGRA would be similar to those described for Heber. Serious wildlife habitat loss can be avoided at the Salton Sea by placing facilities away from the rivers or shoreline marshes. Care must also be taken in transmission line placement in order to avoid frequent waterfowl collisions. Development at East Mesa does not require loss of agricultural land or important wildlife habitat. Intensive archaeological surveys will be required in order to avoid destruction of cultural resources. The consequences of induced subsidence are less serious outside of the agricultural area.

Several successful production wells have been drilled in each of these KGRAs. The Salton Sea KGRA has very high temperatures and salinities (over 300°C and 300,000 ppm total dissolved solids) (Palmer 1975). Brawley KGRA has temperatures near 260°C and salinities of approximately 100,000 ppm (Williams, Cohen, Pfundstein, and Pond 1978). East Mesa has temperatures and salinities of approximately 180°C and 25,000 ppm (Williams, Cohen, Pfundstein, and Pond 1978).

Geothermal development is proceeding past the drilling stage in many areas of the valley (Wilson 1978). The Southern California Edison Company has signed an agreement to buy steam from the Chevron Resources Company for a 50-MW double-flash steam plant 2 miles southeast of Heber. Operation is planned to start in 1982. Edison has also announced plans for 10-MW pilot flash steam plants at Brawley and Niland to be completed in 1980 and 1982 respectively. San Diego Gas and Electric has operated an experimental test loop at Niland since 1976 with ERDA as a financial partner. SDG&E has an agreement to buy fluids from the Magma Power Company for a 50-MW plant to be built near Niland. The Bureau of Reclamation has operated a pilot desalinization plant and component test facility at East Mesa since 1975. Magma Power has nearly completed an 11-MW binary-cycle demonstration plant at East Mesa. Plans for a 6-MW plant in East Mesa for 1980 and a 42-MW add-on unit for 1982 have been made. The steam supplier, Republic Geothermal, has financed its drilling costs with a DOE-guaranteed loan.

9.5.2 Roosevelt Hot Springs

The Roosevelt Hot Springs KGRA lies on the northeastern edge of the Escalante Desert, near the town of Milford, Beaver County, Utah. The KGRA occupies an area of Great Basin Desert that is managed as unimproved pasture by the Bureau of Land Management. The vegetation is natural, but the biota is unremarkable. The eastern portion of the KGRA receives some use as mule-deer winter range. No aquatic habitats are found on the KGRA. The nearest municipality is Milford, a town of 1,300 persons, 13 km (8 miles) from the KGRA. Although many sites of obsidian tool manufacture occur within the KGRA, these lack sufficient cultural context to give them archaeological significance. An obsidian quarry outside the KGRA has been nominated for the National Register of Historic Places.

Ten geothermal wells have been drilled in the KGRA, seven of which have been successful. The resource has a high temperature (260°C) and low salinity (4277 to 7067 ppm). Hydrogen sulfide constitutes 8 ppm by weight of the total fluid and is expected to reach 24 ppm in the flashed steam. A preliminary plant design for this resource calls for a flashed steam cycle with a hydrogen sulfide scrubber and mechanical-draft cooling towers. Phillips Petroleum Company, the primary leaseholder in the KGRA, and Rogers International are reportedly preparing a DOE loan guarantee application for a 50-MW(e) plant (Wilson 1978). Power would be sold to Utah Power & Light. No significant environmental issues have been identified for this property (U.S. Geological Survey 1976).

9.5.3 Beowawe

Northern and central Nevada contain 18 KGRA with temperatures higher than 150°C (328°F) (White and Williams 1975). Together, these areas represent a major segment of the hydrothermal resource in the United States. Although other areas, such as Dixie Valley with its rumored dry-steam reservoir, may prove to have better resources, this discussion will consider the best-known prospect, Beowawe. Geothermal drilling has been conducted at Beowawe since 1959 by several companies. As of 1977, 14 wells have been drilled, and seven more were approved (U.S. Geological

Survey 1977). Although the highest reported downhole temperature is 214°C (443°F), resource temperatures are expected to reach 240°C (490°F) with total dissolved solids of 1,200 ppm (Williams, Cohen, Pfundstein, and Pond 1976).

Beowawe KGRA contains typical Great-Basin desert communities. No state- or Federal-listed threatened or endangered plants or animals have been found (U.S. Geological Survey 1977). A single pair of golden eagles has been afforded special protection from disturbance during the nesting season (U.S. Geological Survey 1977). The primary land use is grazing. Low-level recreational use includes hunting, rockhounding, and sight-seeing at the "geysers" created by vandalized wells. Some oil and gas leases are held in the KGRA. The human population density is low — only a few small towns (less than 500 persons) occur in the area. There is little unemployment in the area, housing is in short supply, and services are limited. Some archaeological resources have been identified in the KGRA.

Both noise and hydrogen sulfide levels are high near the "geysers." Hydrogen sulfide measurements only reached 29 ppb near the plumes (U.S. Geological Survey 1977), suggesting that hydrogen sulfide problems are not serious. No permanent surface water exists in the KGRA except for hot springs. If geothermal water cannot be used for cooling, other sources may be difficult to obtain.

The only known potentially serious environmental issue associated with development at Beowawe is social disruption during plant construction.

9.6 ALTERNATIVE PLANT DESIGNS

The environmental impact analysis for this project is based on a proposed design that was selected from several alternative configurations. The existing systems and components represent the optimum economic, technological, schedule, and environmental mix on the basis of the analyses performed by the commercial partners and the proposed evaluation performed by DOE. Reasonable alternatives to the proposed plant design are discussed here for the purpose of later describing the environmental trade-offs each alternative could involve.

9.6.1 Cooling system alternatives

The selected cooling system employs a mechanical-draft wet cooling tower with eight cells. Condensed steam from the turbine will serve as the cooling water supply. Condensate from the cooling tower will be transferred to the injection plant.

Alternative cooling systems that have been considered for the demonstration plant include the use of (1) natural-draft towers, (2) dry towers, (3) wet/dry towers, and (4) fresh makeup water supply. A once-through cooling system was not considered to be a feasible alternative because of the lack of available water in the area.

9.6.1.1 Natural-draft towers

Natural-draft towers bring the circulating cooling water in contact with an airstream whose movement is induced by the chimney effect created by the hyperbolic shape of the tower.

Both the wet-bulb temperature and the relative humidity at a site are important to the design of natural-draft towers. Conditions favorable to the use of natural-draft towers include (1) low wet-bulb temperatures, (2) high relative humidity, (3) large-sized installations, (4) winter peaking loads, and (5) need to limit fogging, icing, and drift (Robertson 1978).

Natural-draft towers are not expected to be widely used in the southwestern United States or in conjunction with geothermal installations. The Southwest and the proposed site, in particular, are characterized by conditions (e.g., relatively high wet-bulb temperatures, low relative humidities, and summer peaking loads) under which natural-draft towers do not function efficiently. The 50-MW(e) demonstration plant is relatively small, so that natural-draft towers are not expected to be cost-effective. Natural-draft towers are estimated to cost 3 to 4 times as much as mechanical-draft towers (Robertson 1978). The potential for seismic activity and ground subsidence in geothermal areas is also a deterrent to the use of natural-draft towers.

9.6.1.2 Dry towers

Dry towers employ air-cooled heat exchangers to remove heat from the circulating water by means of radiation and convection, thus eliminating water loss from evaporation. Dry towers are dependent on the ambient dry-bulb temperature, theoretically the lowest temperature dry towers can achieve. Because of the higher condensing temperature, dry-bulb as opposed to wet-bulb, the turbine must operate under a high back pressure, generally from 5 to 10 in. of mercury. The high turbine back pressure results in a reduction in plant efficiency, which can be recovered partially by the use of turbines specially designed to operate under high back pressures (Robertson 1978).

The major advantages of dry towers are the elimination of evaporative losses and the minimization of fogging, icing, and drift. The principal disadvantage is their cost, which has been estimated at 5 to 10 times the cost of mechanical-draft wet towers, depending on the turbine back pressure. In addition to economic penalties of approximately $13 million above the cost of wet cooling (Maddox 1979), dry cooling towers also would result in less efficient turbine designs, which in turn would require up to twice as many geothermal wells per megawatt as the proposed design. Thus, the use of dry cooling towers is a tradeoff among water consumption, technological risk, and increased environmental impact from well drilling and pipelines.

9.6.1.3 Wet/dry towers

The properties of both wet and dry towers are combined to cool the circulating water by evaporation, radiation, and convection. Wet/dry towers are designed so that the dry portion operates alone when dry-bulb temperatures are low and the wet portion supplements during hotter periods. The combination of evaporative and dry cooling allows control of drift, fogging, and icing while the evaporative loss of cooling water is substantially reduced (Robertson 1978). However, wet/dry towers are more expensive than either wet or dry towers.

9.6.1.4 Fresh makeup water supply

A 50-MW geothermal power plant with a reservoir temperature of 300°C, as at the Baca Location, would require a makeup water supply of approximately 2.84 cfs (1275 gpm) (Goldsmith 1978). The water rights at the Baca Location are already appropriated and new allocations are not expected, making the option of fresh makeup water legally impossible (Public Service Company of New Mexico 1978).

9.6.2 Hydrogen sulfide abatement system alternatives

The abatement system selected for use at the Baca Location is based on the patented Stretford process. The condenser off-gas is brought into contact with oxidized Stretford solution twice so that less than 1 ppm of hydrogen sulfide by volume and less than 50 ppm of other sulfur compounds are vented to the atmosphere. Ninety-nine percent of the delivered hydrogen sulfide is expected to be removed. The Stretford solution is regenerated as an elemental sulfur froth is formed and removed in oxidation tanks (Weres, Tsao, and Wood 1977, Laszlo XXXX). It is estimated that an annual revenue of $25,000 will be realized by selling the dried and purified elemental sulfur froth (Union Oil Company 1978). The only other abatement methods deemed promising are the iron catalyst method and upstream absorption scrubbers.

9.6.2.1 Iron catalyst method

The iron catalyst system uses dissolved ferric ion (Fe^{3+}) to catalyze the reaction

$$H_2S + 1/2\ O_2 = H_2O + 1/8\ S_8$$

so that

$$2Fe^{3+} + H_2S = 2Fe^{2+} + 1/8\ S_8 + 2H^+ ,$$

$$2Fe^{2+} + 1/2\ O_2 + 2H^+ = 2Fe^{3+} + H_2O .$$

In the process the ferric ion is regenerated, so that more hydrogen sulfide is oxidized. The iron concentration in the cooling water is maintained at 30 ppm by weight or higher. The condenser off-gas is released in the cooling water, so that its hydrogen sulfide content is also oxidized.

The major problems associated with the iron catalyst system are corrosion of metal parts in contact with the cooling water and rapid accumulation of sludge. The corrosion of metal parts has resulted in the use of only type 316, 316L, and 17-4 PH stainless steels for the parts that come in contact with the cooling water. The sludge produced by the free sulfur is 90% water by weight. Accumulation of the sludge is so rapid that it must be removed continuously and hauled to a proper disposal site.

9.6.2.2 Upstream absorption scrubbers

Upstream removal of hydrogen sulfide, not degrading the steam to an unacceptable level, is considered to be the ideal method. However, such a system has not yet been developed.

An upstream absorption scrubber has been used at The Geysers with an aqueous cupric sulfate ($CuSO_4$) solution. Efficiencies of 90% have been achieved with an NH_3/H_2S ratio of 1.6 to 1 and recent internal reports indicate an order of magnitude improvement is feasible. The efficiency drops with the NH_3/H_2S ratio; therefore this system using cupric sulfate as the scrubbing solution will be restricted to geothermal areas with significant amounts of ammonia in the steam. This system is not commercially available, and research is continuing in the area of cupric sulfate regeneration. Research has also been conducted using zinc oxide as the scrubbing solution; however, regeneration of the zinc oxide is a problem (Weres, Tsao, and Wood 1977).

9.6.3 Alternative power cycles

The Baca reservoir is characterized by a relatively high reservoir temperature, 260°C (500°F), and low salinity, less than 7000 ppm total dissolved solids. The power cycle to be used at the Baca reservoir is a single-flash design. The geothermal fluid from up to five production wells, in one area, is transmitted to a high-pressure production separator in a satellite location. The steam is separated from the geothermal water at 125 psia and transmitted to a high-pressure scrubber, prior to entering the expansion turbine. The exhaust steam enters a surface condenser, where the noncondensable gases are removed by steam jet ejectors and piped to a hydrogen sulfide abatement system. The condensed steam is circulated through the cooling tower and serves as cooling water makeup. Excess cooling water is returned to the injection plant to be reinjected with the geothermal water from the satellite separators (Union Oil Company 1978).

Other power cycles that received consideration are the binary cycle and the dual-flash cycle.

9.6.3.1 Binary cycle

The binary cycle is thought to be more economic than the flash cycle for reservoirs having a moderate (90 to 150°C) to low (less than 90°C) temperature (Lombard 1977). Heat from the geothermal fluid is transferred to a working fluid through a heat exchanger, making more efficient use of the available heat energy. The working fluid is then expanded through the turbine. This cycle generally requires a smaller turbine because of the low molecular weight, high critical pressure, and high vapor-phase energy density of the working fluid (Milora and Tester 1975). However, it is estimated that the total capital cost of a binary-cycle plant for Baca would be approximately 24% greater than the single-flash plant cost. One advantage of the binary cycle is the relatively low releases of noncondensable gases, since both the geothermal fluid and working fluid are contained in closed loops. There is a problem with corrosion and scaling of the heat exchanger tubes if the geothermal fluid is hypersaline (ERDA 1977); however, this is not the case at Baca. The binary cycle requires an external supply for cooling water (Goldsmith 1978). It has been estimated that a binary plant at Baca would require approximately 4,000 acre-ft of cooling water makeup per year. All surface and shallow water rights at Baca have been appropriated, and new allocations are not expected to be made (Union Oil Company 1978).

9.6.3.2 Dual-flash cycle

The dual-flash design differs from the single-flash in that the geothermal water separated in the first flash unit is fed into a second flash unit operating at a lower pressure. The low-pressure steam is fed into a low-pressure turbine connected in tandem with the high-pressure turbine (Science and Public Policy Program 1975) or into the turbine at a point where its pressure matches that of the expanding steam from the first unit (ERDA 1977). The dual-flash cycle increases the amount of energy recovered from the goethermal fluid, thus reducing the well flow rate required. The remainder of the system is essentially the same as for the single-flash cycle. At Baca it is estimated that one less production well would be required using dual flash; however, because of a possible deficiency of low-pressure steam, the thermal efficiency of the plant is likely to be reduced (Union Oil Company 1978). Although the dual-flash plant requires one less production well, the saving is offset by an increase of 3 to 4% in the capital cost of the plant.

9.6.4 Alternative flash unit location

The flash system to be used at Baca consists of four flash units to be located at satellite positions. Each flash unit will serve up to five production wells in one area. From the flash unit a single-phase pipeline will carry the separated steam to a power plant. The satellite arrangement eliminates long lengths of large two-phase piping and offers flexibility for makeup well hookups. Alternative flash system configurations include locating the flash unit at the turbine and separate wellhead flash units. Turbine flashing requires the use of large two-phase piping from each wellhead to the power plant. This configuration offers little flexibility in case of unexpected well production variations and may result in an undesirable concentration of heat, from steam venting, at the power plant during turbine downtimes (Union Oil Company 1978). Use of separate flashing units located at the wellheads eliminates two-phase piping requirements; however, this arrangement, like turbine flashing, offers little flexibility in case of well production variations and may result in a significant increase in labor requirements for separator inspection.

9.7 ALTERNATIVE TRANSMISSION CORRIDORS

An analysis of an alternate route to the TA-3 substation is included in Sect. 4.4. The nearest alternate load center for power from the proposed plant is Albuquerque via a substation at San Ysidro, owned by another utility.

A generic study of feasible transmission routes were considered by PNM during an early study of possible egress for the power to be generated at the Baca plant. Of these, the proposed routes (southern and Baca) and two San Ysidro routes were identified as possible candidates for this project. The San Ysidro routes are indicated in Fig. 9.2 as alternatives I and II. These routes were eventually rejected for further consideration for the present 50-MW plant in favor of a route to Los Alamos. The reasons for the rejection were threefold: their greater length, the fact that the negotiations for right-of-way with the various tribal landowners could not be accomplished within the time limits set for completion of the power plant, and because Los Alamos was the only terminus available by which PNM could serve its own customers. However, in the event that future expansion of the project to 400 MW necessitates a 345-kV transmission line, these two alternatives probably would be reexamined in the context of the PNM system as it exists at that time. Inasmuch as specific environmental studies of these alternative routes were not undertaken, a detailed analysis of their impacts cannot be made; however, a general discussion of the types and to some extent the severity of potential environmental constraints for these two alternative routes is feasible.

Alternatives I and II are very similar in many ways. Both are approximately 48 km in length and are composed of complex land ownership patterns (Table 9.2). Both routes cross land owned by Indian pueblos. Jemez and Zia Pueblos are national historic sites. Also, the possibility of infringement on Indian religious freedom exists along both routes. Both essentially utilize mesas to approach San Ysidro. The routes coincide for the 8 to 9.5 km out of the plant site, then diverge to traverse different mesas south to San Ysidro. The routes exit the Baca Location almost due south of the plant site, crossing the Banco Bonito.

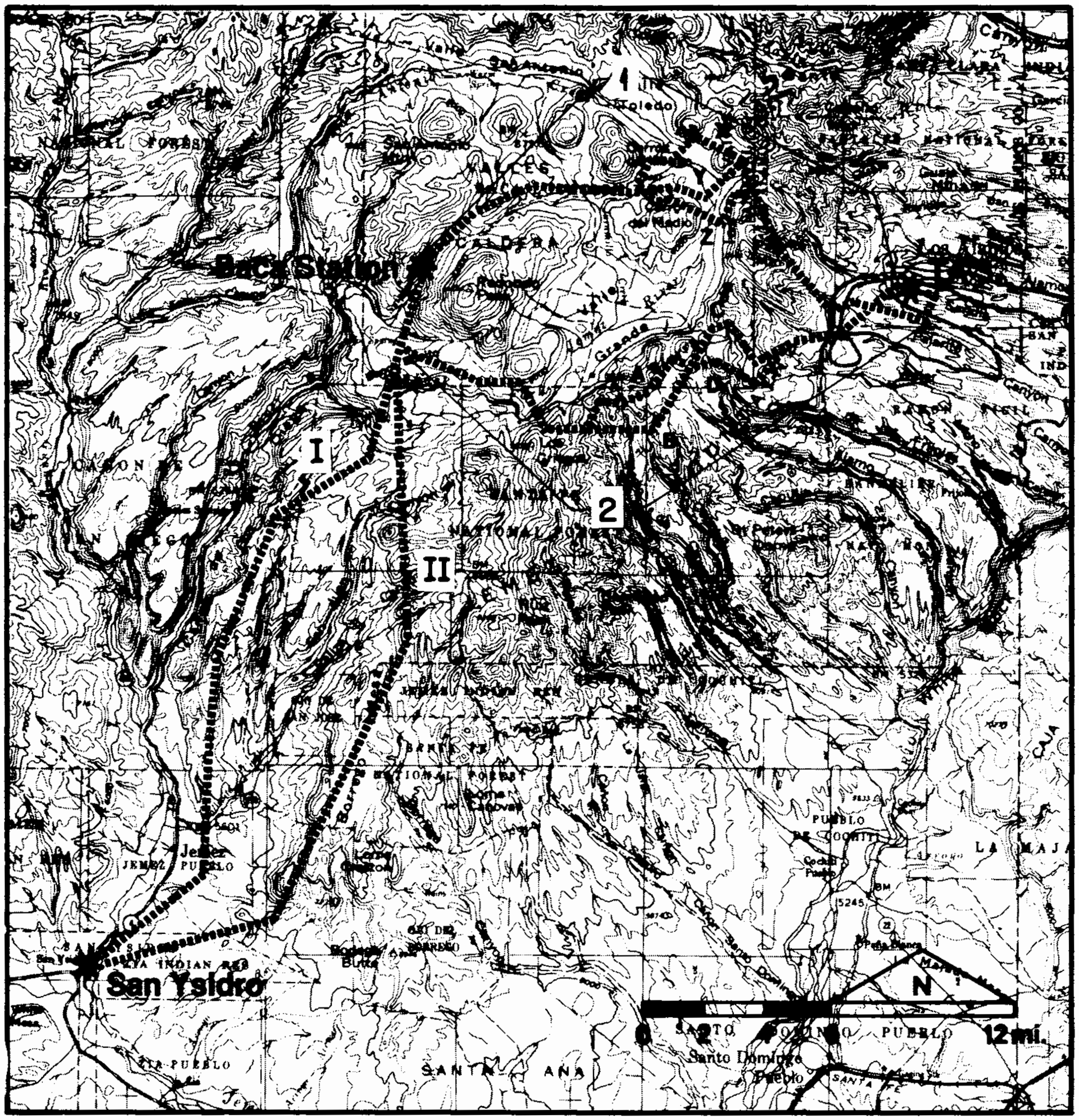

Fig. 9.2. Map showing proposed transmission corridor.

They cross NM-4 just before it turns north into the Baca Location. They cross the East Fork of the Jemez River between Jemez Falls and the village of Vallecitos de los Indios. These crossings have significant visual and recreational conflicts.

After crossing the river, the routes diverge. Route I utilizes San Juan Mesa. The route will be visible as it ascends to the mesa from the valley around the Vallecitos de los Indios. Once the line is on the mesa tops, avoidance of archaeologic sites, including the historic site

Table 9.2. Land ownership for alternative routes I and II

Route I	
Private (Baca location)	4.0 miles
U.S. Forest Service	5.5 miles
Private (Canon de San Diego land grant)	5.5 miles
Jemez Pueblo Indian Reservation	9.0 miles
Zia Indian Reservation	6.0 miles
	30.0 miles
Route II	
Private (Baca location)	4.0 miles
U.S. Forest Service	12.0 miles
Tribal Indian land of the Jemez Pueblo (Canada de Cochiti land grant)	2.0 miles
Jemez Pueblo grant and reservation	5.0 miles
Zia Pueblo grant	9.0 miles
	32.0 miles

on San Juan Mesa, will be of major concern. As route I emerges from San Juan Mesa it crosses Vallecito Creek and NM-290. Visual impacts and highly erodible soils resulting from overgrazing are the major considerations at these crossings. The route will also cross NM-44 and the Jemez River before reaching San Ysidro.

Alternative route II utilizes Borrengo Mesa, east of alternative I. Generally, the terrain is more diverse along this route. NM-4 is crossed near Borrengo Canyon, and the crossing will be a sensitive one because of the undisturbed nature of the area. Once on the mesa, visual and recreational conflicts are lessened, but archaeological sites must be avoided. Route II also must cross NM-44 and the Jemez River to enter San Ysidro.

The visual impacts of routes I and II are equal to or greater than those of the proposed corridors to Los Alamos. Routes I and II cross more state highways than the proposed corridors, and alternatives I and II cross where traffic will be heavier. Routes I and II cross sensitive recreation areas as identified by U.S. Forest Service (Sects. 4.4.1 and 4.4.1.5) and residential areas south of the Baca Location. Routes I and II also involve more crossings of perennial streams. The alternative routes will be visible on the mesas from recreation use areas on San Juan and Cat Mesa. Route I will be visible from the historic site on San Juan Mesa.

Because routes I and II are at lower elevations than the proposed corridor, they cross different vegetation types. Approximately 25% of the routes will be in mixed conifer, 25% in ponderosa pine, 25% in pinyon juniper, 15% in juniper grasslands, and the remainder in meadows and riparian areas. Because routes I and II utilize relatively open vegetational communities, they will probably require equal amounts (or less) of timber clearing than required for the shorter proposed corridors. Revegetation of disturbed areas will be difficult because of arid conditions and deterioration from overgrazing. The potential for occurrence of rare flora along routes I and II is not known. Except for the portion of the alternative routes within Redondo Canyon, these routes will not cross elk or salamander habitat. Ecological impacts of the alternative routes I and II would probably be less than those of the proposed corridors.

The potential for erosion along routes I and II may be higher than along the proposed corridors for a number of reasons. The alternatives are longer and would require proportionally more surface disturbance. The alternative routes cross more perennial streams. The soils along portions of the alternative routes are moderately to highly erodible; overgrazing and the difficulty of reclamation because of more arid conditions along alternatives I and II exacerbate the erosion potential.

REFERENCES FOR SECTION 9

California Department of Fish and Game. 1976. *At the Crossroads, a Report on California's Endangered and Rare Fish and Wildlife*, The Resources Agency, State of California.

Geonomics, Inc. 1976. *Geotechnical Environmental Aspects of Geothermal Power Production at Heber, Imperial Valley, California*, EPRI ER-299, Electric Power Research Institute, Palo Alto, Calif.

Goldsmith, M. 1976. *Geothermal Development and the Salton Sea*, EQL Memorandum No. 17, California Institute of Technology, Pasadena, Calif.

Goldsmith, M. 1978. "Cooling Water Requirements for Geothermal Power Plants and Water Availability in the Imperial Valley," *Geothermal Resource Council Transactions*, Vol. 2, July 1978.

Imperial County Department of Public Works. 1971. *Terms, Conditions and Standards and Application Procedures for Initial Geothermal Development — Imperial County*, May 1971.

Laszlo, J. XXXX. *Application of the Stretford Process for H_2S Abatement at the Geysers Geothermal Power Plant*, pp. 724-730, 11th IECEL.

Layton, G., and D. Ermak. 1976. *A Description of the Imperial Valley, California for the Assessment of Impacts of Geothermal Energy Development*, UCRL-52121, Lawrence Livermore Laboratory, Livermore, Calif.

Lombard, G. 1977. "Heber Geothermal Demonstration Plant," *Geothermal Resource Council Transactions*, Vol. 2, May 1977.

Maddox, J. 1979. Public Service Company of New Mexico, *Testimony at the Public Hearing on Environmental Impact Statement*, Geothermal Demonstration Program, Albuquerque, N.M., August 30, 1979.

Meidav, M. Z., and H. T. Meidav. 1977. "Impact of Geothermal Energy Development on the Heber Area, Imperial Valley, California," pp. 217-19 in *Geothermal: State of the Art*, Transactions vol. 1, Geothermal Resources Council, Davis, Calif.

Milora, S. L., and J. W. Tester. 1975. *Geothermal Energy as a Source of Electric Power*, Oak Ridge National Laboratory, Oak Ridge, Tenn., October 1975.

Myers, Dale. 1978. *Selection of Proposal for Cooperative Agreement for Design, Construction and Operation of a Geothermal Electric Power Demonstration Plant Utilizing Liquid-Dominated Hydrothermal Resource*, U.S. Department of Energy.

Palmer, T. D. 1975. *Characteristics of the Geothermal Wells Located in the Salton Sea Geothermal Field, Imperial County, California*, UCRL-51976, Lawrence Livermore Laboratory, Livermore, Calif.

Public Service Company of New Mexico. 1978. Responses to DOE proposal questions Feb. 13, 1978.

Robertson, R. C. 1978. *Waste Heat Rejection from Geothermal Power Stations*, ORNL/TM-6533, Oak Ridge National Laboratory, Oak Ridge, Tenn. (December 1978).

San Diego Gas and Electric Company. 1977. *Geothermal Environmental Studies, Heber Region, Imperial Valley, California*, EPRI ER-352, Electric Power Research Institute, Palo Alto, Calif.

Science and Public Policy Program of the University of Oklahoma. 1975. *Energy Alternatives: A Comparative Analysis*, prepared for CEQ, ERDA, EPA, FEA, FPC, DOI, NSF, May 1975.

Tomany, J. P. 1977. "Air Pollution Emissions Control for Geothermal Energy Plants," *Geothermal Resources Council Transactions*, Vol. 2, May 1977.

Union Oil Company of California and Public Service Company of New Mexico. 1978. *Geothermal Demonstration Power Plant*. Vol. 1. *Project Abstract*. Vol. 2. *Technical and Management Proposal*, submitted to the Department of Energy, Jan. 31, 1978.

U.S. Department of Energy. 1979. *Environmental Assessment, Westmoreland Development Project, Imperial County, California*, DOE/EA-0058, Department of Energy, San Francisco Office, April 1979.

U.S. Department of the Interior. 1973. *Final Environmental Statement for the Geothermal Leasing Program*, vol. II, U.S. Government Printing Office, Washington, D.C.

U.S. Department of the Interior. 1977. "Endangered and Threatened Wildlife and Plants," *Fed. Regist.* 42(135): 36421-31.

U.S. Environmental Research and Development Administration. 1977. *Environmental Impact Assessment of the Hydrothermal Subprogram of the Division of Geothermal Energy*, EIA/GE/77-2 (March 1977).

U.S. Geological Survey. 1976. *Final Environmental Analysis, 16 Deep Test Wells, Roosevelt Hot Springs Unit, Phillips Petroleum*, EA. No. 33, Office of the Area Geothermal Supervisor, Menlo Park, Calif.

U.S. Geological Survey. 1977. *Environmental Analysis Prepared for the Drilling of Seven 5,500 Foot Exploratory Wells in the Beowawe Unit, Lander County, Nv., Chevron U.S.A., Inc.*, EA No. 55, Office of the Area Geothermal Supervisor, Menlo Park, Calif.

U.S. Nuclear Regulatory Commission. 1974. *Final Environmental Impact Statement Related to the Proposed Comanche Peak Steam Electric Station.* Docket Nos. 50-445 and 51-446. 1974.

VTN Consolidated, Inc. 1978. *Final Environmental Impact Report, Heber Geothermal Demonstration Project*, prepared for Imperial County Planning Department, No. 170-77.

VTN Consolidated, Inc. 1979. *Draft Environmental Impact Report for a 500-Megawatt Geothermal Development at Heber, Imperial County, California, September 1979*, submitted to County of Imperial Planning Department, p. III-144-146.

Weres, O., K. Tsao, and B. Wood. 1977. *Resource, Technology and Environment at The Geysers*, LBL-5231 (June 1977).

White, D. E., and D. L. Williams, eds. 1975. *Assessment of Geothermal Resources of the United States — 1975*, Geological Survey Circular 726, U.S. Geological Survey.

Williams, F., A. Cohen, R. Pfundstein, and S. Pond. 1978. *Site Specific Analysis of Geothermal Development — Data Files of Prospective Sites*, vol. III, HCP/T4014-01/3, U.S. Department of Energy, Washington, D.C.

Wilson, Howard M. 1978. "Pace of Action Quickens in U.S. Geothermal Areas," *Oil Gas J.*, Dec. 18, 1978, pp. 15-18.

Wilson, J. R., Imperial Irrigation District. 1979. Telecommunication with G. W. Suter, Oak Ridge National Laboratory, Oak Ridge, Tenn., Feb. 21, 1979.

10. ENVIRONMENTAL TRADE-OFF ANALYSIS

The environmental impacts of the reasonable alternatives were briefly discussed in Chap. 9. In this chapter, the relative impacts of the alternatives compared with the proposed action will be discussed. In most cases a qualitative comparison will be sufficient.

10.1 ACTION ALTERNATIVES

The alternatives of no action and delayed action by DOE will have little effect on environmental impacts except to delay the construction of a power plant in the Baca Location for approximately ten years. The commercial partners will be likely to proceed without Federal funds when the economics of power generation at this geothermal area become competitive.

There may be some change in the status of surrounding land uses within that time period, but all other environmental interfaces should be similar to those of the currently proposed project. Delay of the project might allow Congress time to resolve the issue of public acquisition of lands in the Valles Caldera.

Information that would be obtained from the project would not be available to potential developers if the no action alternative were implemented. Also, implementation of the no action or delayed funding alternatives may allow sufficient time for the resolution of issues such as that of public ownership. If the no action alternative is implemented and private development does not proceed, the Baca property will remain in its natural condition and the status of the National Natural Landmark will not be threatened.

10.2 SITE ALTERNATIVES

Alternative sites within the Baca Location and at other places within the United States were discussed, although all are not equally feasible under the present project contract structure. Refer to Sect. 9 for more detail on the conditions permitting the feasibility of different sites. The commercial partners may develop all of the alternative sites discussed here eventually.

10.2.1 Alternative sites in the Baca Location

The alternative sites within the Baca were discussed according to the amount of geothermal potential currently forecast. The sites with the highest potential are the two additional sites in Redondo Canyon, which would use essentially the same reservoir that the proposed plant site will use. Because of the very similar environmental setting, there will be essentially no difference in environmental impact from any of the three sites in Redondo Canyon except that the site closer to the Baca boundary might result in higher concentrations of hydrogen sulfide offsite.

The location with the next highest development potential is the Sulfur Creek canyon area near Redondo Canyon. Exploration results have not been as promising in the Sulfur Creek areas, so the sites are currently not as attractive for development by the commercial partners.

If the resource were deemed adequate to support a 30-year, 50-MW electric power plant in Sulfur Creek canyon, the sites would have essentially the same potential impact on habitat, hydrology, and the elk and salamander. A major difference, however, is that prior human activity has been greater in that area and the natural sulfur emissions have prevented vegetation cover from forming in many of the thermal springs and thermally altered areas. Thus the effects of vegetation removal would be somewhat less than in Redondo Canyon. The number of permanent residences within 3 miles of the Sulfur Creek canyon site is greater than in Redondo Canyon, and thus noise and hydrogen sulfide may have a greater impact.

Transmission line routes out of Sulfur Creek canyon have not been evaluated. However, routes out of Sulfur Creek canyon will overlap the Redondo Canyon route for the most part.

Table 10.1 summarizes the environmental effects of alternative sites within the Baca.

10.2.2 Alternative sites at other geothermal areas

Environmental characteristics of the Baca site compared to the six alternative sites at other geothermal areas considered in the United States

Table 10.1 Environmental effects of alternative sites in the Baca location

Site location	Ecology	Land use	Hydrology	Air quality	Archaeological and cultural resources
Proposed site in Redondo Canyon	Elk range disturbed; endangered species losses; some habitat damage to trout fishery possible	Immediate land use unaffected; area recreation affected	Reservoir depletion will reduce available surface flow in some streams and hot springs	Hydrogen sulfide limits exceeded only during abnormal operation	Infringement on Indian religious freedom; potential loss of archaeological and cultural resources
Site 2 miles north of proposed site in Redondo Canyon	Same as proposed site	Same as proposed site	Same as proposed site	Same, except limits will not be exceeded as often by abnormal operations	Possibly worse than proposed site
Site 2 miles south of proposed site in Redondo Canyon	Same as proposed site	Same as proposed site	Same as proposed site	Hydrogen sulfide limits may be exceeded off site during normal operation	Possibly better than proposed site
Sites in Sulfur Creek Canyon	Same as proposed site except that prior disturbance is greater	Immediate recreational use	Same as proposed site	Hydrogen sulfide limits may be exceeded off site during normal operation	Same as proposed site

Table 10.2. Environmental effects of the proposed and alternative sites

Site	Ecology	Land use	Geology	Socioeconomics	Cultural resources	Air	Water
Baca	Important elk range disturbed; endangered species loses some habitat; damage to trout fishery possible	Grazing and logging largely unaffected; major recreational resources affected	Induced subsidence and seismicity are very unlikely	Minor effects of dis-association between costs of services and tax benefits	Identified archeological sites; sacred sites; designated natural landmark Potential religious infringement	High background H_2S; state H_2S and other standards met	Reservoir depletion will reduce the flow of thermal springs Availability of water rights
Heber and Brawley	Depauperate aquatic and terrestrial communities; nearby endangered species not affected	Irrigated agriculture may be affected by subsidence; drift will require increased salt removal	Significant induced subsidence and seismicity unlikely but high background and potentially serious effects cause concern	High unemployment; low average income; significant tax and employment benefits; little additional demand for public services	None	Small increase in high background particulate levels; a non-binary-cycle plant would require H_2S control	Water is available but use will slightly hasten Salton Sea salinization
Salton Sea	As above for Heber; also high concentrations of waterfowl and other wildlife which must be avoided	As above for Heber; also hunting and bird watching in refuges which must be avoided	As above for Heber	As above for Heber	None	As above for Heber	As above for Heber
East Mesa	Colorado desert community, disturbed and unremarkable, further disturbed	Low level of ORV use, sand and gravel extraction; small loss of area available	As above for Heber	As above for Heber	Identified archaeological sites	As above for Heber	As above for Heber
Roosevelt	Great Basin desert; some deer winter range lost	Grazing; small-scale mining; small loss of area available	Induced subsidence and seismicity are very unlikely	Significant tax and employment benefits; some new housing required; utilities are adequate	Minor archaeological resources	8 ppm H_2S in fluid; control anticipated to eliminate H_2S odor in plant area	Condensed steam used for cooling; no surface water; reservoir communication is ill defined
Beowawe	Great Basin desert; some deer migration may be diverted	Grazing; low-level recreation; small loss of area available	As above for Roosevelt	New housing and services required	Identified archaeological sites	High local background H_2S and particulates	Water availability may be a problem if a binary cycle is used; reduced flow of natural hot springs likely

are summarized in Table 10.2. Differences in impacts between the sites arise primarily from differences in the receiving systems rather than in the resources. None of the geothermal fluids will require surface disposal, and atmospheric emissions appear to be controllable to acceptable levels at all sites.

Effects on major ecological resources are anticipated only at Baca and the Salton Sea. The high waterfowl concentrations at the Salton Sea are sufficiently localized to permit avoidance during facility siting. The extent and importance of the loss of elk range at Baca is difficult to determine from existing information, but some disturbance of elk is inevitable. Loss of Jemez Mountains salamander habitat will occur but is not believed to be significant to the survival of the species. Siltation and fluid spills could severely damage the trout fisheries of Redondo Creek and the Jemez River.

Land use conflicts are anticipated at Baca and the three central Imperial Valley sites, Heber, Brawley, and Salton Sea. Subsidence in the Imperial Valley could disrupt irrigation water flow, but intensive monitoring should permit early detection and mitigation. Salt drift deposition could require additional use of agricultural irrigation water for leaching. Geothermal development is not expected to induce seismicity, but because of the high seismic background in the Imperial Valley, this problem is being intensively studied. Geothermal development does not conflict with existing land use at the privately owned Baca site but could conflict with the plans for public acquisition which are now under study. The transmission lines and visual intrusion of the plant would conflict with the recreational and religious use of existing public lands.

Significant local socioeconomic benefits could result in the Imperial Valley and at Roosevelt Hot Springs, where tax benefits will be associated with the areas incurring the costs, costs of new services will be low, and current unemployment is high. Because of its remote location, development at Beowawe could cause significant demand for services and social disruption in nearby small communities. Local socioeconomic effects at Baca are expected to be minor. At all sites, most of the expenditures for wages and material purchases will have regional rather than local benefits.

Archaeological resources are found at all but the central Imperial Valley sites. None of these appear to be so extensive or of such importance that they cannot be avoided or salvaged. Further archaeological investigations are required at Baca as well as the other sites to confirm this conclusion. Archaeological resources are particularly dense in the Baca area. Several sites in the Baca area are sacred to the local Native Americans. The largely unspoiled character of the area that led to its designation as a national natural landmark will be reduced by development.

Although the water supply is limited at all of the sites discussed, suitable supplies are known to be available at all sites except Beowawe. Water requirements and availability at this site are unknown. Communication between the geothermal reservoirs and other aquifers is ill-defined at Roosevelt and Beowawe. Water use in the Imperial Valley will hasten the State of California's decision concerning ultimate management of the Salton Sea.

More environmental conflicts arise from geothermal development at the Baca Location than from development of any of the other sites considered. Roosevelt Hot Springs is conspicuously free of significant known environmental conflicts. Problems at the other alternative sites are largely technical and therefore are more readily solved than the general problem of industrial intrusion in the scenic and environmentally valuable location.

10.3 ALTERNATIVE PLANT DESIGNS

The presently proposed project design is preliminary and is based upon the optimization of geothermal, economic, engineering, and environmental factors. As more detail is developed in the design by the commercial partners, slight changes may occur; however, it is unlikely that any of the alternatives discussed in Sect. 9 will be implemented unless a major change occurs in the design parameters originally assumed for the plant.

10.3.1 Power cycle and cooling system

The alternative cooling systems and power cycle types may be grouped together for environmental trade-off discussions because the method of design selection is similar and the environmental effects are similar. A single-flash vs double-flash vs binary-power-cycle selection is an engineering-economic decision based on geothermal resource characteristics. Impacts of the binary vs the flash cycles are different; however, the economics of the systems incorporated additional subsystems to mitigate these environmental effects, thereby factoring environmental concerns into the design process. On this basis the proposed plant design was selected to be a single-flash system using mechanical-draft cooling towers.

The alternative cooling systems affect the release of hydrogen sulfide and geothermal vapor to the atmosphere. Wet cooling towers at the Baca geothermal plant will use the geothermal fluid as cooling water; therefore, the loss of water to the atmosphere will represent a consumptive use of geothermal fluid rather than of fresh water. Dry cooling towers would reduce this geothermal fluid loss by blowing heated air through large radiators, and because the geothermal fluid would not be exposed to the atmosphere as in wet towers, there would be a minimal release of hydrogen sulfide from dry towers. Dry cooling towers are technically feasible for small power plants but are expensive for most applications. Many dry cooling towers are quite noisy, some having fan noise as high as 85 dBA 15 m (50 ft) from the tower, compared with about 65 dBA for a mechanical-draft wet tower. The wet/dry cooling tower, employing the wet or the dry cooling method as environmental conditions or plant needs dictate, has the advantages and the problems of both of the types it combines. Hydrogen sulfide abatement would be required for the wet portion; consumptive use of water would be less than for all-wet towers; and expense and noise would be high for the dry portion. Operating experience is limited for all but the mechanical-draft wet cooling tower at goethermal plants.

The double-flash power cycle and the binary power cycle were evaluated by PNM as alternatives to the proposed single-flash cycle. The double-flash system would require one less geothermal supply well but is more expensive to construct and operate. Otherwise the environmental effects of its construction and operation would be essentially the same as for the single-flash system. The binary system, on the other hand, could potentially produce very different operating impacts than the flash system. Because there would be no release of geothermal fluid to the atmosphere, hydrogen sulfide abatement would be minimal; however, the binary plant requires cold water (near ambient) for the binary turbine condenser. Since there is no source of fresh water in sufficient quantity, it is presumed that cooled geothermal fluid would be the only source of condenser water. This requires a return to the cooling system alternatives. Therefore consumptive use of geothermal fluid would be at least equal to that of the flash systems, and the potential for release of hydrogen sulfide would be as great for each cooling system considered.

Alternative cooling systems and power cycle environmental effects are summarized in Table 10.3.

10.3.2 Hydrogen sulfide abatement

The alternative of no hydrogen sulfide abatement was not considered. Refer to the discussion of accidents in Sect. 4.3 for estimates of unmitigated release of hydrogen sulfide.

The iron catalyst is the only economically feasible alternative to the Stretford process selected for the proposed project. Experience with the iron catalyst is extensive at The Geysers. Although experience with the Stretford process at geothermal plans is limited, there is extensive application experience for the process in the petrochemical industry. Design estimates for the two processes predict that the Stretford process will be at least as effective as the iron catalyst in preventing the release of hydrogen sulfide from cooling towers, but more pessimistic assumptions were made for the Stretford process in estimating the operation effluents for the proposed plant. Although the plant capital cost is higher for the Stretford process, plant reliability should be higher, thereby making it the preferred system for the proposed plant. The sludge generated in the condenser water by the iron

Table 10.3. Environmental aspects of alternative cooling systems and power cycles

System alternative	Cost	Geothermal fluid	Air quality	Noise
Proposed single-flash power cycle, wet tower cooling system	Base	Consumptive use of ~ 800,000 lb/hr	Release of less than 50 lb/hr hydrogen sulfide (2 ppb or less concentration)	65 dBA at 50 ft for cooling tower only
Dry tower cooling system	Higher than base	Negligible	Negligible	100 dBA at 50 ft for cooling tower only
Wet/dry tower	Higher than base	Significant but less than base case	Significant but less than base case	More than base case
Double-flash power cycle wet tower cooling system	Same as base	Slightly less than base case (one less production well)	Slightly less than base case	Same as base case
Binary power cycle	More than base case	[a]	[a]	[a]

[a] Refer to cooling system alternative above for environmental effects.

catalyst system has been responsible for higher-than-desirable maintenance costs at The Geysers. Also, a substantial amount of the catalyst reaction products must be mixed with the geothermal injection fluid for disposal.

10.4 ALTERNATIVE TRANSMISSION LINES

Alternative corridors to the TA-3 substation are discussed and compared in detail in Sect. 4.4. Section 9.7 contains a discussion of two alternative routes to a load center at San Ysidro and compares these routes with the corridors to Los Alamos.

Comparisons between the Baca corridor and the southern corridor to Los Alamos indicate that the Baca corridor is by far the least environmentally sensitive route to the TA-3 substation at Los Alamos. The Baca corridor has less potential for impacts to land use, recreational resources, biota, and archaeological resources and less potential for erosion. Although one section of the Baca corridor within the Santa Fe National Forest has relatively severe visual impact, overall the entire corridor entails less impact to visual resources than the southern corridor.

Routes I and II are very similar to each other. They are about one-third longer than the proposed corridors. Overall, routes I and II have the same potential for visual impacts as the proposed corridor, if not more. Erosion potential is greater along routes I and II than along the proposed corridors. The ecological impacts of routes I and II are less than those of the proposed corridors, primarily because routes I and II traverse lower elevational (and thus more common, state-wide) vegetational communities. The proposed corridors and alternative routes I and II have high potentials for occurrence of archaeologic sites; however, mitigation by avoidance of sites during right-of-way placement is almost always possible. These corridors also traverse Indian Pueblo land and have potential for affecting historic sites. The Pueblos are listed as National Historic sites. The possibility of infringement on Indian religious freedom also exists. The greater length of routes I and II complicates the comparison of impacts by proportionally increasing all impacts for these routes over the proposed corridor. Generally, the environmental impacts of routes I and II are probably similar to or slightly greater than those of the proposed corridor. Choice of routes I and II would cause project delay because of negotiations with tribal landowners and considerably increased project costs because of the delay and the longer routes. In the future, however, routes I and II would probably be the logical choice for any 345-kV transmission line from the Baca plant that might be necessitated by future development to 400 MW (Sect. 4.5).

11. MITIGATION AND MONITORING

11.1 MITIGATION

The following measures and procedures will be implemented to mitigate the impacts of the proposed action as identified in the FEIS.

11.1.1 Construction

11.1.1.1 Land use

Potential land use related impacts have been discussed in Section 4.1.1. Mitigation of effects on nearby residences from construction related traffic and noise will be achieved through consultation with affected residents and by avoidance of night-time construction traffic. Potential impacts related to increased erosion will be mitigated by adherence to accepted construction practices to reduce erosion. All roads and drill pads will be diked; runoff from these areas will be directed to settling ponds before discharge to the surface drainage in order to minimize potential sedimentation of streams. All disturbed areas will be revegetated as soon after disturbance as is feasible according to the construction schedule.

11.1.1.2 Water quality and use

The most serious potential impact on water quality from project construction could result from increased sediment loads in streams. Refer to the above section for a discussion of measures to reduce increased stream turbidity and sedimentation and to Sect. 11.1.2.2.2 for a discussion of measures to offset stream flow depletion.

11.1.1.3 Air quality

Air quality related impacts during construction have been discussed in Section 4.1.3. Fugitive dust emissions will be reduced by watering of disturbed land as is necessary to control dust. Gaseous emissions from well testing will be minimized by venting through a submerged discharge tube and cutting back well flow to 10% of flow as soon as feasible after testing.

11.1.1.4 Impacts on biota

Potential impacts on biota from well field development and power plant construction are detailed in Sect. 4.1.4. Mitigation of effects on vegetation will be accomplished by minimizing forest clearing and revegetating disturbed areas with native species. A mitigation plan to reduce impacts on rare plants has been cleared through the New Mexico Heritage Program (see Appendix H). The plan calls for surveying of all areas of the well field potentially involved in well pad, road, pipeline or plant construction for presence of rare plants and subsequently avoiding any populations of rare plants thus identified if possible.

Well field development and power plant construction will inevitably involve year-round elk habitat. Complete mitigation of effects on elk will be impossible; however, disturbances to elk will be minimized by avoiding the heaviest elk use areas in Redondo Canyon. These areas include identified elk wallows and favored feeding areas. Forest cover will be maintained surrounding well pads and roads to screen them from elk use areas. Further mitigation will be coordinated with New Mexico Game and Fish.

The presence of the Jemez Mountain salamander, a state designated endangered species has been confirmed in Redondo Canyon. A plan for mitigation of effects on this species has been approved by the New Mexico Game and Fish Department (Appendix H). Dense salamander populations that are identified during preconstruction surveys will be avoided. Where avoidance is not possible, removal and relocation of individuals will be accomplished by PNM biologists. If salamanders are not active on the surface, no removal mitigation will be performed.

Mitigation of potential adverse effects on aquatic biota will be accomplished by measures to reduce erosion (see Sect. 11.1.1.1). Settling ponds will be constructed to reduce sediment impact to Redondo Creek.

11.1.1.5 Impacts on historic and archaeological sites

An approved mitigation plan to prevent the loss of significant historic and archaeological information is presented in Appendix E.

11.1.1.6 Impacts on Indian religious and cultural activities

In compliance with Sect. 2 of the American Indian Religious Freedom Act (P.L. 95-341), the Interagency Task Force on Indian Religious Freedom submitted a report to the President which outlines the policies and procedures to be followed by the various Federal agencies to protect and preserve Indian religious rights and practices. That report contains a tentative 4-step approach by which DOE would satisfy the provisions of the Act. Before DOE would proceed with its proposed activity:

(1) An investigation would be made to determine if the site is related to Indian religious sites or ceremonies;

(2) If the site is currently the subject of religious practices, religious leaders will be consulted to determine whether the proposed activity would infringe on the free exercise of religion;

(3) If consultation indicates there would be an infringement, alternate plans would be prepared in consultation with religious leaders;

(4) If no alternate plan is feasible, and a conflict still exists, the DOE Assistant Secretary for Environment will balance the compelling interest of the proposed activity with the infringement on the free exercise of religion. Any decision to proceed with the proposed activity must be approved by the Secretary of DOE.

DOE is applying this 4-step procedure to the Baca geothermal demonstration project.

The project area is located at the base of Redondo Peak, the summit of which is a known sacred site to the Pueblo Indians. Hence, the project is related to and could impact a religious site or religious practices on that site. Consultations with Indian leaders revealed the extent of possible infringement by the project. Particular concerns for impacts on Indian religious freedom were identified (DOE Public Hearing, Aug. 30, 1979). Those concerns have been addressed in this document (Sect. 4.1.7).

The impact analyses resulting from consultations with the Indians indicate there would be infringement on the free practice of the Pueblo religion. To this point the Indians have been extremely reluctant to divulge the details of their religion, especially the location of religious sites. Therefore, the exact nature and extent of the infringement is still somewhat speculative. The discussion of potential impacts (Sects. 4.1.7, 4.5.1.6, and 4.5.2.6) provides a reasonable qualitative description of the infringement.

In accordance with the DOE tentative procedure for handling infringement, consultations with Indian leaders have been held. As an alternate plan, DOE proposed the following provisions on which to base a mitigation plan for protecting Indian religious freedom:

1. consultations with Indian leaders on the design, siting, and construction of power plant facilities, including transmission lines, to minimize impacts on areas of religious significance;
2. consultations throughout the operating period of the facility to assure minimum interference with religious rights and practices;
3. protection and preservation of religious sites located in the project area or otherwise under the project operator's control;
4. guarantees of access to religious sites under the project operator's control;
5. prompt notification of Indian leaders in case of an accident that may cause contamination of fresh water supplies;
6. assistance in identifying areas within Baca location where religious objects may be collected; and
7. consultation on plans for any future geothermal development by the project operators in Baca location.

The above provisions and any others would be subject to negotiation and approval by the Pueblo Indians, DOE, and the project operators. The proposed mitigation measures have been rejected (see Appendix J). The only alternate plans acceptable to the Pueblos would be no Federal action or relocation of the project to other sites in the United States. These alternatives have been addressed in Chapter 9.

11.1.1.7 Noise impacts

Noise is potentially a high level impact with geothermal development; however, noise abatement procedures have been developed that substantially reduce these potential impacts. Noise mitigation occurs at four stages: construction, drilling and flow testing, operation and accidents. During construction, equipment that might result in high noise levels will be restricted to daylight operation. During well drilling, muffled diesel rigs will be used, and air drilling will not be necessary. During flow testing, venting will be through submerged discharge diffusers. Steam releases required as result of accidents will be muffled vents or through submerged diffusers. These mitigation measures will result in the estimated noise levels used to analyse noise impacts in Sect. 4.

11.1.2 Plant operation

11.1.2.1 Land use

Impacts on surrounding land uses during plant operation will be minimal. No mitigation is proposed.

11.1.2.2 Water quality and use

11.1.2.2.1 Surface water

Impacts on water quality during operation would accrue only from an accidental release of geothermal fluids. A spill mitigation and prevention plan is on file with the State of New Mexico (refer to Appendix G). A discussion of measure to mitigate depletion of the Jemez River is presented below.

11.1.2.2.2 Groundwater

To help mitigate potential adverse impacts to shallow groundwater from plant operations, fluids will neither be directly withdrawn from, nor injected into, shallow aquifers and shallow aquifers will be protected from surface infiltration by the use of impermeable pits (sumps) with high freeboard to contain vented and/or drilling fluids.

Depletion of flow of the Jemez River resulting from the withdrawal of geothermal fluids will be offset (mitigated) by the acquisition of water rights. Union has applied for a permit to withdraw a total of 14 ha (34.59 acres) from irrigation, equivalent to 44 acre-ft of water. The land will be retired in 0.57 ha (1.4 acres), equivalent to 1.77 acre-ft of water, at five-year intervals. It is estimated that 5.67 ha (14 acres) or approximately 17.7 acre-ft of water will be required to offset the impact of the 50 MW facility. The remaining water rights (approximately 26 acre-ft) will be available to offset the impacts of any future development. These lands are located near La Cueva.

11.1.2.3 Impacts on air quality: hydrogen sulfide mitigation

The estimated releases of hydrogen sulfide to the environment during normal plant operation are based on a H_2S abatement system that uses the Stretford process to remove a high percentage of the H_2S and convert it to elemental sulfur for disposal or resale. Absence of this or a similar abatement system would result in the release of up to 230 lb/ton of H_2S during normal plant operation, compared to up to 43 lb/ton abated.

Efficient drift eliminators on the cooling towers will reduce the resultant salt drift to the lowest possible levels.

11.1.2.4 Impacts on biota

Impacts to biota from normal operation would be minimal (see Sect. 4.2.4). Hydrogen sulfide abatement and efficient drift eliminators on the cooling should reduce emissions well below levels that will affect biota.

11.1.2.5 Seismic and geologic-related impacts

No mitigation measures for induced seismicity or land subsidence resulting from plant operations have been proposed by the applicant. Suggested mitigations would be: cessation of forced reinjection if it was determined to induce seismicity and decreased rates of fluid withdrawal to slow induced subsidence.

11.1.3 Potential accidents

11.1.3.1 Blowouts

Blowout-prevention equipment will be used on both the exploration and production wells. Cement packing around the casing is intended to contain the fluids in the event of a casing failure; however, if rupture occurs, the well will be recompleted.

11.1.3.2 Pipe rupture

Pipelines can be isolated within a matter of several hours by shutting back production of the appropriate wells. In the meantime, flow will be diverted into a reserve pit. If necessary, the generating plant will be shut down until repairs are made. It is to be expected that downstream users will be notified in case of a spill reaching the Jemez River.

11.1.4 Mitigation for transmission lines

Mitigation of adverse effects from transmission line construction will include adherence to recommended criteria for route planning, tower design, right-of-way clearing and line construction detailed in U.S. Department of Interior and U.S. Department of Agriculture (1970).

Vegetation clearing along the right-of-way will be held to a minimum. Along much of the right-of-way, selective removal and topping of danger trees will be sufficient. Where necessary, structure placement will be accomplished by helicopter to reduce disturbance. Long spans will be utilized at stream crossings to prevent disturbances to streambanks and riparian vegetation.

To mitigate soil-related impacts, a detailed engineering and soil stability survey will be conducted along the right-of-way to identify soils that would be unsuitable for construction. These soils will be avoided in transmission line construction. Erosion control methods outlined in the U.S. Department of Agriculture and U.S. Department of the Interior (1970) criteria will also be used for mitigating adverse soil-related impacts. All areas disturbed during construction will be reseeded immediately following line construction to minimize erosion and effects on vegetation.

Mitigation of effects on rare and endangered species will be the same as those described for the well field and plant site (Sect. 11.1.1.4). Mitigation of effects on elk from line construction will be achieved by avoidance of important elk use areas. If the line is placed near elk calving areas, construction will not occur during the calving season.

Visual impacts will be minimized by final placement of right-of-way to reduce visibility from public use areas. Long spans will be utilized at road crossings to reduce structure visibility. A screen of vegetation will be maintained between the line and roads and public use areas.

The corridor will be surveyed for archaeologic resources prior to final line placement. All identified archaeologic sites will be avoided if possible. Mitigation of effects on archaeologic resources is described in more detail in the mitigation plan submitted to the State Historic Preservation Officer.

11.2 MONITORING

Environmental monitoring studies have been conducted at the project site to establish a baseline for comparison of project impacts and to provide data for the environmental analyses contained in this document. The preoperational ecological studies and air quality and hydrologic monitoring are described below. Additionally, studies of land use, socioeconomics, and a predictive study of archaeological resources were accomplished. These studies and results are discussed in detail in Sect. 3 of this document. Also, LASL is conducting a generic assessment of the environmental readiness of the liquid-dominated, hydrothermal technology for the Office for Environment in DOE. This effort focuses on the Baca demonstration project as the prototype facility.

A detailed plan for environmental monitoring during plant construction and operation to measure impacts associated with the proposed project is in preparation by the commercial partners. Much of the plan is yet to be formulated for approval by DOE. Therefore, it is not possible to discuss the entire monitoring program in detail. The following is a brief summary of the proposed surface-water, ecological, and air quality operational monitoring.

11.3 PREOPERATIONAL MONITORING

11.3.1 Ecological

11.3.1.1 Terrestrial

Monitoring of the terrestrial biological systems consisted of five baseline studies of the region surrounding the proposed project area conducted between 1974 and 1978. The studies included vegetational surveys, sampling of small mammal populations by live-trapping methods, bird transect surveys, elk pellet group transect counts, and general observation of sign and scat for larger mammals. A detailed survey of rare and endangered species was conducted for the region surrounding Redondo Canyon; the study included detailed searches for Jemez Mountains salamander habitat. Also, a winter survey of large mammal populations and movements was conducted for the region surrounding Redondo Canyon. Results of all these studies are summarized in the present document and are elsewhere reported in detail (Public Service Company of New Mexico 1978; Whitford 1974; Whitford Ecological Consultants 1975a, 1975b, 1975c).

11.3.1.2 Aquatic

Preoperational monitoring of aquatic biota of Redondo Creek, Sulfur Creek, and the San Antonio River was conducted during July and August of 1978 by Whitford Ecological Consultants, Las Cruces, New Mexico. Monitoring consisted of (1) a physical description of Redondo, Sulfur, and San Antonio creeks, (2) sampling and taxonomic description of the algal community at 18 stations in Redondo and Sulfur creeks, and (3) sampling (using a Surber sampler) and qualitative description of the macroinvertebrate benthic community at 25 stations in Redondo, Sulfur, and San Antonio creeks.

11.3.2 Hydrologic

Discharges of Redondo Creek, Sulfur Creek, San Antonio Creek, and the East Fork of the Jemez River were monitored from November 1975 through October 1976 (1 year) by Water Resources Associates, Scottsdale, Arizona. However, the hydrologic data collected were broken and of poor quality. Surface-water samples were collected from Redondo Creek and other streams and springs in the vicinity of the site from 1974 through 1976 and analyzed for a number of water quality parameters (see Table 3.3). In September 1974 samples were collected at three stations at Redondo Creek. During the October 1975 and 1976 sampling periods, however, sampling was limited to one station on Redondo Creek (Station BC-8). A limited number of water quality parameters (temperature, pH, hardness, alkalinity, dissolved oxygen, and transmittance) were measured in situ at 19 stations in Redondo, Sulfur, and San Antonio creeks in an aquatic ecology survey conducted in the summer of 1978 by Whitford Ecological Consultants.

A preoperational groundwater monitoring program will be administered by the commercial partners. This program will be directed toward establishing regional baseline groundwater quality, water levels, and movement. The monitoring program is currently in effect and will continue subsequent to baseline data collection (see Sect. 11.2.2.2). Sample localities are the springs and wells to the west and south of the project site, with additional sites on the Baca Ranch lands. As proposed, three data collections will be made per calendar year, with emphasis on spring and fall seasons.

Discharge measurements and sampling for water quality analyses will be made at the following springs:

- McCauley Hot Springs
- San Antonio Hot Springs (two sites)
- Soda Dam (two sites)
- Spence Spring
- Sulfur Springs
- San Antonio Warm Springs
- Jemez Springs (one site)

The following wells will be sampled for water quality, and water-level measurements will be made:

- Three Hofheims Wells (at La Cueva)
- Forest Service Well (at Horseshoe Springs)
- LASL Test Wells A, B, C, and D
- Baca Ranch Wells
- Two USGS Wells (near Battleship Rock)

11.3.3 Atmospheric monitoring

The monitoring of the atmospheric environment in the vicinity of the project site involved both air quality monitoring and meteorological data collection.

Air quality monitoring consisted of sampling at 50 stations in the general area for hydrogen sulfide concentrations over a 50-day period. In the area of the geothermal wells themselves, H_2S concentrations were monitored at 24 loci over a period of 11 months. The "Colortec" detector marketed by Metronics Associates Inc. was used for the measurements. Suspended particulate measurements have been obtained at the site using a high-volume air sampler.

Meteorological data — wind speed and direction 8 ft above terrain level — were collected at four locations; temperature, humidity and precipitation measurements were taken at the project office. The four sites where wind observations were obtained are: one at the proposed plant site, two in a saddle at the head of the canyon (Redondo Creek), and one at the flat location below the mouth of the canyon. Wind observations were also made at this fourth location as a function of height using weather balloons, some of which carried radiosonde transmitters to collect temperature data also.

11.4 OPERATIONAL MONITORING

11.4.1 Ecological

11.4.1.1 Terrestrial

Proposed operational monitoring will consist of a continuation of many of the preoperational baseline studies of flora and fauna as outlined below and will extend over the five year period of DOE involvement with the project.

Avian Monitoring Program. Roadside census will be conducted seasonally along all established roads in the well field-plant site area for four consecutive days. Along with these roadside censuses, plot censuses would be conducted in the three habitat types (mixed conifer, wet meadow, and xeric-south-facing slopes) occurring in the plant site-well field area. One habitat type will be censused each day for the three consecutive days of seasonal monitoring.

Mammalian Monitoring Program. Small-mammal live trapping will be conducted seasonally in each of the three habitat types in the well field-plant site area for four consecutive days. These three habitats will be censused utilizing a 100- by 100-m grid and utilizing Sherman live traps. Three sets of 50 traps will be used for performing assessments in different areas of the project area.

Elk and deer pellet transect plots will be established throughout the project area. These will be read seasonally to determine the population size of the elk herds in the project area. Major elk migration trails and wintering areas will be determined and monitored for use.

Faunal Reconnaissance Program. Two days will be spent traversing the project area searching for signs of larger animals, such as bear and cougar. These reconnaissance sessions will also turn up species not encountered during censusing sessions. A search for reptiles and amphibian occurrence in the project area will also be a part of the outing.

Jemez Mountains Salamander Monitoring Program. During optimum periods (cool wet spring and summer days), two to four days will be spent searching for the salamander to provide more information on its range and general abundance in the project area.

Peregrine Falcon Monitoring Program. In carrying on other portions of the monitoring program, field observers will note any peregrine sightings. If any sightings are made, a determination of the proximity of nests will be made.

Biotic Summary, Monitoring of Floral Components on the Baca Geothermal Project. The program delineated below serves to expand existing information of the floral characteristics of the Baca project area. Realizing that a sizable quantity of information exists (Whitford 1974, Public Service Company of New Mexico 1978), this program essentially supplements baseline data to complete the picture of the floral composition of Redondo Creek Canyon. With this completed baseline picture prior to actual startup of the generation station and with continued monitoring, any modification of the ecosystems in the project area will become evident.

The program outline is as follows:

1. Complete the identification of both taxa and plant associations.
2. Delineate study points (i.e., transects) within the Redondo Canyon study area for future monitoring.
3. Monitor components seasonally for changes in vegetation type and physiological stresses induced in the vegetation.

11.4.1.2 Aquatic

Operational monitoring of aquatic biota will include (1) collection and species identification of aquatic macrophytes at each sampling location, (2) sampling and generic identification of the more abundant periphyton at each site, (3) sampling (by Surber sampler) and qualitative description of macroinvertebrate benthos at each site and identification to family or genus, and (4) qualitative description of the fish community at each station by collection (seining), identification, and enumeration of fishes. In conjunction with monitoring of aquatic biota, stream substrate diversity will be measured by mapping substrates according to size of the exposed surfaces. Five replicate square-foot-areas will be mapped at each sampling site. Neither sampling stations nor sampling frequencies have been defined for the operational program for monitoring aquatic biota.

11.4.2 Hydrologic

During construction and after plant operation has begun, the applicant intends to continue monitoring of surface-water quality and aquatic biota at the site to detect environmental effects. To monitor the effects of construction and operation on surface-water quality, surface waters will be collected at the following seven locations:

BC-2 — Jemez River at Battleship Rock below its confluence with San Antonio Creek.

BC-6 — East Fork of the Jemez in Valle Grande above its confluence with San Antonio Creek.

BC-4 — San Antonio Creek at La Cueva Campground below its confluence with Sulfur Creek.

BC-5 — San Antonio Creek at San Antonio Campground above its confluence with Sulfur Creek.

BC-11 — Sulfur Creek above its confluence with Redondo Creek.

BC-8 — Redondo Creek above its confluence with Sulfur Creek and below the project site.

BC-9 — Headwaters of Redondo Creek above the project site.

These locations were selected to coincide with those included in a previous study of the Baca watershed conducted for Union Geothermal Company of New Mexico in 1974. Water samples from each sampling location will be analyzed for parameters that are considered to have health or environmental significance; however, specific parameters to be determined have not been indicated by the applicant. Sampling frequency, initially once a month, minimum, will be reduced after the initial collection of baseline data is complete. In conjunction with monitoring of aquatic biota (described below), determinations of water velocity and discharge, dissolved oxygen, free carbon dioxide, carbonate and bicarbonate alkalinity, conductivity, water temperature, turbidity, suspended solids, dissolved solids, pH, total nitrogen, and total phosphorus will be conducted.

A continuation of the preoperational groundwater monitoring program (Sect. 11.3.2) will be administered by the commercial partners during plant construction and operation. This program will be instrumental in evaluating the effects on the regional groundwater system of geothermal fluid withdrawal from the Caldera Reservoir. In particular, the monitoring schedule is designed to detect spring and streamflow depletion in the project vicinity and along the Jemez River in San Diego Canyon. The monitoring program is being expanded to include other major streams whose headwaters lie in the Valles Caldera (e.g., Santa Clara Creek). Monitoring will be conducted as described in Sect. 11.3.2 as long as necessary to detect and mitigate any project-related groundwater impacts.

11.4.3 Atmospheric monitoring

A meteorological and air quality monitoring program is planned to go into effect in July 1979. Data will be collected from four stations, two of which will be at fixed locations — the plant site and the Meadow location at the mouth of Redondo Canyon — and two of which will be mobile.

At the plant site, a 200-ft tower will be employed to collect data on wind speed and direction, temperature and relative humidity at three levels, together with solar radiation and precipitation data collected at ground level. Pilot balloons will also be launched and tracked for several weeks each season. The air quality monitoring program at the plant site will employ a Meloy-285 sulfur analyzer for H_2S monitoring and monitors for measuring suspended particulates.

At the Meadow site a bistatic acoustic sounder is to be employed to gather information on winds aloft and atmospheric stratification.

Each of the mobile stations will have a 30-ft tower for wind speed and wind direction observations together with a Meloy-285 sulfur analyzer and a monitor for measuring suspended particulates.

11.5 ENFORCEMENT

Enforcement is defined as the procedure to be used to institute corrective measures to address problems identified by environmental monitoring. Enforcement is the feedback loop that links problem identification to mitigation. The first step is recognizing that a problem exists. Monitoring will identify changes or impacts on the environment; however, the significance of those changes must be assessed before they can be defined as problems. The following significance criteria will be used to determine if a problem exists:

1. Does the magnitude of the change exceed the impact predicted in the EIS?
2. Does the change occur in an area where no impact had been predicted in the EIS?
3. Does the change occur for a longer duration than predicted in the EIS?

If a problem is found to exist, its impact and significance will be assessed and mitigation measures or corrective actions identified and implemented as required by applicable Federal, state, and local regulations.

REFERENCES FOR SECTION 11

Public Service Company of New Mexico. 1978. *Baca Baseline Studies.*

Whitford, W. G. 1974. *The Biota of Redondo Creek Canyon, Sandoval County, NM: with Emphasis on Big-Game Species and Rare and Endangered or Threatened Species*, Southwest Environmental Research and Development Corporation report to Union Oil.

Whitford Ecological Consultants. 1975a. *Winter Activity and Habitat Use by Elk in the Redondo Creek Area with Comments on Activities and Relative Abundance of Other Species*, prepared for Union Oil — Geothermal Division.

Whitford Ecological Consultants. 1975b. *The Biota of the Baca Geothermal Site*, report to Union Oil — Geothermal Division.

Whitford Ecological Consultants. 1975c. *Studies of Rare and/or Endangered Species of the Union-Baca Geothermal Lease and Surrounding Area (with Discussion of Other Species)*, prepared for Union Oil Geothermal Division.

12. DISCUSSION OF COMMENTS RECEIVED CONCERNING THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Comments on the DEIS were received from 19 individuals and organizations prior to the end of the comment period on Sept. 7, 1979. In addition, 28 persons made oral presentations at the public hearing held in Albuquerque on Aug. 30, 1979; and nine persons representing five Indian pueblos made oral statements at a public meeting in Albuquerque on Aug. 16, 1979. The areas of substantive concerns raised in the comment letters and in the public hearing and meeting statements, and which are considered in this final document, include: (1) infringement on religious freedom and desecration of sacred sites, (2) effects of geothermal development beyond the initial 50-MW plant, (3) transmission-line corridor impacts, (4) surface-water and groundwater impacts, (5) air quality degradation, (6) disturbance of historic sites and degradation of natural scenic beauty, (7) socioeconomic and cultural impacts on local communities, and (8) failure of the DEIS to adequately consider alternatives in the areas of technology and land use.

This section summarizes the areas of comment, provides a generic response to each category of comment, and indicates where major modifications to the DEIS have been made.

The hearing board summary and responses are contained in Appendix H; written comments and responses are contained in Appendix I.

12.1 PUBLIC MEETING WITH PUEBLO REPRESENTATIVES

A public meeting was held at the request of the All Indian Pueblo Council in Albuquerque on Aug. 16, 1979. Attendees included representatives from DOE's San Francisco office and its Albuquerque Project Office, and representatives from Union Geothermal Company of New Mexico (Union), Public Service Company of New Mexico (PNM), Oak Ridge National Laboratory, the New Mexico Water Resources Association, the All Indian Pueblo Council, and the Santa Clara, Jemez, Tesuque, Cochiti, and San Filipe Pueblos.

This was an information-exchange meeting. Representatives of DOE, Union, and PNM described the proposed project and presented background information. Statements were also made by nine representatives of the five pueblos, who expressed their opposition to the project. Areas of substantive concern with respect to the project and the DEIS, as expressed in the statements by Pueblo representatives, included:

1. The Indian Pueblos were not consulted early in the preparation phase of the DEIS or before exploration activities were begun.
2. Geothermal development would probably degrade the quality and decrease the available supply of surface water and groundwater in the area.
3. Geothermal development would intrude upon the religious and cultural life of the Indians and would violate the American Indian Religious Freedom Act.
4. No benefits would accrue to the Indians as a result of geothermal development.
5. The DEIS does not address the impacts of full development of geothermal resources in the known geothermal resource area (KGRA) by PNM and Union or by other geothermal developers.

Reference 1 is a complete transcript of the presentations and statements at this meeting.

12.2 PUBLIC HEARING

A public hearing on the DEIS was held on Aug. 30, 1979, at the Shalako Motor Inn in Albuquerque. This hearing was attended by about 125 persons, and oral statements were made by 28 participants. Reference 2 is a transcript of this hearing. Appendix E is a summary by the hearing board of the concerns expressed and the objections made concerning the DEIS during the public hearing. Concerns and substantive issues were classified in the hearing board report as follows:

1. Objections to the Scope and Sufficiency of the DEIS
   - A. Objections were raised that the DEIS is legally insufficient in that it does not adequately consider the effects of full development of the geothermal reservoir.

B. The DEIS was stated to have failed to address sociological and cultural impacts of the project upon the native American Indian population.

2. Objections to Technical Studies
   A. Hydrology data and computational methods were questioned.
   B. Air pollutant emissions and computer codes used to model concentrations were questioned.
   C. Noise impacts of the project closer than the nearest resident were questioned.
   D. Spills, accidents, and vandalism were stated to be inadquately addressed.

3. Objections to Environmental Evaluations
   A. The DEIS was stated to have not evaluated the adequacy of highways and road ways to be used by the construction companies during the projected two-year construction schedule.
   B. Location and type of transmission lines to be built for proposed 50-MW plant and subsequent additions were stated to be inadequately discussed.
   C. The effects on the existing and proposed designation and use of the Baca Location as a natural landmark or as potential public land were stated to be insufficiently treated.
   D. Legal responsibilities for protecting the site from being altered or destroyed as a recreational and scenic area were questioned.
   E. It was requested that alternatives to proposed power-generating plant design in order to save limited water resources in the area be exercised.
   F. Economic feasibility of the project as compared to coal or oil-fired plants was questioned.
   G. Increased activities by other drilling companies in the Jemez Mountains area were cited as potential outgrowths of this project.
   H. Future development beyond the initial 50-MW plant was stated to require more analysis.

I. General frustrations in dealing with the government were expressed by some individuals.

12.3 SUMMARY OF COMMENTS

The substantive concerns raised in the written comments and in the oral statements made in the public meeting and hearing all fall within the following categories: (1) potential infringement on religious freedom and desecration of sacred sites, (2) effects of geothermal development beyond the initial 50-MW plant, (3) transmission-line corridor impacts, (4) surface-water and groundwater impact, (5) air-quality degradation, (6) disturbance of historic sites and degradation of natural scenic beauty, (7) socioeconomic and cultural impacts on local communities, and (8) failure to adequately consider alternative land uses and alternative power plant technology.

The following discussions have been prepared to clarify and summarize the areas of substantive concern that were raised and to indicate the general nature of the modifications that have been made to the DEIS in response thereto.

12.3.1 Infringement on religious freedom and desecration of sacred sites

Many comments written and orally presented at the public meeting and at the public hearing expressed concerns by pueblo residents that the proposed development and, to a much greater extent, the anticipated additional future geothermal development in the area, will result in extensive physical disturbance to sites considered sacred by the Indian communities. In addition, fears were expressed that the proposed construction and plant operations will result in an influx of people into the area that will result in intrusions into sacred areas and will interfere with the Indians' traditional religious activities and ceremonies.

Section 4.1.5.2 has been expanded and Sects. 3.1.10 and 4.1.7 have been added to reflect the potential impacts to sacred sites and to the Indians' use of the area for ceremonial purposes. Reference is also made to the past, current, and planned future consultations, meetings, and information exchanges with the Indian pueblos by DOE and participant project representatives. Also, DOE is continuously consulting with Indian religious leaders in order to minimize the potential for infringement on the religious freedom of native Americans.

12.3.2 Effects of geothermal development beyond the initial 50-MW plant

Many comments were received pointing out the inadequate evaluation and presentation of potential impacts associated with additional future development of geothermal resources in the area. Particularly, mentioned was the possibility that Union and PNM will build up to two additional 50-MW plants in Redondo Canyon if the first plant proves to be economically viable. Also mentioned were statements in the DEIS to the effect that up to 400-MW of generating capacity may be built to use this reservoir.

Section 2.5 has been rewritten to better explain the potential development beyond 50-MW. Section 4.5 has been expanded to provide more explicit estimates, where existing data permit, of the potential impacts of the construction and operation of up to seven additional 50-MW plants in Redondo and Sulphur Creek canyons.

12.3.3 Transmission-line corridor impacts

Several comments expressed concern that the DEIS does not adequately present analyses of impacts and tradeoff studies involving alternative transmission line corridors, particularly possible corridors extending west and south from the proposed Baca Location. It was pointed out that the proposed 115-kV line to the Los Alamos substation will accommodate only two additional 50-MW power plants. Further development would require additional transmission capability.

Section 4.5 has been expanded to include more detailed evaluations of environmental impacts expected for alternative 345-kV transmission lines extending generally north, west, and south from the initial 50-MW plant site.

12.3.4 Surface-water and groundwater impacts

Concerns were expressed that geothermal development, particularly expansion to 400-MW capacity, could seriously impact both the quantity and quality of the surface water and groundwaters in the area and even far downstream from the geothermal well fields. Such concerns were expressed both in terms of the physical well-being of persons living in the area and in terms of infringements on religious freedom. It was pointed out that local spring, stream, and river waters are a key element in Indian religious ceremonies, customs, and daily rituals. Any unnatural alteration of the waters (chemical or thermal alteration or reduction in quantity) is considered debasement of a sacred element of the Indian culture and religion. In addition, concern was expressed that the supply of fresh groundwater for domestic, livestock, and agricultural use might be adversely affected by the proposed project. Also, concerns were raised over the use of arsenic in establishing dilution ratios, rather than a more stable ion such as chloride or boron.

Section 4.5, which addresses effects of future developments beyond 50 MW, has been rewritten to address, to the extent possible, the expected impacts on surface water and groundwater quality and quantity caused by three 50-MW plants in Redondo Creek Canyon and five 50-MW plants in Sulphur Creek Canyon. Also, Sect. 3.1.3.2 and 4.2.2 have been revised to include dilution analyses using more conservative ions (i.e., chloride, bromide, boron, and lithium).

12.3.5 Air quality degradation

Some comments expressed concern for the impacts resulting from pollutants emitted into the air from cooling towers, venting wells, and accidental spills. Particular concern was expressed that the DEIS does not adequately address the significance of air pollutants, particularly hydrogen sulfide, resulting from full (400-MW) field development.

Section 4.5 has been expanded to include discussions of potential impacts to air quality resulting from development beyond the initial

50-MW plant. This future development is considered in two increments: the completion of two additional 50-MW plants in Redondo Creek Canyon, for which the air quality impacts are expected to be simply additive; and a second increment involving five more 50-MW plants built over a period of several years in Sulphur Creek Canyon, Alamo Canyon, San Luis Canyon, Valles Seco, and possibly portions of Valles San Antonio. For this second increment, the cumulative effects on air quality outside the property boundaries are expected to depend on interactions of pollutant streams from the two canyons.

12.3.6 Disturbance of historic sites and degradation of natural scenic beauty

Concerns were expressed that well field development, plant construction and operation, and the construction and extended existence of the power transmission lines would, or could, result in irreversible disturbances of historic and archaeological sites and would degrade the natural scenic beauty of the area.

These concerns were addressed in Sects. 2.2, 2.3, 3.1.6, 3.2, 4.1.5.1, 4.4.1.4, 4.4.1.5, and 4.5. Where appropriate, these sections, particularly Sect. 4.5, have been expanded to address these concerns in further detail.

12.3.7 Socioeconomic and cultural impacts on local communities

Criticisms were repeatedly expressed in public hearing statements and in written comments that the interests of Indians had not been given due consideration in the areas of cultural and economic impacts. In particular, there were complaints that the DEIS does not indicate any significant benefits accruing to the Indians from the proposed development. Indian representatives stated that they believe that few if any jobs resulting from the construction and operation of this plant, and from further future geothermal developments, would be available to Indians. The Indians thus perceive this project as one in which they would suffer the most from the adverse impacts without even partial compensation in the form of economic benefits.

Section 4.1.5 contains an accurate statement of the latter situation. Section 4.5 has been rewritten to present, to the extent possible with available information, estimates of the impacts of future geothermal developments in this area on socioeconomic and cultural aspects of local communities.

12.3.8 <u>Failure to adequately consider alternatives</u>

Some comments were directed toward a perceived deficiency of the DEIS in evaluating alternative uses of the land and resources of the BACA Location. In particular, it was suggested that public ownership of the land as a public park or national forest should be considered as an alternative to geothermal development.

In Sect. 3.1.1 these concerns are addressed in terms of competing land uses rather than as viable alternatives to geothermal development because these other possible land uses do not contribute toward providing alternative energy sources and hence cannot be considered viable alternatives for DOE.

A few comments suggested that alternative plant designs and basic power conversion technology should be considered. These concerns were addressed in Sect. 10.3 of the DEIS, where it was pointed out that current available technology was evaluated before the decision was made to pursue the proposed plant design concept. The decision was based on economic, technology readiness, and environmental considerations.

All comment letters on the DEIS and DOE responses are presented in Appendix H.

REFERENCES FOR SECTION 12

Transcript of Proceedings, Hearing on the Draft Environmental Impact Statement, Geothermal Demonstration Program, Baca Ranch at the All Indian Pueblo Council Cultural Center, Albuquerque, N.M., Aug. 16, 1979.

Transcript of Public Hearing on Draft Environmental Impact Statement, Geothermal Demonstration Program, held at Shalake Motor Inn, Albuquerque, N.M., Aug. 30, 1979.

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This Environmental Impact Statement was prepared by Oak Ridge National Laboratory for the Division of Geothermal Energy of the Department of Energy. ORNL and DOE staff contributing to this report are listed below. Also indicated are their areas of contribution.

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Appendix A

MAPS SHOWING LOCATIONS OF THERMAL SPRINGS IN THE VALLES CALDERA-JEMEZ VALLEY REGION, NEW MEXICO

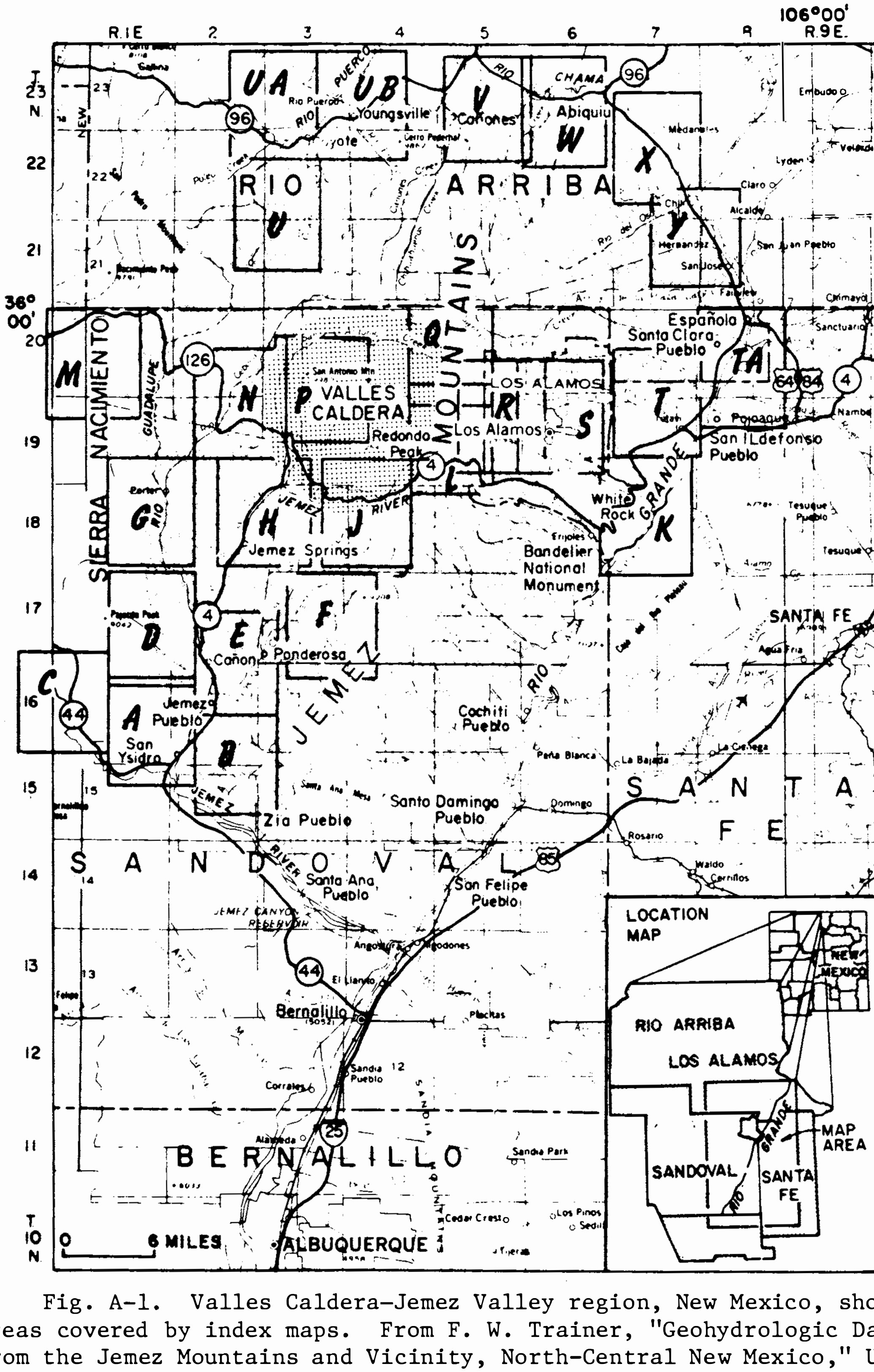


Fig. A-1. Valles Caldera–Jemez Valley region, New Mexico, showing areas covered by index maps. From F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.

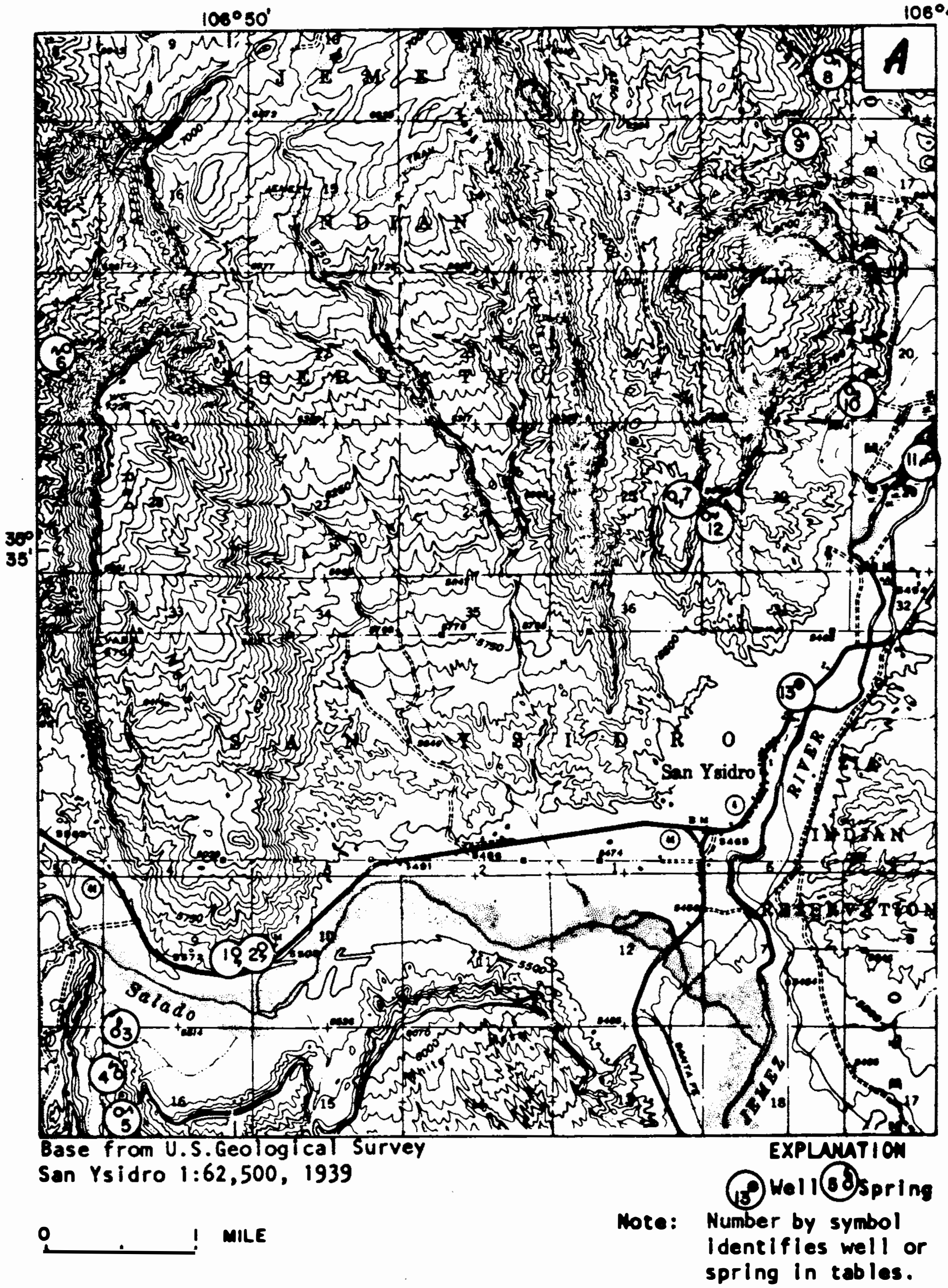


Fig. A-2. Spring location index map A. From F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.

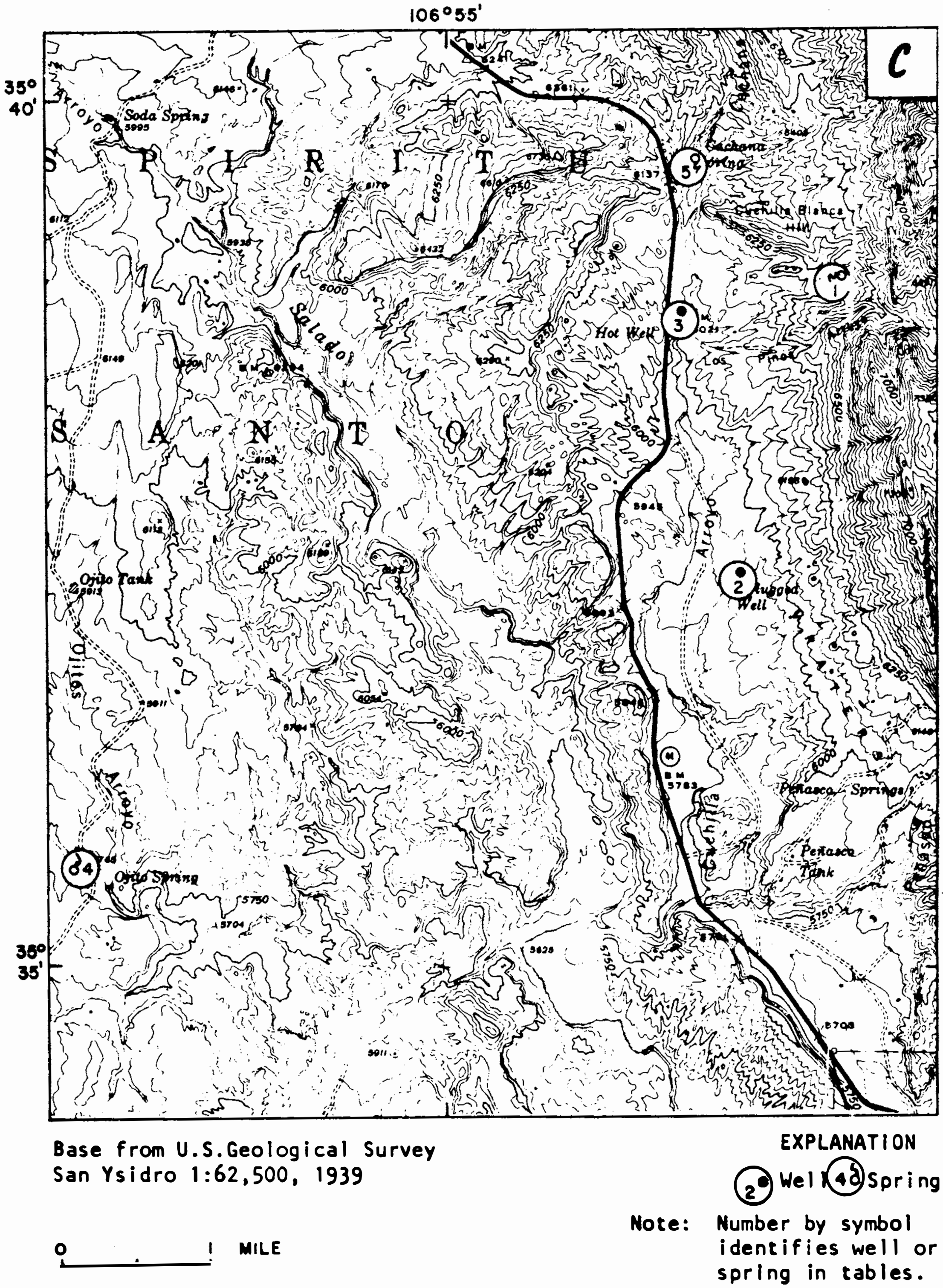
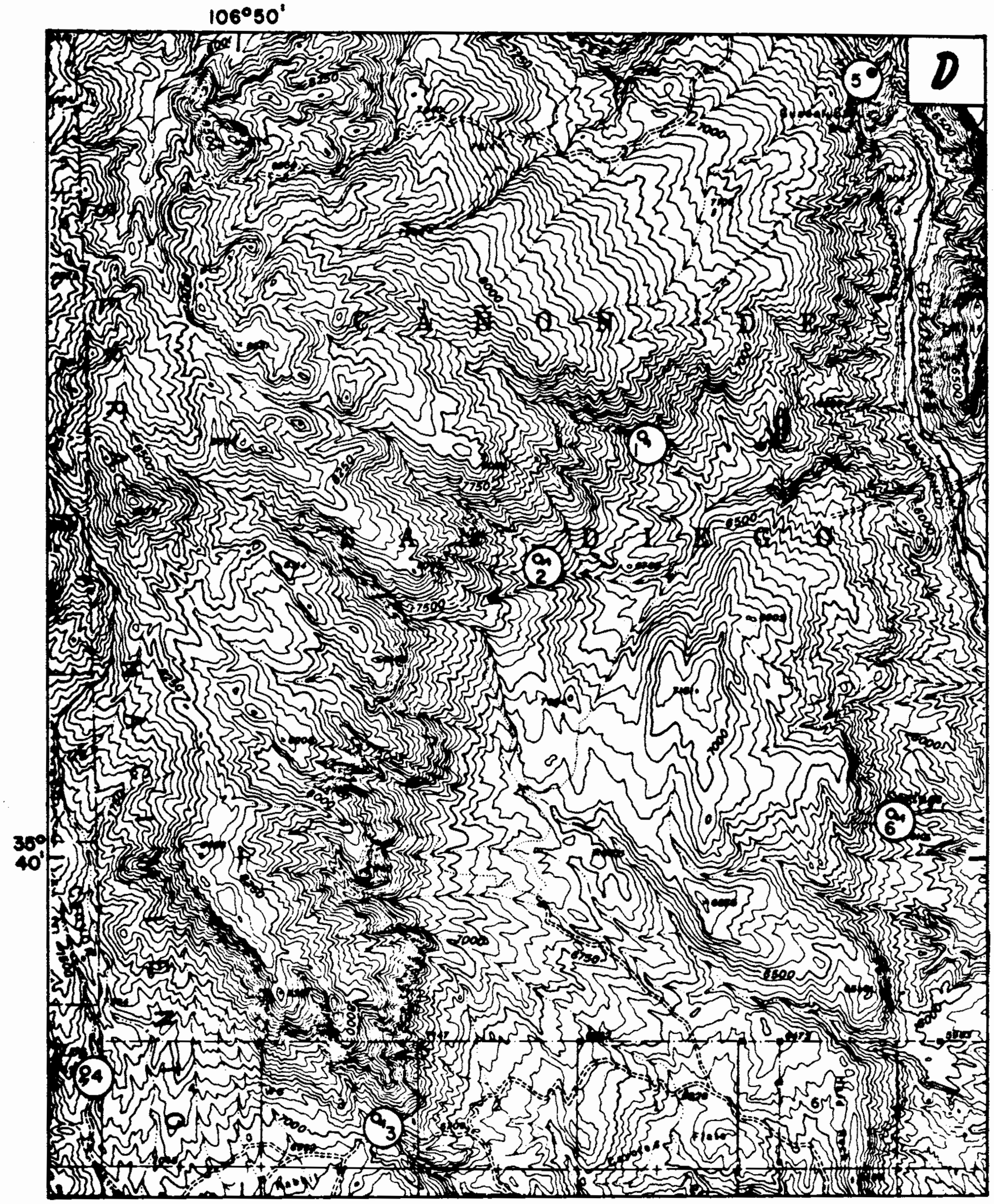


Fig. A-3. Spring location index map C. From F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.



Base from U.S.Geological Survey
San Ysidro 1:62,500, 1939

0 1 MILE

EXPLANATION

(5) Well (3) Spring

Note: Number by symbol identifies well or spring in tables.

Fig. A-4. Spring location index map D. From F. W. Trainer, Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.

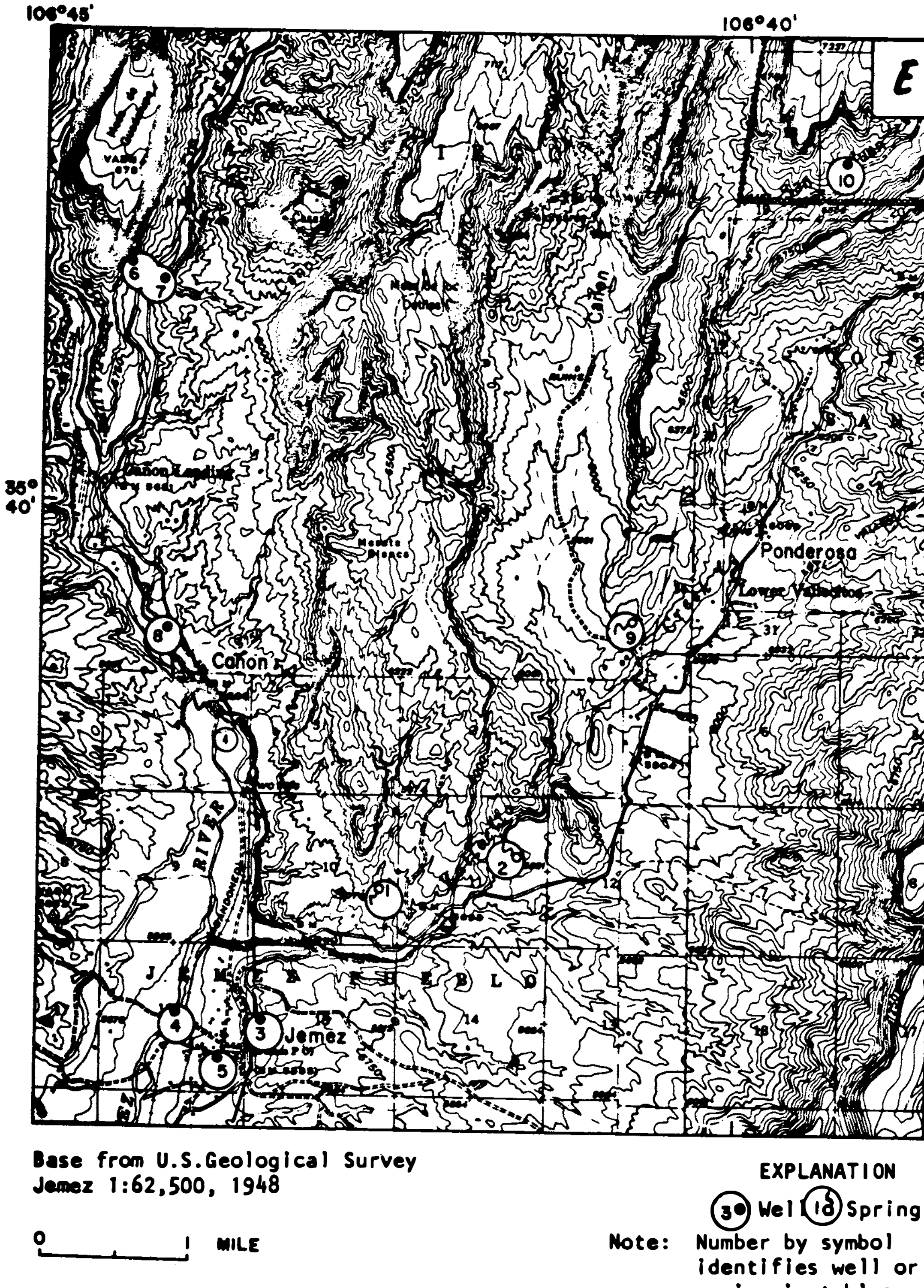


Fig. A-5. Spring location index map E. From F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.

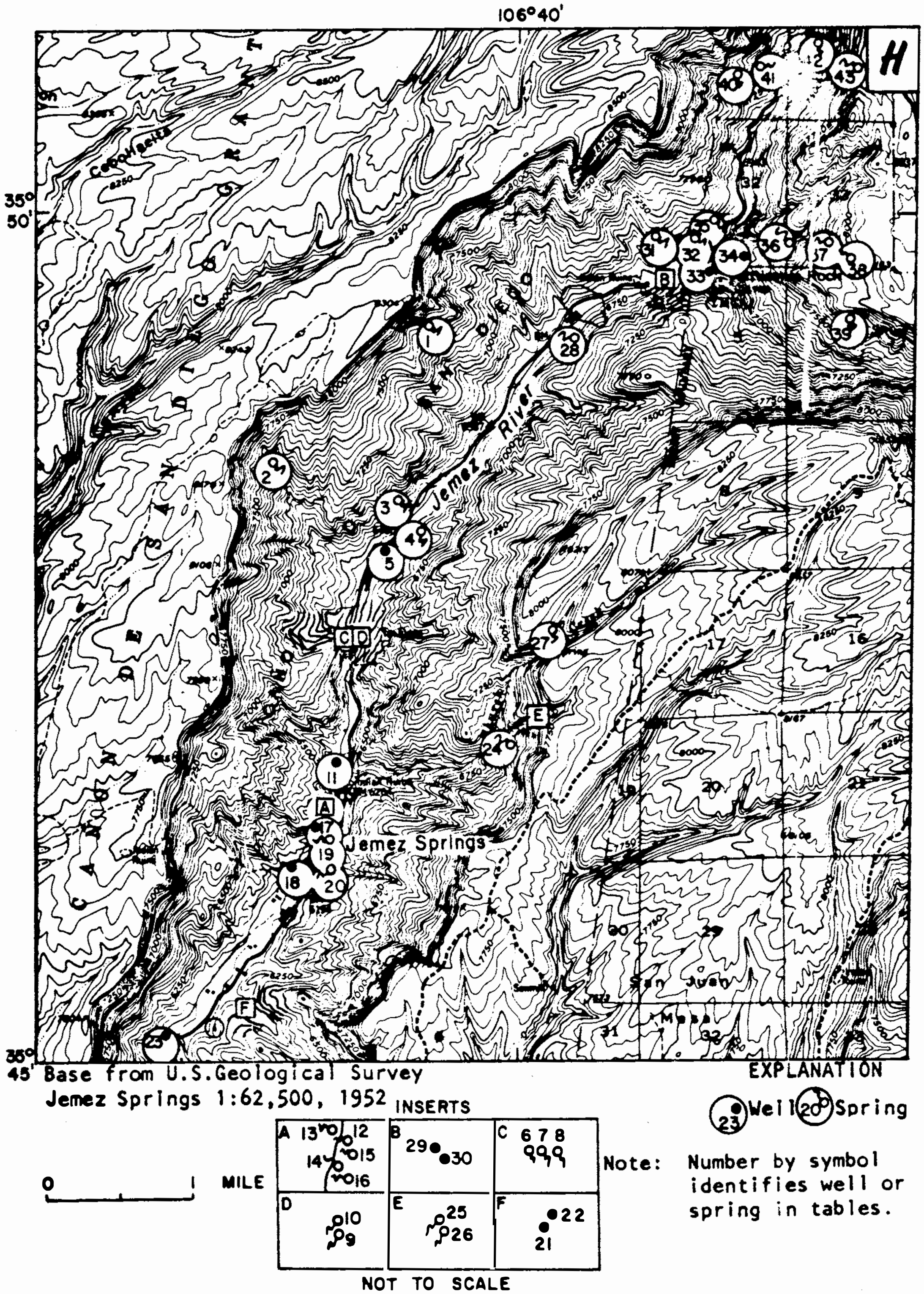


Fig. A-6. Spring location index map H. From F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.

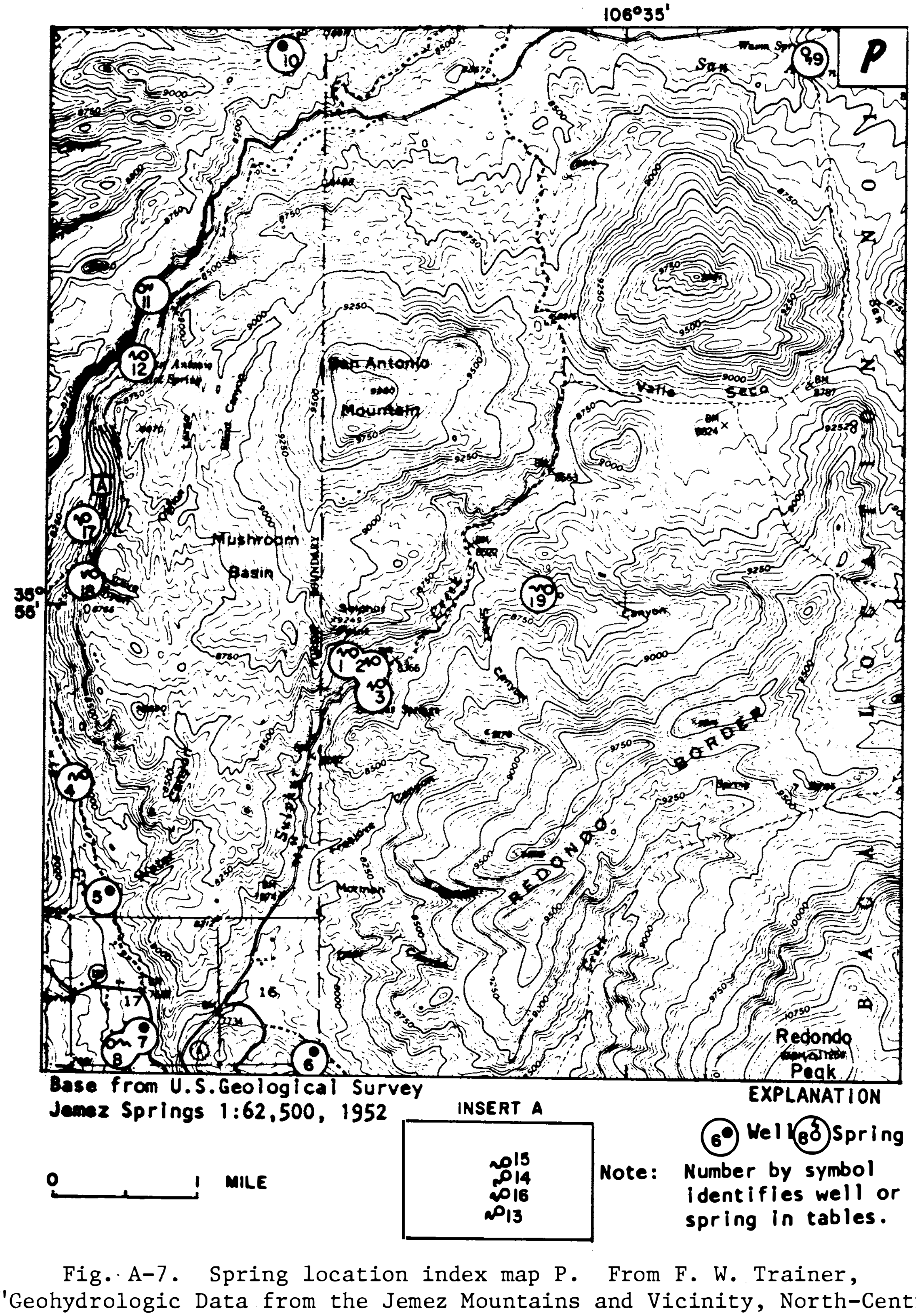


Fig. A-7. Spring location index map P. From F. W. Trainer, "Geohydrologic Data from the Jemez Mountains and Vicinity, North-Central New Mexico," U.S. Geological Survey WRI-77-131, 1978.

Appendix B*

DESCRIPTION OF VEGETATION COMMUNITIES OCCURRING IN THE BACA STUDY REGION

*Source: W. R. Pilz and D. G. Sabo, 1979. *Biotic Inventory, Baseline Information for the Transmission System for the Proposed Baca Geothermal Project,* Public Service Company of New Mexico, Albuquerque.

Appendix B

DESCRIPTION OF VEGETATION COMMUNITIES OCCURRING IN THE BACA STUDY REGION

B-1 SPRUCE-FIR FOREST

This habitat type extends from timberline down to an integradation of mixed-conifer forest at various altitudes within the Rocky Mountains. The dominant species within this habitat are Engelmann spruce (*Picea engelmannii*), Douglas fir (*Pseudotsuga menziesii*), and aspen (*Populus tremuloides*).

The spruces and firs grow very close together under favorable conditions and generally have a very slender growth form. Undergrowth within this forest habitat type is extremely variable, depending on moisture conditions. Within more xeric (dry) forests the undergrowth is scant, usually dominated by false water parsnips (*Pseudocymopterus montanus*) and Louisiana wormwood (*Artemisia ludovicinana*). Under more mesic (moist) conditions the undergrowth consists of rank growth of dicotyledonous herbs. Some of the species found in these areas are sego lily (*Calochortus gunnisonii*), various cinquefoils (*Potentilla hippiana* var. *hippiana* and var. *diffusa, P. pulcherrina*), and many violets (*Viola canadensis*).

Aspens are a common seral species in the spruce-fir habitat and generally are found either in small sporadic groves or as individual trees within the forest. When a fire occurs, the aspen roots, which are protected from all but the heaviest fires, sprout rapidly. Spruce and fir seedlings appear under the canopy of the aspens and eventually crowd them out.

Ecotonal areas near timberlines are well known for their stunted trees. Some writers recognize this zone as a krummholz (literally "crooked wood"). None of the study areas exceeds timberline, but on the tops of the highest peaks around Baca Location No. 1, a type of krummholz occurs.

B-2 MIXED-CONIFER FOREST

This is the most common type of forest association found within Baca Location No. 1. Distinct transitions from the mixed-conifer habitat to pure associations of either spruce-fir or ponderosa pine do not occur.

The dominant species of the mixed-conifer habitat are ponderosa pine (*Pinus ponderosa* var. *scopulorum*), Douglas fir (*Pseudotsuga menziesii* var. *glauca*), and Engelmann spruce (*Picea engelmannii*). Mixed-conifer habitat is generally found in the more xeric areas and on south- and west-facing slopes at high altitudes (above 9,000 ft) in the Baca project study area. Because of this xeric condition, understory vegetation is often composed of scrub oaks (*Quercus gambelii*) and dwarf juniper (*Juniperus communis*), with fescue grasses (*Festuca ovina* and *F. thurberi*).

As in the spruce-fir habitat, a duff layer accumulates on the forest floor. Because of the lesser density of this drier forest, the layer will not be as thick as in the higher forest. In a mixed-conifer forest, it is not uncommon to find Douglas fir stands so dense that very little understory can grow; however, this is not the case in the Baca study area.

Seral species are predominantly aspen, and the invasion may be so strong as to appear to be maintaining a climax population. Specimens a meter in diameter are on record (Anon. 1942).

B-3 PONDEROSA PINE HABITAT

The mixed-conifer forest gradually gives way to a forest dominated by ponderosa pine. The round crowns and open spacing of the older trees are the conspicuous feature that distinguishes this forest from the mixed-conifer forest. The canopies of the trees may cover no more than 25% of the ground (Pearson 1931).

The general sparceness of the shrub cover and litter favor a grass understory. Within the Baca project study area, the understory is dominated by Arizona fescue (*Festuca arizonica*). Usually, other thin-leaved species are found as components of the understory: wild onion (*Allium cernuum* var. *obtusum*) and cinquefoil (*Potentilla hippiana* var. *diffusa*) as well as the grasses mountain muhly (*Muhlenbergia montanus*), little bluestem (*Andropogon scoparius*), and Canada wild rye (*Elynus canadensis*).

Many of the areas of ponderosa pine in this study have been selectively logged. These areas are in various states of recovery indicated by different-sized "dog hair" thickets of young ponderosa. Seral development after either clear cutting or fire usually results in a brush vegetation (*Cercocarpus*, *Ceanothus*, *Quercus*, etc.). At the upper limits of the habitat, aspen may develop after fire.

B-4 PIÑON-JUNIPER SAVANNA

South of Baca Location No. 1, a piñon-juniper association is developed at lower elevations. This lowest subdivision of coniferous vegetation covers mesa tops and drops into valleys.

The dominants in this area are alligator bark juniper (*Juniperus deppeana*), one-seeded juniper (*Juniperus monosperma*), and piñon (*Pinus edulis*). This habitat does not show a strong break from the ponderosa pine habitat above it but rather shows a gradation of less juniper and more ponderosa pine.

Because of the low stature of the trees (10 to 30 ft), this zone is frequently referred to as a woodland. More recently, Daubenmire (1978) has referred to this habitat as a type of savanna. Partially this is because the grass cover in the interstices between the trees, such as bitterweed (*Hymenoxys richardsonii* var. *floribunda*), squirreltail (*Sitanion hystrix*), sand dropseed (*Sporobolus cryptandrus*), and Hungarian brome (*Bromus inermus*). Around Indian ruins, gosseberry (*Ribes cereum*) is found in large numbers.

A large amount of logging is being carried out in this area, probably for firewood. There appears to be no clear successional stage in these logged areas except perhaps invasion by broad-leafed shrubs. No seral development after fires in this woodland is indicated from the literature.

B-5 LOGGED AREAS

Large areas of the forest within the Baca location have been clear-cut. The resultant slash has been left in place, and this heavy detrital layer has somewhat slowed natural successional processes. The slopes most often logged are those with generally north-facing aspects.

Seral development has begun, with many larger broadleaf dicotyledonus shrubs. Many small conifers are already in evidence, probably as a result of their being in place before logging. The common shrubs and forbs present are raspberry (*Rubus strigosus*), bluebells (*Mertensia lanceolata*), snowberry (*Symphoricarpos rotundifolius*), and false Solomon's seal (*Smilacina racemosa*).

A maze of roads has been constructed within the logged areas. The amount of area devoid of vegetation because of these roads actually exceeds 35% of the total area. No apparent seral development is evident on most of these roads because of their occasional use by ranch vehicles. These roads will probably be evident for centuries to come.

B-6 OPEN MEADOWS

Three types of open meadows are encountered in the Baca project study area: wet meadows or seep areas, open valley meadows or *valles*, and high-altitude meadows or forest glades.

B-6.1 Wet meadows

Wet meadows may be found within the riparian habitat (Sect. B-7) or in seep and spring areas. Wet meadows are usually dominated by a sedge, for example, *Carex scoparia, C. nebraskensis,* or *C. siccata.* Usually diversity of other species is high in or around these seeps, and many species may be found in these areas only.

As examples of the diversity, species identified include bluebells (*Campanula parryi*), violets (*Viola canadensis*), Sego lily (*Calochortus gunnisonii*), Indian paint brush (*Castilleja lineata*), and others.

B-6.2 Open valley meadows, valles

Open valley meadows are drier and therefore contain fewer species than wet meadows. Open valley meadows are grazed by cattle, and this also could limit the numbers of species found. Common species in these meadows are Thurber fescue (*Festuca thurberi*), cinquefoil (*Potentilla hippiana* var. *hippiana*), and daisy fleabane (*Erigeron superbus*).

B-6.3 High-altitude meadows

High-altitude meadows are generally very exposed and show little similarity to other types of meadows. The dominant vegetation on these areas consists of fleabane (*Erigeron formosissimus*), oat grass (*Danthonia intermedia*), sheep fescue (*Festuca ovina*), ninebark (*Physocarpus monogynus*), and rock spirea (*Holodiscus dumosus*).

B-7 RIPARIAN OR STREAMSIDE VEGETATION

The vegetation found along most of the small streams in the Baca study region is typical of most areas of the southern Rocky Mountains. The dominant trees, if any, are box elder (*Acer negundo*) and alder (*Alnus tenuifolia*). The grasses and forbs are the same as in seeps and wet meadows. Often found as understory beneath the small trees are buttercups (*Ranunculus inamoenus*) and bog violets (*Viola nephrophylla*).

B-8 TALUS SLOPES

Steep slopes in portions of the study region consist of rock rubble, or talus. These talus slopes, often unstable, are subjected to frost action and weathering. They are devoid of vegetation except for mosses and lichens on the rocks and a few individual deep-rooted shrubs such as cunant (*Ribes* sp.) and rock spirea (*Holodiscus* sp.).

REFERENCES FOR APPENDIX B

Anonymous, 1942, "Big Trees, The Giant Aspen of Utah," *Am. For.* 48: 148.

Pearson, E. A. 1931. *Forest Types in the Southwest as Determined by Climate and Soil,* USDA Tech. Bull. 247, pp. 1-143.

Public Service Co. of New Mexico. 1978. *Baca Baseline Studies,* Albequerque, New Mexico.

Appendix C

PRIME AND UNIQUE FARMLAND CORRESPONDENCE

United States Department of Agriculture

Soil Conservation Service

Box 2007
Albuquerque, NM
87103

December 1, 1978

Ms. Kathleen M. Oakes
Research Associate
Environmental Sciences Division
Oak Ridge National Laboratory
P.O. Box X, Bldg. 1505
Oak Ridge, TN 37830

Dear Ms. Oakes:

The Soil Conservation Service has not recognized any land within the area covered by quadrangle maps (1) Valle San Antonio, (2) Valle Toledo, (3) Guaje Mountain, (4) Redondo Peak, (5) Bland, (6) Frijoles, (7) Bear Springs, and (8) Canada, as prime or unique farmland.

The nearest prime farmland to the above quadrangle maps is along the Rio Grande River from Espanola to the village of Pajarito. Additional prime farmland occurs down-river from Cochiti Dam.

Sincerely,

for

A. W. Hamelstrom
State Conservationist

Appendix D

THE FOREST SERVICE VISUAL MANAGEMENT SYSTEM

Appendix D: THE FOREST SERVICE VISUAL MANAGEMENT SYSTEM

The Forest Service Visual Management (U.S. Forest Service, 1974) system employs a dual rating system to characterize visual resources within a study region. Areas of the study region are categorized with respect to the scenic quality of the visual resources and the sensitivities of the people viewing the areas. The combination of what is physically present and who sees it results in one of five visual quality management objectives being assigned to an area; the quality objectives indicate the degree of acceptable alteration to the area in question.

To classify scenic quality, areas are assigned to one of three variety classes, based on comparisons with other areas within the same physiographic province. These variety classes are:

Class A — distinctive: those areas where landscape elements such as landform and vegetative pattern are of unusual or outstanding visual quality when compared to the general character of the physiographic area being inventoried. These landscapes are not common and are, therefore, distinctive.

Class B — common: those areas where landscape elements contain variety in form, line, color, and texture but are common throughout the surrounding area. Additionally, the variety of the landscape is not as great as in class A.

Class C — minimal: those areas where features have little change in form, line, color, or texture. This includes all areas not found under class A or B.

Travel routes and use areas within the region are classified as primary or secondary, depending upon frequency of use. Next, areas within the study region seen from the travel routes and use areas are classified according to the sensitivity level of people using them as described in the Sensitivity Levels Table below (Table D-1). Areas which can be seen are mapped as foreground (fg), middle ground (mg), and background (bg) for sensitivity levels 1 and 2. A third sensitivity level is assigned to low-level sensitivity areas or unseen areas.

Table D.1. Sensitivity level criteria for travel routes and use areas

Use	Sensitivity level 1	Sensitivity level 2	Sensitivity level 3
Primary travel route, use area, or water body	At least 1/4 of users have major concern for scenic qualities	Fewer than 1/4 of users have major concern for scenic qualities	
Secondary travel route, use area, or water body	At least 3/4 of users have major concern for scenic qualities	At least 1/4 and not more than 3/4 of users have major concern for scenic qualities	Fewer than 1/4 of users have major concern for scenic qualities

Source: Forest Service Visual Management System (1974).

Finally, one of five visual quality management objectives is assigned for each area based on the matrix of variety classes and sensitivity levels depicted in Table D-2. The five management objectives are described as:

Preservation — allows natural ecological changes only. Generally applied to wilderness, primitive areas or other specially classified areas.

Table D.2. Visual quality objective matrix[a]

Variety class	Sensitivity level[b] fg1	mg1	bg1	fg2	mg2	bg2	3
Class A: Distinctive	R	R	R	PR	PR	PR	PR
Class B: Common	R	PR	PR	PR	M	M	M[c] / MM
Class C: Minimal	PR	PR	M	M	M	MM	MM

[a]Visual quality management objectives: P, preservation; R, retention; PR, partial retention; M, modification; MM, maximum modification.

[b]fg, foreground; mg, middle ground; bg, background. Sensitivity levels 1–3 are defined in Table D.1.

[c]If a 3B area is adjacent to an R or PR area, select the M objective; if adjacent to M or MM area, select MM.

Retention — provides for management activities which are not usually evident. Activities may only repeat form, line, color, and texture which are frequently found in the characteristic landscape.

Partial Retention — allows activities which remain visually subordinate to the characteristic landscape. Activities may repeat form, line, color, or texture common to the characteristic landscape or they may introduce elements of form, line, color, or texture found infrequently or not at all.

Modification — allows activities which may visuably dominate the original characteristic landscape, but must borrow from natural form, line, color, or texture.

Maximum Modification — permits management activities of vegetative and landform alteration which may dominate the characteristic landscape.

REFERENCES FOR APPENDIX D

U.S. Forest Service. 1974. "The Visual Management System, Agriculture Handbook No. 462, *National Forest Landscape Management*. vol. 2, chap. 1, Department of Agriculture, U.S. Government Printing Office, Washington, D.C.

Appendix E

NATIONAL REGISTER OF HISTORIC PLACES — ELEGIBILITY
OF 29 SITES AND 1 LOCALITY AND
DETERMINATION OF NO ADVERSE EFFECT

United States Department of the Interior

HERITAGE CONSERVATION AND RECREATION SERVICE
WASHINGTON, D. C. 20243

IN REPLY REFER TO: 661

AUG 6 1979

Mr. Art C. Wilbur
Project Manager
Geothermal Power Plant Project Office
U. S. Department of Energy
Plaza del Sol Building, Room 712
600 Second Street, N.W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

Thank you for your letter requesting a determination of eligibility for inclusion in the National Register pursuant to Executive Order 11593 or the National Historic Preservation Act of 1966, as amended. Our determination appears on the enclosed material.

As you understand, your request for our professional judgment constitutes a part of the Federal planning process. We urge that this information be integrated into the National Environmental Policy Act analysis in order to bring about the best possible program decisions. This determination does not serve in any manner as a veto to uses of property, with or without Federal participation or assistance. Any decision on the property in question and the responsibility for program planning concerning such properties lie with the agency or block grant recipient after the Advisory Council on Historic Preservation has had an opportunity to comment.

We are pleased to be of assistance in the consideration of historic resources in the planning process.

Sincerely yours,

Charles A Herrington

Charles A. Herrington
Acting Keeper of the National
Register

Enclosure

RECEIVED
AUG 10 1979

E-4

E.O. 11593

DETERMINATION OF ELIGIBILITY NOTIFICATION

National Register of Historic Places
Heritage Conservation and Recreation Service

Name of property: Baca Geothermal Lease Archeological District

Location: **State:** NM

Request submitted by: DOE/Art C. Wilbur

Date received: 4-9-79 **Additional information received:** 4-18-79; 6-16-79

Opinion of the State Historic Preservation Officer:

☒ **Eligible** ☐ **Not Eligible** ☐ **No Response**

Comments: "...I concur that the twenty-nine sites and Locality 3 are likely, as a group, to yield significant scientific information."

The Secretary of the Interior has determined that this property is:

☒ **Eligible** **Applicable criteria:** D ☐ **Not Eligible**

Comments: The district, which corresponds to the project area, and encompasses an entire small valley, is eligible for its potential to yield information important in the understanding of the manner and timing of prehistoric utilization of upland areas in this region.

☐ **Documentation insufficient**
(Please see accompanying sheet explaining additional materials required)

Charles A. Herrington [signature]
Keeper of the National Register

Date: 8-6-79

HCRS 266 2/79

STATE OF NEW MEXICO

DEPARTMENT OF FINANCE AND ADMINISTRATION PLANNING DIVISION

BRUCE KING
GOVERNOR

DAVID W. KING
SECRETARY

ANITA HISENBERG
DIRECTOR

505 DON GASPAR AVENUE
SANTA FE, NEW MEXICO 87503
(505) 827-~~2873~~ 2106
(505) 827-5181

August 14, 1979

Mr. Art C. Wilbur
Project Manager
Geothermal Power Plant Project Office
U. S. Department of Energy
Plaza del Sol Building, Room 712
600 Second Street, N. W.
Albuquerque, New Mexico 87102

Dear Mr. Wilber:

This is to state that I have received a copy of Mr. Charles A. Herrington's August 6, letter to you, in which twenty-nine sites and one locality on the Baca Geothermal lease are identified as being collectively eligible to the National Register of Historic Places as being likely to yield significant scientific information.

I have read the report entitled "Proposal to Union Geothermal Co. for a Program of Archeological Testing", etc. (Office of Contract Archeology, University of New Mexico, June, 1979), and wish to state that in my opinion the significant information derivable from this archeological district may be recovered in the manner proposed in that report.

I therefore recommend that you send the mitigation proposal with this letter to the Advisory Council's Denver Office, attached to a request for Council comment. I will discuss this matter with the Council staff soon and ask for an expeditious review. The Council's comments will specify what further action is necessary.

Thank you for your continuing cooperation.

Sincerely,

Thomas W. Merlan
State Historic Preservation Officer
Historic Preservation Bureau

TWM:lm

RECEIVED
AUG 16 1979

Department of Energy
San Francisco Operations Office
Geothermal Demonstration Power Plant Project Office
Room 712, Plaza del Sol Building
600 Second Street, N.W.
Albuquerque, New Mexico 87102

August 15, 1979

Mr. Louis S. Wall, Deputy Director
Advisory Council on Historic
Preservation
Office of Review and Compliance
P. O. Box 25085
Denver, Colorado 80225

Dear Mr. Wall:

The Project Site for the Geothermal Demonstration Power Plant has been determined by the Heritage Conservation and Recreation Service to be eligible for the National Register of Historic Places (Enclosure 1).

A mitigation plan to prevent loss of significant archeological and historic information has been prepared (Enclosure 2). This letter is to request your comments on the mitigation plan. I would also appreciate your approval to proceed with project activities as areas are cleared in following the mitigation plan.

Also enclosed (Enclosure 3) is a letter from Dr. Thomas W. Merlan, State Historic Preservation Officer of New Mexico, accepting the mitigation plan. To further complete your file on this subject, I have enclosed Dr. Merlan's March 19, 1979, letter to me on this subject (Enclosure 4), and my April 4, 1979 letter to the Keeper of the National Register (Enclosure 5).

I would appreciate your early consideration of this matter.

Sincerely,

Arthur C. Wilbur

Arthur C. Wilbur
Project Manager

Enclosures:
As Stated

cc: Ray Brechbill, DOE/SAN, w/encls.
Bill Manning, DOE/SAN, w/encls.
Al Jelacic, DOE/HQ, w/encls.

United States Department of the Interior

HERITAGE CONSERVATION AND RECREATION SERVICE
WASHINGTON, D. C. 20243

IN REPLY REFER TO: 661

AUG 6 1979

Mr. Art C. Wilbur
Project Manager
Geothermal Power Plant Project Office
U. S. Department of Energy
Plaza del Sol Building, Room 712
600 Second Street, N.W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

Thank you for your letter requesting a determination of eligibility for inclusion in the National Register pursuant to Executive Order 11593 or the National Historic Preservation Act of 1966, as amended. Our determination appears on the enclosed material.

As you understand, your request for our professional judgment constitutes a part of the Federal planning process. We urge that this information be integrated into the National Environmental Policy Act analysis in order to bring about the best possible program decisions. This determination does not serve in any manner as a veto to uses of property, with or without Federal participation or assistance. Any decision on the property in question and the responsibility for program planning concerning such properties lie with the agency or block grant recipient after the Advisory Council on Historic Preservation has had an opportunity to comment.

We are pleased to be of assistance in the consideration of historic resources in the planning process.

Sincerely yours,

Charles A. Herrington

Charles A. Herrington
Acting Keeper of the National
Register

Enclosure

RECEIVED
AUG 10 1979

E.O. 11593

DETERMINATION OF ELIGIBILITY NOTIFICATION

National Register of Historic Places
Heritage Conservation and Recreation Service

Name of property: Baca Geothermal Lease Archeological District

Location: **State:** NM

Request submitted by: DOE/Art C. Wilbur

Date received: 4-9-79 **Additional information received:** 4-18-79;6-16-79

Opinion of the State Historic Preservation Officer:

☒ **Eligible** ☐ **Not Eligible** ☐ **No Response**

Comments: "...I concur that the twenty-nine sites and Locality 3 are likely, as a group, to yield significant scientific information."

The Secretary of the Interior has determined that this property is:

☒ **Eligible** **Applicable criteria:** D ☐ **Not Eligible**

Comments: The district, which corresponds to the project area, and encompasses an entire small valley, is eligible for its potential to yield information important in the understanding of the manner and timing of prehistoric utilization of upland areas in this region.

☐ **Documentation insufficient**
(Please see accompanying sheet explaining additional materials required)

Charles A Herrington
Keeper of the National Register

Date: 8-6-79

Attachment 4

R. O. ENGEBRETSEN
JUN 13 1979
Discuss w/ A.W.

PROPOSAL

To

Union Geothermal Co.

For

A Program of Archeological Testing and Excavation:
The Baca Geothermal Electrical Generating Station

By

University of New Mexico
Office of Contract Archeology
Department of Anthropology
Albuquerque, N.M. 87131

ncipal Investigator

e: Mark E. Harlan

le: Acting Director - Contract Archeology

. Sec. No.: 471-54-8533

artment: Anthropology

Proposal Data:

New or Renewal: New

Amount Requested: $126,039.00

Proposed Starting Date: Indefinite

Proposed Duration: Indefinite

	Submitted by:	Recommended by:	Approved by:
:	Mark E. Harlan	Philip K. Bock	Edmund B. Kasner
ature:	Mark E. Harlan	Philip K. Bock	E. B. Kasner
/Title:	Acting Director Principal Investigator	Department Chairman	Director, Research Services
e:	(505) 277-5853	(505) 277-4524	(505) 277-3746
:	June 4, 1979	6/7/79	JUN 8 1979

I. OBJECTIVES AND PROCEDURES

The Office of Contract Archeology, University of New Mexico, conducted an inventory survey of approximately 1984 acres located on privately owned lands in the Jemez Mountains of north central New Mexico. This acreage comprises a portion of Union Oil Company's Baca Geothermal Lease, an area which is to be impacted as a result of construction required by a pilot geothermal electrical generating station. This is a joint project of the Union Oil Company and the Public Service Company of New Mexico. As reported in Moore et. al. (1978), 29 significant locations manifesting cultural remains were encountered and recorded by the survey. In response to recommendations in the survey report and concurrence by Mr. Thomas Merlan, the State Historic Preservation Officer for New Mexico, the Keeper of the National Register of Historic Places has deemed that these sites jointly constitute a significant historic district (Letter to Art C. Wilbur from William J. Murtach, May 14, 1979).

Given this determination of significance as provided under part 800 of 36 CFR, implementing section 106 of the National Historic Preservation Act of 1966, protection is afforded to these properties. Cultural remains are also defined as nonrenewable environmental resources under the Environmental Policy Act of 1969. However, inasmuch as the nation's need for alternative energy sources constitutes an overriding consideration, land altering activities and commitment of the cultural resources may be allowed, provided that this action is preceded by a scientific study which recovers the information inherent in them. This document constitutes a proposal to conduct such a scientific study which is designed to mitigate the potential adverse effects created by irrevocable commitment of the resources.

The universe of this proposed study is bounded by the culturally significant district which will be impacted by construction of the experimental generating station and related activities.

The specific boundaries of the cultural district are addressed below in the section dealing with research orientation. Within the scope of the project area, the following sites should be considered as subject to potential adverse impacts: OCA:BG:1,2,4,5,6,7,8,9,10,12,14,16,17,18,19, 20,21,22,23,24,25,26,27,28 and 29. The remaining properties (OCA:BG: 3,13 and 11) fall outside the area of land altering activities. The appropriate strategy in the case of these sites is avoidance, which will preserve their information potential for future investigation.

As discussed in detail in section III, the approach of this program is to delineate the extent of the remains and to recover and analyze a controlled sample of the cultural materials they contain. The information gained from this program will then be synthesized into a research monograph for dissemination to the sponsor, federal and state authorities and the public. That monograph will constitute a data record whose existence compensates for the loss of the cultural properties themselves.

The cultural properties on the Baca Geothermal Lease fall into two main categories: (1) prehistoric remains of unknown or poorly defined cultural/temporal affiliation and (2) historic remains. As discussed in detail in sections II and III, these two categories will be investigated by separate programs of study. The approach to the prehistoric remains will be by conventional archeological methods (intensive surface collection, subsurface testing and controlled excavation). The historic remains will be studied through documentary research and interview of local informants. This approach will be taken for two reasons: (1) the character of the historic remains clearly indicates that they will yield only limited information to a conventional archeological approach and (2) the cost of conventional archeological data recovery is much greater than is incurred in the course of documentary research and interviewing.

In designing this project, the following factors have been given primary consideration:

(1) The intent and letter of the governing legislation: this factor has been addressed by designing a project which will maximize the recovery of information pertinent to the cultural properties of the project area. Provision has been made for a synthesis of the information recovered so that the contribution to our understanding of regional history/prehistory can be maximized.

(2) The needs of the project sponsor for a program which allows efficient planning of the overall endeavor: flexibility is maintained so that interim clearances may be granted for the most urgent sections of the project area. Further, every possible consideration has been given to minimizing project costs, while at the same time allowing production of a final report which meets the highest standards of the archeological profession.

II. RESEARCH ORIENTATION

This section of the proposal presents the basic orientation of the research. It must be emphasized that this is not itself a formal research design; rather it presents the basis on which a formal design will be developed when the project is actually implemented. There are two elements to this research orientation: (1) a theoretical set which will determine the questions addressed by the program of investigation and their integration with the broader aims of Southwestern Archeology and (2) a concept of the universe of study and how it should be sampled. Since definition of the universe of study is of prime concern to the Keeper of the National Register of Historic Places and the State Historic Preservation Officer, this aspect will be addressed first.

1. The Study Area

In correspondence to Mr. Art C. Wilbur of the Department of Energy, dated May 14, 1979, the Keeper of the National Register has raised five questions concerning the nature of the culturally significant district on the Baca Lease. These are: (1) What are the boundaries of the District? (2) Do these boundaries reflect a cultural reality? (3) If they reflect arbitrary project boundaries, what would be the approximate boundaries of a larger real district of which this project area is a part? (4) How may the district as defined, be considered a viable unit of study? (5) Do "empty" areas reflect actual site distribution or survey bias? If the latter, what is the expected distributional pattern?

The boundaries of the project area (and, therefore, of the district) are defined by the rim of Redondo Canyon. They extend from the lease boundary at the mouth of the canyon, to the saddle where Redondo Creek shares a common origin with San Louis Creek and Jaramillo Creek. These boundaries were arbitrarily defined, based upon the maximum zone in which impacts are expected.

Since this district is defined on the basis of project requirements, it does not fully reflect a cultural reality. However, the study area does encompass an entire small valley system; and since this area seems to exhibit the range of available habitat zones in the Valle Caldera region, it does form a cohesive unit of study from a geographic perspective.

Determination of the boundaries of a broader cultural district is dependent on the perspective taken. As discussed in the survey report (Moore et. al. 1978), the activities which took place in the vicinity of Redondo Creek seem to reflect only a part of the adaptive systems of each culture which exploited the zone. Viewed in this way, a larger unit would encompass the entire area occupied by the cultural populations which entered Redondo Creek Canyon. Obviously, the boundaries of that zone vary through time. In Archaic times, they may have included the Jemez Mountains and immediately adjacent lowlands. In Pueblo times, the boundaries almost certainly extended to include the prehistoric population of Bandelier National Monument in the initial phases and probably later included the historic population of Jemez Pueblo as well. It is also likely that the peoples who formerly occupied Jemez State Monument exploited the region, including Redondo Canyon. Thus, at some point in its occupational span, the project area probably participated in developments over a broad region of north central New Mexico.

Although the study area represents only part of a regional adaptive system, it may still be viewed as a viable unit for investigation. The questions which may be addressed are detailed below. In sum, study of the Baca Geothermal Lease area will enable us to ask questions concerning the manner in which the prehistoric population of the region utilized the highland areas which they appear to have occupied only intermittently.

The last of the questions raised by the Keeper of the Register is the most difficult to address. On the one hand, it is clear that the cultural materials do not manifest a continuous distribution over the survey area. On the other hand, it is quite likely that a number of the manifestations may be more extensive than the surface materials indicate.

A degree of bias is likely to exist, based upon the fact that the areas where surface remains were encountered had largely been impacted by the road construction connected with earlier logging activities. It is, however, felt that if the known areas of remains are sampled and if areas immediately adjacent to them are tested, adequate data recovery will result. This approach is discussed in greater detail below.

2. A Research Perspective

The questions which any investigator poses with regard to a given body of archeological data are determined by a specific view of which information is most important. That determination is in turn colored by his theoretical assumptions about the nature of cultural systems. The basic orientation of the Office of Contract Archeology is toward cultural ecology, rather than culture history. From this perspective, one views cultures as adaptive systems which articulate their participants with the natural environment. Culture change is then seen as a shift in adaptation.

Areas of investigation are not determined solely by the investigator's theoretical orientation; they must also be tailored to the data which are likely to be recovered. In the case at hand, there is little possibility that a study of the Baca Lease will yield data pertinent to entire adaptive systems. It is far more likely that only a specific segment of the prehistoric subsistence systems were ever engaged when populations visited the Lease area. That segment must have been tailored to the resources available above 9000 feet.

Given these considerations, the following questions are suggested for investigation:

(1) What is the range of available biotic and nonbiotic resources in the study area?

(2) What segment of the available range was actually exploited and did this change through time?

(3) Is there marked seasonality in the availability of the resources chosen for exploitation?

(4) What techniques were utilized in gaining access to the resources chosen for exploitation?

(5) What is the likely articulation between the segment of the subsistence system manifest in the study area and the overall subsistence systems of the participating cultures?

Speculation on the answers to these questions is possible and will be briefly outlined. This should not, however, be regarded as the only, or even the most likely outcome of the proposed research.

First, the results of the survey (Moore et. al. 1978) indicate that biotic resources, rather than lithic raw materials, were the most likely objective of the populations which visited the project area. Secondly, it would seem that the bulk of the activities took place in late summer.

If these preliminary conclusions hold, then the function of exploitation of resources in the study area was to provide [supplementary?] subsistence at one particular point in the annual cycle. However, the precise supplement sought may have varied through time. It seems likely that Archaic populations visited the lease at times when dessication had limited the availability of food at lower elevations. Since semi-arid environments (at lower elevations) are notable in the extent of natural vegetable storage during dry periods, it is possible that Archaic populations sought aggregations of larger game at higher elevations. If this is the case, it may be postulated that their occupations were oriented toward the exploitation of both plants and animals. Since the onset of dry conditions varies a good deal from year to year, similar variations may be expected in the seasonality of Archaic occupations. These sites should also be placed to give access to highly productive vegetative zones. Given the known practices of hunting and gathering groups, the availability of game in the immediate vicinity of base camps should be a minor consideration in site placement, since game is normally taken by groups of males who conduct their hunting expeditions out from the base.

The introduction of agriculture in surrounding areas of lower elevation should have resulted in a changed emphasis for utilization of the study area. Although plant materials may still have been an objective, particularly in years when crops failed, game animals should have taken on an increased importance. It may be that sites occupied in Puebloan times are actually the base camps of hunting parties. This should be reflected in both the placement of sites and in their artifact content.

If the questions suggested here can be answered, the information gained will have import in the interpretation of regional systems. If a fine-grained chronology can be developed (by the techniques discussed below), it may be possible to monitor the development of increased dependence on agriculture in surrounding regions. It may also be possible to postulate cycles of subsistence stress, both for agricultural and preagricultural groups. If this can be done, it will greatly improve our understanding of developmental cycles over a broad region of north central New Mexico. The procedures which may yield these results are discussed in the next section.

UNIVERSITY OF NEW MEXICO
OFFICE OF CONTRACT ARCHEOLOGY

Estimated Budget

for

Archeological Excavation and Testing: A Program of Mitigation for the Baca Geothermal Project

to

Baca Geothermal Corporation

I. SALARIES AND WAGES

Administrative

A.	Principal Investigator salary @ $1,625.00/month for 8.14 months X 1/4 time	$ 3,307.00
B.	Project Director (Archeologist III) salary @ $1,370.58/month for 8.14 months	11,157.00
C.	Clerical Specialist V salary @ $750.00/month for 8.14 months X 1/3 time	2,035.00
D.	Bookkeeper salary @ $5.00/hour for 100 hours	500.00

Field Investigations

E.	Field Director (Archeologist II) salary @ $1,184.31/month for 3.69 months	4,370.00
F.	Crew Members (Assistant Archeologist) salary @ $880.96/month for 3.69 months X 4 positions	13,003.00
		$ 34,372.00

Laboratory Analysis

G.	Laboratory Supervisor (same as E) salary @ $1,184.31/month for 2.46 months	$ 2,913.00
H.	Laboratory Technicians (same as F) salary @ $880.96/month for 2.46 months X 4 positions	8,669.00
I.	Draftsman salary @ $7.50/hour for 250 hours	1,875.00
J.	Research Archeologist salary @ $6.00/hour for 176 hours	1,056.00
K.	Ethnologist salary @ $80.00/day for 81 days	6,480.00
		$ 20,993.00
	Subtotal—Salaries and Wages	$ 55,365.00
	Subtotal—Employee Fringe Benefits @ 19%	$ 10,519.00

Estimated Budget
Page 2

II.	TRAVEL AND PER DIEM		
	A.	Field Crew Per Diem @ $32.00/day for 81 days X 5 personnel	$ 12,960.00
	B.	Administrative Per Diem @ $32.00/day for 60 days	1,920.00
	C.	Vehicle Costs	
		1. Rental of one pick-up truck @ $350.00/month for 4 months (includes pick-up time)	1,400.00
		2. Mileage @ 15¢/mile for 8000 miles	1,200.00
		3. Gasoline @ 84¢/gallon X 800 gallons	672.00
		Subtotal--Travel and Per Diem	$ 18,152.00
III.	MATERIALS AND SERVICES		
	A.	Expendable Field Supplies @ $25.00/day for 81 days	$ 2,025.00
	B.	Laboratory Supplies @ $10.00/day for 54 days	540.00
	C.	Office Supplies @ $5.00/day for 180 days	900.00
	D.	Field and Laboratory nonexpendable Equipment	200.00
	E.	Computer Services	500.00
	F.	Reproduction	1,500.00
	G.	Samples	
		Pollen @ $40.00/each X 15 samples	600.00
		Obsidian Hydration @ $10.00/each X 150 samples	1,500.00
		Flotation @ $6.00/each X 30 samples	180.00
	H.	Consultants	
		Historian @ $100.00/day for 5 days	500.00
		Ecologist @ $100.00/day for 5 days	500.00
		Technical Editor @ $75.00/day for 20 days	1,500.00
		Subtotal--Materials and Services	$ 10,445.00
IV.	INDIRECT COSTS		
	At 57% of Salaries and Wages = $55,365.00 X 57%		$ 31,558.00
		TOTAL COST	$ 126,039.00

III. METHODS AND PROCEDURES

1. Sampling of the Prehistoric Components

The first point to address in the development of a sampling design is the delineation of the universe for study. The usual definition is the total of known sites in the area of proposed impacts. In the case of the Baca Geothermal Lease, it seems that this is not the appropriate base, since site boundaries are poorly defined. The approach taken here has been to use areas where cultural remains are known to occur as the boundary of the sampling universe. Table 1 lists the sites which are subject to potential impact, their surface areas and the number of artifacts encountered on the surface. The percentage of the total area and of the total number of artifacts is also listed for each site.

On the basis of the information in Table 1, the sites may be divided into three groups. The first group is formed by sites OCA:BG:7, 17 and 22. Sites 7 and 17 together account for approximately 89% of the total site area. Site 22 is included in the group because, although it is much smaller in area, it accounts for approximately 20% of the surface artifacts encountered by the survey crew. The second group is formed by sites OCA: BG:12, 19 and 21. These are smaller sites but account for a disproportionate share of the total surface artifacts. The third group consists of all the remaining sites. The design proposed here calls for sampling each of the groups as a separate universe. This is done to increase the accuracy of representation and not allow the larger sites or those with the densest artifact scatters to swamp the remainder.

TABLE 1

ARCHEOLOGICAL SITES

Site No.	Area	% Area	Artifacts	% Artifacts
1	0.75	.0008	5	.2092
2	480.00	.5238	53	2.2175
4	840.00	.9167	48	2.0084
5	1,050.00	1.1458	7	.2929
6	187.00	.2041	12	.5021
7	60,000.00	65.4766	1000	41.8410
8	140.00	.1528	21	.8787
9	240.00	.2619	8	.3347
12	780.00	.8512	108	4.5188
14	96.00	.1048	22	.9205
15	108.00	.1179	8	.3347
16	210.00	.2292	20	.8369
17	21,875.00	23.8717	300	12.5523
18	36.00	.0393	7	.2929
19	2,304.00	2.5143	118	4.9372
20	225.00	.2455	19	.7950
21	414.00	.4518	106	4.4351
22	2,240.00	2.4445	500	20.9205
23	200.00	.2183	12	.5021

TABLE 2

DERIVATION OF SAMPLE

1.960t d= .10 v= .0026

pq= .25

no.= 96.04

Group 1

$$\frac{96.04}{1+((95)/84,115)}$$ 95.89 96 Meter squares

Group 2

$$\frac{96.04}{1+(95/3,498)}$$ 93.50 94 Meter squares

Group 3

$$\frac{96.04}{1+(95/258)}$$ 70.019 70 Meter squares

The sampling fraction for each group of sites was derived using Cochran's (1977) method. A sampling unit is defined as one square meter of surface area. The confidence limits for the sample were set to 0.05% and the error of the estimate at 0.1. This yields the following sample sizes for the three groups:

1) Group 1
   (Sites OCA:BG:7,17 and 22) 96 meter squares
2) Group 2
   (Sites OCA:BG:12,19 and 21) 94 meter squares
3) Group 3
   (Sites OCA:BG:1,2,4,5,6,8,9,14 and 15) 70 meter squares

The actual number of grids to be excavated at each site is derived from the percentage of each group's surface area which is represented by each site (with appropriate rounding). The actual choice of grids will be random, but with provision that several grids may be placed contiguous to an initial random selection, if structure in the archeological record warrants it.

The selection of grids will be adjusted so that approximately 10% of them fall outside the boundaries of any given site, as defined on the basis of intensive surface collection. The surface collection and controlled excavation will also be supplemented by test holes dug with a soil auger or post hole digger.

2. Analysis of the Prehistoric Materials

The research questions outlined above will require two basic kinds of artifact analysis: (1) a sample of the obsidian flakes will be subjected to hydration analysis for dating purposes and (2) standard typological observations will be made on all materials to determine lithic reduction strategies. At least a statistically valid sample of the utilized materials and all shaped tools will be subjected to an edge wear analysis to determine function.

In order to recover the paleoecological information required, two kinds of soil samples will be taken and subjected to both palynological and macrobotanical analysis. These are: (1) samples from the excavated squares and (2) a controlled profile from a noncultural context. Hopefully, it will be possible to build a sequence from the samples associated with obsidian hydration dates. To this end, an effort will be made to take samples from cultural contexts which have associations with dateable obsidian flakes. It should be clear that the key to answering the questions raised above is in accurate dating of changes in the patterns of plant and animal exploitation and in the frequency or particular patterns of artifact use. The very high percentage of obsidian flakes in the sites holds out considerable promise in this area.

3. Investigation of the Historic Sites

Two sources of information will be exploited in the documentation of historic sites: (1) Local and state government records, as well as other documentary sources will be examined to determine who has had use rights on the Baca Grant. (2) Local residents will be interviewed to build an oral history of the lease and its immediate surroundings. These tasks will be accomplished by the project ethnologist and the consulting historian.

In addition, the archeological field crew will extensively photograph the historic sites. Scale plans of all historic sites will also be prepared, using standard archeological mapping techniques. Special attention will be given to past sheepherding on the Baca Grant.

IV. PROJECT DESIGN

1. General Considerations

The estimates of field time have been derived as follows: (1) Sites have been divided into low, medium and high artifact density. It is estimated that each square meter of sampling on sites with low densities will require one man day, two man days for sites with medium densities and three man days for sites with high densities (460 man days total). Surface collection time, auger hole testing, and mapping time are built into these estimates.

Other activities, such as mapping the historic sites, will be accomplished by supplementing the field crew with the presence of the Project Director and/or the Principal Investigator. This will also allow them to achieve the full familiarity with the remains in the study area which is required for successful project implementation.

2. Project Phases

A. Administrative Gear-up

Duration: 10 days (working) or two work weeks

During this phase, the Project Director and Principal Investigator will identify and provide for the logistical needs of the project. Potential project personnel will be interviewed and the crews hired.

B. Field Investigations

Duration: 3.69 work months

During this phase, the field crew of three persons, under the supervision of the Field Director, will map and surface collect the prehistoric sites and excavate the sample squares. The Project Director and/or Principal Investigator will spend an aggregate total of 60 working days in the study area, assisting the field crew and familiarizing themselves with the cultural manifestations. At the conclusion of this phase, the Project Director will prepare the preliminary field report and the Principal Investigator will submit it, in order to gain an interim clearance for construction and other activities.

C. Laboratory Investigation and Preliminary Report Preparation

Duration: 2.46 work months

During this phase, the materials recovered in the field will be subjected to technical and typological analysis. Statistical and computer techniques will be employed, as appropriate. The Project Director will supervise preparation of sections of the final report which will be written by various project members.

D. Report Finalization

Duration: 1.5 work months (funded)

During this phase, the Project Director and the Principal Investigator will finalize the report draft. The project will conclude with submission of this report to Union Oil, the State Historic Preservation Officer, the Keeper of the National Register of Historic Places and the interested scientific community. The entire project is budgeted for a duration of 8.14 work months; however, an additional 6 months non-funded "period of performance" will be required to produce a report meeting O.C.A.'s customary standards. Thus, O.C.A. agrees to deliver final reports approximately 14 months from the date of initial expenditure of funds. Draft reports will, of course, be provided earlier.

V. COST CONSIDERATIONS

The attached budget has been prepared in accordance with the schedule of salaries and wages established by The University of New Mexico. All project employees will be bonafide professionals. While the estimation of cost on excavation projects is always a difficult matter, due to the fact that subsurface deposition cannot be precisely predicted from surface manifestation, an attempt has been made to indicate the maximum cost under reasonable conditions. No provision has been made for unusual delays due to extended periods of inclement weather or postproposal changes in Union Oil's requirements.

If this proposal is found to be acceptable, work can begin under a letter of intent which references the proposal number and provides a ceiling on expenditures. It is expected that this will be followed by a formal contract within a reasonable period of time. Billings will be based upon actual documented expenditures. The invoices will be sent monthly and will indicate expenditures by major budgetary categories. Documentation will be maintained at The University of New Mexico and held available for audit upon reasonable notice. All fiscal arrangements can be made by contacting Mr. Bill Richards, Contract and Grant Accounting Manager, The University of New Mexico (phone 505/277-4721).

VI. OTHER CONSIDERATIONS

This project is subject to a number of special considerations, especially due to the high elevation of the project area. First, in all cases where a conflict of interest arises between specific aspects of the project design and the safety of the crew, the conflict will be resolved in favor of crew safety. Second, the time estimates have been based on a presumption that it will not be necessary to remove all equipment from the archeological sites at the conclusion of each workday. Union Oil will be expected to provide for the physical security of equipment left on sites. Further, the completion of the field work will require the cooperation of Union Oil in problem situations, such as stuck vehicles or stranded crew members. It is also presumed that full access will be provided to scientific studies, such as biological surveys which have been carried out on behalf of Union Oil or the Public Service Company of New Mexico.

Attachment 3

STATE OF NEW MEXICO

DEPARTMENT OF
FINANCE AND ADMINISTRATION
PLANNING DIVISION

RUCE KING
GOVERNOR

D W. KING
SECRETARY

ANITA HISENBERG
DIRECTOR

505 DON GASPAR AVENUE
SANTA FE, NEW MEXICO 87503
(505) 827-2073
(505) 827-5191

August 14, 1979

Mr. Art C. Wilbur
Project-Manager
Geothermal Power Plant Project Office
U. S. Department of Energy
Plaza del Sol Building, Room 712
600 Second Street, N. W.
Albuquerque, New Mexico 87102

Dear Mr. Wilber:

This is to state that I have received a copy of Mr. Charles A. Herrington's August 6, letter to you, in which twenty-nine sites and one locality on the Baca Geothermal lease are identified as being collectively eligible to the National Register of Historic Places as being likely to yield significant scientific information.

I have read the report entitled "Proposal to Union Geothermal Co. for a Program of Archeological Testing", etc. (Office of Contract Archeology, University of New Mexico, June, 1979), and wish to state that in my opinion the significant information derivable from this archeological district may be recovered in the manner proposed in that report.

I therefore recommend that you send the mitigation proposal with this letter to the Advisory Council's Denver Office, attached to a request for Council comment. I will discuss this matter with the Council staff soon and ask for an expeditious review. The Council's comments will specify what further action is necessary.

Thank you for your continuing cooperation.

Sincerely,

Thomas W. Merlan
State Historic Preservation Officer
Historic Preservation Bureau

TWM:lm

RECEIVED
AUG 16 1979

Attachment 2

STATE OF NEW MEXICO
EDUCATIONAL FINANCE AND CULTURAL AFFAIRS DEPARTMENT
HISTORIC PRESERVATION PROGRAM
SANTA FE
87503

P.O. BOX 1629

AREA CODE 5C
TELEPHONE 827-2108

March 19, 1979

Mr. Art Wilbur, Project Manager
Geothermal Project Office
Department of Energy
Plaza del Sol, Room 712
600 2nd Street, N.W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

This is with reference to the report entitled "An Investigation into High Altitude Adaptations: the Baca Geothermal Project" (University of New Mexico Proposal No. 185-30; October 4, 1978).

The report describes twenty-nine archeological or historical sites and three localities identified by an inventory survey of a 1984-acre tract.

Having read the report's discussion (pp. 127-135) of these resources, I concur that the twenty-nine sites and Locality 3 are likely, as a group, to yield significant scientific information. The manner in which such information will be obtained in the field and the laboratory depends on the nature of the eventual land modification. I agree that sites should be avoided when possible. In any case, the data recovery program will be based on a sampling strategy, and will not necessarily mean investigation and analysis of every site. I do not believe that these resources have any value which may not be preserved by recording and analysis. This includes the architectural sites. I do not regard in-place preservation as essential.

I have the following specific recommendations to offer. You, as the representative of the involved federal agency, should forward this letter, your own conclusions, and the report to Dr. William J. Murtagh, Keeper of the National Register, at your earliest convenience. His address is:

Dr. William J. Murtagh
Keeper of the National Register
Office of Archeology and Historic Preservation
Heritage Conservation and Recreation Service
Department of the Interior
440 G. Street, N.W.
Washington, D.C. 20243

RECEIVED MAR

Mr. Art Wilbur
March 19, 1979
Page 2

Dr. Harlan will be writing a mitigation program in the meantime. If Dr. Murtagh's answer agrees with our conclusions, (we can expect to hear from him in about ten days) you should forward the program to the Advisory Council on Historic Preservation in Denver. Address:

Mr. Louis S. Wall, Deputy Director
Advisory Council on Historic Preservation
Office of Review and Compliance
P.O. Box 25085
Denver, Colorado 80225

If you do not agree that these resources are significant, Dr. Murtagh still has final authority to decide the question. If he does not agree that they are significant, the Department of Energy need not take any further action. If, however, Dr. Murtagh does agree with the above, Mr. Wall will have to indicate his agreement with the proposed mitigation (we can expect to hear from him within 45 days, but probably sooner). If he does agree, the program can be carried out by Dr. Harlan at the convenience of all the concerned parties.

Please let me know if you need further information.

Sincerely,

Thomas W. Merlan

Thomas W. Merlan
State Historic
Preservation Officer

TWM:dg
cc: Richard Engebretsen
Charles Carroll
Mark Harlan

Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

April 4, 1979

Dr. William J. Murtagh
Keeper of the National Register
Office of Archeology and Historic Preservation
Heritage Conservation and Recreation Service
Department of the Interior
440 G. Street, N.W.
Washington, D C. 20243

Dear Dr. Murtagh:

At the suggestion of Dr. Thomas W. Merlan (enclosure 1), New Mexico State Historic Preservation Officer, I send you herewith a copy of the "Station and Well Site Archeological Analysis (an investigation into high altitude adaptations) for the proposed Baca Geothermal Project" (enclosure 2).

The geothermal project noted in the report is the Geothermal Demonstration Power Plant Project. This Project is cost shared amongst Public Service Company of New Mexico, Union Geothermal Company of New Mexico, and the U. S. Department of Energy. The early stages of the Project are proceeding under a Letter Cooperative Agreement, and a definitive Cooperative Agreement is in final negotiation. Project activities on-site are limited until the Environmental Impact Statement process is completed sometime later this year.

I have no differing conclusions nor issues to take with either the report or Dr. Merlan's letter. If there are any actions I should take in addition to those recommended by Dr. Merlan, I would appreciate hearing of them.

Sincerely,

A C Wilbur

Art C. Wilbur, Project Manager
Geothermal Power Plant Project Office
U. S. Department of Energy
Plaza del Sol Bldg, Rm 712
600 Second Street, N.W.
Albuquerque, NM 87102

Advisory Council On Historic Preservation

1522 K Street N.W.
Washington D.C.
20005

Reply to: P. O. Box 25085
Denver, Colorado 80225

September 7, 1979

SEP 10 1979

Mr. Arthur C. Wilbur
Project Manager
Department of Energy
San Francisco Operations Office
Geothermal Demonstration Power
Plant Project Office
Room 712, Plaza del Sol Building
600 Second Street, N. W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

On August 20, 1979, the Council received your letter requesting comment on the mitigation plan which was enclosed and clearance for the proposed Geothermal Demonstration Power Plant, Rio Arriba and Sandoval Counties, New Mexico. The cultural resources which may be affected are 29 archaeological sites which have been determined eligible for inclusion in the National Register of Historic Places. However, the supporting documentation for our review and comment is inadequate. Please submit the following additional information, as required by Section 800.13(a), to enable us to complete our review of your request:

1. The Agency's determination of the effect of the undertaking.

2. The written views of the State Historic Preservation Officer.

Upon receipt of adequate documentation, we will initiate our 30-day review of the determination of effect pursuant to Section 800.6(a) of the Council's regulations, "Procedures for the Protection of Historic and Cultural Properties" (36 CFR Part 800) and inform you of any objections within that time. If no objection is noted, you have satisfied your responsibilities under Section 106 of the National Historic Preservation Act. If you have any questions, please call Jane King, Staff Archaeologist, at (303) 234-4946, an FTS number.

Sincerely,

B.R. Savoy

Louis S. Wall
Chief. Western Division of Project Review

Advisory
Council On
Historic
Preservation

1522 K Street N.W.
Washington D.C.
20005

"Guidelines for Making "Adverse Effect" and "No Adverse Effect" Determinations for Archeological Resources in Accordance with 36 CFR Part 800.

Archeological properties included in or eligible for inclusion in the National Register of Historic Places are generally, nominated under National Register Criterion "d" (36 CFR Part 60.6) which states that a property may qualify if it has "yielded, or may be likely to yield, information important in prehistory or history." While disturbance of archeological properties should be avoided, under certain circumstances, properties primarily significant for the data they contain can be said to realize their significance when this data is retrieved in an appropriate manner.

In such cases where a Federal undertaking (36 CFR Part 800.2(c)) can result in the recovery of data from an archeological property or in eligible for inclusion in the National Register of Historic Places, the Agency Official should take the following steps to decide whether a "no adverse effect" determination can be made:

> The Agency Official shall, in consultation with the State Historic Preservation Officer (SHPO), apply the criteria set forth in Part I below. If these criteria are not met, the Agency Official shall comply with the procedures set forth at 36 CFR Part 800.4(d) *et seq*. If the criteria are met, the Agency Official may issue a determination of no adverse effect for any data recovery program conducted in accordance with the requirements set forth in Part II below. Documentation that the criteria and requirements set forth in Parts I and II below have been met, along with the comments of the SHPO, shall be forwarded to the Council for review in accordance with 36 CFR Part 800.4(c).

Part I: Criteria

1. The property is not a National Historic Landmark, a National Historic Site in non-federal ownership, or a property of national historical significance so designated within the National Park System.

2. The SHPO has determined that in-place preservation of the property is not necessary to fulfill purposes set forth in the State Historic Preservation Plan.

3. The SHPO and the Agency Official agree that:

   a. The property (including properties that are subsidiary elements in a larger property defined in Criterion 1) has minimal value as an exhibit in place for public understanding and enjoyment;

   b. Above and beyond its scientific value, the property is not known to have historic or cultural significance to a community, ethnic, or social group that would be impaired by the retrieval of data;

   c. Currently available technology is such that the significant information contained in the property can be retrieved.

4. Funds and time have been committed to adequately retrieve the data.

Part II: Data Recovery Requirements

1. The data recovery will be conducted under the supervision of an archeologist who meets the "Proposed Department of the Interior Qualifications for the Supervisory Archeologist (Field Work Projects)." (See Attachment #1.)

2. The data recovery will be conducted in accordance with "Professional Standards for Data Recovery Programs." (See Attachment #2.)

3. A specified date has been set for completion and submission of the final report to the Agency Official.

4. Plans have been made for disposition of the material recovered after they have been analyzed for the final report. (See Attachment #3.)

5. Regarding the status of the affected property, documentation of the condition and significance of the property after data recovery will be provided the Agency Official and SHPO for forwarding to the National Register of Historic Places for action to include nominations, boundary changes or removal of National Register of eligibility status, in accordance with National Register procedures (36 CFR Part 60.16 and 60.17).

Attachment #1 <u>Proposed Department of the Interior Qualifications for the Supervisory Archeologist (Field Work Projects)</u>

The minimum professional qualifications for the Supervisory Archeologist are a graduate degree in archeology, anthropology, or a closely related field, or equivalent training accepted for accreditation purposes by the Society of Professional Archeologists, plus: (1) at least sixteen months of professional experience or specialized training in archeology field, laboratory, or library research, including (a) at least four months of experience in general North American archeology, and (b) at least six months of field experience in a supervisory role; (2) a demonstrated ability to carry research to completion, usually evidenced by timely completion of thesis, research reports, or similar documents.

For work involving prehistoric archeology, the Supervisory Archeologist should have had at least one year of experience in research concerning archeological resources of the prehistoric period.

For work involving historic archeology, the Supervisory Archeologist should have had at least one year of experience in research concerning archeological resources of the historic period.

Attachment #2 Professional Standards for Data Recovery Programs

1. The data recovery program should be conducted in accordance with a professionally adequate recovery plan (research design):

   a. The plan shall be prepared or approved by the Supervisory Archeologist and shall reflect a familiarity with previous relevant research;

   b. The plan shall include a definite set of research objectives, taking into account previous relevant research, to be answered in analysis of the data to be recovered;

   c. The plan shall provide for recovery of a usable sample of data on all significant research topics that can reasonably be addressed using the property or a justification for collecting data on a smaller range of topics at the expense of others;

   d. The plan shall specify and justify the methods and techniques to be used for recovery of the data contained in the property. (Methods destructive of data or injurious to the natural features of the property should not be employed if non-destructive methods are feasible.)

2. The data recovery program should provide for adequate personnel, facilities, and equipment to fully implement the recovery plan.

3. The data recovery program should insure that full, accurate and intelligible records will be made and maintained of all field observations and operations, including but not limited to excavation and recording techniques, stratigraphic and/or associational relationships where appropriate, and significant environmental relationships.

4. Particularly when a data recovery program is conducted upon a potentially complex historic or prehistoric property (e.g., an historic town site; a prehistoric site that may contain many occupation layers, cemeteries, or architectural remains), situations may arise or data be encountered that were not anticipated in designing the program. Adequate provision should be made for modification of the data recovery plan to cope withunforeseen discoveries or other unexpected circumstances.

5. The data recovery program should include provisions for dissemination of the results of the program. Generally, the final report should be made available to the SHPO, the State archivist, the State archeologist, the Departmental Consulting Archeologist of the Department of the Interior, and the Chairman, Department of Anthropology, Smithsonian Institution.

Attachment #3 Treatment of Recovered Materials

The recommended professional treatment of recovered materials is curation and storage of the artifacts at an institution that can properly insure their preservation and that will make them available for reserach and public view. If such materials are not in Federal ownership, the consent of the owner must be obtained, in accordance with applicable law, concerning the disposition of the materials after completion of the report.

Department of Energy
San Francisco Operations Office
Geothermal Demonstration Power Plant Project Office
Room 712, Plaza del Sol Building
600 Second Street, N.W.
Albuquerque, New Mexico 87102

September 12, 1979

Mr. Louis S. Wall, Chief
Western Division of Project Review
Advisory Council on Historic Preservation
P. O. Box 25085
Denver, Colorado 80225

Dear Mr. Wall:

This is in response to your September 7, 1979, letter regarding DOE's request for comment on the mitigation plan and clearance for the Geothermal Demonstration Power Plant.

In the opinion of DOE there will be no adverse effect on the National Register - eligible archeological sites in the Geothermal Demonstration Power Plant project area providing the mitigation plan is followed. In consultation with the New Mexico State Historic Preservation Officer (SHPO) I have applied the criteria, Part I, of your "Guidelines for Making 'Adverse Effect' and 'No Adverse Effect' Determinations for Archeological Resources in Accordance with 36 CFR Part 800" in making this determination. The mitigation plan, which you have already received, is offered evidence that the data recovery requirements of Part II are satisfied. Enclosure 1 is a letter expressing the views of the SHPO.

Sincerely,

Arthur C. Wilbur
Project Manager

cc: Jane King
Bill Manning, DOE
Al Jelacic, DOE
Bennie DiBona, DOE

STATE OF NEW MEXICO

DEPARTMENT OF FINANCE AND ADMINISTRATION PLANNING DIVISION

BRUCE KING
GOVERNOR

DAVID W. KING
SECRETARY

ANITA HISENBERG
DIRECTOR

505 DON GASPAR AVENUE
SANTA FE, NEW MEXICO 87503
(505) 827-2073
(505) 827 5191
827-2108

September 11, 1979

Mr. Arthur C. Wilbur
Project Manager
Department of Energy
San Francisco Operations Office
Geothermal Demonstration Power
Plant Project Office
Room 712, Plaza del Sol Building
600 Second Street, NW
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

This is to state that I have reviewed the archeological/historical site documentation and proposed mitigation plan for the proposed Geothermal Demonstration Power Plant in Sandoval County.

I understand that the Advisory Council on Historic Preservation requires determinations from your office and from me of the effect of this project.

In my opinion, this proposed undertaking will have an effect on the cultural properties identified as eligible to the National Register (twenty-nine sites and one locality) which will not be adverse, provided that the mitigation program proposed by the Office of Contract Archeology, University of New Mexico to Union Geothermal Company (June, 1979) is carried out.

Please let me know if you need further information.

Sincerely,

Thomas W. Merlan
State Historic Preservation Officer
Historic Preservation Bureau

TWM:dg
cc: Louis S. Wall

Enclosure II

Application of Guidelines for Making a Determination of Effect on the Archeological Resources of the Site of the Baca Geothermal Demonstration Power Plant

Part I: Criteria

1. The site of the Baca Geothermal Demonstration Power Plant (GDPP) is not a National Historic Landmark, a National Historic Site in non-federal ownership, or a property of national historical significance. The GDPP site has been declared eligible for the National Register of Historic Places (Attachment 1).

2. The New Mexico State Historic Preservation Officer (SHPO) has determined that in-place preservation of the archeological property on the site is unnecessary (Attachments 2 & 3).

3. a) Archeological materials have been identified at varieus locations throughout the GDPP site (Reference 1). These materials consist of lithic scatter and the remains of several historic log structures. Given the nature of the material and its degree of scatter, coupled with the rough, steep terrain and present inaccessibility of the site, the property has minimal value as a public exhibit.

   b) The Valles Caldera, of which the GDPP site is a part, is known to have religious significance to the Indians of the region. However up to this time the Indians have not identified specific religious or sacred sites within the Caldera. An archeological survey of the GDPP site has not revealed any indications of active or abandoned religious sites, nor have the Indians suggested the presence of such sites (Reference 2).

   The historic materials found on the site derive mostly from a period of seasonal occupation by sheepherders. There is no outstanding or unique feature of these materials which would suggest they possess special significance. No community, ethnic or social group has expressed an interest in their preservation.

   On the basis of the best available information, the GDPP site has no apparent historic or cultural significance above and beyond its scientific value.

c) The archeological information contained at the site will be retrieved according to a proposed mitigation program (Attachment 4). This program will use standard archeological practices for field data collection; it has been approved by the SHPO.

4. The Union Geothermal Company has funded the mitigration program proposed by the University of New Mexico (Attachment 4). This program allows for adequate time and funds to accomplish data retrieval and analysis.

Part II: Data Recovery Requirements

1. The Supervisory Archeologist for the GDPP site mitigation program will be Dr. Mark E. Harlan, Department of Anthropology, University of New Mexico. Dr. Harlan has ten years' experience in field archeology, including two years as a supervisory contract archeologist.

2. Data retrieval and analysis will be conducted in accordance with the mitigation program (Attachment 4) prepared by Dr. Mark E. Harlan. Dr. Harlan participated in a previous study of the site's archeological values. The current program has as its objectives to answer the following questions:

   (1) What is the range of available biotic and nonbiotic resources in the GDPP site?

   (2) What segment of the available range was actually exploited and did this change through time?

   (3) Is there marked seasonality in the availability of the resources chosen for exploitation?

   (4) What techniques were utilized in gaining access to the resources chosen for exploitation?

   (5) What is the likely articulation between the segment of the subsistence system manifest in the study area and the overall subsistence systems of the participating cultures?

   Statistically significant data samples will be collected randomly from unitized grids within 3 groups of identified archeological sites (Attachment 4 p12). Artifacts will be collected at the surface and by controlled excavation supplemented by test holes. In addition, representatives soil samples will be taken. Data on historic sites will be collected from official records, interviews, photographs, and archeological maps.

The mitigation program provides for adequate resouces to fully implement the data recovery effort (Attachment 4, p14-19).

Complete records of recovered data will be taken and maintained. The records will be published in reduced form as part of the program's final report. The report will be distributed to the SHPO, the Keeper of the National Register of Historic Places, the interested scientific community, and the public.

The mitigation program has been designed with sufficient flexibility to enable unexpected significant finds to be recovered if they are encountered.

3. The final report will be submitted in August 1980.

4. Material recovered during the mitigation program will archieved and preserved for possible exhibition or further scientific investigations at the Maxwell Museum of Anthroplogy, University of New Mexico.

5. Documentation of the conditions and significance of the GDPP site after data recovery will be provided to the SHPO within one month after the completion of field work.

References.

1. Moore, James L. et al, "An Investigation into High Altitude Adaptation, the Baca Geothermal Project," University of New Mexico, October 4, 1978.

2. Hearing on Draft Environmental Impact Statement -- Geothermal Demonstration Program, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico -- Before All Indian Pueblo Council, Transcript of Proceedings, August 16, 1979.

Advisory Council On Historic Preservation

1522 K Street N.W.
Washington D.C.
20005

September 25, 1979

Mr. Arthur C. Wilbur
Project Manager
Geothermal Demonstration Power Plant
Project Office
Department of Energy
Plaza del Sol Building, Room 712
600 Second Street, N.W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

On August 20, 1979, supplemented by additional information on September 17, 1979, the Council received your determination that construction of a Geothermal Power Plant, Rio Arriba and Sandoval Counties, New Mexico, would not adversely affect the Baca Ranch Archeological District, properties eligible for the National Register of Historic Places. In accordance with Section 800.6(a) of the Council's regulations (36 CFR Part 800), the Executive Director does not object to your determination.

As provided in Section 800.9 of the Council's regulations, a copy of your determination of no adverse effect, along with supporting documentation and this concurrence, should be included in any assessment or statement prepared for this undertaking in compliance with the National Environmental Policy Act and should be kept in the Department of Energy's records as evidence of compliance with Section 106 of the National Historic Preservation Act and the Council's regulations.

Thank you for your cooperation.

Sincerely,

Louis S. Wall
Chief, Western Division
of Project Review

RECEIVED
SEP 28 1979

Appendix F

APPROVED MITIGATION PLANS FOR EFFECTS ON
RARE AND ENDANGERED SPECIES

February 20, 1979

Dr. John Hubbard
New Mexico Department
of Game and Fish
Endangered Species Program
Villagra Building
Santa Fe, NM 87503

Dear Dr. Hubbard:

Subject: Jemez Mountains Salamander Mitigation Plan

This letter describes Public Service Company of New Mexico's (PNM) proposed mitigation plan for the Jemez Mountains salamander (Plethodon neomexicanus) along the proposed Baca geothermal transmission route, and within the plant site area. The mitigation plan is a result of our January 9, 1979, meeting.

Mitigation will be done on all construction activity areas; this includes: the transmission line, access roads in and out of the ROW, the generating plant area, associated structures, and parking lot.

The mitigation plan is as follows:

1. PNM will completely avoid the type locality of the Jemez Mountains salamander. The type locality is in the east one-half of section 3, township 18 north, range 4 east.

2. PNM will avoid areas of dense populations, if possible.

3. Where avoidance is not possible, preconstruction removal and relocation of the salamanders within the proposed transmission route and plant site areas would be performed by PNM biologists. Those salamanders present on the surface or under rocks and logs would be removed the day before blading of the road and structure landing areas. They would then be moved to suitable nearby habitat. It is possible, due to lack of rain or low temperatures, that no salamanders would be active the day of the removal program. In such case, no removal mitigation would be performed.

I hope this mitigation plan is acceptable. If you approve of this plan, would you please indicate so in a letter. A copy of your letter, along with the mitigation plan, will be sent to Oak Ridge National Laboratories for EIS purposes.

Thank you for your cooperation.

Wayne R. Pilz
Environmental Scientist

WRP:av
cc: Ms. L. Berger, Union Oil
bcc: Mr. W. Eckles
Mr. D. E. Hines
Mr. E. D. Kist
Mr. J. D. Maddox
Mr. T. M. Moynihan
Mr. A. B. Rodney
Mr. D. G. Sabo

January 22, 1979

Bill Issaccs
Heritage Program
Department of Natural Resources
Villagra Building
State Capitol
Santa Fe, 87503

Dear Mr. Issaccs:

This letter is to indicate mitigation procedures to you for the various plant taxa we discussed in our meeting of January 5, 1979. The species of interest include:

Cornus Canadensis
Lilium umbellatum
Malaxsis soulei
Viola pedatifide

As you know, Public Service Company of New Mexico is in the planning stages for a transmission line from the Baca Geothermal Project to Los Alamos. This line is being planned in conjunction with the U.S. Forest Service and the National Park Service. We hope to develop a corridor which will be acceptable to all parties. Within this corridor the eventual transmission line will be situated.

Public Service Company of New Mexico generally tries to allow for some freedom of movement of the transmission line within a corridor to avoid impacts to significant portions of the environment (ie. visual, archeological, or biotic resources).

We propose, basically, to avoid the populations of the above named plant species whenever possible. If complete avoidance is not possible then we propose to notify your office so that other mitigating measures may be discussed.

If this proposal is acceptable to your office, I would appreciate receiving your concurrence in writing at your possible convenience. If there are questions relating to the proposal, please notify me at once.

Yours truly,

Dave

Dave Sabo
Environmental Coordinator

DS:kh
cc: L. Berger-Union
W. Eckles
D. Hines
E. Kist
J. Maddox
T. Moynihan
A. Rodney

STATE OF NEW MEXICO
NATURAL RESOURCES DEPARTMENT
ADMINISTRATIVE SERVICES DIVISION
VILLAGRA BLDG. SANTA FE 87503
PHONE 505-827-5231
JIM KING DIRECTOR

NATURAL RESOURCES DEPARTMENT

BRUCE KING
GOVERNOR
WILLIAM S. HUEY
SECRETARY
OF NATURAL RESOURCES

February 13, 1979

Mr. David Sabo
Public Service Company of New Mexico
P. O. Box 2267
Albuquerque, New Mexico 87103

Dear David:

The plants that you mentioned are the ones of principal concern to us here. Those are Malaxis soulei, Viola pedatifida, Cornus canadensis, and Lilium philadelphicum var. andinum. Also, in regions where there is a stream, you should look for Epipactis gigantea. Finally, in the vicinity of Los Alamos Calochortus nuttallii does locally occur as well. In the case of the Malaxis, I have found it to be difficult to locate until the summer rains come. The Lilium appears to come up in late May at the earliest.

Recently, Terralene Foxx located a "rare" plant in Bandelier National Monument and you might wish to check with her on just what it was that she found.

The first five species mentioned in the letter are of importance to us while the Calochortus ought to be avoided if possible, but cannot be considered as rare.

Thank you for your efforts to communicate with us on these matters. We appreciate your interest and concern.

Sincerely,

Bill

Bill F. Isaacs, Program Coordinator
New Mexico State Heritage Program

BFI:lm

STATE OF NEW MEXICO
NATURAL RESOURCES DEPARTMENT
ADMINISTRATIVE SERVICES DIVISION
VILLAGRA BLDG. SANTA FE 87503
PHONE 505-827-5231
JIM KING DIRECTOR

NATURAL RESOURCES DEPARTMENT

BRUCE KING
GOVERNOR
WILLIAM S. HUEY
SECRETARY
OF NATURAL RESOURCES

February 15, 1979

Mr. David Sabo
Public Service Company of New Mexico
P. O. Box 2267
Albuquerque, New Mexico 87103

Dear David:

After reviewing your recent letter to us concerning mitigation for rare plant in the Baca Geothermal development area and Electric Transmission Corridor, I feel your plan is entirely adequate. In my letter of February 13, I outlined the species that are of concern to us.

I shall reiterate this list as well as include the one federally listed species. These are:

1) Pediocactus papyracanthus - Federally listed as threatened

2) Malaxis soulei - State rare species

3) Viola pedatifida - State rare species

4) Cornus canadensis - State rare species

5) Lilium philadelphicum ssp. andinum - State rare species

6) Epipactis gigantea - State rare species

7) Calochortus nuttallii - Locally rare and worthy of consideration

I expect that you will be surveying sensitive areas in regard to these taxa and will inform us as to your findings. I anticipate having a computer printout available shortly with the known locations of these taxa within this area.

Thank you for your cooperation.

Sincerely,

Bill Isaacs

Bill F. Isaacs, Program Coordinator
New Mexico State Heritage Program

State of New Mexico

DEPARTMENT OF GAME AND FISH

STATE CAPITOL
SANTA FE
87503

March 9, 1979

Mr. Wayne Pilz
Public Service Company
of New Mexico
P. O. Box 2267
Albuquerque, New Mexico 87103

Dear Mr. Pilz:

We have reviewed the "Jemez Mountain Salamander Mitigation Plan", as proposed by your company in correspondence dated February 20, 1979. The approach meets with our approval, and I commend the Public Service Company of New Mexico for taking such pains to benefit the Jemez Mountains salamander (Plethodon neomexicanus). The need for concern is certainly warranted, as this animal occurs nowhere else in the world except New Mexico. If the species is to be conserved, it will require the cooperation of all concerned.

Let us know as soon as permits are needed for capture and moving of salamanders, and these will be processed with due speed by our Division of Law Enforcement.

Sincerely,

Harold F. Olson
Director

Appendix G

EMERGENCY ACCIDENTAL SPILLS AND DISCHARGES CONTROL PROCEDURES

and

SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN

EMERGENCY ACCIDENTAL SPILLS & DISCHARGES CONTROL PROCEDURES

Baca Geothermal Project - Sandoval County, New Mexico

I. Introduction

The Baca Geothermal Project is located approximately 25 miles west of Los Alamos and 55 miles north of Albuquerque in North Central New Mexico, in the sparsely populated Jemez Mountains. The countryside is used for geothermal electrical power generation, for cattle grazing, watershed and for hunting Numerous creeks lace the hillsides, including Redondo, Sulphur, San Antonio, San Luis, Jaramillo, and La Jara Creeks.

II. Regulations - State of New Mexico Oil Conservation Commission

Rule 117. Notification of Fire, Breaks, Leaks, Spills and Blowouts.

The Commission shall be notified of any fire, break, leak, spill or blowout occurring at any geothermal drilling, producing, transporting, treating, disposal, or utilization facility in the State of New Mexico by the person operating or controlling such facility.

"Facility", for the purpose of this rule, shall include any geothermal drilling, producing, injection, or disposal well; any pipeline through which geothermal resources or the waste products thereof are gathered or transported; any tank or other storage unit into which geothermal products, waters, or wastes are produced, received, or stored; any treating plant in which geothermal resources are treated or processed; any electrical generating plant in which geothermal resources are utilized; and any drilling pit, slush pit, or storage pit or pond associated with geothermal drilling, producing, treating, or utilization processes in which hydrocarbons or hydrocarbon waste or residue, salt water, strong caustics or acids, or other deleterious chemicals or harmful substances are present.

Notification to the Commission of such fire, break, leak, spill, or blowout shall be in accordance with the provisions set forth below:

A. Well Blowouts. Notification of well blowouts and/or fires shall be "immediate notification" described below.

B. "Major" Breaks, Spills, or Leaks. Notification of breaks, spills, or leaks of wellheads, pipelines, or tanks, or drilling pits, slush pits, or storage pits or ponds, the result of which 50 barrels or more of liquids containing hydrocarbons or hydrocarbon wastes, salt water, strong caustics or strong acids, or other deleterious substances reach a water course or enter a stream or lake, or in which noxious gases escape or any quantity of fluids are lost which may with reasonable probability endanger human health or result in substantial damage to property, shall be "immediate notification" described below.

C. "Minor" Breaks, Spills, or Leaks. Notification of breaks, spills, or leaks of wellheads, pipelines, or tanks, or drilling pits, slush pits, or storage pits or ponds, the result of which 25 barrels or more but less than 50 barrels of liquids containing hydrocarbons or hydrocarbon wastes, salt water, strong caustics or strong acids, or other deleterious substances are lost or in which noxious gases escape, but in which there is no danger to human health nor of substantial damage to property shall be "subsequent notice" described below.

D. Fires. Notification of fires at geothermal installations in which there is reasonable probability of danger to human health or substantial damage to adjoining properties or substantial loss of geothermal resources shall be "immediate notice" described below. Notification of fires of lesser magnitude but of $500.00 or more of property damage or $500.00 or more of geothermal resources loss shall be "subsequent notice" described below.

IMMEDIATE NOTIFICATION - "Immediate Notification" shall be as soon as possible after discovery and shall be in person or by telephone to the Santa Fe office or the nearest district office of the Commission if the incident occurs during business hours. If the incident occurs after business hours, notification shall be in accordance with the latest Commission memorandum on the subject. A complete written report of the incident shall be submitted to the Santa Fe office of the Commission within ten days after discovery of the incident.

SUBSEQUENT NOTIFICATION - "Subsequent Notification" shall be a complete written report of the incident and shall be submitted to the Santa Fe office of the Commission within ten days after discovery of the incident.

CONTENT OF NOTIFICATION - All reports of fires, breaks, spills, leaks, or blowouts, whether verbal or written, shall identify the location of the incident by quarter-quarter, Section, Township, and Range, and by distance and direction from the nearest town or prominent landmark so that the exact site of the incident can be readily located on the ground. The report shall specify the nature and quantity of the loss and also the general conditions prevailing in the area, including precipitation, temperature, and soil conditions. The report shall also detail the measures that have been taken and are being taken to remedy the situation reported.

WATERCOURSE, for the purpose of this rule, is defined as any lake-bed or gully, draw, stream-bed, wash, arroyo, or natural or manmade channel through which water flows or has flowed.

III. Potential Locations Where Discharge Incidents Might Occur

A. Produced Water and Condensate - The produced liquids are collected in ponds and transferred by pipeline to injection wells which conduct the fluid back to the producing formation. Potential locations for accidental spills are:

1. Muffler ponds.
2. Water disposal ponds.
3. Pipelines
4. Injection wellheads.

B. Drilling Muds - Muds are a mixture of water, chemicals, and solid particles used in drilling operations to lubricate and cool the bit in the hole and to carry cuttings out of the hole. Drilling muds are stored in sumps at the drilling locations. These sumps are open and are adequately sized to hold the volume necessary for the operation. Potential circumstances of discharge are minimal, but could occur by:

1. Sump overflow.
2. Sump wall seepage or wall breakdown.

3. Mud discharge from elsewhere on location.

4. shallow lost circulation channeling to surface.

C. Lubricating or fuel oils and petroleum products - A discharge of this type would probably be very small and from equipment used in the field. Potential locations for accidental spills are:

1. Drilling equipment and machinery at and around drilling locations.

2. Other miscellaneous equipment and machinery at well sites, on roads, or at generating plants and production shops.

D. Construction/maintenance debris - Minor consideration, usually able to be cleaned up on the job. Potential locations are the same as for lubricating or fuel oils (c), above.

IV. Possible Water Quality Affects, Redondo Creek and Others

A. Condensate or drilling muds.

1. Contaminate water possibly making it unsuitable for human or wildlife consumption.

2. Possible detrimental affect to flora of area.

3. Increase turbidity of water by particulates in fluid or by soil erosion.

B. Petroleum products.

1. Contaminate water.

2. Cover wildlife and plant life.

3. Mud discharge from elsewhere on location.

4. shallow lost circulation channeling to surface.

C. Lubricating or fuel oils and petroleum products - A discharge of this type would probably be very small and from equipment used in the field. Potential locations for accidental spills are:

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2. Possible detrimental affect to flora of area.

3. Increase turbidity of water by particulates in fluid or by soil erosion.

B. Petroleum products.

1. Contaminate water.

2. Cover wildlife and plant life.

C. Construction debris - possibly increase turbidity.

V. Plan for Clean-up and Abatement

In the event of discharges of produced water condensate, drilling muds, petroleum products or construction debris, the overall contingency plan for the Baca Field, Sandoval County, is as follows:

A. The person responsible for the operation will make an immediate investigation, then call the Area Manager and advise him of spill. The Area Manager will in turn call out company employees to man heavy equipment, regulate field production, or do other work as applicable for control and clean-up of spill. If spill is small (i.e., less than 25 barrels) and easily containable without endangering watershed, the Area Manager will direct and supervise complete clean-up and return to normal operations.

B. If spill is larger than 25 barrels, or is not easily contained, or endangers or has entered watershed, the Area Manager will proceed to take necessary action to curtail, contain and clean-up spill, and notify personnel as follows:

1. Call out company employees, as above, to man heavy equipment, regulate field production, etc.
2. Call District Manager and advise of spill.

3. Call contractors for crews and equipment, if necessary.
4. Call contract vacuum trucks.
5. Advise State of New Mexico Oil Conservation Commission of spill and work closely with them in all phases of operations.
6. Specific procedures:
   a. For produced water and condensate:
      Contain spillage with dikes if possible.
      Haul to disposal well by vacuum truck.
   b. For drilling muds (contact Drilling Foreman):
      Repair sump or contain with dikes.
      Haul liquid to another sump or available tank or County approved disposal site.
      Dry and solidify other material, compact and bury solids where possible.
   c. For petroleum products:
      Contain spill with available manpower.
      Use absorbents and dispose of same in County approved areas.
   d. For construction debris:
      Pick up or otherwise contain and remove to disposal area.
7. Have source of spill repaired at earliest practical time - return as many Union Oil employees as possible

to their regular assignments to get the field back to normal operations.

8. Continue working contract crews, equipment and vacuum trucks on clean-up until all concerned agencies are satisfied.

9. Advise all Union Oil employees and outside contract foremen not to make any statements to the press, particularly of a liability admitting nature. They should direct the press to the Area Manager, who will refer the press to appropriate Company Public Relations personnel.

C. Baca Field Information:

Personnel responsible for carrying out overall contingency plans.

Area Manager - Richard Engebretsen 505-897-1776
505-296-4434

1. Field Personnel:

John Merhege	- Production Foreman	505-829-3374
Joseph Bowen	- Production Operator	505-829-3771

2. All Others As Needed:

3. Union Oil District Personnel Notification: Santa Rosa, California District Office. During office hours, notify one of the following at 707-542-9543 or, after hours or on weekends:

S. C. Lipman	- District Manager	-707-544-7600
A. J. Chasteen	- Dist. Prod. Sup't.	-707-823-4462
D. Ash	- Dist. Prod. Sup't.	-707-539-9314

4. Regulatory Agency Notification

State of New Mexico Oil Conservation Commission

Santa Fe Office

Business Hours	827-2533
Nights & Weekends	
C. G. Ulvog	982-8985
D. S. Nutter	982-0757

Aztec Office

Business Hours	334-6178
Nights & Weekends	
A. R. Kendrick	334-2555
C. C. Gholson	632-2193
N. E. Maxwell Jr.	334-6650

Artesia Office

Business Hours	746-4861
Nights & Weekends	
W. A. Gressett	746-4166
L. A. Mermis	746-9205

Hobbs Office

Business Hours	393-6161
Nights & Weekends	
J. T. Sexton	392-5874
L. A. Clements	393-8348
N. E. Clegg	393-4781
J. W. Runyan	392-5696

All the above numbers carry a 505 Area Code.

5. Field equipment available:

   Caterpillar D-9 Tractor

   Caterpillar Motor Grader

   Caterpillar #920 Wheel Loader

   Hyster Lift Truck

   Hyster Grid Roller

   Kenworth 3-axle tractor, 2 flatbed trailers

   #930 Wheel Loader & Backhoe

   Various 1/2-Ton Pickups

6. Advise livestock owners or hunting clubs if spill affects cattle or property.

7. Outside contractors for crews and equipment, if necessary:

   C.J.C. Construction - La Cueva

   Allen Construction Company - Farmington

8. Vacuum trucks.

SPILL PREVENTION CONTROL
AND COUNTERMEASURE PLAN

BACA GEOTHERMAL PROJECT
Sandoval County, New Mexico

Revision No. 3 - April 5, 1979

MANAGEMENT APPROVAL

This SPCC Plan will be fully implemented as herein described. Further, Union Oil Company makes this written committment of the manpower, equipment, and materials required to expeditiously control and remove any harmful quantity of oil discharged.

Signature ______________________

Name S. C. Lipman

Title District Manager

CERTIFICATION

I hereby certify that I have examined the facility, and, being familiar with the provisions of 40 CFR, Part 112, attest that this SPCC Plan has been prepared in accordance with good engineering practice.

Samuel L. Gray
Printed Name
Registered Professional Engineer

REGISTERED PROFESSIONAL ENGINEER
STATE OF
NO.
4301
NEW MEXICO
SAMUEL L. GRAY

____
Signature of
Registered Professional Engineer

Registration No. 4301 State N.M.
Dated this 16 day of Apr. '79

SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN

BACA GEOTHERMAL FACILITY
Sandoval County, New Mexico

April, 1979

TABLE OF CONTENTS

SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN (SPCC)

Baca Geothermal Project
Sandoval County, N.M.

I. LOCATION

The Baca Geothermal Field is located approximately 25 miles west of Los Alamos and 55 miles north of Albuquerque in North Central New Mexico, in the sparsely populated Jemez Mountains. Exhibit 1 (UOCC Dwg. No. 1114) is a vicinity map showing the location of the project relating to nearby towns and roads. Exhibit 2 (UOCC Dwg. No. 1141) is a Baca Geothermal Project Map. The countryside is used for geothermal electrical power generation, for cattle grazing, watershed and for hunting. Numerous creeks lace the hillsides, including Redondo, San Antonio, Sulphur, San Luis, Jaramillo and La Jara Creeks.

SPCC PLAN

II. POTENTIAL SPILLS AND MITIGATIONS

No crude oil is handled at the Baca Project, though refined petroleum products (fuels, lubricating oils, etc.) are stored and used. Field equipment and petroleum storage areas would be the potential locations for accidental spills. These two areas are addressed below.

A. Field Equipment - Possible Spills

1. Water Disposal Pumps - Two water disposal pumps and appurtenant fuel storages are used for produced water disposal. One pump is stationary, located in the vicinity of the Baca Well No. 6 location. The second pump is skid mounted and can be transported to wherever it is needed. Normally it is also stationed in the vicinity of Baca Well No. 6. No spills have occurred during the operation of these pumps to date.

   Possible spills from these pumps could originate during filling of the fuel tanks or in the course of the pumps' normal operation. In each case, the probable cause of the spill would be operator error. Operator familiarity with the pumps will reduce the possibility of any spill from the machine. The pumps are observed daily by field operators and are maintained on a regular basis by trained mechanics. Proper caution exercised by personnel filling the tanks will reduce the possibility of an accidental discharge during this operation.

The fuel tank for these pumps is situated and bermed in such a manner as to take advantage of secondary containment features of the produced water holding ponds at that location. Exhibit 3 (UOCC Dwg. No. 1139) indicates the location of the fuel storage tank and the secondary containment features designed into the location.

2. <u>Drilling Activity Fuel Storage</u> - Part of the normal equipment compliment for each drilling rig are fuel storage tanks. Normally, there are two 10,000 gallon and one 1,000 gallon skid-mounted portable tanks. These tanks move with the drilling rig to various locations throughout the project. There may be one to four drilling rigs working in the project at any given time.

As discussed above, the most likely cause of an accidental discharge would be human error. Comments as above address this problem.

Spill incidents could occur if fuel storage facilities are positioned in natural drainage areas. Therefore, special spill prevention control measures utilized for these facilities include location grading and placement of tanks.

A drilling waste disposal site is constructed adjacent to each drilling location. Three feet of freeboard is maintained at each site for spill and precipitation contingency. This freeboard capacity amounts to approximately 20,000ft^3 (150,000 gallons) for a small disposal site, more for a larger site. The tanks are positioned on the location and the location is graded in such a manner that any spillage will run into the disposal area. Berms and ditches are utilized in some cases to assure that any spillage is captured and directed into the disposal site. Exhibit 4 (UOCO Dwg. No. 1140) is a typical drill site location showing general precautionary measures taken to contain any spilled oil.

It would not be practical to address the fate of the oil spilled from these locations on an individual basis due to the many locations at which drilling operations have been or will be conducted. In each case, however, it shall be the responsibility of the personnel in charge of constructing the location to consider and make proper engineering designs to provide for secondary containment.

B. Petroleum Storage

1. Fuel Storage - a 6,000 gallon gasoline storage tank is located in the proximity of the field office and storage yard at the Marshalling Area. This tank serves as the fuel supply for project vehicles.

   Possible spills at this location are most likely to occur during the time of fuel transfers, either during the filling of the storage tank or during the filling of individual vehicles. The probably cause of a potential spill would be operator error.

   Operator's have been trained in proper fuel transferring procedures, and are in attendance at all times during the transfer, so the potential magnitude of any spill would be slight. The rate of transfer to individual vehicles is low, so any spill during this time could be easily stopped, contained, and cleaned up.

   A secondary berm has been installed around the fuel storage tank to contain any spills in this area. Exhibit 5 (UOCC Dwg. No. 1138) shows the tank and berm arrangement. A drain line with a manually operated valve has been incorporated into the design of the secondary containment feature to drain off accumulated water.

2. Lubricating Oil Drum Storage Area - There is very little lubricating oil drum storage on the Project. Where it occurs, it usually consists of one 55 gallon drum on a rack supplying oil to one or a group of engines. Any spill from this source would be limited to the contents of the drum.

A drum storage area for waste oil and other chemicals has been provided at the Baca Well No. 6. location. It is bermed so that any spillage will run into the produced water holding ponds. Exhibit 3 (UOCC Dwg. No. 1139) shows this area.

III. OIL SPILL CONTINGENCY PLAN

The contingency plan is broken down into four sections: Section A establishes some definitions for guidance in a spill situation; Section B contains procedures for the personnel involved in a spill; Section C is the notification procedures to be followed in the event of a spill; Section D is containment and cleanup for specifically identified areas.

A. Definitions

For this plan a minor spill is less than 25 Bbl. with no chance of reaching a water course. A major spill is 25 Bbl. or more and/or a spill which has or could enter a water course. All spills in which oil enters a water course must be reported, regardless of volume. A water course shall be any flowing or standing water, or any seasonally dry channel or bed where there could reasonably be flow during flooding. A drilling sump or produced water holding pond is not a water course.

B. Procedures

The desired course of action in spill incidents is listed below in descending order of importance. Judgement must be exercised by personnel involved as to proper implementation of the plan.

1. Control at Source of Spill - Simply stated, if a spill is occurring, shut it off by any means

available. This might include shutting a valve, shutting off a pump, or plugging a leaking tank or appurtenant thereof with a rag, wooden bung, sack of gel or other makeshift devices normally found around a producing or drilling operation.

2. <u>Containment of Spill</u> - Use expedience in isolating and containing the spilled product. Most spills are small and can be easily contained with hand tools which are carried on all company trucks or are located in tool lockers at the field office complex. Palletized sand bags are stored in the field yard to aid in containment. If the spill cannot be contained with hand tools or if secondary containment facilities are in danger of failing, larger equipment will be called in as appropriate. This equipment may include backhoes, front loaders, graders or bulldozers readily available from local contractors.

3. <u>Secure Help</u> - Call the immediate supervisor to secure help as soon as possible, depending on nature and magnitude of spill. This will trigger implementation of the oil spill contingency plan.

4. <u>Spill Cleanup</u> - Cleanup operations should be commenced as soon as containment has been put into effect. Cleanup will depend on the nature of spill but may

range from absorbing spilled product with dirt and properly disposing of dirt, to picking up product with small portable pumps and empty drums, or utilizing vacuum trucks. Oil that has entered a water course may be picked up with oleophilic sorbent pads stored at the field office.

5. Repair of Damage and Return to Normal Operations - Upon completion of cleanup, the reason for the spill will be determined, and remedial action will be taken to prevent future occurrences.

C. Notification

1. Responsibilities of Field & Contract Drilling Personnel - In the event that oil should be accidentally discharged during any operation (drilling or production) it shall be the responsibility of the personnel involved to notify their immediate supervisor. The supervisor shall in turn notify the company Drilling Foreman regarding a drilling spill or the field Production Foreman in case of a production spill. Exhibit 6 (UOCC Dwg. No.1117) is a schematic outline of the oil spill notification procedure.

2. Responsibilities of Company Drilling Foreman - In the event of a minor spill the company Drilling Foreman will direct containment, cleanup, and any

necessary repairs. In the event of a major spill, the company Drilling Foreman will notify the field Production Foreman and then assist him in containment, cleanup and repairs.

3. Responsibilities of the Field Production Foreman - The field Production Foreman shall assess the spill, and, if there exists a chance that spilled oil has been or could reasonably be discharged to any natural water course, he shall immediately notify the Area Manager or other management personnel in the order specified in Section III, C, 5b, Emergency Notification. The Production Foreman's notification responsibility shall be discharged after the Area Manager has been notified.

If the spill is minor (i.e. less than 25 bbl.), has been contained, and cannot reach any natural water course, the Production Foreman shall direct and supervise complete cleanup and return to normal operations without immediate notification of district level personnel.

In either case the field Production Foreman shall be the person immediately charged with containment of any spilled oil. In this capacity he is authorized to:

a. Call out company employees to man heavy equipment, regulate field production, etc.

b. Call contractors for crews and containment and cleanup equipment, if necessary.

4. Responsibilities of Area Manager - Upon notification by the foreman, it shall be the responsibility of the Area Manager to promptly notify the EPA and any other regulatory agencies as applicable. For this purpose a special listing has been compiled under the heading "Agency Notification."

5. Emergency Notifications -

a. In the case of any spilled oil, the following should be notified immediately:

Area Manager - R. O. Engebretsen
Office Telephone - (505) 897-1776
Residence Telephone - (505) 296-4434

Production Foreman - John Merhege
Office Telephone - (505) 829-3700
Residence Telephone - (505) 829-3374

Field Operator - Joseph P. Bowen
Office Telephone - (505) 829-3700
Residence Telephone - (505) 829-3771

b. If these persons are unavailable, then the following list should be pursued in descending order until one of the following is notified: (Note: Personnel below may be reached during normal working hours at (707) 542-9543 or at their home phones listed below after hours. The office phone above is monitored after hours and on weekends by an answering service. The answering service is equipped with a Union Oil Company radio.)

A. J. Chasteen	- Dist. Prod. Supt.	(707) 823-4462
D. Ash	- Dist. Drlg. Supt.	(707) 539-9314
S. C. Lipman	- District Manager	(707) 544-7600

D. Containment and Cleanup for Specifically Identified Areas - Two areas have been specifically identified for containment and cleanup. These areas are indicated on Exhibit 2 (UOCC Dwg. No. 1141) and are numbered accordingly. These areas are where the road crosses Redondo Creek just above Baca Well No. 12 location and at the turn off to the rock quarry approximately 3/4 mile below Baca Well No. 12 location.

Any spill which enters the watershed in Union's current area of activity will eventually enter Redondo Creek. The points selected for containment and cleanup are on

Redondo Creek, below the major activity center, and are places where the creek flow has been confined to a culvert crossing under the road.

A plywood dam can easily be installed at the mouth of these culverts and designed to allow water to flow through but to skim oil. The oil can then be picked up with small portable pumps or oleophilic sorbent pads stored at the project for that purpose.

IV. TRAINING OF PERSONNEL IN SPILL PREVENTION PROCEDURES

Regular meetings are held during which topics of personnel safety, field operating procedures and environmental protection are discussed with field personnel.

A copy of the emergency notifications and general spill procedures is available to each employee who operates in the field and who would likely be involved in a spill situation. The supervisor working for the drilling contractor is required to review the SPCC Plan and familiarize himself with its contents so that he will be able to act promptly in a spill situation.

Training sessions are held to acquaint the operation personnel with recent developments in pollution control and safety as well as improved operation procedures.

Artesia Office

Business Hours	746-4861
Nights & Weekends	
W. A. Gressett	746-4166
L. A. Mermis	746-9205

Hobbs Office

Business Hours	393-6161
Nights & Weekends	
J. T. Sexton	392-5874
L. A. Clements	393-3348
N. E. Clegg	393-4781
J. W. Runyan	392-5696

All the above numbers carry a 505 Area Code.

3. New Mexico Environmental Improvement Agency - Water Quality Division

P.O. Box 2348, Room 518, P.E.R.A. Bldg.,
Santa Fe, New Mexico 87503

Joseph Pierce (505) 827-3286
(24 hours)

B. Confiramtion of Verbal Notifications

Verbal notification of spills shall be confirmed by the Area Manager in writing within two (2) weeks of incident. The confirmation reports shall contain the following information:

V. REGULATORY AGENCY NOTIFICATION

The district level personnel shall notify the following agencies immediately in the event of any oil spill with total volume in excess of 25 Bbl., or any spill, regardless of volume, if there exists a chance that spilled oil has been, or could reasonably be, discharged to any running or dry water course.

A. Verbal Notification

1. Duty Officer, National Response Center (800) 424-8802
   (505) 766-2338

2. State of New Mexico Oil Conservation Commission

   Santa Fe Office

Business Hours	827-2533
Nights & Weekends	
C. G. Ulvog	982-8985
D. S. Nutter	982-0757

   Aztec Office

Business Hours	334-6178
Nights & Weekends	
A. R. Kendrick	334-2555
C. C. Gholson	632-2193
N. E. Maxwell, Jr.	334-6650

1. Reason for discharge of spillage.
2. Duration and volume of discharge.
3. Steps taken to correct problem.
4. Steps taken to prevent reoccurrence of problem.

APPENDIX

Exhibit 1 (UOCC Dwg. No. 1114) Baca Geothermal Project Vicinity Map

Exhibit 2 (UOCC Dwg. No. 1141) Baca Geothermal Project Map

Exhibit 3 (UOCC Dwg. No. 1139) Diesel Fuel Storage Tank at Baca Well No. 6 Location

Exhibit 4 (UOCC Dwg. No. 1140) Typical Drilling Location Site Plan & Equipment Layout

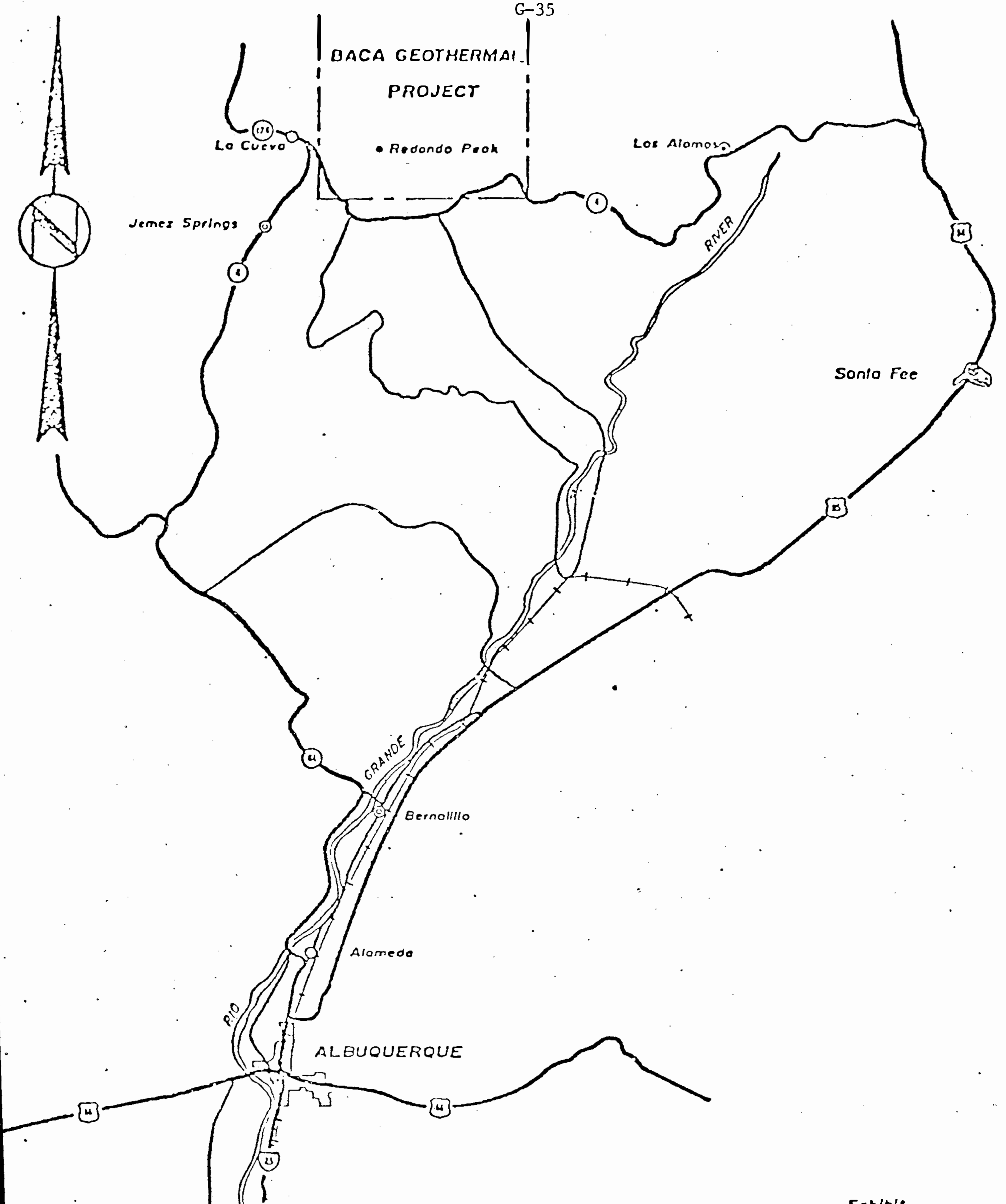
Exhibit 5 (UOCC Dwg. No. 1138) Gasoline Storage Tank at Marshalling Area

Exhibit 6 (UOCC Dwg. No. 1117) Oil Spill Notification Procedure

Exhibit 7 Baca Geothermal Project Personnel List

Exhibit 8 List of Baca Project Supplies and Equipment

Exhibit 9 Contractor List



Exhibit

SED	DATE	UNION	DRAWN
.W.	2-24-76	UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION	FOR: O.W.
		VICINITY MAP BACA GEOTHERMAL PROJECT	BY: L.D.C.
		SANDOVAL CO. NEW MEXICO	DATE: 12-19-7
			SCALE:
			DRAWING NUM

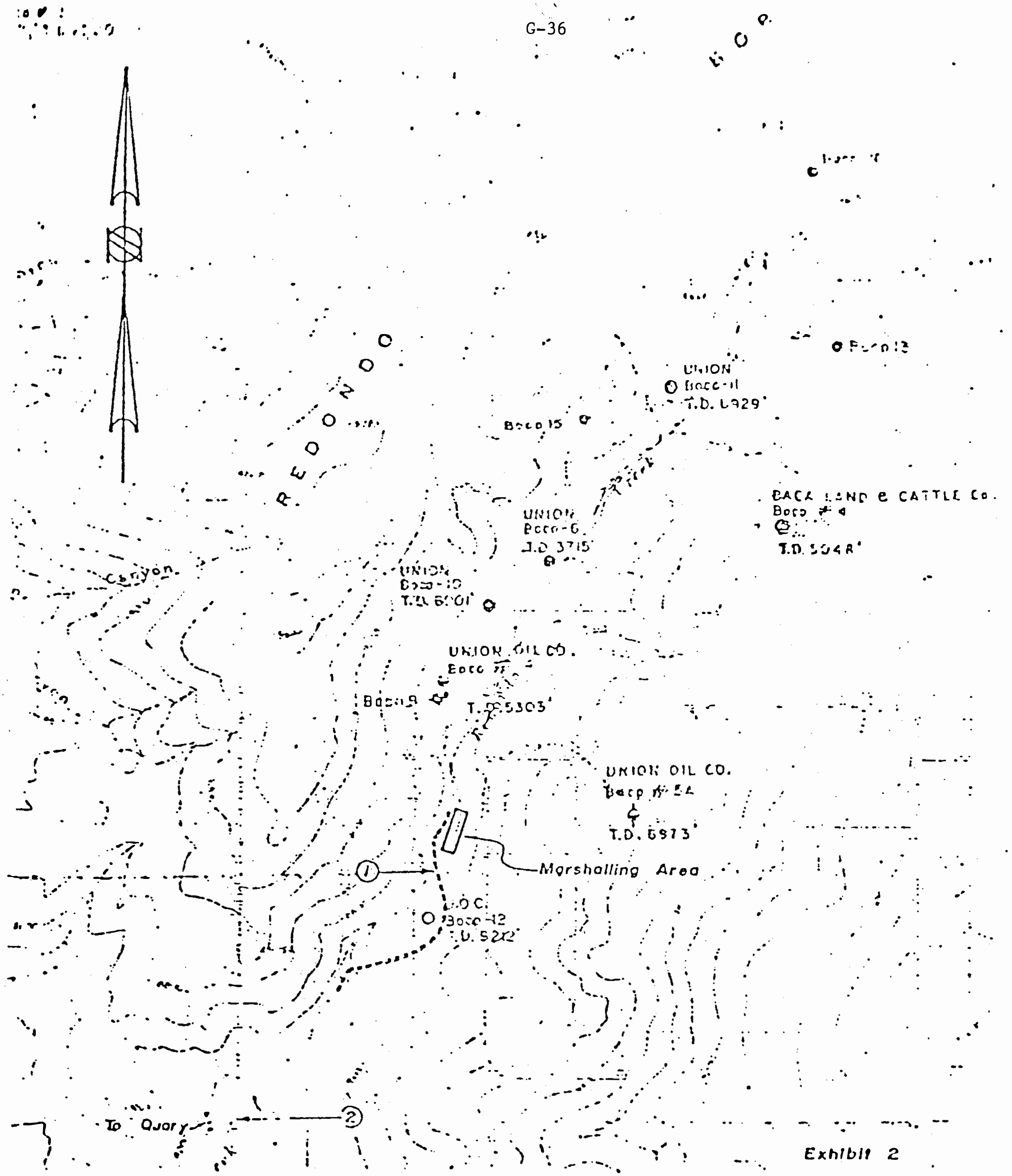


Exhibit 2

REVISED	DATE		
		UNION 76	DRAWN FOR: ODW
		UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION	BY: LDC
			DATE: 2-24
		BACA GEOTHERMAL PROJECT	SCALE: 1" = 20
			DRAWING NUMB

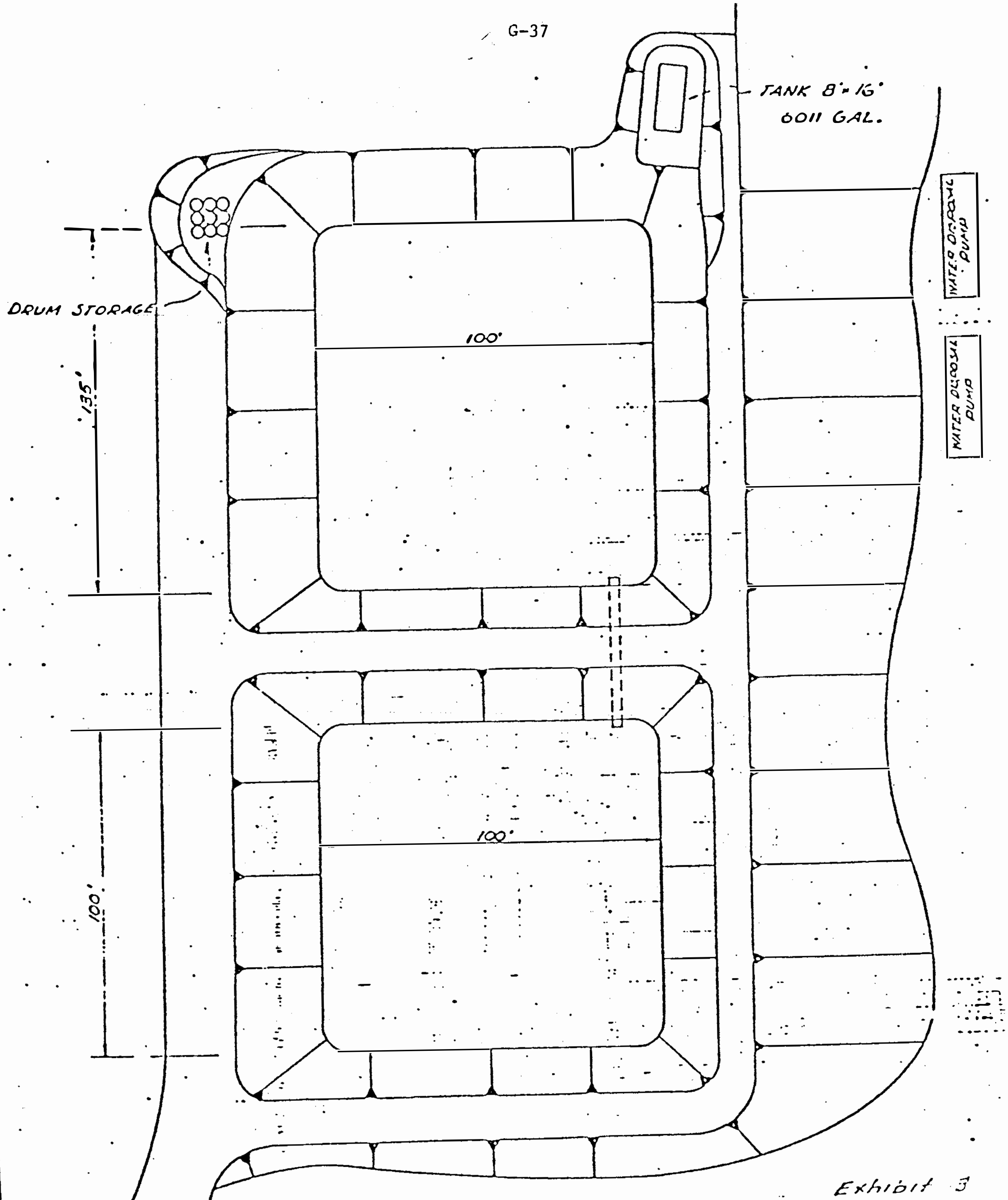


Exhibit 3

ISED	DATE	UNION 76 — UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION	DRAW
			FOR:
			BY:
			DATE:
		WELL LOCATION	SCALE:

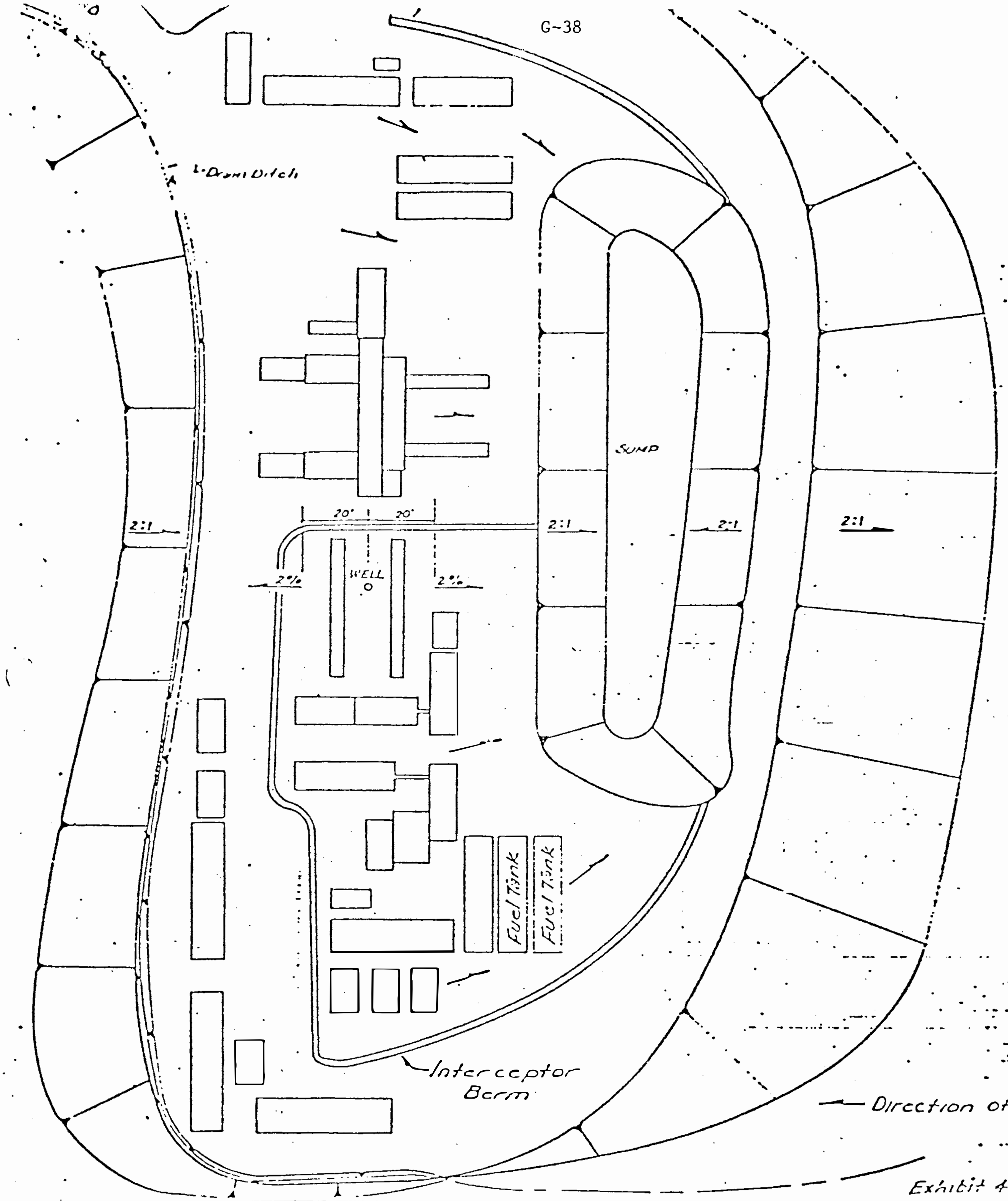


Exhibit 4

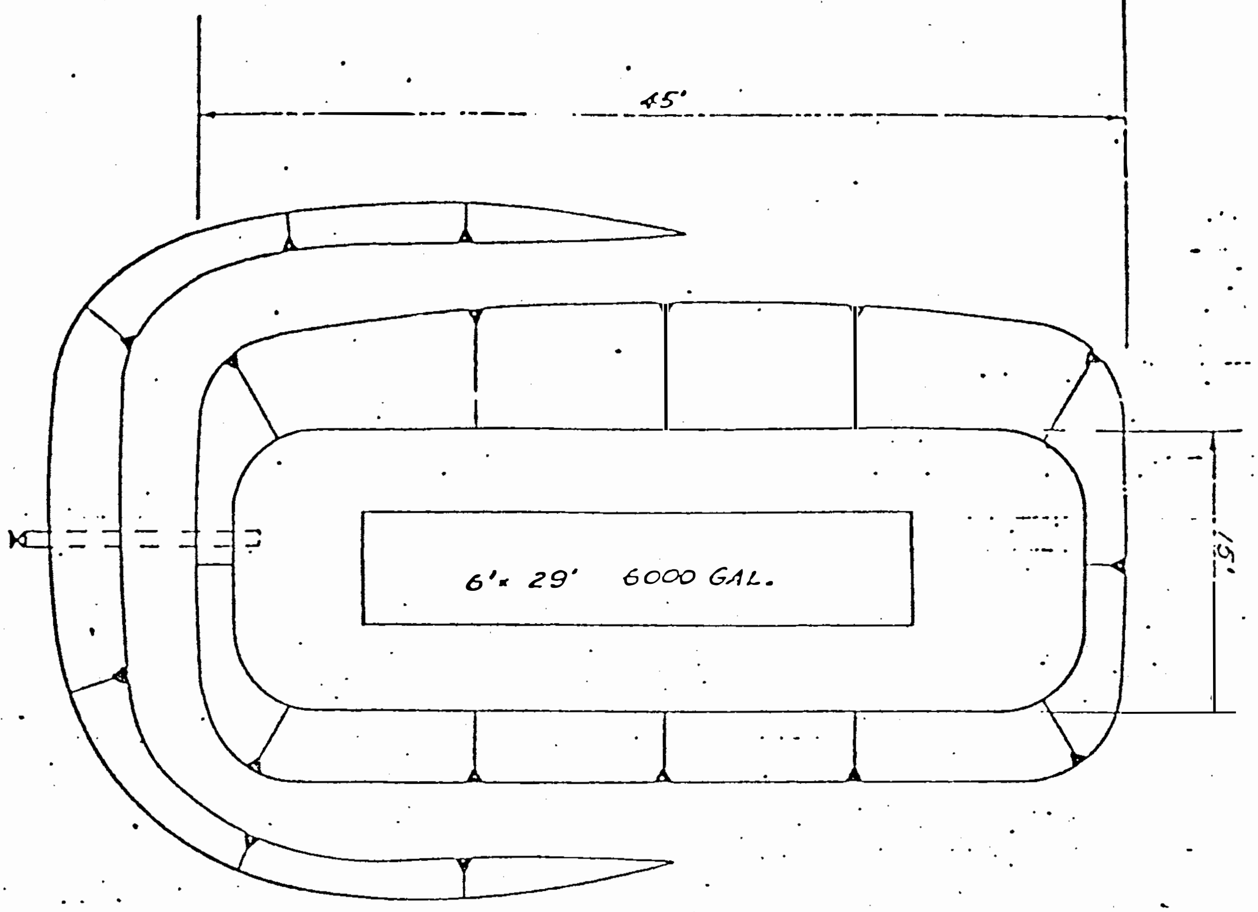
REVISED	DATE
	10-12-75
	11-21-75

UNION

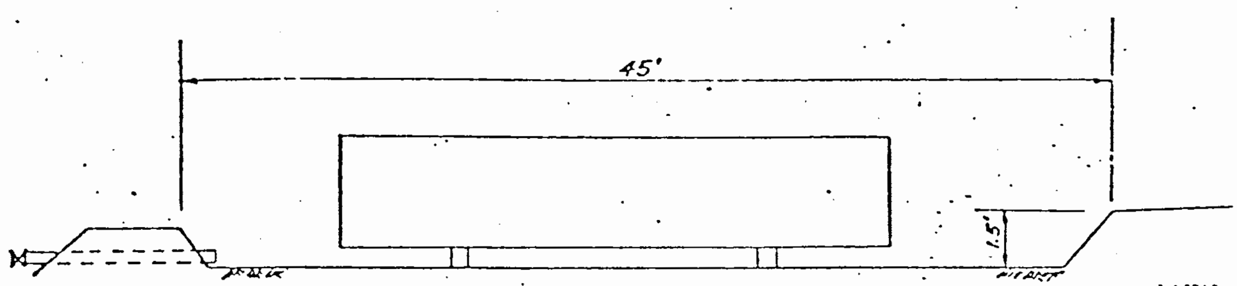
UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION

TYPICAL DRILLING LOCATION SITE PLAN & EQUIPMENT LAYOUT

DRAWN
FOR:
BY:
DATE:
SCALE:
DRAWING NO.



PLAN VIEW



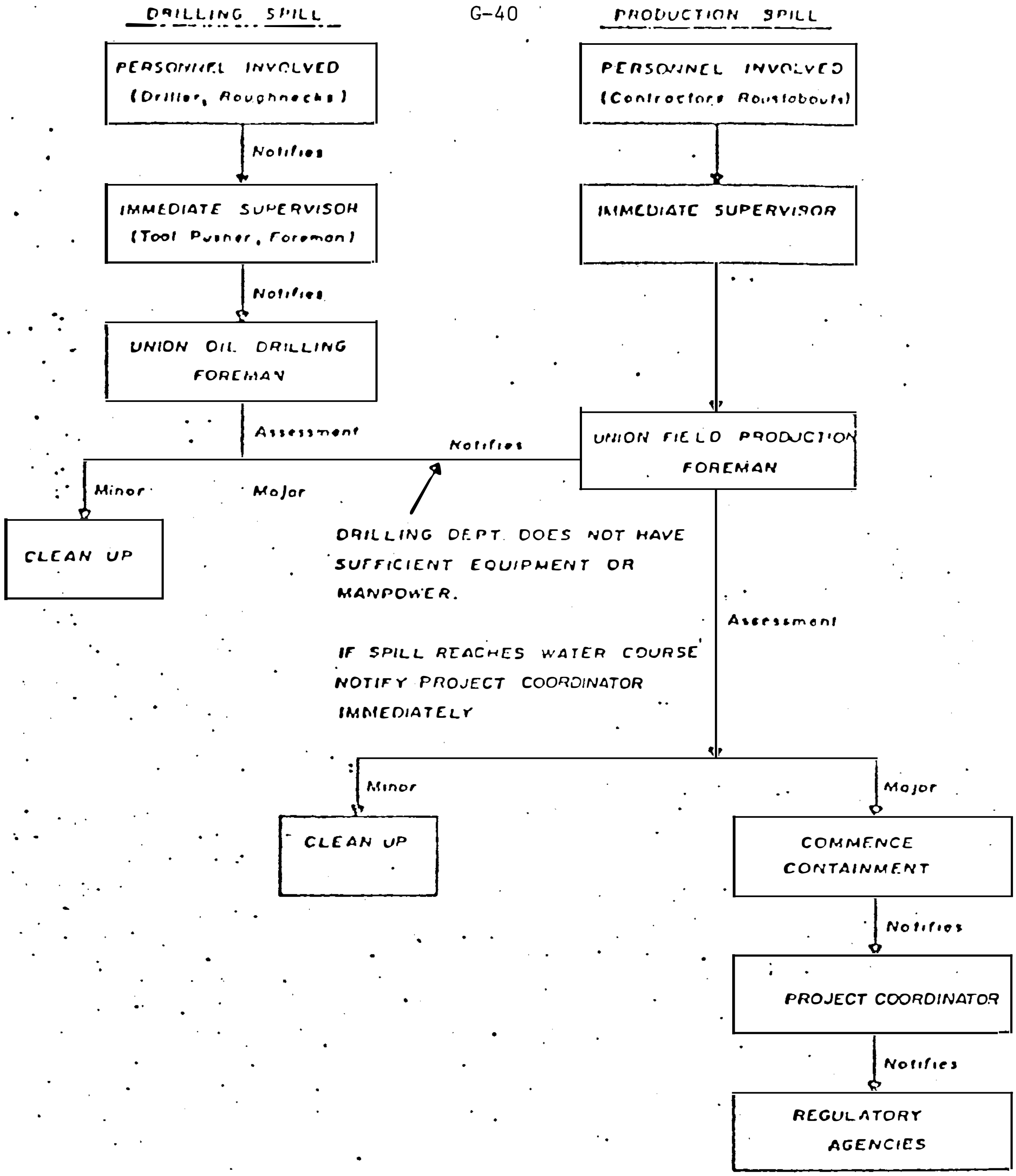
PROFILE

CAPACITY OF BERM 15' x 45' x 1½' = 1012 FT.3

" " TANK 6½2 x .133680555 x 821 FT.3

Exhibit 5

SED	DATE	UNION	DRAWN
		UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION	FOR: O.G.W.
		GASOLINE STORAGE TANK ABOVE MARSHALLING AREA	BY: L.G.C.
		BACA GEOTHERMAL PROJECT	DATE: 2-22
			SCALE:
			DRAWING NU



Minor — Less than 25 bbls. with no chance of reaching a water course.

Major — 25 bbls. or more and or a spill which has or could enter a water course.

All spills where oil enters a water course must be reported, regardless of volume.

Exhibit G

D	DATE
	2-24-76

UNION

UNION OIL COMPANY OF CALIFORNIA - GEOTHERMAL DIVISION

SCHEMATIC OUTLINE OF OIL SPILL NOTIFICATION PROCEDURE

DRAWN
FOR: R E C
BY: L D C
DATE: 11 13 75
SCALE:
DRAWING NUMBER

EXHIBIT 7

BACA PROJECT PERSONNEL

August 1, 1978

Baca Field - Union Oil Staff	Address	Telephone	Company 2-Way Radio
R. O. Engebretsen Area Manager	1408 Nemesia Place, N.E. Albuquerque, N.M. 87112	(505) 296-4434	Unit #1
John F. Merhege Production Foreman	P.O. Box 127 Jemez Springs, N.M. 87025	(505) 829-3374	Unit #5
Joseph P. Bowen Operator II	P.O. Box 66 Jemez Springs, N.M. 87025	(505) 829-3771	Unit #6

EXHIBIT 8

SUPPLIES AND EQUIPMENT

BACA NEW MEXICO GEOTHERMAL PROJECT

DESCRIPTION	CO.NO.	QUANTITY
Chevrolet (1974) Blazer, Utility, 4-Wheel Drive, Serial #CKV 184F146743 License #AP9134	3259	1
GMC (1974) Pick-Up Model #TK20903 4-Wheel Drive, Serial #TKY 244Sf20988 License #224292	3358	1
Ford (1978)Granada, 4-Door Sedan Serial #8W82F194978 Lincense #CJY097	8211	1
Ford (1975) Truck, Model #F750E Serial #F75EVV49664, Lic. #BP1961 With RO Model TC70-2B Crane, Serial #SN-666	4154	1
Chevrolet (1976) Blazer, 4-Wheel Drive Serial #CKL186F191520 License #BX9810	3610	1
Chevrolet (1977) 3/4 Ton Truck, 4-Wheel Drive, V-8 Engine, Serial #CKL 237S206981 License #CH9565	3853	1
Chevrolet (1977) Blazer, 4-Wheel Drive, V-8 Engine, Serial #CKL187Z207602 License #CH1944	3854	1
Portable Centrifugal Water Pumps		
2" x 3" x/5 HP Gasoline Driven, Air-Cooled Engine		1
2" x 3" w/15 HP Gasoline Driven, Air-Cooled Engine		1
Palletized Burlap Sand Bags		100
Oleophilic Sorbent Pad Bales		2
Hand Shovels		12
Hand Rakes		12
Plastic Garbage Bags		100

EXHIBIT 9

CONTRACTOR LIST

BACA NEW MEXICO GEOTHERMAL PROJECT

Allen Contruction Company Farmington, New Mexico Roustabout Crews Gang Trucks and Tools	(505) 325-5076
Brown Trucking Company Farmington, New Mexico Vacuum Trucks	(505) 327-9861
CJC Jemez Springs, New Mexico Roustabout Crews Gang Trucks and Tools Caterpillar D6 Tractors (3) Caterpillar Motor Grader Caterpillar No. 920 Front Wheel Loader Caterpillar No. 930 Front Wheel Loader and Backhoe Autocar 3-Axle Tractor, 2 Flatbed Trailers Various 1/2 Ton Pick-ups	(505) 829-3342
Thompson Vacuum Truck Service Farmington, New Mexico Vacuum Trucks	(505) 325-3181

Appendix H

DEIS HEARING BOARD SUMMARY
AND RESPONSES

LOUISIANA STATE UNIVERSITY
PAUL M. HEBERT LAW CENTER
BATON ROUGE, LOUISIANA 70803

September 25, 1979

Law Faculty

(504) 388-8701
(504) 388-8846

Mr. Bennie G. DiBona
Director, Division of Geothermal Energy
Department of Energy
Washington, D.C. 20585

In re Report of Hearing on Draft Environmental Impact Statement for Geothermal Demonstration Program 50 MWe Plant, Baca DOE/EIS-0049-D.

Dear Mr. DiBona:

Pursuant to your request a Public Hearing on the above matter was held on August 30, 1979 in accordance with the notice published on July 9, 1979 in the Federal Register (44 F.R. 40113) by the panel appointed to conduct the same: Thomas A. Harrell, Robert P. Hartley and Jose Luis M. Cortez.

Transmitted herewith is the record of such hearing consisting of:

1. A copy of the notice as published in the Federal Register.

2. A report by the panel of the matters raised during the hearing.

3. Copies of the Exhibits considered by the panel and identified in the List of Exhibits attached to the panel's report.

4. A transcript of the hearing as reported by the public reporter engaged to record the same.

5. A transcript of a meeting held between representative of the Dept. of Energy and others with the All Indian Pueblo Council, Inc. which was introduced as part of the proceedings.

6. A copy of the Draft Environmental Impact Statement.

I trust that the panel has, by its report and the matters enclosed herewith, satisfactorily discharged its responsibility.

Very truly yours,

Thomas A. Harrell
Chairman

TAH/ebs
Encls.

REPORT IDENTIFYING VIEWS AND ISSUES ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE GEOTHERMAL DEMONSTRATION PROGRAM

Pursuant to a notice of hearing[1] a public hearing was held on August 30, 1979 by the undersigned Hearing Panel on the Draft Environmental Impact Statement (DEIS),[2] for a proposed Department of Energy (DOE) Project to share the costs of construction and operation of a geothermal power plant with Union Geothermal Company of New Mexico (Union) and Public Service Company of New Mexico (PNM) on the Baca Ranch in Sandoval and Rio Arribas Counties, New Mexico. A technical panel comprised of representatives of DOE, Union, PNM and persons involved in the preparation of the DEIS[3] were also present to provide assistance.

The hearing was conducted under the rules set forth in the notice.

INTRODUCTION

Approximately 125 persons registered their attendance at the hearing and oral statements were received from 28 of the participants. A transcript of the oral presentations is transmitted with this report. Written comments from various organizations and individuals were received

1. 44 Federal Register 40113 (July 9, 1979).
2. Draft Environmental Impact Statement - Geothermal Demonstration Program - 50 MWe Power Plant - Baca Ranch - Sandoval and Rio Arribas Counties, New Mexico, July 1979. U.S. Dept. of Energy DOE/EIS-0049-D.
3. The members of the technical panel were: Arthur C. Wilbur, Project Manager, DOE; Jack Maddox, Project Manager for Union and PNM; Harry Arnold, Kathy Oakes, and Mary Moran all of Oak Ridge National Laboratory.

at the hearing and during the period provided for the filing of such comments.[4] These are identified in the List of Exhibits attached hereto, and are sent with this report. On August 16, 1979, as a consequence of the notice, a meeting was held by representatives of DOE, Union and PNM with officers and members of the All Indian Pueblo Council, Inc., at the request of the latter, for the purpose of reviewing the project and its potential environmental impacts.[5] By consent, a transcript of the meeting was made and was submitted on behalf of the All Indian Pueblo Council, Inc., as a part of the record of the hearing.[6] It is also transmitted herewith.

The Panel has organized and discussed the concerns expressed and objections made to the DEIS under three headings:

Part I considers substantial, widespread and serious concerns expressed and objections made to the DEIS on the grounds that its scope was unduly restricted and that it failed to properly address and evaluate impacts upon the environment which would result from the federal action under consideration as mandated by law.

Part II considers objections made and questions raised as to the accuracy and correctness of the technical studies conducted to determine the physical changes the project may cause to the environment and

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4. The time for responding expired Sept. 7, 1979. The Panel did not consider the responses, if any, received from other governmental agencies except those who had representatives appear at the hearing or whose responses were forwarded to it and are contained in the Exhibits to this report.
5. H.5. Note Reference to pages in transcript of hearing will be made as follows: "Tr._____"; to pages of the meeting of August 16 as "H._____"; to Exhihits as "Ex._____" and to pages of D.E.I.S. as "DEIS_____".
6. Tr. 37.

upon which the environmental evaluations in the DEIS are based.

Part III considers a number of objections made and questions raised as to the evaluation in the DEIS of the benefits to be derived and detriments which will result from the project.

Although the Panel has, by this method, attempted to organize its report to permit an orderly and thorough review of the various concerns expressed to the Panel it should be recognized that there is some overlapping of the topics and in a few cases a duplication of the matters covered. For example, in many cases objections to technical studies were also based upon their limited scope and questions were raised as to the evaluations of the impact of the project on the grounds the participants lacked sufficient information as to the total scope of those impacts to intelligently appraise them.

PART I

OBJECTIONS TO THE SCOPE AND SUFFICIENCY OF THE DEIS

A. Objections that the DEIS is legally insufficient in that it does not adequately consider the effects of full development of the Geothermal Reservoir.

The proposed 50 MWe geothermal plant will be constructed under a cost-sharing arrangement between DOE, Union and PNM. Union holds a geothermal lease on the Baca Ranch which occupies approximately 96% of a 100,000 acre tract in the Valles Caldera. The DEIS describes the geothermal reservoir from which the wells for the demonstration plant will be producing as covering an area of 40 square miles and containing hot water on the order of 4.7 x 10^{12} lbs.[7] The agreement between DOE and the other parties is limited to the construction of the 50 MWe plant. The DOE agreement does not cover or involve participation by DOE in the other areas held by Union under lease. Following completion of the demonstration period DOE will withdraw from the project and relinquish any operating responsibilities. The Panel understands Union and PNM are free to develop the remaining portions of the Baca lease and also to conduct other or additional activities on the area covered by the cost-sharing agreement so long as, in the latter instance, such operations are not inconsistent with or do not conflict with the demonstration project.[7a] It would therefore appear future developments of the reservoir beyond the limits of the cost-sharing arrangement or after its termination will not involve substantial federal action requiring other or additional Environmental Impact Statements.[8] There is also evidence geothermal exploration is occurring on lands adjacent to the Baca grant by other companies.

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7. DEIS 3-3.

7a. A letter (Ex. 16) from Mr. James P. Dunigan for Dunigan Enterprises, Inc., owner of the Baca Ranch objects to references in the DEIS at pages 1-3, 3-14 and 4-1 indicating that with full development approximately 746 acres of Baca Ranch will be committed <u>solely</u> to geothermal development. The objection, if the Panel properly interprets it, is to the implication that the use of an area for geothermal development would exclude other uses by the landowner which do not interfere with the geothermal development or operation. It would appear the correctness of Mr. Dunigan's statements are dependent upon the proper interpretation of the lease and what rights were granted or reserved by it. The Panel has not seen the lease.

8. "Expansion beyond 50 MW without Federal funding will require environmental review at the state level for each additional stage of Development" DEIS 4-66.

Many of the participants who made oral presentations expressed concern or raised questions as to the environmental consequences of the additional development to the reservoir which will result from the successful operation of the demonstration plant.[9] It is the Panel's perception that most, if not all, of those persons were also inferentially asserting the DEIS should have fully considered the effect upon the environment which might result from such additional development.[10] A number specifically challenged the sufficiency of the DEIS on these grounds.[11] These challenges (as the Panel perceives them) are substantially based upon the following contentions:

1. The DEIS should address itself to the effects which will be directly caused to the environment if the government action is successfully pursued;
2. One of the stated purposes of the project is to assist, encourage and induce Union and PNM (and perhaps others) to develop the total geothermal reservoir in the Valles Caldera of which the demonstration project is admittedly a part;

9. Sando, Tr. 41; Pino, Tr. 52; Toya, Tr. 61; Poydalena, Tr. 75; Sando, Tr. 84; Lincoln, Tr. 94; Davis, Tr. 159; Biggs, Tr. 170; Dasheno, Tr. 115; Blewer, Tr. 213; Tafoya, Tr. 271. See also Exhibits 18 and 19. A great deal of the discussion at the meeting of August 16 concerned the effects of the full development of the reservoir. See also Ex. 23.
10. As the references in Note 8 will disclose, many of the objections to the project were expressed in terms of uncertainty, lack of knowledge and concern as to what such development might bring to the area.
11. Tr. 41, 75, 76, 95-100, 169, 170, 184, 195, 213, 271. See also H.41. An informal brief by the attorney for the Santa Clara Indians (Ex. 19) especially objects to this as a matter of law. To the contrary, Mr. Dick-Peddie, Tr. 114.

3. Union and PNM indicated they view "the project" as including development of the complete reservoir; and

4. While the DEIS evaluation indicates the principal benefits which will accrue from the project are those intangible advantages occurring from the complete development of the particular reservoir and others of similar nature, it has either inadequately considered or ignored the detriments which may flow from such development.

One or more of the participants called the Panel's attention to the following as supporting the argument that the federal action under consideration is designed to cause such additional development:

1. The stated purposes of the Program Opportunity Notice (PON) from which the proposed project resulted and (presumably) which were evaluated in selecting the project under consideration are (partially):

   "[To] demonstrate reservoir producing characteristics of a specific liquid-dominated hydrothermal reservoir . . . [and to] provide Federal assistance needed to initiate development at a resource of large potential.[12]

2. The costs of the proposed transmission line for the demonstration plant are among those in which DOE will share. This line is designed to carry the power generated by two additional 50 MWe units which will be located in the Valles Caldera reservoir,

12. DEIS 2-2; See also Tr. 15.

thus (presumably) decreasing to PNM the total cost of such additional units.[13]

3. The DEIS recognizes in its summary that "future expansion up to 400 MWe may be encouraged by the 50 MWe demonstration project."[14]

For the proposition that Union and PNM view "the project" as leading to full development of the reservoir:

1. A pamphlet[15] made available to the Panel and distributed by DOE's local office, prepared by Union Oil Company of California[16] entitled "Geothermal Energy - Harnessing the Natural Heat of the Earth" discusses Union's participation in the demonstration plant and describes it as follows: "This development [the 50 MWe plant] is the first step in a project which could produce enough geothermal energy to power electric generating facilities with a total capacity of at least 400,000 kilowatts."[17]

2. At the meeting held by DOE, Union and PNM with the All Indian Pueblo Council, Inc., a presentation was made by a representative of PNM, describing PNM's perceptions of the advantages which will accrue from the project and some of its positive environmental impacts.[18] Among those mentioned was the saving of an estimated 30 billion cubic feet of gas that could be replaced by geothermal

13. DEIS 4-66.
14. DEIS 1-5.
15. Ex. 20.
16. Union Oil Company of California in the parent company of Union Geothermal.
17. Last unnumbered page of Ex. 20.
18. H.21.

steam in the future "if ultimate development takes place in the Baca location and 400 megawatts of electricity are developed".[19]

3. The DEIS concludes that the hydrogen sulfide emissions of the 50 MWe plant should meet existing state standards (of approximately 3 ppb). One participant who questioned the validity of these conclusions (which is discussed elsewhere) also asserted that PNM had applied for a change in the existing New Mexico standards.[20] Another participant claimed that among the justifications given by PNM to the State agency for the change was that the existing standards would prevent full development of the Baca ranch reservoir. It was asserted that PNM had represented to the agency the 50 MWe demonstration plant and full development of the Valles Caldera reservoir were, at least in the view of PNM, inextricably related.[21] The PNM representative at the hearing responded by stating that a change in the standards has been requested by PNM because existing standards were "unduly restrictive" for geothermal development.[22]

If full development by Union and PNM of the reservoir is determined to be an effect or potential effect of the proposed federal action of DOE in sharing the costs of the first stage of the development of the Valles Caldera geothermal reservoir (a question which the Panel is not to resolve)

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19. H.22; See also: "The principal benefit of the proposed project is the intangible benefit of enhancing geothermal development", DEIS 2-28.
20. Tr. 84.
21. Tr. 222.
22. Tr. 191.

the consideration given to the environmental consequences of such development by the DEIS, while not completely absent, appears limited. Part 4.1 of the DEIS describes the impact of the construction of the proposed 50 MWe plant as it relates to land use, water, air, biota, socioeconomic and cultural matters. Parts 4.2, 4.3 and 4.4 contain similar discussions of the impact of the operation of the plant; of potential accidents, and of the construction of the transmission lines. With minor exceptions, the impacts and evaluations considered in these sections are restricted to those directly caused by the construction and operation of the 50 MWe plant, except perhaps to the extent the design and operation of the transmission line contemplates transmission of power from two additional plants.

Section 4.5 of the DEIS does purport to cover "The Effects of Full Scale Development to 400 MWe". This section notes the total environmental impact stemming from the 50 MWe demonstration plant will include the future development of these geothermal resources [i.e., those in the Baca location and under leases outside the boundary] as well as the potential development of up to 400 MWe in the Redondo Canyon/Sulphur Canyon portions of the Baca Location. It then states "the potential environmental impacts of development to 400 MWe cannot be accurately estimated with current information."[23] There then follows an analysis of the possible environmental effect of certain conjectured developments. The Panel is not certain whether the portion of the DEIS quoted above is intended as a statement that the information assembled for the DEIS was inadequate to permit com-

23. DEIS 4-64.

plete evaluation of the development or that the effects of such development are so remote and speculative as to be meaningless and not required for the DEIS. Since the detailed discussion of such matters as water quality, air pollution and noise in the DEIS do not generally consider any effects beyond those caused by demonstration plant and the subject of complete development of the reservoir is treated as a distinct topic in the DEIS, the Panel would assume it to be the former. The matter is also considered in Section 2.5 "Potential Development of Geothermal Resources." This part of the DEIS also indicates the success of the project will probably lead to extensive additional development, describes some of the possible changes such development might bring to the area but appears to disclaim significant consideration of the subject.

B. Failure to Address Sociological and Cultural Impacts of the Project Upon the Native American Indian Population

The Santa Clara and Cochiti Indian reservations are adjacent to the Baca Ranch, on its southern and eastern sides. The principal road providing access to the project site traverses a valley leading into the Valles Caldera from the southwest. This road in main part also parallels the major streams leading from the demonstration site (and the surrounding area) to the Rio Grande River some miles away. The road and streams paralleling it pass through the Jemez, Zia and Santa Ana Reservations.[24] Other Pueblos are in the area.

24. See DEIS A-3.

Representatives and members of the All Indian Pueblo Council[25] strenuously objected to the DEIS on the grounds that it failed to address the impact the project would have upon the unique or particular social, cultural and religious aspects of their communities and way of life.[26] Individual representatives and members of the Santa Clara, Jemez, Cochiti and Zia Pueblos also appeared at the hearing and made presentations. Representatives of the Teseque and San Felipe Pueblos made statements at the meeting of August 16.

The members of all tribes and their representatives also universally complained of the failure of the DEIS to address the effect the project would have upon their community, culture and religion.[27] There was also specific objection made by other persons that the DEIS was legally deficient in this respect.[28]

The Pueblo representatives and members asserted in particular that:

1. The area in which the development will occur, although private property, has traditionally and from time immemorial been used by the tribes for the conduct of religious observances.[29]

2. There are sites within the area of great religious, historic and cultural significance to them.[30]

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25. The council is composed of 19 Indian Pueblos in New Mexico including those mentioned, Tr. 38.
26. Tr. 39.
27. Sando, Tr. 39; Pino, Tr. 47; Toya, Tr. 61; Sando, Tr. 74; Dasheno, Tr. 192-193; Wall, Tr. 223, Herrera, Tr. 258; Palilla H.74; Wehakee, H.84; Tenerio, H.89.
28. Tr. 230, 233, 47, 228, 223. The brief by the Santa Clara attorney (Ex. 19) specifically objects to this.
29. Tr. 44.
30. Tr. 40, 192, 258.

3. They have traditionally gathered herbs and materials from the area for their religious observances which the project would endanger;[31]

4. The water flowing from the general area and particularly down the Jemez river watershed (upon which the Jemez, Zia and Santa Ana Pueblos are located) is of vital importance not only to the economic survival of their pueblos but in terms of their religious and cultural perceptions.[32]

5. The hot springs in the area which may be adversely affected have religious significance.[33]

They complained that the failure of the DEIS to address these matters, was a violation of both the National Environmental Protection Act[34] and the Joint Resolution of Congress commonly called the American Indian Religious Freedom Act.[35]

The members or representatives of the Pueblos who appeared either at the meeting of August 16 or the hearing proper were generally opposed to the Project. It is somewhat difficult for the Panel to evaluate the full extent of the opposition, since in most cases the opponents also coupled their complaints with statements that: (1) the DEIS does not address itself to these concerns and they were unable to determine precisely what impact may occur from the project;[36] (2) the DEIS does not (as discussed in Part A above) address itself to the impact of the full development of

31. Tr. 61, 44, 47.
32. Tr. 49. See also the letter of the Pueblo of Zia, Ex. 21.
33. Tr. 63.
34. Tr. 226.
35. Tr. 47, 192, 199, 226, 230, 233.
36. *Id*.

the reservoir and uncertainty as to the effects such development also occupied much of their presentations;[37] and, (3) they were not consulted adequately as to these matters.[38]

The DOE local office submitted a response directed to the last concern indicating it has taken extensive action since the inception of the process to advise the Pueblos and their representatives of the existence of the proposed demonstration project, that a DEIS was in preparation and to solicite their views on certain aspects of it.[39] It is the Panel's perception that the thrust of most of the complaints concerning lack of consultation were not addressed so much to the lack of notice by DOE but that they were not consulted by those preparing the DEIS concerning the impact the project will have upon religious, social or historic factors deemed relevant to them as mandated by the Joint Resolution of Congress.[40] For example, Governor Dasheno of the Santa Clara Pueblo stated:

> "Secondly, I think the question about consultation is another concern that we have. . . By 'consultation' we mean there was no respect in relation to the social and cultural values that the tribes have."[41]

They also indicated that the failure to consider such matters in the DEIS has effectively denied them the opportunity (which the hearing is to afford) to understand the DOE's plan in light of such factors and criticize or com-

37. *Supra* notes 31-33.
38. Tr. 50.
39. Ex. 14.
40. Ex. 19.
41. Tr. 193.

ment upon the tentative evaluation of the effects of the federal action upon these aspects of their society.[42]

Support for the contention that the DEIS does not adequately address itself to the impact of the project upon the particular cultural, religious and historic values of the Native American Indians and that the failure to do so has deprived them of the opportunity to intelligently present their comments and views was specifically found by the participants in:

1. DEIS Section 4.1.5.2 under the heading "Cultural Impacts" where the concluding sentence notes: "In accordance with the Native American Religious Freedom Act P.L. 95-341 consultation with representatives of Indian groups is <u>currently taking place</u> to share project information and <u>to determine</u> whether the rights of a tribe or tribes may be adversely affected (emphases supplied)".

(The Panel does not find in the DEIS any further consideration of the matters raised; any description of the impacts of the federal action thereon nor any evaluation of such impacts.)

2. Union and PNM requested Dr. Jim Chalmers who made the socioeconomic studies upon which the DEIS was largely founded to appear and describe his work.[43] Mr. Arnold of the technical panel, in response to Dr. Chalmers' presentation, noted that Dr. Chalmers' study was the major (but not the sole) source of socioeconomic data upon which the analysis contained in the DEIS

42. This point, and the argument that the DEIS must be revised and additional hearings then held upon it is made and supported with citation of authority in the Santa Clara brief. (Ex. 19).
43. Tr. 130.

is based.[44] Significantly, Dr. Chalmers described his efforts along those lines as follows:

> "The social concerns we did not investigate in great detail due to the small number of people involved. . . It should be noted that our interviews were largely with people who held elective office, appointive positions, or were some of the major property owners in the area. . .[45]
>
> * * *
>
> Mr. Wilbur: I would like to inquire in the process of your studies, did you have contact with the Indian Tribes in the area, could you outline very briefly what these were?
>
> Mr. Chalmers: No, we did not."[46]
>
> * * *
>
> "Mr. Harrell: I gather from the comment you made earlier that you did not consider in any way the peculiar values that the Indian population may hold that would be affected by the project, is that correct?
>
> Mr. Chalmers: That's correct. . ."[47]

44. Tr. 143.
45. The Panel also notes the owner of the Baca Ranch on which the development is occurring complained of lack of consultation (Ex. 16).
46. Tr. 142.
47. Tr. 144.

PART II

OBJECTIONS TO TECHNICAL STUDIES

Concerns were expressed by several participants as to the adequacy of the technical analysis in the DEIS regarding hydrology and water quality, air pollutant emissions and standards, operational noise, potential fluid spills, and the impacts of accidents and vandalism.

A. Hydrology and Water Quality

The hydrological analysis in the DEIS and the supporting assumptions were extensively questioned by one of the participants,[48] e.g. the use of arsenic as a tracer may be incorrect because it is not a stable constituent in natural waters of the area.[49] The same participant also contended that a total inventory of streams, springs, and aquifers is needed to estimate deep circulation flow and surface water loss.[50] Objection was made to lack of analysis of potential stream depletion other than that of the Jemez River. The concerns regarding the hydrological analysis did not appear to question the validity of the data base but rather the scope and methodology of interpretation.[51] Further concerns related to the hydrological analysis included comments as to general inadequacy[52] and fears that stream and spring flows would decrease and that no mitigation has been considered.[53]

Some concern was also expressed as to the validity of very limited water quality sampling, whether the sampling locations are near enough to

48. Tr. 21-27.
49. Tr. 23.
50. Tr. 24.
51. Tr. 32.
52. Tr. 224
53. Tr. 153.

populated areas, and the inattention given to the effects of water use on the downstream villages.[54] The DEIS includes chemical data from three sites[55] and appears to use earlier data from other sources to complete its surface water description. The discussion is in fact limited.

Several participants expressed views, that the Panel interprets as a serious general concern, regarding the hydrological and water quality effects of the much larger development the project is expected to stimulate. The Panel has previously noted that the hydrological effects of full development do not appear to be materially addressed by the DEIS.[55a] Union proposes to mitigate the effect of any reductions in the flow of the Jemez River system caused by the project by abandoning certain water rights of unspecified quantity it has obtained for the irrigation of some 54 acres on the river. The DEIS states approximately 14 acres will be retired as a result of the 50 MWe demonstration plant, the balance being held for "future development". The DEIS notes that the water of the Jemez system is fully appropriated. The Jemez and Zia Pueblos claimed they possessed prior rights to the water; that existing state records are incomplete, inaccurate and unrepresentative of existing rights.[56] They denied the validity of Union's rights or that they had either parity with or priority over theirs. The DEIS does not reveal the location of the land affected by Union's rights; discuss the impact caused by withdrawal of irrigated crop lands caused by the project, nor address itself to the questions of whether the rights obtained are adequate - i.e. Union proposes

54. Tr. 224.
55. DEIS 3-42, 3-44, 3-46.
55a. Infra, Part I.
56. Similar objections are made by Santa Ana Pueblo, Ex. 23.

withdrawing approximately 30% of the rights held for the first plant - but asserts its future plans contemplate as much as an eight-fold expansion of the reservoir.[56a]

B. Air Pollutant Emissions and Standards

The technical validity of the mathematical model used to predict the dispersion of hydrogen sulfide (H_2S) emissions from the project site was questioned by several participants.[57] The DEIS methodology used a modified flat terrain model.[58] Two of the participants suggested "high-terrain" models be used[59] to more accurately predict H_2S dispersion in the mountainous project area. One participant[60] suggested such models are available. The Panel notes that neither the participants nor the DEIS specifically addressed the adequacy of any models to reliably predict dispersion in the project situation. It would appear that the ability to predict the ambient H_2S concentration resulting from the 50 MWe plant operation is very important because of the State's low ambient H_2S standard of 3 parts per billion (ppb) and the nearness to that of the DEIS prediction of 1 to 2 ppb at the nearest Baca property line.[61]

As previously mentioned, concern was expressed regarding the request by PNM for a relaxation of the State's standards - apparently in anticipation of the much larger development which may be stimulated by this project.

56a. A letter (Ex. 11) from the Chief, Water Rights Bureau, State of New Mexico Water Resource Division, describes that Bureau's understanding of the New Mexico regulatory scheme for water rights.
57. Tr. 82, 175, 215.
58. DEIS 4-27.
59. Tr. 82, 175
60. Tr. 175.
61. DEIS 4-27.

The requested change is to not exceed 50 ppb, as a one-hour average, more than three times per day, nor more than 140 ppb as a one-hour average, more than twice a year.[62] Although the Panel recognizes that this request in no way implies that the State will approve it or any other deviation from the present standard, it may confirm that PNM expects a much larger development to evolve from this project. The DEIS does not materially address a development larger than 50 MWe, nor the effects of the resulting higher H_2S emissions.

One participant asserted that the options available to reduce H_2S emissions had not been adequately addressed in the DEIS[63] and further suggested that, since the uncontrolled emissions were from the cooling tower, a dry cooling tower could reduce these by up to 98 percent. The DEIS indicates three options for H_2S control were considered; the "Stretford process";[64] the "Iron Catalyst process", and "upstream absorption scrubbers".[65] The Stretford process was selected and will allow from 43 to 50 lb/hr of H_2S to be released to the atmosphere from the cooling tower during normal operations.[66] The DEIS does not consider the advantages (or disadvantages) of further reduction of H_2S emissions which might be obtained by other means such as the use of a second process.

One participant[67] questioned the origin of the particulates that averaged 40 mg/m^3 over a 3-month period at a site above Redondo Creek.[68]

62. Tr. 217.
63. Tr. 173.
64. DEIS 2-23, 2-25.
65. DEIS 9-21, 9-22.
66. DEIS 2-25.
67. Tr. 175.
68. DEIS 3-59.

He inferred the origin to be in geothermal activities since the value is far above natural ambient values expected in the area. The DEIS does not explain the origin of the particulates.

Finally a concern was raised as to the possibility of the presence in geothermal fluids of hydrides of other elements closely associated with sulfur, i.e., tellurium, selenium, arsenic and phosphorus, all of which were claimed to be much more toxic than H_2S.[69] The technical panel observed that the formation thermodynamics of these other hydrides indicate they would not be expected to be present in the geothermal fluids.[69a]

C. Noise

One participant expressed a concern about the noise levels at the proposed project and its potential impacts[70]. The DEIS indicates a noise level from air drilling and steam ventings may be as high as 133 dBA, a level damaging to the human ear.[71] The Union Oil representative said that drilling and steam venting of the kind referred to would not occur at the site. The DEIS does not discuss the possible venting of the total steam supply, nor the control thereof, in the event of unplanned plant shutdown. There is indication that this may not necessarily be a rare occurrence, particularly if the development expands beyond the 55-MWe project stage. Such an occurrence would appear to represent a significant change in the now-existing character of sound in the project area. Additionally, the DEIS[72] does

69. Tr. 179-180. See also Ex. 8 for a description of the basis for this concern.
69a. Tr. 185.
70. Tr. 206-213.
71. DEIS 3-91.
72. DEIS 4-37.

not appear to substantially address the impacts of operational noise.

D. Spills, Accidents, and Vandalism

The Panel has grouped these concerns because, if they occur, they will probably be temporary or isolated events that may be interrelated. Concerns were expressed for increased highway accidents resulting from increased traffic,[73] inadequate discussion of plant spills resulting from turbine trips, blowouts and pipe ruptures,[74] and spill mitigation measures.[75] Spills might result from human error, vandalism, or equipment failure. The concerns were noted for both plant personnel safety and the surrounding population. The Panel interprets the concerns to imply an assertion that the planned preventive and mitigative measures, as described in Section 4.3 of the DEIS, are insufficient. Although the impacts of spills are discussed at some length in the DEIS (Section 4.3), the DEIS does not address potential vandalism, nor the measures that would be implemented to prevent or correct the consequences of fluid losses, should they occur, for example, in Redondo Creek.

PART III

OBJECTIONS TO ENVIRONMENTAL EVALUATIONS

During the course of the hearing, several concerns were discussed by participants which relate the evaluation of the effects of the proposed project. While some of these appear to concern quite peripheral matters, others do involve direct and significant effects upon the environment.

73. Tr. 154.
74. Tr. 157.
75. Tr. 167.

All are reported to permit full evaluation of the impact on the communities most affected.

A. <u>Adequacy of highways and road ways to be used by the construction companies during the projected two year construction schedule</u>.

Several times during the hearing, the question was raised as to whether highways are suitable to accommodate growth in the Jemez area, specifically,

1. At the meeting with the Indian pueblo representatives on August 16, 1979, it was noted that the DEIS did not address the problem of inadequate road conditions or bridges on State Road 4 leading to geothermal site from the South. The Indian representatives were concerned as to who would upgrade highways 4 and 44 to make them safe under increased heavy traffic conditions.[76] The DEIS describes State Highway 4 (which crosses the Jemez Pueblo) as "being ruled unsafe by the New Mexico Highway Dept. principally for hazardous conditions. . ."[77]

2. The same question was raised during the hearing by the Indian Pueblo Council representatives who again questioned the effect of the geothermal development on the road system.[78] Two other participants also noted that the State Roads 4 and 44 (the best routes to the site) traverse the Pueblo of Jemez. Indian residents are within twenty or thirty feet from State Highway 4

76. H.109.
77. DEIS 3-89
78. Tr. 40

which has been given unfavorable ratings by the New Mexico State Highway Department. The Zia Pueblo's representative specifically expressed the Pueblo's concern with the increased traffic the project would bring to these highways. The Zia representative stated that in the past two years there has been a number of accidents resulting in the death of 2 percent of the tribal population.[79]

3. Dr. Chalmers, as previously noted, assembled the data which was the principal source of the socioeconomic analysis made in the DEIS. He characterized the highway situation both on New Mexico 44 and Route 4 as having "some problems as does much of the state systems". Although "he did not believe the problems were truly serious". He did consider it "imperative" that close communication be maintained between the project and State Highway Department in this regard. Dr. Chalmers also indicated his conclusions were derived solely from consideration of the effect of construction of the 50 MWe plant, and did not take into account the effect of full development of the reservoir.[80]

B. Location and type of transmission lines to be built for proposed 50 megawatt pilot plant and subsequent additions.

The subject of transmission lines, their type and location was touched upon several times during the hearing. Questions were raised about the transmission lines for several reasons:

79. Tr. 48, 54; Ex. 21.
80. Tr. 133, Ex. 13 p.3.

1. Concern was expressed as to why the size of the proposed transmission lines for the 50 Megawatt facility were larger than required for that plant and are designed to accommodate up to two additional units.[81]

2. The exact location within the proposed "corridor" (which is a mile in width) of the line was not exactly given to inform the public where this line would be.[82]

3. The effect of additional transmission lines required for future development was inadequately discussed.[83]

It was asserted that the justification for the size and location of the power line to the nearest major load center located near Los Alamos, New Mexico was reached primarily for economic reasons.[84] The record shows that PNM has stated additional transmission line facilities may have to be constructed depending on the magnitude of the geothermal development.[85] Objections were made that the DEIS does not address the environmental impacts resulting from such power lines. It was stated that the transmission line right-of-way problems are critical to the project because of their effect on the scenic beauty of the Jemez Mountains.[86] The need for care in planning future location of transmission lines was noted by Dr. Chalmers.[87] Dr. Ted Davis, a Jemez Spring resident, objected to the large area to be cleared for the purpose of installing towers along the transmission line

81. H.20.
82. Tr. 81.
83. See in particular the Forest Service response Ex. 18.
84. See Ex. 18.
85. H.20-21.
86. Tr. 81.
87. Tr. 141.

corridor.[88] Concern was expressed that the southern route is 20% longer and has more potential for causing erosion and stream sedimentation due to the ruggedness of path than the northern route. The disadvantage noted in the DEIS for the northern route (Baca) route indicates it may be more related to the fact that it traverses more of the Baca's property which is designated as the Valles Caldera National Landmark than to direct environmental consequences of the construction.[89]

C. <u>The effects on the existing and proposed designation and use of the Jemez area</u>.

The Jemez Mountain area surrounding the Baca property contains numerous recreational areas which are part of the National Park Service lands and the Santa Fe National Forest. The Baca Ranch itself is currently designated as a National Natural Landmark. It was stated this designation is based upon the fact that the Valles Caldera is the world's largest extinct volcano.[90] The area has historical and archaeological significance. It was asserted on several occasions by many of the participants[91] that the proposed 50 megawatt power plant and subsequent development of the site would compromise the area's special status and also affect nearby recreational facilities. It was contended that in reports by the U.S. Park Service, geothermal development activities and subsequent development were said to be a major threat to the integrity of the Landmark and might destroy Landmark status.[92] It was stated that at least three federal agencies and the

88. Tr. 156, 157.
89. Tr. 171, 172.
90. H.45, 46; Tr. 171
91. Tr. 171, 88, 89.
92. Tr. 168. See also Ex. 22.

state of New Mexico have expressed interest in procuring the Baca property or portions thereof because of its geologic, biologic, historic and religious significance to the surrounding Indian tribes.[93]

It was said that conversion of the privately owned Baca property to public holdings would lead to land use priority questions. Mr. Sanders of the Los Alamos Mountaineers reported that, based on conversations with Mr. Dunigan of Dallas, Texas (representative of the owner of the Baca Ranch), such a transfer of ownership of the Baca properties is probable. He urged the environmental impact study to consider the effect large scale industrial development of the area would have upon both its present recreation and wilderness use and that which might occur if land is transferred to public ownership.[94]

D. Who has the legal responsibilities to protect the site from being altered or destroyed as a recreational and scenic area?

One of the participants expressed a concern as to how and by whom the public will be assured that environmental requirements and guidelines are actually adhered to,[95] and whether the public is assured that environmental damage will be prevented where quantitative limits do not exist. He specifically mentioned the disposal of drilling muds, reseeding, air quality standards, noise, cooling tower drift, erosion, siltation and plant abandonment. While the DEIS describes the initial permitting procedures required to implement the process it does not address the assurances

93. Tr. 82, 169; H.45, 46.
94. Tr. 88, 89. Mr. Dunigan's letter (Ex. 16) tends to confirm such matters are under consideration.
95. Tr. 183-184.

sought by the participant or what laws and viable implementation mechanisms exist to control environmental impacts throughout the operational phase. It has previously been noted that DOE's participation in the project is limited to about 5 years of the estimated 30 year life of the demonstration plant and does not extend to other parts of the reservoir. Mention is made, indirectly, of the environmental legal regime with respect to air pollution. To some extent the DEIS appears contradictory regarding the H_2S standards where they are variously described as being an ambient standard of 3 ppb, and as "3 ppb above ambient concentrations".[96]

E. Alternatives to proposed power generating plant design in order to save limited water resources in the area.

It was asserted the DEIS implies water consumption from the proposed 50 megawatt plant of twenty-six hundred forty acre-feet per year.[97] Representatives of the Bureau of Indian Affairs, Albuquerque Office, asserted such a consumption rate could have significant adverse impact on the water resources. They noted an alternative plan of operations using dry towers is described in section 9.6.1.2 of the Draft Environmental Impact Statement which contemplates an alternative dry tower cooling system that eliminates consumptive water loss.[98] The technical members of the panel responded to this suggestion by saying that such an alternative system would be too expensive and may not be technically feasible.[99] The DEIS concludes the effect upon ground and surface water supplies of the water consumption

96. DEIS 3-59, 4-22.
97. Tr. 26.
98. Tr. 23, 27.
99. Tr. 34, 35.

of the demonstration plant will not itself be significant.[100] The importance of water to the area and its scarcity appears to be unquestioned. The environmental and economic trade off of such matters in the context of a <u>demonstration</u> project and its effect upon the hydrology of the area, if the process it demonstrates is adopted as the mode of geothermal development in the reservoir or region is not addressed by the DEIS. It was asserted that in view of the importance of the water issue dry cooling towers or other alternatives should be considered as a way of reducing the water consumption.

F. <u>The economic feasibility of the project was questioned in terms of the cost of producing electrical energy by geothermal means as opposed to coal or oil fired plants</u>.

One of the participants raised questions about the economics of the project.[101] Economic analysis was presented which was said to show that the DOE's participation was not only necessary but essential to the project since the cost of a geothermal plant would be several times that of an ordinary natural gas or coal burning plant.[102] It was then argued that even with DOE support, the resulting price of electricity to the consumer would still be going up.[103] The PNM representative on the technical Panel responded and pointed out that with Federal assistance the 50 megawatt facility would be cost-competitive.[104] The DEIS does not mention what factors are sought to be demonstrated by the plant which would encourage

100. DEIS 4-19.
101. Thomas W. Hill (Tr. 115).
102. Tr. 115.
103. Tr. 119.
104. Tr. 124.

belief or demonstrate that similar plants would be cost-competitive or economical to operate without federal support.

G. Concern was raised regarding the presence of other drilling companies in the Jemez Mountain area.

In addition to the Union Oil Company of California exploration activities in the Jemez Mountains it was stated that there are several other companies doing exploration work in the area. The Indian tribes named several companies presently searching for geothermal resources by drilling the region: Amax, Chevron, Aminol, Sunco, Phillips and Union Oil of California.[105] The Indian tribes contended the present project will lead to total development of the overall geothermal resource of the area.[106] Indians claimed that Amax, for example, has some understanding for the sale of the geothermally produced steam to the PNM.[107] Their concern for this has previously been mentioned as giving rise to questions as to the scope of the DEIS.

H. The concern was raised that the success of the proposed geothermal power development will lead to the generation of a substantial amount of power unnecessary for area needs.

It was claimed the power developed from the geothermal reservoir will be exported outside the state and that it is unfair to ask the local people to bear the environmental burdens of producing power for others.[108] The Indians contended that the success of this project will bring a great number of other companies to do similar activities and this will have an im-

105. H.38.
106. H.39, 40, 95.
107. H.45.
108. Tr. 269, H.40.

pact on the total area of the Jemez Mountains. They foresee a compounding of effects which will ultimately affect the area significantly.[109]

The need or requirements for the power to be produced by this and ensuing projects has not been addressed in the DEIS, nor is the use to be made of the power arising from development of the Baca Reservoir considered, except for the statement that Los Alamos can use the 50 MWe and that it will "help solve an existing voltage fluctuation" there.[110]

I. <u>In addition to related issues and comments, some of the participants used the occasion to express certain frustrations in dealing with government</u>.

In addition to the comments directly related to the environmental aspects of the 50 megawatt geothermal power plant, some participants expressed considerable frustration arising from governmental actions generally occurring in the area and involving federal lands. Objections were expressed to "outside" corporations, and government agencies coming to the southwest and making determinations and decisions concerning local resources, and developing those resources for the benefit of the rest of the United States and leaving the local communities to deal with only the adverse effects.[111]

Mr. E. Lujan, an employee of the New Mexico Legal Services of Albuquerque, New Mexico, addressed himself to the rights of Indians and Chicanos in the area to be most affected by this project. He made references to the Treaty of Guadalupe Hidalgo signed between Mexico and the

109. H.95, Tr. 268.
110. DEIS 2-17. The Forest Service also questions the decision to direct the power to Los Alamos. (Ex. 18).
111. Tr. 227, 228.

United States in 1848, which he claimed is the basis for Indian and Chicano rights in this area ceded by Mexico. He asserted the treaty protected their culture and language. On this basis, Mr. Lujan claimed limited information was provided the Spanish speaking Chicano community in regions affected by this project. Mr. Lujan also specially objected to the fact that the socioeconomic study neglected the Indian and Chicano cultural and historic values.[112] He specifically requested more information be made available to the Chicano community in Spanish as well as English.

Indian participants made reference to other private and government projects located in Indian land such as the uranium mines near Grants, New Mexico, and the nuclear waste site in southwestern New Mexico where the Mescalero Apache Indians live.[113] The thrust of these comments and tenor of the complaints is represented by the summary of one participant; "to the Indians, geothermal, uranium and/or nuclear makes no difference, to them this constitutes the destruction of the land and to destroy the land is to destroy the people."[114]

Submitted by:

Thomas A. Harrell, Chairman

Robert P. Hartley, Member

Jose Luis M. Cortez, Member

112. Tr. 230-232.
113. H.80, Tr. 244.
114. Tr. 244

LIST OF EXHIBITS

Exhibit No.	Document
1	Letter dated July 4, 1979 from G. Theodore Davis
2	Letter dated July 16, 1979 from Richard Holden for New Mexico Public Interest Research Group
3 *	Letter dated July 19, 1979 from Robert F. Mattheis - Acting Director, Environmental Affairs Division, General Services Administration
4 *	Letter dated August 3, 1979 from Charles T. Crowley, Chief Environmental Services Branch, U.S.D.A. (R.E.A.)
5 *	Letter dated August 7, 1979 from William H. Regan, Jr., Acting Assistant Director for Environmental Projects and Technology U.S. Nucleur Regulatory Commission
6 *	Letter dated August 8, 1979 from A. W. Hamelstrom State Conservationist, U.S.D.A.
7 *	Letter dated August 14, 1979 from Bill F. Isaacs and Janie Chavez for New Mexico State Heritage Program
8	Letter dated August 17, 1979 from G. J. Biggs, Board Member for New Mexico Citizens for Clean Air and Water
9 *	Letter of August 24, 1979 from Raymond R. Gallegos, State Forester, New Mexico Natural Resources Department
10 *	Letter dated August 25, 1979 from Bob E. Wyatt
11 *	Letter dated August 27, 1979 from D. E. Gray, Chief, Water Rights Bureau, New Mexico Natural Resources Department
12 *	Letter dated August 29, 1979 from William Stone, Program Chairman, Sangre de Christo Audubon Society

13 **	"Testimony by" Dr. James A. Chalmers, Arizona State University and Mountain West Research Inc. dated August 30, 1979
14	"Draft" dated September 1, 1979, entitled DOE/GDPP Office Efforts at Communications with Indians, etc. from Arthur C. Wilbur, Project Manager, D.O.L.
15 *	Letter dated August 31, 1979 from Jack M. Heinemann, Advisor on Environmental Quality, Federal Energy Regulatory Commission
16 *	Letter dated September 5, 1979 from James P. Dunigan, for Dunigan Enterprises Inc., and Baca Land and Cattle Company
17 *	Letter dated September 6, 1979 from George Scudella, Geothermal Energy Consultant, New Mexico Energy and Minerals Department
18 *	Letter from James C. Overbay, Acting Regional Forester, U.S.D.A. Forest Service
19 *	Informal Brief dated September 7, 1979 by Bruce J. Terris, attorney for Santa Clara Pueblo
20 ***	"Geothermal Energy" undated pamphlet by Union Oil Company of California
21 *	Letter dated September 6, 1979 from "Pueblo of Zia"
22 *	Letter dated September 11, 1979 from Louis S. Wall, Chief, Western Division of Project Review, Advisory Council On Historic Preservation.
23 *	Letter dated September 10,1979 from Luebben, Hughes & Kelly, attorneys for Pueblo of Santa Ana.
24 *	Letter dated September 5, 1979 from G. J. Biggs, Board Member for Geothermal Energy, Los Alamos Chapter, New Mexico, Citizens for Clean Air and Water.

* These exhibits are found in Appendix F of the FES, Comments and Responses

** Refer to Hearing Transcript, see references for Chapter 12 for complete citation.

*** This pamphlet is not reproducable. Available upon request from Union or DOE, Division of Geothermal Energy.

PO Box 21
Jemez Springs
NM 87025
July 4, 1979

F.A. Leone
Division of NEPA Affairs
US DOE
Washington, DC

Dear Mr. Leone:

Enclosed are ten more signatures requesting public hearings on the BACA Geothermal Project. The total petition signatures submitted by me is now 87.

I recently heard through a member of New Mexico Clean Air and Water that public hearings are indeed scheduled, but only in Albuquerque and only 45 days after release of the DEIS.

In order to assure public awareness and understanding, and per our suggestion, it would be helpful to hold hearings in Santa Fe, Albuquerque, and Los Alamos, and no sooner than 4 months from the public availability of the DEIS. A failure to allow adequate time for evaluation and discussion concerning this project could on y lead to greater misunderstanding between the people and the utilities, oil companies and DOE. I will look forward to hearing from you concerning this matter.

Sincerely,

G. Theodore Davis MD

G. Theodore Davis, M.D.

To: Mr. F.A. Leone
Division of NEPA Affairs
Mail Station E-201, GTN
U.S. Department of Energy
Washington, D.C. 20545

Re: Proposed Union Oil of California/Public Service Company of New Mexico/DOE Jemez Mountain Geothermal Development

Dear Sir:

We, the undersigned, are concerned about geothermal power development in the Jemez Mountains, Baca Location. We request separate public hearings in Albuquerque, Santa Fe and Los Alamos in order to address the various potential and known environmental, social and economic impacts of this development. To assure adequate public input and awareness, we request that these hearings be scheduled no sooner than four months from the date of public availability of the Draft Environmental Impact Statement (DEIS).

NAME	ADDRESS	Please send me a copy of the DEIS (check here)
1. John Vitale John Vitale	338 Washington N.E. ALBUQ. N.M 87108	✓
2. Richard T. Barton RICHARD T. BARTON	1641 PRINCETON SE ALBUQ. NM 87106	✓
3. Christine Peterson	1641 Princeton SE Alb. 87106	
4. David J. Lindner DAVID J. Lindner	4812 Aztec NE 87110 (Albuquerque)	✓
5. David L. Whitlam	5115 Glenfield Rd. NW Alb. 87114	
6. Michael Dennis	1205 Las Lomas N.E. (Albuquerque)	
7. Dana Williams	PO Box 10185 Alameda 87184 (Albuquerque)	
8. Arthur W. Elfendahl	712 Princeton S.E. 87106 Alb. N	
9. Philip Eric Jackson	616 Spruce NE 87106	✓
10. Perry R. Walker Jr.	5147 Jennie Rd SW 87105 Alb. N	

NM PIRG new mexico public interest research group

1057 Mesa Vista Hall ·UNM
P.O. Box 4564
Albuquerque, N.M. 87106
(505) 277-2757

July 16, 1979

Department of Energy
Division of Geothermal Energy
Room 3122C
Washington, D.C. 20585

Dear Mr. Bennie G. Di Bona,

As a representative group of over 21,000 students at the University of New Mexico in Albuquerque, our public interest group would like to make an oral presentation at the pbulic hearing on The Draft Environmental Impact Statement, DOE/EIS-0049-D. We will be present at the Shalako Motor Inn in Albuquerque, New Mexico on August 30, 1979. As our current staff includes university students who have class schedules, it is of utmost importance to know the exact time of our presentation.

We will also be preparing written comments by September 7, 1979 to insure that our comments will be noted in the final preparation of the final environmental impact statement.

Thank you for informing us of our presentation time. Do you have any format for the presentation to follow? Your prompt assistance in these matters is greatly appreciated.

Sincerely,

Richard G. Holden

Richard Holden
Program Assistant
Treasure ,NMPIRG

RH: mjd

New Mexico Citizens for Clean Air and Water

P.O. Box 5
Los Alamos
New Mexico 87544
17 August 79

Mr. Bennie G. DiBona
U.S. Department of Energy
ET-57
Division of Geothermal Energy
Mail Stop 3122C
20 Massachusetts Avenue, NW
Washington, D.C. 20585

Dear Mr. DiBona:

This letter is to confirm the content of the telephone conversation I had the morning of August 15 with Mr. Robert Oliver of your Division.

The Los Alamos Chapter of NMCCA&W intends to speak (preferred time: p.m.) at the public hearing on the Baca Geothermal Demonstration Power Plant Draft EIS to be held on August 30, in Albuquerque. Statements will be presented by myself and perhaps one or two other members of the Los Alamos Chapter.

Although even a brief summary of our presentation cannot be provided at this time, we do intend to address such topics as: possible contamination of local creeks due to pipe rupture and failure of holding basins; drawdown of nearby surface springs; threat to the National Natural Landmark Status of Baca Location No. 1; visual impact of transmission lines (especially those seen from the Los Alamos townsite); emission of hydrogen sulfide and the Public Service Company of New Mexico's request for a variance to the State ambient air standard; lack of hard facts concerning potential release into the air of the highly toxic tellurium and selenium compounds of hydrogen; atmospheric dispersion models used in the DEIS; certain socioeconomic aspects of the project; and the general question of legal responsibility for environmental damage and the lack of quantitative limits at both the State and Federal levels.

Sincerely,

G.J. Biggs
Board Member for Geothermal Energy
Los Alamos Chapter

DOE Form AD-10A
(12-71)

U.S. DEPARTMENT OF ENERGY
memorandum

DATE: September 5, 1979

REPLY TO ATTN OF: Geothermal Demonstration Power Plant Project Office

SUBJECT: GDPP Project Office Contacts With Native Americans

TO: Bill Manning, Assistant Manager for Projects, DOE/SAN

The DEIS Public Hearing may have created the impression that our Project Office has been less than diligent in working with local tribes to mitigate GDPP impacts. My own impression is that we have made an appreciable effort to promote contacts and information exchange. I think the tribes discontent on this issue predates our Project Office establishment in New Mexico.

For the record, the following summarizes our efforts towards effectively interfacing with the Indians.

1. <u>Contacts and meetings with All Indian Pueblo Council (AIPC) beginning April 1979</u>

   Numerous telecons and at least six face-to-face. AIPC said they would arrange for meetings with interested Tribal Councils and Governors.

2. <u>Contacts and Meetings with Tribes</u>

   a. <u>Santa Clara</u>

   - April 1979 (with PNM) met with Governor and tribal officials (at their request) to give information on project.
   - June 8, 1979 met with tribal officials at Santa Clara Pueblo. Stated my desire to avoid infringement of religious sites, needs and practices and asked their help (they referenced a book, which I purchased and am reading).
   - Provided (through phone calls and mailings):
     - U.S.Forest Service EIS
     - Information on Amax operations and other Government agency responsibilities re: those operations
     - A U.S. Geological Survey contact for discussing Amax operations.
     - Other information on geothermal energy

   b. <u>Jemez</u>

   - June or July 1979, met with Jemez Governor and Council to provide information and answer questions. Stated my desire to avoid infringements on their religious sites, needs, and practices, and asked their help.

c. Cochiti

Followed up on DEIS meeting with Pueblos re Clarence Weahke's contention that Indians are excluded from Bandelier National Monument (he told me this is historical complaint, no longer a problem).

- Tried to follow up with Mr. Herrera (who is also Director of New Mexico State Office of Indian Affairs), following Pueblo site tour, to see if any more information or meetings desired (left that message, but call not returned).

d. Zia

- On Americans for Indian Opportunity (AIO) project site tour, while stopping at Zia, reiterated to Governor my interest in meeting with him and council to provide information and answer questions, if they are interested.

e. Isleta

In response to letter from Isleta Governor re project, called Governor. Encouraged him to come to DEIS meeting with Pueblos and to come to Public Hearing. Also made offer to come talk with him and his Council. Followed up with letter, reiterating.

3. Project Briefing and Project Site Tour - May 14, 1979

This was arranged through AIPC. It covered both the GDPP and Hot Dry Rock. A briefing and Q and A session at LASL was followed by a tour of both sites. Participant provided buses at LASL and lunch for Indians.

At least the following Pueblos were represented: Jemez, Santa Clara, Zia, Cochiti, Tesuque. I offered to meet with any individual Pueblo or groups for further interchange. Also asked their help in the matter of religious impacts, since we are anxious to avoid all adverse impacts.

4. Pueblo Meeting on DEIS - August 16, 1979

AIPC tried to get all Pueblos to attend. Meeting was on their territory. Meeting was organized and chaired by them, with their rules for meeting conduct. We paid costs (including meeting room at Pueblo Indian Cultural Center, court recorder, and transcript of meeting). Transcripts were provided to Pueblos through AIPC.

5. Meeting on Native Americans Religious Freedom Act - June 22, 1979

A DOI, (Washington, D.C.) taskforce (including a DOE Office of Indian Affairs representative) held a meeting on the Native Americans Religious Freedom Act to get reactions of Indians on the act and how it should be implemented. I attended at the invitation of the DOE member of the Task force.

6. Americans for Indian Opportunity (AIO)

Project site tour, July 11, 1979. This tour was for the AIO Directors. Pueblo representation was sparse as AIO is a national organization (Jemez was represented, and there are pueblo Indians on the AIO staff).

7. Media Interaction, Specific to Pueblos

- Jan. or Feb. 1979 - Interview of self and PNM by Pueblo News.
- August 1979 - Article (attached re The Pueblo DEIS Meeting).
- August 1979 - PNM and I appeared on Pueblo's half-hour TV program and answered questions on GDPP.

A C Wilbur

Arthur C. Wilbur
Project Manager

Enclosure:
As Stated

cc: Al Jelacic, DOE/HQ, w/encl.
Bennie DiBona, DOE/HQ, w/encl.
Harry Arnold, ORNL, w/encl.

RESPONSES TO HEARING BOARD SUMMARY

OBJECTION TO RESTRICTING DEIS TO 50MW(e)

The DEIS addressed the proposed Federal Action which by previous NEPA interpretations within DOE consists of Federal Support by direct funding, shared funding, or loan guaranty, and Federal action such as licensing of facilities. In conformance with the spirit of NEPA, various court rulings, and precedents set by previous EIS's, the possible future consequences of the federal action were also discussed. For this specific project the Federal Action is shared funding by DOE which extends only five years into operation of the 50 MW plant. As a direct consequence of a successful demonstration the chances of increased development in the project area are substantially greater than with an unsuccessful demonstration, therefore, the potential environmental consequences of this enhanced development are delineated in the DEIS. It is not possible to perform a detailed analysis of potential impacts for future plants in Redondo Canyon and Sulfur Canyon until a development scenario is postulated, plant locations are identified, and reservoir interactions are better known.

In recognition of the numerous comments with respect to full-scale development, Sections 2.5 and 4.5 of the DEIS have been expanded in the FES to provide a more complete explanation of the cumulative effects of development and the potential erroneous results from direct extrapolation from a 50 MW plant.

IMPACT ON CULTURAL AND RELIGIOUS VALUES OF NATIVE AMERICANS

The DEIS recorded the amount of information available to the writers regarding religious and cultural impacts. As a result of the public meeting with the AIPC and the public hearing on the DEIS there is substantially more documentable information on the subject which has been summarized in the FES.

The religious issue is a cultural and a legal metter. The legal aspects are being addressed by DOE by identification of and consultation with, Pueblo Religious leaders in accordance with DOE's suggested procedure for carrying out Federal Policy established by the American Indian Religious Freedom Act.

TRANSMISSION LINE CORRIDOR ANALYSIS

The impact analysis of transmission lines was done in the DEIS on the basis of generalized corridors, which is a well established method frequently employed by Public Service Company of New Mexico and other utilities. At this early stage in the project a specific right-of-way along a selected corridor has not been identified. As described in Section 2.2.4.1 of the FEIS, right-of-way selection studies will proceed after one of the two proposed routes has been chosen. The right-of-way selection and structure placement within the corridor will be based upon detailed engineering and environmental studies and decided upon in consultation with the landowner or land management agencies involved. All potential impacts of construction and operation of the 115 kV line anywhere within the generalized corridors have been discussed in the FEIS; a final right-of-way within the selected corridor will be chosen which will involve the least possible environmental impact.

HYDROLOGY AND WATER QUALITY

1. The arsenic dilution method study for determining the amount of geothermal reservoir-derived component of spring and streamflow was used in the DEIS as a "best available" estimate of flow depletion resulting from reservoir production. It was recognized by the staff that the amount of leakage from the geothermal reservoir determined in this manner would probably be less than that actually occurring. It was subsequently determined from a study using chloride, bromide, boron, and lithium ratios that as much as 24% more geothermal outflow was occurring in the Jemes River than had been estimated using arsenic dilution ratios. The EIS has been modified to reflect the change (Summary, Sections 3.1.3.2.1, 3.1.3.2.2, and 4.2.2.2).

2. A recent inventory of the groundwater and associated surface water resources of the Jemez Mountains has been conducted (Trainer, 1978) (see Sections 3.1.3.2.1 and 3.1.3.2.2).

3. It was determined that the Jemez River system would be the only one potentially depleted by geothermal reservoir production; therefore, other major streams in the region were disregarded.

4. A groundwater monitoring program to determine potential impacts on stream and springflow has been proposed and implemented. The program is described in Sections 11.1.1.2 and 11.2.2.2.

5. The surface water quality data given in the DEIS were the best available, and should be approximately representative (a number of the values listed were averages of analyses made on several different dates). As stated in Section 3.1.3.1.2 of the DEIS, domestic (including drinking) water for larger communities along the Jemez River is obtained from wells or springs. The chemical quality of groundwater in the area is currently being determined as part of the proposed hydrologic monitoring program (Sections 11.1.1.2 and 11.2.2.2.).

6. Union proposes to mitigate the effect of any reductions in the flow of the Jemez River system caused by the project by abandoning certain water rights of unspecified quantity it has obtained for the irrigation of some 54 acres on the river. The DEIS states that approximately 14 acres will be retired as a result of the 50 MWe demonstration plant, the balance being held for future development (see Section 2.2.5.3 and 11.1.2.2).

NOISE

The DEIS stated that the loudest noises of geothermal development, air drilling and steam venting will not occur for this project. This is because those two operations are only necessary with a steam resource, whereas the Baca resource is predominantly liquid. Futhermore, advances in muffling technology have made it possible to substantially reduce these high noise levels (to approximately 90 dBA) at places where they are necessary, such as at the Geysers field in California. The expected construction and drilling noises at Baca, as stated in the DEIS will be a maximum of 90 dBA, at 15m (50 ft)(DEIS pp. 4-16) not 133 dBA, based on measurements and experiences with development of this type of geothermal resource. A muffled steam vent such as from a turbine trip, will be expected to produce noise levels of approximately 95 dBA at 15m (50 ft.) for the period of maximum discharge (less than 48 hours, approximately 2 times per year). The effects of multiple noise sources from full scale development will be to add approximately 3 db per identical noise source to the ambient level.

The effects of operational noise were discussed in Section 4.2.6 of the DEIS. The only known impacts of noise are related to human perception for which the DEIS states it will be virtually inaudible to the nearest humans. It is not possible to predict the effects of noise on animals nor to separate noise effects from the effects of human presence (discussed in Sections 4.1.4 and 4.2.4 of the DEIS). A statement to this effect has been added to Section 4.2.6.

SPILLS, ACCIDENTS, AND VANDALISM

The reference to vandalism in the DEIS was intended to show that (1) surface pipe ruptures are infrequent and (2) the causes of the historical surface ruptures are potentially controllable in that deliberate acts were involved in several unattended locations. There was no intent to forecast that vandalism will cause environmental impacts at this site and existing and future access control measures of the proposed plant should be adequate to keep this probability low.

FUTURE PUBLIC OWNERSHIP OF THE BACA RANCH

The discussion of potential future public ownership of the Baca Location No. 1 has been expanded in the FEIS to reflect the results of a Department of Interior/National Park Service study of public acquisition alternatives for the Valles Caldera/Baca Location No. 1, which was received after issuance of the DEIS. The expanded discussion may be found in Sections 3.1.1.4 and 4.1.1 of this FEIS.

LEGAL ENFORCEMENT OF ENVIRONMENTAL REGULATIONS

The legal enforcement of environmental regulations arises from two potential sources; (1) regulatory agencies within state, local, and federal governments that have jurisdiction over environmental effects of the proposed plant, and (2) contractual agreements between DOE and the commercial partners to provide certain services, design philosophies, and monitoring programs. All mitigating measures referred to in the DEIS represent currently agreed-to project philosophies, design parameters, or performance criteria between DOE and the commercial partners and to the extent they are binding on the parties, are legally enforceable.

ALTERNATIVE PLANT DESIGN TO SAVE WATER

The consumptive use of geothermal fluid by the 50 MW power plant is approximately 2640 ac. ft/year without allowance for approximately 20% downtime per year. However, the impact of geothermal fluid consumption on fresh water systems is much less and was estimated in the DEIS (Section 4.2.2.2) to be slightly more than 16 ac. ft/year (10 gal/min.). This impact is expected to be widely distributed and generally not measurable to any single set of water users. The commercial partners are required by law to obtain and retire water rights equal to the estimated consumptive use of fresh water in order to operate the plant.

DRY COOLING TOWERS

In addition to the higher capital and operating cost of dry cooling towers, the technology for application to geothermal power plants is at a developmental stage. Since the PON by which this project was selected did not require a demonstration of water conservative cooling, the cooling system proposed by the commercial partner represented a balance of cost, technological factors, environmental impact, and water consumption among the available plant design alternatives. As discussed earlier, the analysis of impacts in the DEIS does not indicate a potential for significant impact from this consumptive use of water, thereby minimizing the need to demonstrate dry towers with this project.

Appendix I

COMMENTS AND RESPONSES

INDEX

FEDERAL AGENCY COMMENTS AND RESPONSES

Advisory Council On Historic Preservation

1522 K Street NW.
Washington D.C.
20005

Reply to: P. O. Box 25085
Denver, Colorado 80225

September 11, 1979

Mr. Bennie G. DiBona
Division of Geothermal Energy
U.S. Department of Energy
Room 3122C
Washington, D.C. 20585

Dear Mr. DiBona:

This is in response to your request of July 11, 1979, for comments on the draft environmental statement (DES) for the proposed Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico.

Pursuant to its responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969, the Council has determined that this DES does not demonstrate compliance with Section 106 of the National Historic Preservation Act of 1966 (16 U.S.C. Sec. 470f, as amended, 90 Stat. 1320). However, on August 20, 1979, the Council received documentation from the Department of Energy requesting Council comment pursuant to Section 106 and the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800). Upon receipt of additional documentation, requested by our letter of September 7, 1979, we will be able to conclude our review and comment on this undertaking. The Council's comments should be included in the final environmental statement.

Should you have any questions, please contact Mrs. Jane King of the Council's Denver office at P. O. Box 25085, Denver, Colorado 80225, telephone number (303) 234-4946, an FTS number.

Sincerely,

Louis S. Wall

Louis S. Wall
Chief, Western Division
of Project Review

RESPONSE TO ADVISORY COUNCIL ON HISTORIC PRESERVATION COMMENTS

See Appendix E for DOE's compliance with the Council's regulations, "Protection of Historic and Cultural Properties" (36 CFR Part 800).

United States Department of Agriculture
Soil Conservation Service
Box 2007
Albuquerque, NM
87103

August 8, 1979

Mr. Bennie G. DiBona
U. S. Department of Energy
Division of Geothermal Energy
Room 3122C
Washington, DC 20585

Dear Mr. DiBona:

This office received a copy of the DES-Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico.

Our review indicates that the DES presents very adequate information about those natural resources for which the Soil Conservation Service has a concern. We do not find that the identified resource losses or project-induced impacts would have great significance. Proposed mitigation techniques would further reduce the impacts.

We are not aware of additional resource values which would be affected by the proposed actions. There are no Soil Conservation Service projects which would be affected.

Thank you for the opportunity to review this proposed project.

Sincerely,

Ray Margolf, for
A. W. Hamelstrom
State Conservationist

NO RESPONSE REQUIRED

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AUG 0 7 1979

Mr. Bennie G. DiBona
U.S. Department of Energy
Division of Geothermal Energy
Room 3122C
Washington, DC 20585

Dear Mr. DiBona:

This is in response to your request for comments on the Draft Environmental Impact Statement for the Geothermal Demonstration Program 50 MWe Power Plant at Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico.

We have reviewed the statement and determined that the proposed action has no significant radiological health and safety impact nor will it adversely affect any activities subject to regulation by the Nuclear Regulatory Commission. Accordingly, we have no significant comments to make.

Thank you for providing us with the opportunity to review this Draft Environmental Statement.

Sincerely,

Wm. H. Regan, Jr., Acting Assistant Director
for Environmental Projects & Technology
Division of Site Safety and
Environmental Analysis

cc: EPA (5)

NO RESPONSE REQUIRED

UNITED STATES OF AMERICA
GENERAL SERVICES ADMINISTRATION

Public Buildings Service
Washington, D.C. 20405

JUL 19 1979

Mr. Bennie G. DiBona
Division of Geothermal Energy
U.S. Department of Energy
Room 3122C
Washington, DC 20585

Dear Mr. DiBona:

The General Services Administration has reviewed the draft environmental impact statement for the Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico, and have no substantive comments to make.

Thank you for the opportunity to comment.

Sincerely,

ROBERT F. MATTHEIS
Acting Director
Environmental Affairs Division

NO RESPONSE REQUIRED

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER-79/668

SEP 18 1979

Mr. Bennie G. DiBona, ET-57
Division of Geothermal Energy
MS 3122C
Department of Energy
Washington, D.C. 20585

Dear Mr. DiBona:

The Department of the Interior has reviewed the draft environmental statement for the Geothermal Demonstration Program, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico. We have the following concerns and comments.

General

The Department of Energy proposes to cost-share the construction and operation of a geothermal powerplant with Union Geothermal Company and Public Service Company of New Mexico. The proposed plant is located on the Baca Ranch 17 miles west of Los Alamos, New Mexico and 20 miles northwest of the headquarters of Bandelier National Monument and partially surrounded by several Indian Pueblos. The project includes a 115-kV transmission line from the plant to a substation near Los Alamos.

The draft environmental statement generally provides detailed documentation of the project's direct and indirect environmental impacts, many of which are acknowledged to be both adverse and significant. However, the document contains a large amount of site-specific and highly technical information on project impacts. These need to be brought together into summary conclusions on the overall magnitude and significance of the cumulative impacts on various components of the regional environment. The draft environmental statement acknowledges that the area affected by the proposed geothermal powerplant and the associated transmission corridor alternatives contains an exceptional diversity of nationally significant archeological, hydrological, geological, ecological, scenic and recreational resources. The following material will elaborate on these topics.

In our role as trustee for the Indian people on lands under the jurisdiction of the Department's Bureau of Indian Affairs (BIA), we have two basic concerns. One is the Jemez Mountain hydrologic system and the possible effects of the proposed project upon water rights of Indian people. The other is the existence of Indian sacred areas within the Baca Ranch lease area. The draft statement indicates the project will withdraw about 2667 acre-feet per year from the geothermal reservoir. Based on previous studies using certain assumptions, calculations show that this would produce approximately a 16 acre-foot per year reduction of Jemez River flow over the life of the project. This is less than 1 percent of the Jemez flow. While this is a small reduction there remains serious uncertainty about its actual quantity in a river system already fully appropriated, including unquantified first rights for adjacent Indian tribes.

As reported in supporting documents, the estimated discharge to the Jemez River from the geothermal system is based on the dilution ratio of arsenic in the two waters. Essentially, no other data are offered to support the estimate that 264 acre-feet per year is the total natural discharge from the geothermal reservoir. If this figure is in error, so would be any quantification of the impact of the geothermal drawdown.

The description of effects on the surface water and ground-water system is inadequate for the purpose of defining depletion of the downstream hydrological system as detailed below.

1. Arsenic is an unsuitable ion for use as a tracer. Arsenic is naturally lost from waters containing high concentrations by precipitation, complexing, and absorption, particularly upon exposure to the atmosphere. A reduction in arsenic concentration does not necessarily imply dilution by surface waters as was assumed in the applicant's study. Chloride and boron are better suited to dilution studies and imply about two to four times the reported discharge (dilution ratios of 0.024 and 0.04 respectively).

2. The applicant assumes that no geothermal water leaks from the caldera to other perennial streams because surface and shallow groundwater flow into the Jemez River. Water movement can be expected to differ at one-mile depth from that at the surface, and geothermal discharge into the thick unconsolidated sediments and into streams on the north and east sides of the Jemez Mountains is evident from the geometry of the flow system. Discharge to points other than the Jemez River is not treated in the streamflow depletion calculation.

3. Depressurization of the geothermal reservoir will amount to many hundreds of feet. The increased vertical gradient, perhaps doubled, could proportionally increase leakage from the surface streams back into the groundwater system.

4. The supporting report of geothermal discharge is restricted to the Jemez River. A total inventory of streams, springs, and aquifers throughout the Jemez Mountain area is needed to estimate additional flow through the deep circulation system and corresponding greater surface water loss due to the proposed development.

5. The statement describes consumptive use of 2667 acre-feet per year discharged to the atmosphere, with additional surplus condensate being reinjected into the geothermal reservoir. It is apparent that the alternative plan of operations using dry towers, described in section 9.6.1.2 of the draft, could capture and reinject all geothermal water produced. The benefits of maintaining reservoir pressure, minimizing fresh water leakage into the reservoir, and reducing stream depletion and air quality problems would be substantial.

6. The calculation of a schedule of surface water depletion is based on a mathematical model of the Jemez River and its connection to part of the caldera. The change in pressure in the geothermal reservoir is calculated as inversely proportional to the assumed porosity, and the reduction in flow to the Jemez River is calculated accounting for the reduced reservoir pressure, the approximate geometry of the Jemez River system and an original reservoir discharge of 264 acre-feet per year.

The supporting report lists the assumptions in this calculation:

1. Geothermal discharge is 264 acre-feet per year. This value is based on the arsenic dilution ratio and, as remarked above, may be in appreciable error.

2. Initial conditions are in equilibrium.

3. Porosity of 0.1 (10 percent) is the report's "better estimate." The report acknowledges that results are sensitive to this assumption. The pressure decline in the reservoir is more accurately described by the specific storage, i.e., coefficient of expansion of water and rock, rather than the porosity. The pressure decline calculated using the assumed porosity may be in error by a factor of 10 or 100, with a proportional effect of increasing the schedule and magnitude of stream flow depletion.

4. System boundaries are restrictively assumed. Losses from 80 percent of the caldera rim are ignored.

5. Joint and fault control is assumed negligible.

6. The effects of 500°F. water on pressures and hydraulic conductivity is neglected. If this factor were treated in the flow calculation, then well water levels should be reduced to 80 percent of the height above the open interval (reduced as much as 1,000 feet), and water flow would be increased about 8 times due to a reduction in viscosity.

Use of the above assumptions is indicative of the insensitivity of the analysis and limitations on accuracy introduced in the calculation of stream flow depletion. The draft statement acknowledges that "...the total reduction in groundwater outflow...resulting from reservoir drawdown is not known at this time." Because of this uncertainty and the possibility that serious impacts to the surface water flow could result from the project, we recommend a more complete study of the entire caldera. Such a study should seek to minimize the reliance on assumptions and should view the hydrology of the Jemez Mountains and the caldera as an integrated unit.

The statement describes an alternative dry tower cooling system that eliminates consumptive water loss. The Department of Energy is urged to allocate part of the costs of the project to a nonconsumptive dry tower cooling system for this demonstration and as a precedent for future geothermal plants in the arid West.

As the draft statement recognizes on page 3-80, there are numerous active Indian religious sites within the lease area. Considering the responsibility placed upon the Department of Energy by the American Religious Freedom Act of 1978 (P.L. 95-341), we consider the Department of Energy treatment of this concern to be inadequate. The statement "...it has been suggested that the religious significance of the area should be carefully considered in all future plans..." fails to satisfy the Department of Energy's responsibilities in this area. More explicitly, we believe that such consideration is mandated by the legislation.

Additionally, we note that some nominations to the National Register of Historic Places are suggested. We recommend that, if the consent of the tribes holding the areas sacred is received, that the Department of Energy nominate the sites.

In regard to the proposed transmission line corridors, we view as unacceptable the projected impacts of the southern transmission corridor on Bandelier National Monument. This transmission route would have significant adverse impacts on the natural, scenic, and recreational values of the monument. We recognize that the affected area is subject to a leasehold for geothermal development, which encompasses use of the surface estate for reasonable purposes associated with production. In view of the fact that the draft environmental statement provides convincing evidence that a shorter, more environmentally compatible transmission corridor through the Baca Ranch (not involving monument lands) is available, we believe that use of monument lands for transmission purposes does not constitute a reasonable use. We therefore will not authorize use of the monument for this purpose and recommend that further consideration of this alternative be abandoned.

The Department's National Park Service (NPS) and the State of New Mexico have completed a Study of Alternatives for the caldera. This study evaluates the area's resources, identifies existing and potential threats to their integrity, and assesses the consequences and effectiveness of alternative strategies for their protection, use, and management. Authorized by Section 8 of the General Authorities Act of October 7, 1976 (90 Stat. 1940), the study will serve as a major informational document for use in Congressional deliberations on possible future Federal legislation to facilitate the area's protection and management.

Although the study is preliminary and has not yet been reviewed and approved by the Secretary of the Interior, we believe that it firmly underscores the need for protection of the area, and provides a basis for effective action, whether at the State or Federal level. The alternative of NPS acquisition and management is included and assessed in the study. Although we cannot predict the future position of the Administration or the nature of possible future Congressional action, we regard this area as a potential future unit of the National Park System. Until the Congress acts, we cannot support any Federal action which could compromise the existing value of the area's natural ecosystems or its potential value for public use and enjoyment.

From a fish and wildlife resource viewpoint, the document recognizes potential effects of the project on the habitat of Rocky Mountain elk and the State endangered Jemez Mountains salamander. Indications are made that construction activities will be coordinated with biologists from the U.S. Forest Service and New Mexico Department of Game and Fish to minimize impacts on these two species. We urge that this coordination be carried out.

In addition to the above comments on the preferred transmission corridor, we also recommend that the Baca route be used to reduce fish and wildlife impacts with the stipulation that construction through elk calving grounds not be carried out during calving season.

We note that the Department of Energy received only two proposals in response to its initial Program Opportunity Notice of September 1977. We believe that, in view of the strengthened governmental support of alternative energy source development since that time, a readvertisement now would generate considerably more interest than it did two years ago. We strongly support this alternative (p. 9-4) and recommend that DOE give priority consideration to qualifying proposals not using or having significant impacts upon existing units of the National Park System, the National Trails System, the Wild and Scenic Rivers System, or areas under study for potential inclusion in one of these systems or any other ecologically sensitive area.

Specific Comments by Page

Page 2-1. A map showing the relationship between the topography, the proposed powerplant site, field development, and transmission line should be included.

Page 2-8, last paragraph. The description relating to the construction of new drill sites is confusing. Will an existing drill pad for a producing field with three or four wells be enlarged by 1/4 acre for a replacement well, or will a new drill site (1/4 acre in size) be constructed with an additional 2 to 6 acres of minor surface disturbance? If a new well site is developed, the 2 to 6-acre figure would probably be appropriate. This 2 to 6-acre surface disturbance per well pad is significant when all of the powerplant well sites are considered together. This paragraph should be rewritten to clarify the area that would be disturbed.

Page 2-18, paragraph 1. We understand that the Public Service Company of New Mexico is presently considering alternative transmission tower designs to reduce impacts on the visual environment. The final statement should describe and illustrate the design or designs adopted, as well as the impacts peculiar thereto.

Page 2-18. Map is illegible. Somewhere in the final statement, a map on a topographic base showing precise corridor alignments and identifying all important political, natural, and other features should be provided.

Page 2-20, paragraph 1. It would be helpful to indicate what "visual considerations" would require the use of long line spans.

Page 2-20, paragraph 1. The basis for selection of a 100-foot wide right-of-way should be indicated. A more narrow corridor for maintaining the 29-foot wide transmission towers would seem possible.

Page 2-21, paragraph 3. Although the report states that an accurate estimate of the area that would be disturbed by transmission lines and towers is not available, estimates should be used to provide some understanding of the total area that would be disturbed by the project.

Page 2-22, paragraph 1, line 12. A commitment to use helicopters in line stringing to the greatest extent possible should be included as a mitigation measure.

Page 2-25, paragraph 3. Characterize the "Stetford process fluids." It would be very helpful to provide a glossary of terms at the end of this document to provide definitions for the many technical terms used. For example, the distinction between "vapor" and "drift" is not apparent in the text.

Page 2-27, paragraph 3. The reason for the proposed withdrawal of irrigated crop land should be stated clearly. It appears that it is intended to offset the 27 percent loss of geothermal fluid from the reservoir.

Page 2-28, paragraph 2. The text should affirm a commitment to remove the plant and associated structures, as well as all transmission facilities, and to restore all disturbed areas as part of decommissioning of the plant. It is not clear from the text whether the intent is to remove all structures.

Page 2-29, paragraph 3. The report indicates that full field development (400 MW) would require about 6,000 acres. Of this 6,000 acres, 10 percent would be disturbed. Using the data provided in section 2, we note that the 50 MWe project would receive a 20 percent disturbance. Therefore, the 10 percent disturbance factor stated on this page for total area disturbed by development is misleading. This figure should be changed to 15 to 20 percent, which more accurately describes the total surface disturbance impact for the life of the project.

Page 2-20, figure 2.12. The symbols used for depicting exploratory and suspended wells are the same. Three wells on the map have a symbol which is not identified. This should be rechecked.

Page 3-14 to 3-27. The section on geology should include reference to Bailey, R.A., Smith, R.C., and Ross, C.S., 1969, Stratigraphic nomenclature of volcanic rocks in the Jemez Mountains, New Mexico: U.S. Geological Survey Bulletin 1274-P, and by the same authors, 1970, Geologic maps of the Jemez Mountains, New Mexico: Miscellaneous Investigations Series I-571. These are the classic works on the geology of the area.

Page 3-19, lines 1-2. Redondo Peak is not a rhyolite dome.

Page 3-22, line 19. What is meant by "ring graben fractures?"

Pages 3-48 and 3-51. The quality of shallow groundwater (apparently with reference to the alluvium and terrace deposits) is discussed. However, we find no specific information on the quality of groundwater in the primary confined aquifer of the Valles Caldera, the pumiceous sand and gravel caldera fill. The present quality of water in the primary aquifer at depth (see p. 3-50) may be significant for subsequent impact assessment. Present and future data on the water quality of the primary aquifer may also prove to be valuable in evaluating hydraulic relationships between the deep geothermal system and the primary aquifer. The statement should indicate whether the water in the primary aquifer is being sampled during drilling to provide knowledge of baseline conditions. Indirect evidence from geophysical well logs may be useful if no other data are available.

Page 3-51. It is stated that the geothermal reservoir consists of fractured volcanic and underlying sedimentary rocks. It is also suggested that solutioning of limestones of the downdropped caldera interior may have developed porosity and permeability. Has drilling to date indicated whether the permeability and porosity of the geothermal reservoir are the result of discrete, scattered, rather widely separated fractures, as suggested by figure 3.10 (p. 3-25), or is the geothermal reservoir apparently in a highly shattered zone? Has any evidence of solutioning been found thus far? Information of this type would improve the statement and aid in impact assessment.

Page 3-53. It is stated that ground water from the Valles Caldera aquifers recharges the geothermal system at depth by leakage through confining layers such as the altered caprock and by percolation downward through joints, fractures, and fault zones. Recharge is said to move both downward and laterally. As development of the geothermal reservoir progresses, net declines in hydraulic head will probably occur--despite some recovery from reinjection. Presumably, the resultant increased hydraulic gradient downward from the primary aquifer will accelerate the movement of recharge from the primary aquifer, the caldera fill. Will noticeable effects on the temperature and qualify of the geothermal fluids be expected?

Page 3-55, paragraph 1. Are the wells and springs in the Valles Caldera region privately owned? What percent of the available water has already been allocated for livestock and domestic supplies?

Page 3-79, paragraph 3. Revise to delete the implication that the corridor through Bandelier is "proposed." The corridor is one of two alternatives given detailed assessment.

Page 3-79 and 3-80. Section 3.1.6.2 refers to an archeological survey that was carried out on the site of the proposed generating plant. If archeological sites were recorded, there should be information regarding the nature and significance of the sites and the effect of the project on such sites. If the project will adversely affect significant archeological resources, there should be a plan of action cited to mitigate this effect. Contract specifications should include a sentence to the effect that if any archeological resources are encountered during construction, operations will cease at the discovery site and a professional archeologist will be consulted as to the significance of the material.

Page 3-92, Section 3.1.9. We believe that identification of visual resources and analysis of visual quality impacts should be conducted in consideration of the possible future opening of the caldera to public educational, interpretive, and recreational uses. The potential visual impacts of the initial project, and the possible future expansion of geothermal development within the caldera, on the suitability of the entire area for public use and enjoyment is a major concern, which we feel has been inadequately addressed.

Page 3-104, Section 3.2.3. The soils data on numbers and percentage of soil mapping units should be presented in the same fashion for each of the corridors to enable easy comparison of the two corridors. The distinction between "erodibilities," "sensitivity ratings," and "erosion potential," if any, should be clarified. If possible, the line distance of each corridor through soils of each sensitivity rating should be indicated.

Page 4-18, Section 4.2 (General Comment). The analysis should include some discussion of the impacts of project operation on visitor activities and experiences in the project area, particularly in the Valles Caldera should this area be made available for public use. Project-induced changes in air quality, noise, and the visual environment which may affect the suitability of portions of the area for various kinds of recreational activities (particularly primitive camping, hiking, and similar pursuits) should be evaluated.

Page 4-19 ff., Section 4.2.2. The margin of error in the calculations of project-induced changes in surface water flow, groundwater reservoir drawdown and groundwater quality should be indicated. This information is needed to indicate the amount of confidence which should be placed in the highly detailed technical analysis.

Page 4-20. There is reference to the maximum geothermal reservoir "drawdown." Does this indeed refer to total amount withdrawn, or has some reference to hydraulic behavior resulting from the withdrawal been omitted?

Page 4-34, paragraph 1. A comparison of the constituents of the drift and natural salt deposition would be helpful. It would seem that there is at least the potential for accumulation of trace elements to toxic levels in ecological communities near the plant. The possibility has been recognized for boron; other potential problem elements should be identified.

Page 4-42, paragraph 3. The statement should indicate what, if any, action would be taken to minimize long-term impacts on groundwater quality in the event of a casing rupture within an aquifer.

Page 4-56 ff. The analysis emphasizes visibility of the transmission corridors from existing public use areas, such as roads, the Pajarito ski area, and the Las Conchas campground. We believe it is also important to assess visibility from potential vantage points within the Caldera, such as Redondo Peak, and the effects of any impairment in views on the suitability of the area for public use.

Page 4-64. It would be useful to include a map showing the potential 400-MW area.

Page 9-15 ff. Based on the general analysis provided, it appears that development of known geothermal resource areas in the Imperial Valley of California, the northeastern Escalante Desert of Utah, and in northern and central Nevada might be accomplished with substantially less environmental impact than in the Valles Caldera. A re-advertisement of the Program Opportunity Notice, given the heightened emphasis on alternative energy sources present today, might well generate proposals for these and perhaps other areas. If selected in lieu of the Baca Ranch site, the redeployment of funds would delay development of the Valles Caldera, and allow the Congress time to determine the future Federal role in its management before the area is committed to a significant intensification of industrial use. We believe this course of action is in the broadest public interest.

Page 9-24, Section 9.7. We understand that the San Ysidro transmission corridor alternatives were discarded, at least in part, because the cost of additional transmission line and associated facilities would have caused total project cost to substantially exceed the available funding. We believe that these alternatives would greatly reduce the level of impact on the nationally significant resources of the Valles Caldera and Bandelier National Monument and should be assessed in more detail. The text should explain why greater corridor length, the time required for right-of-way negotiations, and the need to serve exclusively PNM customers proved to be insurmountable difficulties warranting rejection of alternatives which may be environmentally preferable.

Sincerely,

Deputy Assistant SECRETARY

RESPONSES TO DOI COMMENTS

General

1. p.2. In preparing the DEIS it was recognized that the arsenic dilution method of determining geothermal outflow along the Jemez River is inadequate in that it implies less geothermal fluid component than what is actually there; however, it was the only such depletion study available. The FEIS has incorporated results of a study using more conservative ions which indicate 24% more geothermal outflow than the arsenic study finding (Sections 3.1.3.2.1 and 4.2.2.2).

2. p.3. There is no indication of deep (geothermal) groundwater outflow into the thick unconsolidated sediments to the north and east sides of the Jemez Mountains, although shallow groundwater does move in these directions. (Information was derived from consultation with W. Purtymun, Los Alamos Scientific Laboratory.) Known discharge points for both shallow and deep groundwater systems are discussed in Section 3.1.3.2.1.

3. p.3. This assumption is correct, and a statement to this effect was added to the FEIS (Section 4.2.2.2).

4. p.3. The comment is valid in that available information is insufficient to enable the behavior of the hydrologic system to be predicted with total certainty. Monitoring of surface and groundwater systems during operation of the facility will provide information to help define the relationship between these systems. In the absence of detailed hydrologic data, a recent hydrogeologic survey of the region by Trainer (1978) was used in the analysis (Section 3.1.3).

5. p.3. Refer to responses to hearing board summary, Appendix H, alternative plant design to save water.

6. p.3-4. The joint and fault control on geothermal fluid outflow is recognized and a statement to that effect has been added to the FEIS in Sections 3.1.3.2.1 and 3.1.2.3.

7. p.5. Comments on dry cooling towers are addressed in responses to hearing board summary (Appendix H). Active Indian religious sites, and American Indian Religious Freedom Act have been addressed by the addition of Sections 3.1.10, 4.1.7, 4.5.1.6, 4.5.26, and 11.1.1.6.

8. p.6. The study draft was received after the DEIS was in printing. A summary of that study has been added to Sections 3.1.1 and 4.1.1.

SPECIFIC RESPONSES TO COMMENTS BY PAGE

ADDITIONAL RESPONSES TO D.O.I. COMMENTS

p. 2-1

These features are illustrated on a number of figures in the FEIS, in particular refer to Figs. 2-7, 2-9, 3-19, 3-21 and 3-25.

p. 2-18, paragraph 1

The only alternative tower design under consideration is a steel single pole structure. Otherwise, mitigation of visual impact will be achieved by line placement and by use of long spans to reduce structure visibility from sensitive crossings.

p. 2-18

The map is replaced by another figure in the FEIS. Precise corridor alignments are not presently available from Public Service Company of New Mexico at the current stage of transmission line planning.

p. 2-20, paragraph 1

Long line spans will be utilized at sensitive crossings such as roads, streams, and canyons to minimize structure visibility from sensitive areas.

p. 2-20, paragraph 1

The 100 foot right-of-way was selected to provide an extra margin of safety based upon the number of tall trees and severe weather conditions encountered at the high altitudes along which the line will be constructed.

p. 2-21

The amount of land disturbed will depend upon the final line placement and the amount of dense forest clearing necessary to protect the line. A maximum (or worst case) estimate of land disturbance may be arrived at by multiplying the right-of-way width by the longest route along each corridor. For the Baca corridor, corridor 1, a maximum of 107 ha. could be disturbed (30.5 m right-of-way multiplied by a maximum length of 35 km); for the southern corridor, corridor 2, a maximum of 126.5 ha could be disturbed (30.5 m right-of-way multiplied by 41.15 km maximum length). These worst case estimates will considerably overstate 30.5 m. right-of-way will not be cleared during line construction.

p. 2-22, paragraph 1

Such a commitment will be between Public Service Company of New Mexico and the landowner or land management agency involved in right-of-way negotiations.

p. 2-29, paragraph 3

Section 2.5 has been extensively revised in the FEIS and this comment among other has been incorporated.

p. 3-14, 3-27

These publications were recognized by the staff as "classic works" and are indirectly referenced by inclusion in the primary references for the EIS a number of times (Sections 3.1.2.1 and 4.2.5).

p. 3-19

Redondo Peak was not described in the text as a rhyolite dome; however, to avoid future inferences as such, the text has been clarified (Section 3.1.2.1.2).

p. 3-22

"Ring graben fractures" are the fractures along the circular ring graben structure of the caldera (Section 3.1.2.1.2).

p. 3-48, 3-51

There is only limited data available (Silica, fluoride, TDS, and hardness) on the groundwater quality in the Valle Grande; this data is given on page 3-51 of the DEIS. Refer to the new sections (11.1.2.2, 11.2.2.2) on groundwater monitoring in the FEIS for information on baseline and ongoing sample collection in the Baca vicinity; routine sampling of groundwater quality in this area is in progress.

p. 3-51

The geothermal reservoir is evidently in a highly fractured zone. It is unknown whether solutioning at depth has occurred, but the possibility has been conjectured (Section 3.1.3.2.1).

p. 3-53

Induced recharge will probably occur at some stage of geothermal reservoir development; however, not enough is known of the system to date that would permit an estimate of these effects on the geothermal reservoir to be made (Section 4.2.2.2).

p. 3-55

The wells and springs in the Valles Caldera region are both privately and publicly owned. A permit is required from the State Engineer to withdraw groundwater. Surface appropriations must be accompanied with appropriate evidence of equivalent set-aside rights for consideration (Chapter 7).

p. 3-79

The corridor through Bandelier is one of two "proposed" corridors. Neither corridor currently has assurances of a complete right-of-way.

p. 3-79, 3-80

Appropriate consultation with the Advisory Council on Historic Preservation has taken place regarding mitigation of impacts on archaeological sites. (Appendix E).

p. 3-92

Only visual studies for the current public access areas were possible within the scope of available data for analysis.

p. 3-104

The soils data were not provided in such a way as to incorporate the letter and number designations (soil types) in a consistent manner (Section 3.1.2.2). It is beyond the scope of this analysis to determine the line distance of each corridor through soils of a particular sensitivity rating, inasmuch as each corridor has a number of subroutes possible within it.

p. 4-18

Current visitor activities are restricted to public access areas. An expanded discussion of possible future public ownership has been added to Section 4.1.1 of the FEIS.

p. 4-19 ff.

The margin of error in the hydrogeologic calculations is not known but appears to be about 24%. The limitations of the arsenic-based analysis are addressed in the FEIS (Sections 3.1.3.2.1 and 4.2.2.2).

p. 4-20

The reference to "reservoir drawdown" specifies the hydrulic behavior (pressure loss) of the reservoir due to production (Section 4.2.2.2).

p. 4-34

The effects of other constituents within the drift with potential for environmental damage were assessed as negligible because of the low rates of deposition.

p. 4-42

See response to Comments from EPA in this Appendix.

p. 4-56

Refer to response for p. 3-92.

p. 4-64

The potential 400 MW area has been described and the location generally referred to in the FEIS (Section 4.5).

p. 9-15

This action is addressed in Section 10.1 "Action Alternatives" (page 10-1) and will be considered in the decision-making process.

p. 9-24

The DEIS reported the stated reason for transmission corridor selection. An expanded discussion of possible future corridors has been added to Section 4.5.

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426

August 31, 1979

Mr. Bennie G. DiBona
Director, Division of Geothermal
Energy
Department of Energy
Washington, D.C. 20585

Dear Mr. DiBona:

I am replying to your request to the Federal Energy Regulatory Commission for comments on the Draft Environmental Impact Statement for the Baca Geothermal Demonstration Program in New Mexico. This Draft EIS has been reviewed by appropriate FERC staff components upon whose evaluation this response is based.

The staff concentrates its review of other agencies' environmental impact statements basically on those areas of the electric power, natural gas, and oil pipeline industries for which the Commission has jurisdiction by law, or where staff has special expertise in evaluating environmental impacts involved with the proposed action. It does not appear that there would be any significant impacts in these areas of concern nor serious conflicts with this agency's responsibilities should this action be undertaken. There are, however, several areas where staff feels modification or additions are needed:

1. The proposed plant is of single-flash cycle type (P. 9-22) which is similar to that used at the Geysers in California. As discussed in the DEIS on PP. 9-23 and 9-24, there are other types of geothermal plant cycle techniques (such as binary or dual flash) which are believed to be superior to the proposed single flash type (although they may not be as economical or adequately tested). However, since the major purpose of the proposed plant is to demonstrate the applicabilities of available techniques, it might be appropriate for DOE to consider the advantages of such a program and utilize binary or dual flash systems, even though it may not be as cost-effective at the present time.

2. According to information available to our staff as of August 1978, there was little potential for oil and gas reserves in the proposed project area.

3. The proposed 115-kV transmission line may be located near or cross over an existing 10-inch natural gas pipeline owned by the DOE. The developer of the proposed project should be directed to contact the field operator of the pipeline to ascertain the exact location of the pipeline in order to avoid any possible accident or interruptions of gas flow. Should the transmission line be located along the same right-of-way as the pipeline, special precaution should be taken to mitigate induced electromagnetic alternating currents and fault currents within the pipeline.

4. Under existing authority, the FERC would have jurisdiction over any aspect of geothermal energy development if one or all of the following conditions occur:

(a) there is a sale of electric energy at wholesale from one utility to another for resale in interstate commerce, or the facilities used for transmitting power from the development are used otherwise for transmitting electric energy in interstate commerce (see FPA, Section 201, 16 U.S.C. 824);

(b) a geothermal plant if classified as a qualified co-generator or small power producer, (see PURPA, Section 201, 16 U.S.C. 796 and PURPA, Section 210);

(c) there is geothermal activity on non-federal lands withdrawn for hydro-electric licensing purposes (see, FPA, Section 24, 16 U.S.C. 818); and

(d) geothermal research was financed by a jurisdictional electric or gas utility. In FY 1979, EPRI and GRI's budgets for geothermal research were $2.5 and 1.5 million respectively, [for electric utilities, see, 18 CFR 35.12, 35.13(b)(4)(iii) Statement E1, and 141.1 (Form 1, page 448.)]

5. Consumptive water use at the plant would cause a small reduction in base flows in the Jemez River and Rio Grande. However, from a hydro-power point of view, this effect would have no significant impact on hydro development in the basin.

Also, no known plans exist to develop hydropower near the project site that would be conflictive.

Thank you for the opportunity to review this statement.

Sincerely,

JMHeinemann

Jack M. Heinemann
Advisor on Environmental Quality

RESPONSE TO FERC COMMENT

As discussed in the Environmental Tradeoff Analysis of the DEIS (Chapter 10), there are only minor differences in the environmental impacts of the alternative power cycles. For this reason the single flash power cycle was considered to be acceptable for the base case DEIS impact analysis.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 14 1979

OFFICE OF THE ADMINISTRATOR

Mr. Bennie G. DiBona, ET-57
Department of Energy
Division of Geothermal Energy
MS 3122C
Washington, D. C. 20585

Dear Mr. DiBona:

In accordance with the Environmental Protection Agency's (EPA) responsibilities under Section 309 of the Clean Air Act, we have reviewed the Department of Energy's (DOE) draft Environmental Impact Statement (DEIS) entitled, "Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, New Mexico," issued July 1979. Our major concerns are outlined below. Our detailed comments are enclosed.

First, we believe that the DEIS is seriously deficient in scope, because it is limited to discussing only the impacts of the 50MWe plant. The contemplated expansion to a 400 MWe plant is not adequately considered in the DEIS. DOE should either expand the final EIS to include a thorough review of the impacts of a 400MWe plant or promise to issue a supplement to this EIS before any expansion takes place. Second, we believe that the discussion of applicable environmental laws and regulations should be expanded and the control methodology required for compliance should be described more fully. Third, we believe that the methodology used for monitoring and mitigation of the impacts should be described more fully.

On the basis of these concerns, we have environmental reservations about the actions proposed in the DEIS and consider that the statement does not provide enough information for the likely environmental impacts of the proposal to be fully evaluated. Therefore, we have rated this draft EIS as "ER-2," and we will publish a notice of this rating in the <u>Federal Register</u>.

Thank you for the opportunity to comment on the DEIS. For further information concerning our comments, please contact Thomas Pierce of my staff at 755-0780.

Sincerely yours,

William N. Hedeman, Jr.
Director
Office of Environmental Review

Enclosure

ENVIRONMENTAL PROTECTION AGENCY

COMMENTS ON
DEIS GEOTHERMAL DEMONSTRATION PROGRAM
BACA RANCH, NEW MEXICO

A. Scope of Approach

The DEIS is seriously deficient in scope because it is essentially limited to only discussing the impacts of the 50 MWe generating plant. While this plant should certainly be addressed in the DEIS, one of the stated objectives of the project is to "provide assistance needed to initiate development of a resource of large potential." Further development of this field to at least 400 MWe can be implied from several statements in the DEIS (P. 1-5, P. 2-5, P. 4-64). Section 4.5, while it purports to describe the effects of development to 400 MWe, admits that "potential environmental impacts cannot be accurately estimated with current information." Because the larger development is intended and a demonstration objective is to promote that development, the resulting larger, much more significant, and perhaps cumulative impacts need to be fully discussed. The DEIS further admits (P. 4-66) that:

> "Development of a proposed 50-MW demonstration power plant already represents a change in character of a portion of the Baca Location from a relatively natural setting to an industrial one. Expansion to 400 MW would considerably escalate this change. The development associated with the 400 MW expansion could alter the character of the Valles Caldera/Baca Location National Natural Landmark to the extent that its status would be severely threatened or even revoked."

If DOE decides not to address the impacts of full development in the FEIS, then DOE should promise to supplement this EIS before any expansion takes place.

B. Federal Environmental Requirements

The environmental laws and regulations that will apply to this and future developments are not fully described, nor is the control methodology required for compliance. For example, the Environmental Protection Agency is not even alluded to, except on p. 7-2 where the need for Prevention of Significant Deterioration review is noted.

A specific concern for EPA is that section 7 be expanded to discuss the Underground Injection Control Program (UIC) under the Safe Drinking Water Act. The proposed technical criteria and standards for that program were published in the Federal Register on April 20, 1979 and will be codified as Part 146 of Title 40, Code of Federal Regulations. Subpart D of Part 146 "Criteria and Standards Applicable to Class III Wells," sets forth the requirements for geothermal activities under the UIC program. That subpart describes the construction requirements, the well abandonment requirements and the operating, monitoring and reporting requirements for geothermal underground injection activities. The final EIS should describe how the project will address the proposed requirements under the UIC program.

Air Quality

(1) The DEIS states that H2S will be controlled by applying the Stretford process to the condenser off-gas "so that less than 1 ppm of hydrogen sulfide by volume and less than 50 ppm of other sulfur compounds are vented to the atmosphere" (DEIS, p. 9-21). The raw loading of 108 kg/hr (240 lb/hr) is inferred from a statement on p. 4-40 and the emission after treatment is given as "less than ... 50 lb/hr" and "more likely ... less than 43 lb/hr" (p. 2-25). Calculations of disperson indicate that the New Mexico ambient air standard will be met under typical conditions (p. 4-22). However, the DEIS description of the New Mexico ambient standard is ambiguous and should be clarified in the final EIS. On p. 4-22, the standard is indicated to be "3 ppb above ambient concentrations," while elsewhere it is stated that the "New Mexico (1-hr) ambient air standard for hydrogen sulfide is extremely low, only 3 ppb" (p. 3-59).

(2) The discussion of H2S and the control system needs to be clarified in the final document. For example, on p. 3-59, it is stated that "Long-term concentrations for naturally occuring emissions averaged as high as 11 ppb, with 24-hr. concentrations as high as 65 ppb. Thus at several sites the background concentrations exceed the New Mexico ambient standard for hydrogen sulfide because of natural venting." It is misleading to make such a statement without stating where the measurements were made; they could have been taken directly over a natural vent. Another example is the lack of a detailed system description; for instance, a surface condenser should be a part of the system, yet it is unclear from reading the DEIS whether this is contemplated. It makes a considerable difference. In a direct contact condenser, a major part of the H2S will go to the cooling tower and be lost from there. On p. 4-40 of the DEIS, it is stated that "Loss of the hydrogen sulfide abatement system would result in the release of approximately 108kg/hr (240 lb/hr) of hydrogen sulfide to the atmosphere from the cooling towers." The EIS does not show how or why the H2S would get to the cooling tower; this should be clarified in the final EIS.

(3) On page 2-23 the DEIS describes the hydrogen sulfide abatement system which converts H2S to sulfur. The final should describe how the sulfur will either be marketed or disposed of.

(4) On page 4-5 in the Air quality section the statement is made: "If more than one well is vented at a time, some periods of concentrations in excess of state limits may be experienced, ..." Clearly, the appropriate mitigation measure would be to ensure that if there is a danger of exceeding the state air quality standard for hydrogen sulfide through simultaneous venting of more than one well, that only one well should be allowed to be vented at a time.

(5) Based on the two paragraphs below exerpted from DOE's Environmental Development Plan for Geothermal (page B-2), the final EIS should discuss possible mercury and radon emissions. We would also recommend that since the project is part of a demonstration program, that the emissions from these two elements be periodically measured.

"Mercury emission rates have recently been reported for the Geysers and Cerro Prieto, Mexico. The airborne release rates are small, 90 μg/kW-hr at Cerro Prieto and 30 to 70 μg/KW-hr at three measured units at The Geysers. These releases appear to be inconsequential. Ambient air at The Geysers has the same concentration of Hg as was measured at background locations, although ambient air at Cerro Prieto was above background levels. Additional measurements at other sites are needed to resolve fully this issue."

"The release of ^{222}RN and other radionuclides has also recently been measured at The Geysers. The average emission rate of ^{222}RN is 130 nCi/KW-hr. Concentrations in ambient air of the short-lived radon daughters at The Geysers are within the rage of concentrations measured at background locations. Levels of other naturally occurring radionuclides in The Geysers area were also within normal background levels. Measurements of radon in fluids at other sites also indicate that the release of radionuclides at hydrothermal sites will not be an important issue. However, confirmatory measurements of emission rates and ambient concentrations in the vicinity of new uses will be necessary."

D. Water Quality

It is not clear whether the fluid will be reinjected immediately upon cycling through the system or whether it will be temporarily held in storage ponds. If the latter is the case, the final EIS should discuss the possibility of storage pond leakage or leachate contaminating the surface or groundwater as well as appropriate mitigation measures.

A major concern is the possible contamination of surface and groundwaters as a result of uncontained blowout or cracked well casings due to siesmic activity as discussed below in section G of these comments.

E. Water Use

The treatment of water use in the final EIS should include a discussion of future, competing water uses particularly in light of the projected expansions of the plant. The discussion on page 4-19 concerning the projected flow-reduction in the Jemez River should be revised to include estimates of reduction in flow to be expected from full-scale development to 400 MW. The final EIS should also discuss projected increase in water use associated with the induced development or secondary impacts which can be expected to occur in the vicinity of the plant.

F. Waste Disposal

The final EIS should include a general discussion of waste disposal methods including disposal of cuttings, drilling fluids, sewage and trash.

G. Siesmic Activity

In the discussion of siesmic activity on page 3-27 and 3-28, the statement is made that active faulting is known to exist and that there is a "definite possibility that felt and possibly structurally damaging earthquakes could occur." DOE's Environmental Development Plan for Geothermal Energy Systems published in March 1978 states on page 3, "the most likely cause of enhanced seismicity is believed to be the injection process. Studies in Colorado have demonstrated that the frequency of microseismic events is enhanced as a result of the high-pressure injection of fluids."

Under these circumstances, and considering the demonstration nature of the proposed project, we recommend that siesmic activity be monitored to determine the siesmic impacts of plant operation. This will become an increasingly important issue if and when the plant is expanded. This concept also relates back to our earlier concern about contamination of surface and groundwater due to cracked well casings from possible siesmic activity.

H. Accidents

We recommend that the discussion of blowouts on page 4-42 be expanded to discuss mitigation measures including emergency containment procedures. The section should also discuss the possibility of geopressurized fluids leaving the well shaft through a permeable channel and traveling to the surface by an alternate route.

Potential rupture of the subsurface system or possible migration of fluids outside the production aquifer are not dicussed. Because of the high quality and use of the uppper aquifers, this potential should be described in the final EIS.

Pollution incidents can result from ruptures in the fluid distribution piping, but with proper maintenance there are likely to be few if any of significance. The DEIS recognizes the serious consequences of a surface spill on Redondo Creek and downstream (p. 4-43). However, it does not adequately describe containment or other mitigation measures.

I. Mitigation

We recommend that the final EIS be expanded to include a section discussing mitigation measures which will be required during wellfield development, plant construction and operation. This section should be written in accordance with sections 1505.2 and 1505.3 of the CEQ regulations implementing NEPA which call for a "monitoring and enforcement program" to be adopted and summarized "where applicable for any mitigation."

J. Abandonment

The final EIS should discuss well abandonment procedures after the project ceases operation or in the event that the well shaft is disrupted due to siesmic activity.

K. Socioeconomic Impacts

One of the criticisms repeatedly expressed at the DEIS public hearing was that the interests of Indians had not been given due consideration. The Pueblo Indians comprise a large part of the resident population. The socioeconomics discussion should address the impacts, both cultural and economic, upon the Pueblo Indians. Some of the Indians' concerns are listed (p. 4-12) but they are otherwise neglected in the DEIS.

RESPONSES TO EPA COMMENTS

A. Refer to responses to hearing board summary (Appendix H) for a complete discussion of the Scope of the approach. Section 4.5 has been expanded to better discuss the impacts of future development.

B. The Commercial Partners are working with the State of New Mexico and the EPA as required to assure compliance with the Underground Injection Control Program.

C. The FEIS has been revised to discuss only concentrations of hydrogen sulfide and the environmental impact of the concentrations (Sections 4.2.3 and 4.2.4). The State standards are defined by, and conformance to the standards is determined by the State.

The discussion of air quality impacts has been clarified (Section 4.2.3).

Mercury concentrations in the produced fluid at the Baca site are extremely low. The maximum concentration of mercury measured in Baca fluid is 0.0009 ppm, (Table 3.8 in the FES) which is less than 1/2 the primary drinking water standard of 0.002 ppm. Mercury concentrations in the steam condensate at the Geysers average .0058 ppm of mercury, (Rosen and Molenkamp 1978 — complete reference at end of Ch. 4 in FES) over 6 times the concentration of the produced fluids at Baca. Considering that airborne mercury levels at the Geysers were "considered inconsequential," mercury at the Baca project is not of any concern.

Radon had been measured within steam vents at various wells. The highest value recorded was 411± 49 pCi/m^3 at Baca #4. By comparision, measurements in turbine steam vents at the Geysers yielded a value of about 10,500 pCi/m^3 (Rosen and Molenkamp, 1978 — complete reference at end of Chapter 4 of this FES). Therefore, preliminary indications are that radon releases at the Baca site are likely to be at least two orders of magnitude less than those at the Geysers. Since ambient atmospheric radon measurements at the Geysers averaged 145 pCi/m^3 which is within the average background of atmospheric radon in "unpolluted continental locations" (Rosen and Molenkamp, 1978), radon releases at the Baca site are not likely to exceed normal background radon levels.

D. Water Quality

The fluid will be injected immediately upon cycling through the system, except for venting and flow testing of wells, when retention ponds will be used to hold the fluid. There is no used aquifer to be contaminated by leakage through the storage pond(s). The only surface contamination would result from holding (storage) pond dam failure.

There should be no contamination of surface water from blowouts or cracked casings; furthermore, any groundwater body contaminated by the escaping fluid is small in area and currently unused. This is addressed in the FEIS (Section 4.3.3).

E. Water Use

These issues are addressed in the FEIS, in the section on future expansion (Section 4.5).

F. Solid Wastes will be removed to an approved disposal area. Cuttings and residue from evaporated drilling fluids will either be treated as solid waste or backfilled in the settling ponds.

G. Seismic Activity

Induced seismicity as a result of geothermal fluid injection at the project site was addressed in the FEIS (Section 4.2.5). (It should pose no problem, and would probably be masked by natural seismicity should it occur.) There is a regional seismic monitoring net in operation at this time.

H. Accidents

Mitigation measures are addressed in the FEIS (Section 11.1.3).

Fluid release traveling to the surface via an alternate route during a blowout has been added to the section on accidents (Section 4.3.3.1).

The migration of reservoir fluids was addressed in the DEIS as a possibility. It was not elaborated upon, however, since there is no "high quality end use of the upper aquifers" in the immediate project vicinity (Sections 3.1.3.2.2 and 4.3.3.1).

The consequences of a surface spill and containment measures have been expanded upon in the FEIS (Sections 4.3.3.2 and 4.3.3.3).

I. Mitigation measures are addressed for the environmental elements of concern in the Section where the potential impacts are analyzed. A separate section has been added in Chapter 11 which identifies mitigation measures (Section 11.1).

J. Abandonment procedures were discussed in the DEIS in Section 2.3 (Reclamation and Restoration).

K. Refer to the responses to the hearing board findings for a discussion of Pueblo interests. Section 4.1.5 has been revised in the FEIS and Section 4.1.7 has been added in response to the comment.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Region 3
517 Gold Avenue, S.W.
Albuquerque, New Mexico 87102

1950
2720
September 6, 1979

Mr. Bennie G. DiBona
U. S. Department of Energy
Division of Geothermal Energy
Room 3122C
Washington, D.C. 20585

Dear Mr. DiBona:

The purpose of this letter is to comment on behalf of the Forest Service, USDA, to the Draft Environmental Impact Statement on the Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico, transmitted to R. Max Peterson, Chief, Forest Service, on July 11, 1979, by Assistant Secretary for Environment, Ruth Clusen.

In line with national energy goals, the Forest Service strongly supports programs to develop the geothermal resources on the Jemez Mountains.

This clear cut support is well documented by the Final Environmental Impact Statement for Geothermal Leasing, Santa Fe National Forest, New Mexico, issued in 1977, and by the number of leases that have subsequently been issued covering areas of the Santa Fe National Forest to the north, west and south of the Baca Location. To date, 14 leases covering 23,631.40 acres have been issued in the KGRA. Other leases are pending and should be issued by the Bureau of Land Management sometime this calendar year. In addition, the Forest Service has been working with the Department of Energy in relation to the Fenton Hill hot dry rock geothermal project. We are quite optimistic that the geothermal capabilities of the National Forest lands will be realized along with those of the Baca Location.

Although the Forest Service supports geothermal power production, we do not find the evaluation and selection of the preferred powerline corridor to be satisfactory. Our principal concern is the lack of supportive data to insure that the long-term power transmission needs of the Jemez Mountains area will be met with the least environmental affect.

In the development of the geothermal resources we will all have a great responsibility to insure that any geothermal development and related facilities, primarily access roads and powerlines, are developed in maximum possible harmony with the outstanding scenic and other resources of the Jemez Mountains. Our specific comments on the Draft Environmental Statement follow:

The Baca Location lands are surrounded by lands of the Santa Fe National Forest except for a narrow portion where the Santa Clara Pueblo Indian Reservation lands adjoin. It is unlikely that the Santa Claras will grant a transmission line right-of-way. Therefore such a right-of-way will have to cross National Forest lands and will have to be covered by a permit or easement issued by the Forest Service. To state it very simply, the Forest Service will not grant a right-of-way for powerlines without thorough evaluation of both short and long term powerline corridor needs.

The development of these needs is illustrated by the enclosed map that shows the current status of geothermal leases on National Forest lands. The map also shows potential development of geothermal lands in the vicinity of Jemez Springs. These latter lands are currently leased and are being evaluated by Sunedco with reported immediate plans for development of five initial production wells. Reportedly, Sunedco has been negotiating a proposed joint venture development with Phillips Petroleum Company for leases #30807 and #30808 to the east of the Sunedco lease areas involving lands of the San Diego Grant. The San Diego Grant was acquired some years ago by the Forest Service and is a part of the Santa Fe National Forest but with mineral rights, including geothermal rights, outstanding.

With the assumption that the United States has issued its geothermal leases in order to obtain geothermal development to meet national energy goals, it is readily apparent that the power so generated must be transported.

Also enclosed is a map that displays the existing and proposed power distribution network of the Public Service Company of New Mexico, Plains Electric, Bureau of Reclamation and perhaps others, that virtually surround the Baca Location. Other lines are in the planning stages. Transmission lines from the Jemez Mountains geothermal development should tie into the existing and proposed power network so as to minimize the environmental and surface impacts.

3
1950/2720-Mr. Bennie G. DiBona- 9/6/79

There is no indication in the report that an adequate analysis of future needs for corridors going south, west and north was made. We believe the probability is high that at least two 500 KV power-lines will eventually be required to export geothermal derived power from the area. We anticipate that these larger lines would not go north or east. Establishing new powerline rights-of-way as the geothermal resource is progressively developed would lead to a spider-web of transmission lines with excessive environmental degradation.

The DEIS lists as reasons for building a powerline across the Santa Fe National Forest south of the Baca Location to Los Alamos (the preferred route) as (1) it is the shortest route, (2) Los Alamos is a PNM load center capable of using the entire generation output, (3) it would solve an existing voltage fluctuation at Los Alamos, and (4) it is the only feasible route by which PNM could directly serve its own customers . The Forest Service does not fully agree with these reasons as applied to the preferred route. The shortest route is not necessarily the best or least impact choice in the long run. In addition, adding lines to Los Alamos -- from the east or upgrading existing lines would be solutions to number (2) and (3); and with reference to number (4), serving PNM customers directly is not sufficient reason to build a high impact powerline.

The reasons given why other alternative corridors were not seriously considered is that: (1) they would be of greater length. The Forest Service view is that greater length is not necessarily more damaging in the longterm; just possibly more costly initially. In local situations, it may be or could be more costly to cross a half-mile of very sensitive terrain than one or more miles of less sensitive terrain; (2) the right-of-way negotiations would not be completed in time for plant completion. Our belief is that both evaluated routes contain serious right-of-way problems in crossing private land in the Baca Location, the Santa Fe National Forest and National Park Service lands in the Bandelier National Monument that may delay approval even more; (3) Los Alamos is the only terminus available by which PNM could directly serve its own customers. PNM is not required to serve its own customers from this energy source. These three reasons appear to be short-term concerns which become much less significant in the long term.

4
1950/2720-Mr. Bennie G. DiBona-9/6/79

The DEIS does not include the selection criteria used to remove the other alternatives for transmission corridors from further consideration and evaluation. Two critical evaluation criteria which should be employed are:

1. The route finally chosen must be capable of serving anticipated future power transmission needs.

The Forest Service is opposed to adding a separate powerline system as each generation increment exceeds the existing transmission capability. This would lead to numerous rights-of-way each influenced and constrained by existing lines, and other surface management constraints. The potential load requirement at Los Alamos could not utilize all the potential power from the Baca geothermal resource area. The Baca Location's generation capability is expected to considerably exceed the initial 50 megawatt plant. The U.S. Geologic Survey gives a high probability or an 80 percent chance that within 10 years there will be an output of 100 megawatts from the upper Redondo Creek area; a moderate probability or 50 percent chance that beyond 10 years there will be an output of up to 1,000 megawatts in an area of 40 to 50 square miles from the west central area of the Baca Location; and a lower probability or 20 percent chance that after 15 years the area in the western-half of the Baca Location could be the source of up to another 1,000 megawatts of electrical generation. This last probability rests on better economics, better technology or new discoveries.

Because of the probability of future generation greatly in excess of this initial demonstration program, transmission line corridors should be carefully chosen in order to accommodate future needs.

2. The selected route must provide for the least environmental impacts in the region over the long term.

The proposed alternatives do not lend themselves to future expansion, nor are they good choices for installing two or more paralleling lines, which could be a secondary phase of development. The western and/or southern corridors are respectively greater than the preferred route in their capability to handle large capacity lines or multiple lines. We cannot endorse any corridor without adequate consideration and evaluation of at least the western and southern routes.

5
1950/2720-Mr. Bennie G. DiBona-9/6/79

Our soils inventory covering the proposed route eastward from Conchas, indicated that many activities are precluded by environmental limitations. The preferred location is largely in mixed conifer timber stands where trees 75 to 100 feet in height are common. This route essentially calls for a 15-mile long clearcut through some of the heaviest timber types on the Santa Fe National Forest. It is an extremely high public use area. We recognize that Los Alamos is physically the nearest large receiver in which some power problems could be solved. We don't believe these considerations, however desirable they may be, out-weigh the total potential impacts likely from long-term development. If these short-term considerations are overriding, the development of less than a 115 KV powerline with portions underground is worthy of evaluation.

In summary all reasonable alternative transmission corridors need to be discussed in detail. There are possible corridors to the north, west and south. The DEIS, should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for a choice by the decision-maker and the public.

In granting permits for projects such as this one, the Forest Service must consider the environmental effects and the tradeoffs. The proposed route for the transmission line favored in the Analysis and its easterly counter route appear to us to be the least environmentally acceptable of the routes available. Least cost or shortest length do not necessarily justify a route selection.

We are cognizant of the fact that DOE's direct involvement in future geothermal development may be more limited than your involvement through funding of this demonstration project. Nevertheless, we consider it extremely important that an assessment of the likely larger development of these geothermal resources be more carefully prepared at this time in order to locate a transmission line corridor capable of holding more capacity later. Without this assessment, the transmission line system of the future will likely be an intolerable spiderweb in one of the State's most scenic areas.

6
1950/2720-Mr. Bennie G. DiBona- 9/6/79

Thank you for this opportunity to review your DEIS. It is adequate in organization and outline, summary, proposal and used for action, description, affected environment and environmental impacts of the proposal.

The Forest Service should be listed in the FEIS as a cooperating agency.

Sincerely,

James C Overbay

JAMES C. OVERBAY
Acting Regional Forester

RECEIVED VIA FACSIMILE

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Region 3
517 Gold Avenue, S. W.
Albuquerque, New Mexico 87102

To: Bob Olive
Div of Geoth.
Energy

1950
September 24, 1979

Mr. Arthur C. Wilbur
~~Department of Energy~~
Room 712 Plaza del Sol Building
600 Second Street, N. W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

This is in response to the question in your latter of September 14, 1979, with regard to meeting Forest Service needs for identification of long-range corridor requirements as set out in our comments dated September 6, 1979, on the Draft Statement on the Baca Geothermal Demonstration Project.

Based on the meetings of September 13 and 14, and on the study of materials furnished for review on September 17, we believe that your proposal for adding the information to the environmental impact statement will adequately display the short and long term power transmission corridor needs as now projected. At a later time, the Forest Service will need to make specific environmental evaluations of the displayed corridors.

We wish to emphasize that we have not agreed to a particular route, but have only accepted your proposed display of corridors in the final environmental statement.

Our view is that when Public Service Company of New Mexico makes a specific right-of-way application, the Forest Service will have to make a detailed feasibility study of the route on National Forest lands.

Please contact us if you have additional questions on this matter.

Sincerely,

M. J. HASSELL
Regional Forester

RECEIVED VIA FACSIMILE

RESPONSE TO USFS COMMENTS

Public Utility Company of New Mexico (PNM) and U.S. Forest Service met on September 13 and 14, 1979, to discuss ways PNM could meet U.S. Forest Service's needs for identification of long-range corridor requirements as identified in their letter commenting on the Baca EIS (dated September 6, 1979). On September 17, 1979, PNM provided U.S. Forest Service with additional materials for review which also addressed the issue of long-range corridor planning. Based on these meetings and the material provided, U.S. Forest Service found that the EIS would adequately display the short- and long-term power requirement needs as now projected (see letter from Hassell to Wilbur dated September 24, 1979; p. I-48 of the EIS). Public Utility Company of New Mexico considers some of the information contained in their internal memo(s) documenting the September 13 and 14, 1979, meetings and in the additional information provided U.S. Forest Service on September 17, 1979, to be confidential and, therefore, does not want it published in the EIS. However, this information has been considered in preparing the FEIS (Sect. 4.5).

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE
ASSISTANT DIRECTOR
FOR ASTRONOMICAL,
ATMOSPHERIC, EARTH,
AND OCEAN SCIENCES

September 4, 1979

Ms. Ruth C. Clusen
Assistant Secretary for Environment
Department of Energy
Washington, D.C. 20585

Re: DEIS on Geothermal Demonstration Program, DOE/EIS-0049-D

Dear Ms. Clusen:

Several individuals at the National Science Foundation have reviewed the subject DEIS, and their comments are enclosed. The reviewers' areas of expertise included chemical and process engineering, meteorology, and geology.

I hope these comments are helpful to the DOE in formulating a final EIS.

Sincerely yours,

Adair F. Montgomery

Adair F. Montgomery
Chairman
Committee on Environmental
Statements

Enclosure

NATIONAL SCIENCE FOUNDATION

Comments on
Geothermal Demonstration Program
DOE/EIS-0049-D

I have read certain sections of the subject report. There are three matters of concern: (1) The release of hydrogen sulfide;(2) The drift from the cooling towers and its effect on the environment; and (3) The amount of the release from the cooling towers.

On page 2-27, section 2.2.5.3 Water use, the statement appears, "The release of vapor by the cooling tower is the primary consumptive use of water by the plant and is about 107 kg/sec (820,000 lb/hr)." This amount, about 98,236 gallons per hour, seems to me to be very high, and I would be concerned about this release to the environment.

p. 58 - Note that reported surface wind speeds at "project site" and "meadow site" are quite different.

p. 59 - Minimum temperature of 90°F should be -90°F.
Otherwise. Section 3.1.4 on Meteorology seems adequate.

We need to investigate many alternative sources of energy, and we know very little about the potential of various types of geothermal reservoirs. This is a well-planned and well-researched project; and, granted that all the data are correct, it should have much less environmental impact than a coal-fired or a hydroelectric plant.

It is a shame that, having amassed so much information, the authors don't present it better. The writing, which I fear is passable by today's low standards, is really inferior. It's intelligible but sloppy. Moreover, some of the conclusions could be more explicit. For example, on pp. 3-27 and 3-28, possible geologic hazards are identified (correctly) as earthquakes, landslides, and volcanic eruptions. Then a statement is made--almost as an afterthought--that "no volcanism is expected to be induced by project activity." Most assuredly. But do the authors want to imply that the project may induce earthquakes or landslides? I would think not. Moreover, should any or all of these hazards occur, their environmental effects would not be altered significantly by the presence of the plant, and this should be simply stated.

In summary, the basic project is sound, and any adverse environmental impacts will be few and small (even the salamanders should survive okay). The Environmental Impact Statement would be more effective if it were better written.

RESPONSE TO NSF COMMENTS

p. 2 -27. The vapor released by the cooling tower is geothermal fluid condensate and is typical for a flashed-steam geothermal plant. Drift rates are substantially lower.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
ATLANTA, GEORGIA 30333

August 31, 1979

Ms. Ruth C. Clusen
Assistant Secretary for Environment
Department of Energy
Washington, D.C. 20585

Dear Ms. Clusen:

We have reviewed the Draft Environmental Impact Statement (EIS) for the Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico. We are responding on behalf of the Public Health Service.

While we recognize the need for pursuing alternative energy sources, we hold some concerns with the Baca Ranch Geothermal Demonstration Program as proposed.

With regard to health and safety, a quantitative assessment of the accidents and injuries associated with construction and operation of the project should be provided in the EIS. In addition, the occupational health and safety program that will be instituted during construction and operation of the well field and plant facilities should be described.

We are aware that noncondensable gases are formed in the vapor phase of a geothermal source. The release of these gases and vapors from accidents or equipment malfunction could cause serious consequences to workers or visitors in or around the site. The type and potential health effects of the gases and vapors associated with plant operations and the preventive measures to be employed should be discussed. A discussion of the potential presence or release of radioactive substances in either water or air should also be addressed.

We are also concerned with the adverse effects associated with blowouts, pipe rupture, and cross-contamination of shallow water aquifers. The probability of these events occurring should be addressed.

With regard to blowouts and pipe ruptures, we believe the spill prevention program should consider the construction of emergency drainage facilities and retention basins to contain accidental spills. In conclusion, the likelihood of contaminating local wells should be thoroughly discussed.

Page 2 - Ms. Ruth C. Clusen

Thank you for the opportunity of reviewing this draft EIS. We would appreciate receiving two copies of the final statement when it is available.

Sincerely yours,

for Chester L. Foote, Jr

Frank S. Lisella, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Bureau of State Services

RESPONSE TO PUBLIC HEALTH SERVICE COMMENTS

The province of worker safety and worker environment is briefly addressed in the DEIS but is considered as a separate requirement upon the project and that all applicable standards and regulations will be adhered to.

There are specific protection programs for worker safety with regard to geothermal fluids, noncondensible gases, and noise that the commercial partners adhere to on this and other projects.

The commercial partners have a spill prevention program on file with the State of New Mexico (see Appendix G).

UNITED STATES DEPARTMENT OF AGRICULTURE
RURAL ELECTRIFICATION ADMINISTRATION
WASHINGTON, D.C. 20250

AUG 3 1979

SUBJECT: Draft Environmental Impact Statement Geothermal Demonstration Program 50 MW Power Plant, Baca Location, Sandoval and Rio Arriba Counties, New Mexico

TO: Mr. Bennie G. Dibona
U.S. Department of Energy
Division of Geothermal Energy
Washington, D.C. 20585

The Rural Electrification Administration (REA) has reviewed the Geothermal Demonstration Project at the Baca Ranch in New Mexico and offers the following comments:

No REA-financed cooperative is directly involved or participating in the Baca Ranch Project at this time. Therefore, the intensity of our research into this document has been limited. The document, however, does contain limited discussions on items such as wetlands and floodplains, prime and unique farmland, and historical preservation. Mitigating measures are noticeably weak in a few sections of the document such as Sections 4.1.4 (Impacts on Biota) and 4.1.5 (Socioeconomic and Cultural Impacts).

Thank you for the opportunity to review and comment on the draft environmental impact statement.

Charles T Crowley

CHARLES T. CROWLEY
Chief, Environmental Services Branch
Environmental and Energy
Requirements Division

RESPONSE

Mitigation measures to reduce impacts on important wildlife species are discussed within the sections of the FEIS which analyze the potential impacts on these species and within Chapter 11 — Mitigation and Monitoring. The mitigation plans that concern the Jemez Mountains salamander have been approved by the New Mexico Game and Fish Department. Mitigation for effects on rare plants has been cleared through the Director of New Mexico Heritage Program. It has been recommended to the commercial partners that mitigation of effects on game species, elk in particular, be finalized through consultation with the New Mexico Game and Fish Department.

University of California
LOS ALAMOS SCIENTIFIC LABORATORY
Post Office Box 1663 Los Alamos, New Mexico 87545

reply refer to: ADTS
Mail stop: 120

September 6, 1979

Ms. Ruth C. Clusen
Assistant Secretary for Environment
Office of Environment
Mail Station 4G-084
US Department of Energy
Washington, DC 20545

Dear Ms. Clusen:

In response to your invitations to comment on the DEIS for the Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico (DOE/EIS-0049-D), addressed to the LASL Director, Dr. Donald M. Kerr, and the LASL Environmental Review Committee Chairperson, Barbara Wade, we would like to submit the following statement.

We believe there are some possible additions to the Draft Environmental Impact Statement (DEIS) that would indicate how the demonstration project will achieve its general objective. In general, we would like to suggest that additions to the discussions regarding mitigating measures and monitoring efforts would aid in demonstrating how the project will be able to succeed in its specific objective to "demonstrate the social and environmental acceptability and the readiness of state-of-the-art technology for the production of electrical power..." (page 2-2).

Several specific examples of possible additions are described in the following paragraphs. They are divided into issues related to the LASL site and to the project in general.

LASL Site Comments

As regards the portion of the proposed transmission line across the LASL site, there are some environmental matters that may require consideration in addition to the land use planning and visual impacts noted in the DEIS (Sec. 4.4.1.1 and 4.4.1.5). Depending on the particular route selected, there could be potential impacts on elk forage, the Federally listed and threatened blue gramma grass cactus (Pediocactus papyrocanthus), and archeological sites. We do not anticipate that any of these matters are likely to be serious, and LASL personnel will be available to participate in detailed final planning to help avoid or minimize any such problems.

Long Range Planning

The DEIS brings out the probability of expanding geothermal production from 50 MW to 400 MW and that the cumulative impacts from such expansion are likely to be substantially greater than from the demonstration project (Sec. 4.5). More consideration should be given to presenting a long range land use plan for the proposed facility and its expansion. Such long range land use plans should define, if only in schematic fashion, the likely locations of, and the functional interrelationships between the geothermal well fields, roads, piping systems, power plants, and transmission line corridors. Doing so will more clearly define the nature of the proposed development and the impact it will have on the National Natural Landmark and other surrounding land uses. In addition to land use plans, it should be possible to discuss how knowledge gained from monitoring during the demonstration phase will be incorporated into the subsequent designs for additional plants to improve mitigation measures as necessary. For example, if the air quality monitoring during the operation of the demonstration plant shows that standards are not being met, the FEIS should discuss measures that could be taken to improve controls on that plant's emissions and alternatives for process design and siting of additional plants that would ensure environmental acceptability of expansion. Similar discussions should be included on potential effects and mitigating measures on ground water and hot springs, elk habitat, and appearance of the National Natural Landmark. Such discussions seem important because it is the intent of the Federal program to accelerate commercial development and, as indicated in the DEIS, no further Federal environmental review would be expected for the commercial expansion from 50 MW to 400 MW.

Accidents

The effects of an accidental spill of geothermal fluid are described as being potentially severe (Sec. 4.3.3.2). It would be desirable to include a discussion of possible mitigating measures that would limit the extent of damage to the million-dollar-a-year fishery downstream. For example, it should be possible to consider including a holding pond or ponds on Redondo Creek. Such ponds could be equipped with control gates that would permit normal flow from Redondo Creek under normal operation, but would limit or prevent flow from a large accidental spill. This approach might also be effective in mitigating effects of large sediment loads expected during construction (Sec. 4.1.2).

Monitoring

Because one of the principal objectives of the project is to provide information on environmental aspects and demonstrate environmental acceptability, we encourage expansion of the section on Monitoring (Sec. 11) in the FEIS to include discussion of the monitoring programs being planned at the time of DEIS preparation. For example, some expansion of the sections on floral monitoring, ground water monitoring, and seismic monitoring might be in order.

Transmission Corridors and Lines

An alternative link that might be considered for either of the two basic transmission corridors described (Sec. 3.2) would be to approach the LASL site though Canyon del Valle. This would not alter the lengths appreciably and may present some advantages especially in relation to minimizing visual impacts for Los Alamos. It might also be easier construction.

We hope these suggestions will be useful in preparation of the Final EIS; if there is anything further we can do in this matter, please do not hesitate to call.

Sincerely,

Charles I. Browne

C. I. Browne
Associate Director
for Technical Support

CIB:mar

RESPONSE TO LASL COMMENTS

Expanded discussions of future expansion, accidents, monitoring, and transmission lines have been added to the FEIS in Sections 4.2, 4.3, and 4.5 respectively.

Comments From The State of New Mexico

STATE OF NEW MEXICO
NATURAL RESOURCES DEPARTMENT

BRUCE KING
Governor
WILLIAM S. HUEY
Secretary

JIM KING
Deputy Secretary

Villagra Building
Santa Fe, New Mexico 87503
(505) 827-5231

August 14, 1979

Ms. Ruth C. Clusen, Assistant Secretary
for Environment
Department of Energy
Washington, D. C. 20585

Dear Ms. Clusen:

Thank you for the opportunity to review your Draft Environmental Impact Statement on the Geothermal Demonstration Program in Sandoval and Rio Arriba counties, New Mexico.

There is one question I would like to ask and that is concerning the Aquatic Ecology part (3.1.5.2, page 3-72) of this report. During the Summer of 1978 a survey was conducted by Whitford Ecological Consultants in Sulfur Creek, at which time they observed some sculpins (Cottus bairdi). If this observation is correct, it would be a new range extention for the sculpins in New Mexico. Thus far the only collections of this fish are from the San Juan river. I would certainly be interested in obtaining more indepth information on this observation, as it would certainly be a noteworthy record for our state.

In addition we have obtained new localities for certain proposed endangered, threatened or rare plants since the draft EIS was published. Species having new site locations in the general area include: Viola pedatifida (Sawmill Meadow), Lilium philadelphicum andinum (Pajarito Canyon), Pediocactus papyracanthus (White Rock) and Epipactis gigantea (White Rock). Data will be supplied on these sites as it is needed.

We will be looking forward to working with you in the future.

Sincerely,

Bill F. Isaacs

Bill F. Isaacs, Program Coordinator
New Mexico State Heritage Program

Jamie Chavez

Jamie Chavez, Environmental Analyst
New Mexico State Heritage Program

<u>Response</u>:

The source for the observation of sculpins in San Antonio Creek is Flavill, P. and W. G. Whitford. 1978. <u>The Biota of Redondo Creek-Union Baca Geothermal Exploration Site, Sandoval County, N.M.</u> Whitford Ecological Consultants, Las Cruces, New Mexico. The report is available in the public reading room in the Santa Fe National Forest Headquarters in Santa Fe. For additional information you might contact the authors at 4210 Tesota Drive, Las Cruces, N.M. 88001.

NATURAL RESOURCES DEPARTMENT

STATE OF NEW MEXICO
NATURAL RESOURCES DEPARTMENT
FORESTRY DIVISION
P.O. BOX 2167 SANTA FE 87503
827-2312

BRUCE KING
GOVERNOR

WILLIAM S. HUEY
SECRETARY
NATURAL RESOURCES

RAYMOND R. GALLEGOS
STATE FORESTER

I - INFORMATION
General

August 24, 1979

Mr. Bennie G. DiBona
Division of Geothermal Energy
Room 3122C
Department of Energy
Washington, DC 20585

Dear Mr. DiBona:

Thank you for the opportunity to comment on the Draft Environmental Impact Statement, DOE/EIS-0049-D, Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico (July 1979). I would like to limit my comments to potential impacts involving recreation and timber production on the Baca Ranch and surrounding National Forest and National Monument lands.

As stated in the draft EIS, recreational impacts would be mainly visual, with the exception of possible encroachment by Corridor 2 into a potential wilderness designation south of highway 4. Aesthetically, I feel Corridor 1 - the Baca corridor would have the least impact, even though the Baca corridor crosses the Guaje trail and passes close to the Pajarito Ski Area and Camp May. Routing Corridor 2 north of highway 4 as an alternative, would result in aesthetic degradation of the Valle Grande itself and threat the possible inclusion of the Valle into the National Natural Landmark Program.

Impacts to timber production for commercial uses is an important activity in the National Forest System. We are concerned, however, with commercial timber production on private forest lands as a service oriented organization. The Baca Ranch has great potential to yield commercial timber on a sustained yield basis. Destructive logging of the past has left areas of high slash concentrations and unsightly, denuded slopes. If alternatives could be outlined concerning proper silvicultural methods, timber production may reach a higher priority on the Baca Ranch. I feel the impact of corridor and plant construction would be negligible to the production of commercial timber with the exception of those areas immediately adjacent to the corridor and plant site. The corridor may effectively remove many acres from potential, commercial timber production on the Baca Ranch.

Mr. Bennie G. DiBona
August 24, 1979
Page 2

More information should be made available concerning the effect construction of the corridor will have on commercial timber volumes, both existing and potential.

The exploration of energy producing alternatives, including geothermal, is important to continue adequate service to the citizens of New Mexico and the United States as a whole. No one development will answer all of our needs. We need to know how our renewable resources can be integrated into an overall program to meet demands which our supplies of coal, natural gas, and oil can no longer meet. I feel, with the present information included in the EIS, a 50 MWe Power Plant could be built with minimal environmental impact in the Redondo Creek area of the Baca Ranch.

Very truly yours,

Raymond R. Gallegos

Raymond R. Gallegos
State Forester

RRG/DDB:cl

Response

A discussion of acerages lost to timber production as a result of the transmission line has been included in the FEIS (Section 4.4.1.1).

STATE OF NEW MEXICO
NATURAL RESOURCES DEPARTMENT
WATER RESOURCES DIVISION

BRUCE KING
Governor

S.E. Reynolds, State Engineer
Bataan Memorial Building
Santa Fe, New Mexico 87503
(505) 827-2526

August 27, 1979

Mr. Bennie G. DiBona
U. S. Department of Energy
Division of Geothermal Energy
Room 3122 C
Washington, DC 20585

Dear Mr. DiBona:

Your letter of July 11, 1979 invites comments to the Draft Environmental Impact Statement of the Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico.

In 1973 the state legislature gave to the Oil Conservation Division the authority and duty of regulating the drilling, development and production of geothermal resources and the authority and duty of conserving and preventing waste of geothermal resources within the state. The 1973 law, Section 65-3-11.2 NMSA, was repealed in 1975 and replaced by Sections 71-5-1 thru 71-5-23, 1978 Annotated. The statute provides that nothing in the act shall be construed to supersede the authority which any state department or agency has with respect to the management, protection, and utilization of the state lands and resources under its jurisdiction (Section 71-5-6).

Under the New Mexico Constitution and case law the surface water and the underground water of the state belongs to the public and are subject to appropriation in accordance with state law. The State Engineer has jurisdiction of the appropriation of all surface water of the state and ground water within the boundaries of declared underground water basins. Outside such declared basins a person may drill a well and appropriate the ground water without a permit from the State Engineer.

In addition to any permits that may be required by the Oil Conservation Division, it will be necessary for the person desiring to drill a geothermal well from which water, either in gaseous or liquid state, will be withdrawn from geologic formations within a declared underground water basin for the purpose of utilizing the thermal energy to first obtain a permit from the State Engineer to drill a well and appropriate public waters. The State Engineer may grant such a permit only upon his finding that its exercise will not impair existing water rights. Any person desiring to drill a well for water within a declared underground water basin must be licensed by the State Engineer.

The Baca Ranch in Sandoval and Rio Arriba Counties, New Mexico is located in that portion of the Rio Grande Underground Water Basin that was declared by the State Engineer on September 7, 1973. After that date it is necessary to make application to and obtain a permit from the State Engineer to drill a well and appropriate the ground water. Information regarding the appropriation of surface and ground water in this area may be obtained from this office or the District I Supervisor, State Engineer Office, Suite 206, 2340 Menaul N.E., Albuquerque, New Mexico, 87107.

On page 3-87 of the report it is stated that La Cueva would need to form a water association to receive water allocations from the State Engineer to provide for any increased population. The State Engineer does not grant allocations to a community to provide for any increased population. Small communities have formed mutual domestic water consumer associations and transferred individual domestic ground water and surface water rights into the system to obtain a more sanitary source of water. This procedure does not increase the availability of water that would provide for any increased population. La Cueva or other communities requiring additional water would need to acquire existing water rights to offset the effect of their increased appropriation on the stream system. The New Mexico statutes provide for the granting of permits for the appropriation of water from individual wells for household use, trees, lawns and noncommercial gardens not to exceed one acre. The total amount of water that can be appropriated from a well under this type of permit is limited to 3.0 acre feet per annum. More than one household may be served from the well but the total amount of water that can be diverted is limited to 3.0 acre feet per annum and the well must be metered.

On page 7-1 it is stated that the permit is valid for five years, and at that time it will be converted to a license, which will be valid until the project is over. If the State Engineer finds that water is available for appropriation and it can be diverted without inpairing existing water rights he may approve the application in whole or in part and, in general, requires that the wells be drilled and water applied to beneficial use within four years. After the four-year period, extensions of time may be granted for periods not to exceed one year if diligence is shown in the development of the permit. Upon completion of the development as contemplated by the permit or when as much of the water as possible has been applied to beneficial use the State Engineer issues a license which sets forth the extent of the right. The license cannot be issued for more than the amount actually placed to beneficial use and in no event greater than that set forth in the permit.

On page 9-20 it is stated that the water rights at the Baca Location are already appropriated and new allocations are not expected, making the option of fresh make-up water legally impossible. Appropriations of fresh water can be granted by the State Engineer after application and notice provided the effects of such an appropriation on the stream system are offset in a similar manner as that proposed to offset the geothermal appropriation and a finding that it will not impair existing water rights.

On page 9-23 it is stated that all surface and shallow water rights at Baca have been appropriated, and new allocations are not expected to be made. The surface waters of the Rio Grande and its tributaries are fully appropriated. However, ground water may be available for appropriation in this area provided the effects of the appropriation on the stream system are offset by the retirement of existing water rights.

Thank you for the opportunity to comment on draft environmental impact statement. Please let me know if some further discussion of this matter would be helpful.

Very truly yours,

S. E. Reynolds
State Engineer

By: D. E. Gray
D. E. Gray, Chief
Water Rights Bureau

DEG*es

cc. J.T. Smith

Responses to Water Resources Division Comments.

The Section on page 3-87 has been clarified to more accurately state the water supply situation.

Fresh make-up water will not be required, since it will be derived from the geothermal reservoir. It is expected that any future appropriations affecting the regional surface flows due to shallow groundwater depletion, geothermal reservoir drawdown, or stream diversion will be offset by the retirement of existing water rights. Union Geothermal is at this point negotiating to retire water rights for 54 acres of irrigable lands along the Jemez River.

ENERGY AND MINERALS DEPARTMENT
ENERGY RESOURCE AND DEVELOPMENT DIVISION

RUCE KING
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September 6, 1979

Mr. Bennie Di Bona, Director
Division of Geothermal Energy
MS 3122C
Washington, D. C. 20585

RE: DOE/EIS-0049-D

Dear Mr. Di Bona:

We would like to thank you for the opportunity to respond to the Baca Ranch Geothermal Demonstration. While we are very supportive of the demonstration our comments will only focus on our evaluation of the actual draft environmental impact statement.

The Energy and Minerals Department views the EIS process as a management tool to assist in making final discussions on major federal actions. Given this statement we feel that this DEIS on the demonstration is a good example of how a document should be prepared and we feel that with one or two exceptions this document is well prepared.

We feel that special consideration should have been given to the socio-economic and religious impacts that might befall the several pueblos in the general area of the Baca Ranch. We would hope to see better information relating to this matte in the final EIS.

We also feel that there is some question as to whether this document is intended to cover more than the demonstration of 50 MW. If this document is intended to cover expansion to 50 MW or 400 MW we feel that more information relating to impacts upon air, water and land is needed for this DEIS to be a good management tool.

Sincerely,

GEORGE SCUDELLA
Geothermal Energy Consultant

GS:bc

Response to Energy and Minerals Dept.
Section 4.1.5 has been revised and Section 4.1.7 has been added to address impacts on Pueblo Indians.

As discussed in the response to the Hearing Board Summary (Appendix H), the DEIS evaluated the Federal action of a 50 MW power plant in detail, and treated the potential future activities resulting from the Federal action, i.e. 400 MW expansion, only to the extent that information is available at this time. The original 400 MW discussion in the DEIS and the expanded discussion in the FEIS should contain sufficient information on the potential future impacts to permit a decision to be made on the current project.

Comments from Pueblo, Public Interest Groups, and Others

LAW OFFICES

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September 7, 1979

Mr. Bennie G. DiBona
U.S. Department of Energy
Division of Geothermal Energy
Room 3122C
Washington, D.C. 20585

Dear Mr. DiBona:

This letter is being written on behalf of the Santa Clara Pueblo which is in north central New Mexico. Their reservation is directly adjacent to Baca Location No. 1, which has been proposed as the site for the 50 MW demonstration geothermal power plant to be built by Union Geothermal Company of New Mexico (Union) and Public Service Company of New Mexico (PNM). This letter contains our comments on the Draft Environmental Impact Statement (DEIS) for that facility.

The Santa Clara Pueblo is seriously concerned about the effects of this project on their way of life and on the natural environment. They have inhabited this area for hundreds of years. Their way of life, religion, and culture are intimately connected to the integrity of the air, land and water in their region. They consider the Jemez Mountains as a sacred area. As a result, any significant harm to the land, vegetation and wildlife by drilling and other activities constitutes a serious interference with their religion and culture. The project will infringe upon their religious and cultural beliefs, have significant socioeconomic effects, contaminate their air and water resources, and permanently scar the natural beauty of the area.

Unfortunately, the DEIS does not adequately address these serious concerns of the Santa Clara Pueblo and other nearby Indian tribes. In the following sections, we will address those deficiencies.

Mr. Bennie DiBona
September 7, 1979
Page Two

I

THE DEIS FAILS TO CARRY OUT THE REQUIREMENTS OF THE NATIONAL ENVIRONMENTAL POLICY ACT AND THE NATIVE AMERICAN RELIGIOUS FREEDOM ACT RELATING TO THE IMPACT OF THE PROJECT ON INDIAN RELIGIOUS VALUES AND PRACTICES

The DEIS admits that there are numerous sacred sites and religious shrines in the project area and that the area "possesses exceptional [religious] significance and sensitivity" (3-80). Yet, the DEIS goes no further than to suggest that "the religious significance of the area should be carefully considered in all future plans" and that there is a "possible impact on religion because of changed access to important religious areas or to indirect impacts on areas of religious importance" (3-80, 4-12). The DEIS reports that consultation with Indian groups on these issues has occurred but gives no information concerning the results of those consultations (4-12). The DEIS makes no determination whether the project would actually interfere with the religious practices of Indian groups. Indeed, the DEIS scarcely analyzes the issue and devotes only three paragraphs of a 280-page report to discussion of the cultural impacts on Indian groups (3-80, 4-12). This discussion plainly does not constitute the detailed analysis required by the National Environmental Policy Act.

In addition, this lack of consideration of the religious and cultural impacts of the project on Indians is inconsistent with the Department's statutory mandate under the Native American Religious Freedom Act, 42 U.S.C. 1996, which establishes a national policy to protect and preserve the religious freedom of American Indians, including access to religious sites. The statute also requires the Executive Branch to report back to Congress after evaluating its programs in light of this statutory policy. In that report to Congress, filed in August 1979, the Department of Energy recognized that before it proceeds with a proposed action, it must do four things: (1) investigate to determine whether a religious site is affected; (2) if a site is affected, consult with Native traditional religious leaders to determine whether religious freedom would be infringed; (3) if an infringement is found, prepare alternate plans which avoid the infringement; and (4) if avoidance is not feasible, weigh the impact on religious freedom with the importance of the project. Report, p. 27-28.

In the present case, the DEIS has not adequately completed step two. The hearings held on August 16, 1979, with Indian groups indicate that DOE has still not progressed beyond that stage. Transcript, pp. 121-123. No determination has been made whether an infringement of Indian religious values exists. Thus, steps three and four could not and have not been done either in the DEIS or elsewhere.

As indicated above, the Santa Clara Pueblo regards the entire Jemez Mountains as sacred. Consequently, religious freedom would be infringed by the project. DOE has the responsibility to carry out steps three and four regardless of whether specific religious sites within the general area are identified. If an infringement can be avoided, it should prepare a plan for the management and protection of this sacred area. If an infringement is inevitable, the Department should attempt to move the project to an alternate location. If this is not feasible, the present project should be rejected because the value of this project clearly does not justify trampelling on basic Indian religious rights.

Moreover, the Jemez Mountain area possesses a number of specific religious sites which would be seriously disturbed by the project. Unfortunately, however, those sites cannot be made public for fear that their privacy and integrity will be violated by unwelcome non-Indian visitors. It appears that the DOE position is that the Indians have revealed inadequate information to demonstrate that a conflict actually exists with Indian religious practices. Hearings of 8/16/79, p. 122. The Santa Clara Pueblo submits that the failure of the Department to identify adequately the harm to their religious practices is the fault of the Department and not the Indians affected. The Department's superficial consultation efforts have not been adequate to identify or clarify the religious objections of Indian groups. The Department's representatives should consult with both traditional religious leaders and governing officials (on a confidential basis, if feasible) to determine how seriously the project will interfere with important religious values. At the same time, the Department should present more detailed quantified information on how the project will affect the religious sites which have already been identified. For example, Redondo Peak has been identified as a sacred site (3-80); yet no determination has been made whether noise will reach that area (4-11). Noise data from other parts of the area will help Indian groups to evaluate their religious objections. In addition, many Indian groups use the waters of the Jemez River for religious ceremonial and other purposes (Hearings of 8/16/79, p. 56). Yet no determination has been made as to how seriously the project will affect these particular areas. Furthermore, the DEIS fails to analyze the project's impact on the migration of wildlife which are essential to Indian religious practices.

Mr. Bennie DiBona
September 7, 1979
Page Four

After this consultation is completed, DOE must complete steps three and four of the methodology with regard to all specific religious sites which are identified. Since alternative sites are available both within and outside the Jemez Mountains and because the report admits that the present site has more environmental conflicts than any other site (10-6), it is clear that alternatives which do not infringe on Indian religious practices do exist. We therefore believe that, if the Department follows its own procedures under the Indian Religious Freedom Act, this project must be rejected.

In any event, the requirements of the Act must be complied with. After this has been done, a new DEIS should be prepared which considers the effects on religious practices and the alternatives available. Such analysis of impacts and alternatives, as Section 102(2)(C) specifically provides, constitutes the very basis of any adequate environmental impact statement.

II

THE DEIS FAILS TO ASSESS
THE SOCIOECONOMIC IMPACTS OF THE PROJECT
ON INDIAN TRIBES IN THE AREA

Taken together, the total number of pages in the DEIS devoted to socioeconomic impacts on Indian tribes does not exceed more than about 3 pages of a 280-page report. See pp. 3-3, 3-47, 3-80, 3-84, and 4-12. This coverage is wholly out of proportion to the tremendous impact that the project will have on Indians in the area. In comparison, at least 10 pages are devoted to the impacts on non-Indians. See pp. 3-81 to 3-89, 4-38 to 4-39.

The cause of this failure is not difficult to uncover. The consultant who evaluated the socioeconomic effects of the project deliberately excluded Indian Pueblos from the local impact study area (3-84). The rationale for this exclusion was that "[Indian] lands are not normally open to residential development by non-Indians" (Id. at 3-84).

This rationale is patently erroneous. It assumes that socioeconomic effects on Indian lands would only occur if there were direct residential construction on those lands. However, many other aspects of the project have direct and indirect socioeconomic effects on Indian groups. The number and scope of these impacts indicate that the study should have given at least equal consideration to impacts on Indian and non-Indian land. Indeed, given the trust responsibilities of the United States to protect the Indians, the study should probably have given more consideration to the effect on nearby Indian tribes.

Mr. Bennie DiBona
September 7, 1979
Page Five

The project will bring a maximum of 250 workers into the area, together with their dependents (3-81). This increased population will have many socioeconomic effects on Indian groups. It will strain the existing housing supply, which has already consumed almost all the available land (3-86). Most workers who move to the area will live in temporary housing, such as campers, trailers, and recreational vehicles (4-13). These temporary facilities often markedly reduce the aesthetic beauty of the area. The children of incoming workers will add to the burden of schools serving those Indian children who receive their education off Indian lands. The additional traffic on local roads will further congest these roads and cause increased noise and activity. The project will bring $4.2 million in payroll to the area (4-14), thereby increasing demand for local goods and services, increasing inflation, and reducing the purchasing power of Indian residents. Finally, the project will likely increase the number of non-Indians in the area, thus aggravating the minority status of the existing Indian population.

The project also has a potential for employing Indian workers. Yet, no analysis has been made as to whether there are Indians presently or potentially qualified to work on the project and, if so, how this can be accomplished. Utilization of resident Indian workers could have the beneficial effect of reducing the need for outside labor, thereby reducing the potential increased burden on community services and resources. In addition, such Indian workers are more likely to be more sensitive to the need to protect the environment of the area and thereby more likely to be more sensitive to reducing environmentally harmful accidents.

III

THE DEIS FAILS TO ANALYZE THE IMPACT OF THE PROJECT ON WATERS USED BY INDIAN TRIBES, INCLUDING A REDUCTION IN WATER FLOW AND THE ACCIDENTAL DISCHARGE OF CONTAMINATED WATER INTO THE JEMEZ RIVER

The Project is directly adjacent to Redondo Creek, which is an important tributary of the Jemez River (3-40). That river is heavily used by the Indians for irrigation and livestock and for domestic, bathing, and medicinal purposes. Hearings of 8/16/79, pp. 37, 56. Yet the sole reference to Indian water use is a single sentence, which states that "Indians living on the Jemez River are among those having rights to surface water" (3-47). The EIS contains no discussion of the impact of the project on Indian water use and water quality. Although the Santa Clara Pueblo does not directly use Jemez waters, it supports the rights of other Indian groups that do.

The DEIS recognizes that the project may reduce surface water flow in the Jemez River, but predicts that the reduction will be de minimus, since it will be less than 1% of the lowest flow recorded (4-19). Nevertheless, to compensate for that reduction in the watershed, Union has applied for a permit to withdraw over 34 acres of irrigated crop land from irrigation by Jemez River water (2-27). Because this irrigated land is upstream from Indian lands, the DOE Project Manager has concluded that surface water flow to Indian lands will not be affected at all. Hearings of 8/16/79, p. 126.

There are two problems with this analysis. First, although there may be no detriment in terms of decreased water flow, there will be a detriment in terms of reduced irrigated land in the area. The DEIS does not specify how this detriment will affect the region.

Second, the DEIS fails to evaluate the impact on water flow which would result from full-scale development to 400 MW or from coordinated development of geothermal plants on surrounding lands. Full-scale development is predicted to increase hydrologic impacts by a factor of 8 (4-65). Presumably, this figure was determined by simply finding the ratio between 50 MW and 400 MW. However, such multiplication does not always provide an accurate prediction of the real qualitative impact. For example, the resulting 8% decrease in the flow of the Jemez River, or the compensatory withdrawal of over 272 acres of irrigated land, may have impacts which are no longer de minimus. In addition, geothermal development of surrounding lands will further exacerbate the water supply problem, since most of those projects appear to lie within the watershed formed by the headwaters of the Jemez River (see 2-30, 3-40). When the total effects of these additional projects are considered, the resulting reduction in water flow cannot be dismissed as insignificant.

The section of the DEIS on water quality is also seriously deficient. The DEIS states that the sole impact on water quality will be from accidents, since all discharges from normal plant operation will be reinjected into the geothermal reservoir (4-19). The accident which would have the greatest impact on water quality is said to be the failure of the geothermal fluid supply and disposal system (4-41). Such failures may result from well blowouts, ruptures of well casing or pipeline, or failures of drilling sumps. The DEIS says that the probabilities of occurrence of these accidents range from "occasional" (4-42) to "impossible to estimate" (4-45). Thus, it would appear that the cumulative possibility of such an accident is substantial. The DEIS should be as specific as possible in quantifying or, at the least, describing this danger.

The DEIS also does not adequately analyze the harm which would result if an accident occurs. It says that, in the case of a rupture in the pipeline system, geothermal fluid heated to 330°F and containing 16 toxic elements would spill into Redondo Creek and then flow into the Jemez River (4-43 to 4-44). The DEIS analyzes the impact of this discharge on aquatic biota (4-43), but wholly fails to analyze its impact on downstream water uses, such as drinking and irrigation. In addition, the DEIS fails to specify how water users will be notified of accidents in time to protect their health and safety, fails to evaluate how long it will take the water to return to safe levels, fails to evaluate the long-range impact of the contamination on the Indian way of life, and fails to outline clean-up measures which could prevent or ameliorate damage.

The DEIS analysis of the impact of other types of accidents on water quality is even more inadequate than its analysis of the effects of a pipeline rupture. A blowout may cause destruction of vegetation and contamination of the surface, water and atmosphere (4-42). The rupture of a well casing may contaminate groundwater (4-42). And the failure of a drilling sump would release drilling muds and fluids into Redondo Creek (4-45). Yet the DEIS makes no effort whatsoever to quantify the probable amount of the resulting pollution, to identify its likely constituents, and to evaluate their toxicity. Lacking this data, the DEIS does not and could not evaluate the impact of such accidents on downstream Indian communities and others.

IV

THE DEIS FAILS TO RECOGNIZE THAT USE OF THE BACA LOCATION AS A PUBLIC PRESERVATION OR RECREATION AREA IS A REASONABLY AVAILABLE ALTERNATIVE TO THE PROPOSED ACTION

The DEIS recognizes that the area of the project is a "scenic wonderland" and that geothermal development activities are a major threat to its present status as a National Landmark (3-6, 4-3). It also recognizes that the status does not provide any legal protection from private uses that could spoil its pristine natural beauty (4-2). Other forms of public ownership would provide protection against such encroachments. The DEIS states that three federal agencies are currently studying the Baca location to determine whether the land should be transferred into public ownership to protect its outstanding scenic, geological and biological features (3-14, 7-2). Nevertheless, the DEIS relegates consideration of those alternative land uses to its section on potential land use conflicts (7-2).

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It is essential that public ownership be discussed in detail as an alternative to the proposed action. Section 9 presently lists only three action alternatives -- no action, delayed action, and funding of a nonelectric use. This incomplete list improperly frames the issue as a choice between energy or no energy. Maintenance of the status quo thus takes on a negative connotation. In fact, the land in its present state has extremely valuable geological, biological and scenic values. These values would be preserved if action were taken to transfer the land into public ownership. The list of alternatives is therefore more properly framed as a choice between public ownership and a continuation of the present private ownership, with immediate, delayed, or no commercial development of the privately-owned land. The choice is not between alternative <u>energy</u> uses, but between alternative <u>land</u> uses.

Viewed in this light, the DEIS repeatedly fails to consider fully the environmental impacts of the proposed project. For example, the section on noise impacts concludes that drilling and construction noises will be "acceptably low" at existing residences and campsites at the area, because those locations are so far from the project site (1.8 miles) that those noises will be attenuated and will not exceed present background noise levels (3-92, 4-16 to 4-18). However, the sounds of well drilling, construction and plant operation will likely exceed ambient noise levels for the area within a one mile radius of the plant site (4-16, 4-37, 3-92). A recreational visitor to the area would undoubtedly feel that the constant hum of a cooling tower or the throb of drilling equipment is incompatible with his enjoyment of natural beauty.

A second example of this analytical failure can be found in the section on the visual impacts of the project (4-18, 4-56). Those visual impacts will include a plume from the cooling tower up to 800 feet high and lengthy transmission lines with their attendant towers and swaths of denuded landscape (4-18, 4-56). The DEIS correctly notes that "[t]he great majority of people who come to the Jemez Mountains come for recreation and sightseeing and are likely to be sensitive to visual intrusions of the cleared right-of-way, lines and towers into the natural setting" (4-56). But when the potential visibility of these obstructions is evaluated, the DEIS considers only sight lines from existing recreational areas and existing roads (4-56). Those sight lines tend to lie outside Redondo Canyon where the plant is to be located. If Redondo Canyon became part of a new park, the visual intrusion on numerous other places would be much greater and would probably be totally inconsistent with a park setting.

Mr. Bennie DiBona
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These two examples make it clear that the DEIS must be revised to include analysis of the impacts of the project on a recreational or preservational use of the Baca location. In addition, the alternatives section should recognize this potential land use as a reasonably available alternative to the proposed action, should analyze its benefits and costs to the public, and compare it directly to the other alternatives.

V

THE DEIS DOES NOT PROPERLY DEFINE THE SCOPE OF THE PROPOSED PROJECT AND THEREFORE FAILS ADEQUATELY TO ASSESS THE CUMULATIVE IMPACT OF GEOTHERMAL DEVELOPMENT IN THE AREA

A. The DEIS Fails to Assess Fully the Environmental Effects of Potential Full-Scale Development of the Baca Site to Produce 400 MW of Electricity

The proposed project is a demonstration. Union obviously expects to develop a far larger project. The DEIS admits that "a successful demonstration of [50 MW] power production may be expected to encourage development" (2-28). The commercial partners to the venture have recently taken actions showing their firm intention to develop 400 MW. Public Service Company of New Mexico (PNM) recently told the state that the 50 MW plant will not be built unless the state's H_2S standard is raised to allow construction of 400 MW. Moreover, a PNM spokeswoman flatly stated that the commercial partners "are not willing to build 50 megawatts unless we can build more." The Energy Daily, Aug. 16, 1979, p. 2, attached. PNM has even gone so far as to withdraw its construction application until the H_2S standard is raised. Ibid. Nonetheless, the discussion in the DEIS on the expected full-scale development is limited to a meager 2-1/2 pages of the DEIS (4-64 to 4-66).

The most glaring omission in this discussion is the total absence of any analysis on the socioeconomic impacts of full-scale development. That omission is especially prejudicial to Indian tribes, who, as we have seen, were not considered in the socioeconomic discussion of the impacts of partial development. The effects of full-scale development on the Indian community cannot be measured by extrapolating from the 50 megawatt plan since there is a void of information on the socioeconomic effects on Indians from the smaller project. Consequently, the increased threat to the Indian way of life, including their religious practices, cultural integrity, water use, and economic stability is left to speculation.

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Since there is little doubt that full-scale development will occur, the DEIS should address all the environmental impacts of such development. It is well established that NEPA prohibits the "piece-mealing" of projects into pieces so that the environmental impacts are minimized. Consequently, the DEIS must analyze the total impacts of the full development which is expected.

B. The DEIS Fails to Consider the Cumulative Impacts of the Project Together with Those of Other Pending Geothermal Projects on Nearby Land

The site of the 50 MW geothermal plant is in a rectangular enclave of privately-owned land within the publicly-owned Santa Fe National Forest. Numerous sections of those forest lands have already been leased for geothermal development. While an EIS was issued for that leasing program on January 7, 1977, it did not consider the impact of geothermal development on nearby private lands, including the present project, because those lands are not available for government leasing. Moreover, while this DEIS indicated that a successful demonstration at Baca may encourage development of the surrounding leaseholds (2-29, 4-64), it did not consider in any way the cumulative impacts of the likely or possible geothermal development on nearby Forest Service land together with this project. Thus, no EIS has been prepared considering the full cumulative impact from nearby projects relating to Indian religious and cultural practices, water quantity and quality, air quality, noise, the socioeconomic system, and other aspects of the environment.

The impacts from the various geothermal projects are obviously cumulative. The effects on the Jemez Mountains as a place sacred to Indians are cumulative from the numerous projects. The socioeconomic impact from non-Indian workers coming into the area from numerous projects is similarly cumulative. Since numerous projects are in the same watershed, the effects on water quantity and quality are cumulative. And it is possible that air quality and noise effects will be cumulative if the projects are close enough together.

The dangers of piecemeal consideration of artificially separated projects are two-fold. First, the quantitative impact of each project, when viewed in isolation, may be insignificant. Yet when the environmental costs of all related projects are accumulated, the combined impact may be extremely large. Second, the qualitative impact of the whole development may exceed the combined quantitative impact. Thus, it is essential that this project not be approved until an EIS is prepared on the cumulative impact of all reasonably possible projects in this region.

VI

THE INADEQUACIES IN THE PRESENT DEIS CAN ONLY BE CURED BY PREPARATION AND CIRCULATION OF A NEW DEIS PRIOR TO PREPARATION OF A FINAL EIS

As described above, the present DEIS wholly ignores the religious, cultural, and socioeconomic impacts on nearby Indian tribes as well as having the other serious deficiencies described above. Due to the total absence of discussion on important environmental impacts and the inadequate discussion of others, it is essential that a new draft EIS be prepared. It would not be sufficient to prepare a final EIS based on the present draft even if it cured all the inadequacies of the draft EIS.

The Council on Environmental Quality has concluded and the courts have held that NEPA requires the preparation of draft EISs, the distribution of these drafts to governmental agencies and the public for comment, and then the issuance of a final EIS which considers the comments received. It is well established that, while the draft EIS is not held to the stricter requirements which a final EIS must satisfy, it must provide sufficient information and analysis so that governmental agencies and the public can intelligently comment. If these standards are not met, a new draft EIS must be prepared.

In Appalachian Mountain Club v. Brinegar, 394 F. Supp. 105 (D. N.H. 1975), the district court held that the final EIS violated NEPA because the draft statement did not include traffic data. The court said that (id. at 121-122):

> There cannot be responsible decision making when data appears in the final EIS without being subject to critical evaluation that occurs in the draft stage. * * *
>
> Supplemental information which has not been processed in the same manner as a draft EIS, cannot resurrect a deficient impact statement.

The court held that "[t]he failure to include traffic data in the draft impact statement denied the plaintiffs the 'opportunity to test, assess, and evaluate the data and make an informed judgment as to the validity of the conclusions to be drawn therefrom.'" Ibid.

The present DEIS fails to meet these standards for an adequate draft EIS. It does not contain basic information on the impacts of the project on Indian communities, including

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impacts on their religious practices, socioeconomic conditions, water use, and culture. Consequently, governmental agencies and private groups and persons have not had any opportunity to appraise and comment critically upon these impacts. That opportunity can only be provided if a new draft EIS is issued. If new information appears in the final EIS for the first time, that opportunity will be foreclosed, since a final EIS would only receive "in-house" review by DOE.

We therefore request that DOE issue a new draft EIS which allows the Santa Clara Pueblo and others a reasonable opportunity to comment on the impacts of the project on their communities.

Respectfully submitted,

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The Energy Daily

IATIONAL PRESS BUILDING · WASHINGTON, D.C. 20045 (202) 638-4260

Thursday, August 16, 1979 Volume 7, Number 157

New Mexico Geothermal Project Threatened By Hydrogen Sulfide Standard

By Burt Solomon

Environmental problems — namely, the rotten-egg aroma of hydrogen sulfide — could put a crimp in the planned development of New Mexico's extensive geothermal resources.

After seven months of haggling, Public Service Company of New Mexico (PNM), Union Oil Co. and the federal Department of Energy finally signed last week a formal contract to build a $124.6 million 50-megawatt demonstration geothermal power plant in the scenic Jemez Mountains 60 miles north of Albuquerque. It is believed that the site's geothermal resources could generate 400 megawatts of power for 30 years, and it is only one of an estimated six or eight potential geothermal sites in the state.

However, on Friday PNM told the state's Environmental Improvement Board that the demonstration plant will not be built unless New Mexico's strict hydrogen sulfide emissions standard is modified. According to a recent federal environmental impact statement, the utility noted, the state's current H_2S standard of three parts per billion (ppb) would allow only a single 50 MWe plant at the Jemez Mountains site.

PNM and Union Oil "are not willing to build 50 megawatts unless we can build more," a utility spokeswoman explained. PNM's interest in the project "is not just to give science a helping hand. We're in it to sell electricity, and Union is in it to sell steam" to the power plant that PNM will build and operate.

Hydrogen sulfide "is not a health hazard, but a nuisance odor," she said. "How much is too much? It's a question of aesthetics. . .Unless the state of New Mexico is willing to compromise, there won't be any geothermal development in the state, because if we can't build, no one else will be able to build." PNM has withdrawn the construction application it had filed with the state and does not intend to resubmit it until the hydrogen sulfide issue is resolved.

New Mexico environmental officials, for their part, scheduled a September 13 hearing on the H_2S standard and have indicated that alterations may be forthcoming — though not necessarily as great as the utility would like. "On the one hand, we would like to encourage geothermal development," Cubia Clayton, deputy director of the state's Environmental Improvement Department, said on Wednesday. "On the other hand, a lot of this would be occurring in areas of high recreational value to the state. We must try to find a level" that meets both needs.

With tourism the third leading industry in New Mexico, "it gets to be a nice little problem," Clayton said. "I'm not sure exactly how it works out, though in the past we've generally been able to strike a reasonable balance." In 1973, he recalled, state officials altered the hydrogen sulfide standard to 100 ppb in the oil- and gas-rich Pecos-Permian Basin in New Mexico's southeastern corner, although the standard has since been tightened to 30 ppb in and around municipal areas. Clayton also noted that some geothermal areas, including PNM's site, have sulfur springs which by themselves push the "natural ambient level probably above the state [H_2S] standard."

One reason that Clayton terms this problem "a toughie" is that "odor is hard to quantify. You can't measure it with an instrument like other air pollutants. It's so subjective." According to Clayton, there is some (though not decisive) evidence that an H_2S level of 30 ppb is above the "odor threshold" for 10 percent of the population — who would be able to smell but would not be overwhelmed by the aroma — though not for the remaining 90 percent. In some local jurisdictions, Clayton added, hydrogen sulfide emissions are judged by "odor panels" of citizens who sniff and decide how bad it is.

According to state officials, PNM has suggested that the present standard of three parts per billion (on a one-hour average) be changed so that — within a 10-mile radius of geothermal sites — 50 ppb couldn't be exceeded more than three times a day and 140 ppb couldn't be exceeded more than twice a year (both as one-hour averages). The state's Environmental Improvement Department staff plans to counter with its own proposal early next month.

Responses to B. J. Terris Letter

I and II — The discussion of cultural impacts and impacts on Pueblo religious sites and practices has been expanded in the FES. DOE Procedures for compliance with the American Indian Religious Freedom Act were implemented prior to issuance of the DEIS and are still actively being pursued by DOE. As stated in the DEIS, facilities located on Indian lands were not considered in the socioeconomic impact analysis because the use of these facilities is closed to non-members. However, Indian users of facilities located on non-Indian lands were included in the total group of facility users. Although they were not singled out as Indian users, they were included in the assessment (see Section 4.1.5.3).

III — The FEIS has been amended to address Indian water uses of the Jemez River in more detail, including any adverse impacts on these uses due to any depletion of streamflow from project operation (Sections 3.1.3.1.2 and 3.1.3.2.2). Impacts of the depletion of flow of the Jemez River on downstream users will be mitigated by acquiring water rights to areas upstream of the potentially effected users. Union has applied for a permit to withdraw 14 ha (34.59 acres) of presently irrigated land from irrigation. This is approximately equal to 44 acre-feet of water. It is expected only 5.67 ha (14 acres or 17.7 acre-feet) will be required to offset the impacts of geothermal fluid withdrawal. The remaining water rights (approximately 26 acre-feet) will be available to offset the impact of any future plant expansions. See Sections 4.5.1.2, 4.5.2.2, and 11.1.2.2 for additional information.

Impacts to surface water quality are addressed in Section 4.2.2.1, including the improved quality of the Jemez River expected from geothermal flow component withdrawal.

The section (4.3.3) dealing with potential effects of an accidental release of geothermal fluid has been amended to clarify hydrologic impacts as completely as possible. Impacts to downstream users have been added to the analysis.

IV — To date, the probability of future public ownership of the Baca Ranch is still unknown. There are no definite plans as yet for acquisition, nor any indication of which Federal or State agency or department would acquire and administer the land (refer to the expanded discussion in Sections 3.1.1.4 and 4.1.1 of this FEIS). However, all alternatives for public ownership in a recent Department of Interior/ National Park Service study considered accomodation of some form of geothermal development. If the Baca Ranch enters public ownership after a geothermal power plant is in place in Redondo Canyon, it is probable that public access to Redondo Canyon for recreation would be restricted.

Visual impacts of the proposed plant and transmission lines were considered in the DEIS on the basis of present public access and use areas. In the event the Baca Ranch is publicly acquired, some use areas would in all probability be established closer to the proposed project area and transmission lines than are present public use areas. Therefore, visual impacts on public recreation areas would necessarily be increased. However, a detailed discussion of impacts on these potential future use areas would require knowledge of their location and the nature of the public use see Sect. 4.1.1 of this FEIS. Such information is not presently available and is not expected to be available until such time as a public agency has definitely moved toward acquiring the land.

The presence of recreational visitors was not evaluated for distances within one mile of the project because the lease provisions between the geothermal operators and the current landowner strictly control and limit access to preclude casual use of the project area. It is presumed that any potential future private owners would not change the accessability of the site because of safety precautions.

V — The relationship of the 400 MW potential of the project area to the more limited federal action of 50 MW is addressed in response to the Hearing Board Summary (Appendix H).

The DEIS addressed the cumulative impacts of the proposed project with those of other potential geothermal projects nearby in only a cursory manner because the status of development of the surrounding lease holds is somewhat tentative at this time. The DEIS acknowledged the potential relationship between this project and increased development of other leases. Refer to the response to Hearing Board Summary. And the expanded discussion of the impacts of full scale development in Section 4.5 of the FES.

PUEBLO OF ZIA

SAN YSIDRO, NEW MEXICO
87053

PHONE (505) 243-5944

September 6, 1979

SEP 10 1979

To: U.S. Department of Energy
Attention: Office of Environmental Project Review

From: Pueblo of Zia, Office of the Governor M.S.

Subject: Review of Draft Environmental Impact Statement on the Geothermal Demostration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, New Mexico.

We have reviewed the subject document and have many concerns. At this time we wish to address three major concerns, they are water rights, religious sites and the anticipated increase in traffic.

The Pueblo of Zia realizes and recognizes the fact that whatever the project does concerning the waters in the Jemez Mountains it well have a bearing on the down stream flow. Regardless of what engineers say, man and-machine can not predict what mother nature will do. We feel that the project will diminish parts of our already small supply of both surface and ground waters. Our very existence depends on the waters which flow through our lands, and waters the farmlands which we hold dear. Its the same waters which inspired our forefathers to be farmers and to settle on the site we now call home. Our forefather settled at the Pueblo of Zia in the 14th century and since than have depended on the waters for survival. Our tribal religious beliefs are based on mother earth and the waters that nurture her. For centuries we have prayed and held ceremonials in order to receive waters from above and feel that we should be entitled to present and future waters. The concern is not only for the amounts of water but also the quality of waters which are in the streams, rivers and under ground. If the project is to become a reality you must assure us, to our satisfaction, that we will not realize a decrease in our waters.

Numerous religious sites are located within the project site, these sites must be considered by the Department of Energy (DOE) before the project can proceed. The Pueblo of Zia and other indian tribes have for centuries, even before the first European arrived, maintained that the area had religious significance. These sites are presently active and need the protection of the Federal Government. We are sure that DOE is aware of the American Indian Religious Freedom Act (P.L. 95-341) which Congress mandated to various federal departments to protect these type of religious sites. The Pueblo has gone on record under the American Indian Religious Freedom Act by taking the position that the project area holds numerous religious sites and that it would be detrimental to our religion to pinpoint the site locations. We request that our concerns regarding these sites be seriously considered by DOE and that a conceted effort be made to address our concerns.

The traffic along State Higway 44, which dissects our reservation, will no doubt increase since Highway 44 is one of two roads which run by the project area. We feel that the increase in traffic will increase safety hazards on Highway 44. In the past two years numerous accidents have occurred on Highway 44 where we lost approximately 2% of our Pueblo population of 580. All fatal accidents involved semi trucks, we fear that the project would utilize semi trucks in its construction and operating phases. We are concerned about the safety of our children, the bus route utilizes Highways 44 and 4 which no doubt will be the same route used by the project. Highway 4 is presently in bad need of improvements. We request the parties involved, to sincerely address our concerns about the traffic.

The Pueblo feels that it has alot to lose and nothing to gain. We cannot justify in our minds how a group of humans can take vital resources from another group and call it progress.

Luebben, Hughes & Kelly ATT. 3
Attorneys

Thomas E. Luebben
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September 10, 1979

RECEIVED
SEP 10 1979

Art Wilbur, Project Manager
DOE-GDPP
Room 712
Plaza del Sol Building
600 2nd Street, N.W.
Albuquerque, New Mexico 87104

RE: Comment on Behalf of the Pueblo of Santa Ana on the Draft Environmental Impact Statement, Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, Sandoval and Rio Arriba Counties, N.M.

Dear Mr. Wilbur:

The Pueblo of Santa Ana, which is located on the Rio Jemez northwest of Bernalillo, N.M., expresses grave concern about the environmental impacts of the 50 MWe geothermal power plant proposed for the Baca location. For the Pueblo, the over-all impacts of plant construction and operation on the environment of the Jemez Mountains is unacceptable, and will adversely affect the Pueblo of Santa Ana.

The Pueblo is especially concerned that the coverage in the EIS of the impact of construction and operation of the plant on water quality and use in the Jemez watershed is inadequate. The Pueblo will be directly affected by any diminution in water quality or quantity in the Jemez River. At page 4-20 the EIS states "The total reduction in groundwater outflow (well and stream depletion) resulting from reservoir drawdown is not known at this time." It is the opinion of the Pueblo of Santa Ana that the final EIS <u>must</u> contain an accurate quantification of the depletion of streamflows in the Rio Jemez, and a discussion of the economic and socio-cultural impact of such depletion on the three pueblos which lie on the Rio Jemez, as well as the non-Indian population along the River. An accurate quantification of depletion to the Jemez River is essential to responsible decision-making by the federal government, since the federal government is the trustee of land and water for the three pueblos.

The Jemez River has long been overappropriated, and the actions of the New Mexico State Engineer in permitting additional consumptive uses of water upstream of the three pueblos have resulted in the depletion of water needed by the pueblos for irrigation. This is aside from the problem of the as yet unexercised Winters Doctrine reserved rights of the pueblos. Any additional diminishment of flows in the Jemez will have a serious impact on the rights, economies and cultures of the pueblos.

Very truly yours,

Thomas E. Luebben
Tribal Attorney

TEL: phm
cc: Sam Armijo, Governor
Pueblo of Santa Ana

Responses to Comments from ZIA and Luebben Hughes & Kelly

The comments presented in these letters were also presented at the Public Hearing and are addressed in the Response to Hearing Board Summary in Appendix H. Accordingly, Sections 4.1.2, 4.1.5, 4.1.7, and 4.2.2 among others have been revised or added in response to the comments.

Sangre de Cristo Audubon Society
927 Los Lovatos Road
Santa Fe, N.M. 87501

August 29, 1979

Mr. Bennie G. DiBona
U.S. Department of Energy
Division of Geothermal Energy, Room 3122C
Washington, D.C. 20585

ubject: Draft Environmental Impact Statement # DOE/EIS-0049-D

Dear Mr. DiBona:

I have reviewed the above mentioned EIS and wish to comment only on the location of the transmission lines. Our society supports the Geothermal Power Plant at the Baca Ranch as a necessary program to help solve our nation's energy crisis:

The report mentions two possible corridors (p. 4-47, #4.4.11), CorridorX 1, the Baca corridor, and Corridor 2, the Southern Corridor. It is clear from the report that Corridor 1, the Baca corridor, will have a much smaller environmental impact than Corridor 2, the Southern Corridor. In addition, it is shorter and less expensive to build. The Southern corridor in addition crosses the Bandelier National Monument. Aside from the damage it would cause the Monument, we feel that no National Park or Monument should be invaded for such purposes. Doing so would create a dangerous precedent which could lead to irreparable damage to the National Park system. We therefore support construction of the power lines in Corridor 1, the Baca corridor, despite the fact that it has been difficult to deal with the owner of the private lands to be traversed.

Sincerely yours,

William Stone

William Stone, Pr

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1447 45TH ST.
LOS ALAMOS, N. M. 87544
(505) 662-3728

August 25, 1979

Mr. Bennie G. DiBona
Rm. 3122C
Division of Geothermal Energy
U.S. Department of Energy
Washington, D. C. 20585

Subject. Comments on the DEIS DOE/EIS-0049-D

Dear Sir:

The following comments deal with a possible hazard due to release of toxic gases accompanying hydrogen sulfide (H_2S), Hydrogen selenide and arsine are the most likely; they are several hundred times as toxic as hydrogen sulfide, so their concentration and that of other gases should be checked.

The discussion below is shortened by noting the chemical similarities of the chemical elements in the Groups IV A, V A and VI A. With the possible exceptions of lead (Pb) and polonium (Po) all of the hydrides are volatile. With the exceptions of water (H_2O) and methane (CH_4) all are toxic in varying degrees. Table I lists some of the properties of interest for the hydrides and some other gaseous constituents which might be associated with a geothermal plant's effluents.

Table 3.3, Water Chemistry of Redondo Creek, in the DEIS gives concentrations for sulfate, arsenic and mercury on three dates. On October 2, 1975, the mass concentration ratio for (sulfate/arsenic) was 444 and for (sulfate/mercury) was 1600. On September 5-7, 1974 the (sulfate/arsenic) ratio was 1500. Upper limits were reported for lead and selenium, giving ratios (sulfate/lead) > 120 and (sulfate/selenium) > 1200. Concentrations for other elements listed in Table 1 were not given.

If the ratio (H_2S/H_3As) is the same as that for (sulfate/arsenic), then arsine (H_3As) would contribute 61% as much toxicity as the hydrogen sulfide. The actual ratios are not known, since no data are given for any of the gases listed in Table 1 other than hydrogen sulfide. Ores of mercury, the V A and the VI A elements are frequently associated with volcanic and hydrothermal systems; the ores are often found together.

It is proposed to vent to the atmosphere approximately a fourth of the hydrogen sulfide via the cooling tower. It is likely that the volatile hydrides would not have the same partition ratio as H_2S in the flash evaporation step, so different fractions would be found in the cooling tower effluent and in the H_2S abatement system. If significant amounts of toxic elements are present, it is important to determine their fate. Reinjection with the cooled geothermal fluid would probably be the preferred disposal technique. As shown in the DEIS Table 3.8 the concentrations of many elements, including arsenic, are well above the values known to be toxic to aquatic biota.

For the reasons given above I suggest that the concentrations of the gases listed in Table 1 should be investigated, with adequate sensitivity to assure that effluent releases from neither the proposed demonstration program nor a fully developed geothermal energy system would produce a health hazard for either on-site workers or the general public.

Respectfully submitted,

Bob Watt

Bob E. Watt (PhD, Nuclear Physics, retired)

Distribution:

New Mexico Congressional delegation
Senator Pete Domenici
Senator Harrison Schmitt
Representative Manuel Lujan, Jr.
Representative Harold Runnels

NMCCAW
George J. Biggs

K. Yarborough

T. Davis

State of New Mexico
Health and Environment Dept.
Secretary Dr. G. Goldstein

Energy and Minerals Dept.
Secretary L. Kehoe

TABLE 1

Chemical Group	Chemical name & formula	Concentration limits ppm	mg/liter	Toxicity ratio to H_2S	Boiling point °C
VI A	Hydrogen sulfide H_2S	20	0.027	1	-61.8
	Hydrogen selenide H_2Se	0.05	1×10^{-4}	270	-42
	Hydrogen Telluride H_2Te				- 4
	Hydrogen polonide ? H_2Po				~ 35 ?
V A→	Phosphine H_3P	0.05	7×10^{-5}	386	-87.4
	Arsine H_3As	0.05	1×10^{-4}	270	-55
	Stibine H_3Sb	0.1	5×10^{-4}	54	-17
	Bismuthine H_3Bi				22
IV A	Silane H_4Si				-111.8
	Germane H_4Ge				-90.0
	Stanane H_4Sn				-52
	H_4Pb ?				?
II B	Dimethyl mercury $Hg(CH_2)_2$				96
	Mercury				357
VI A	Sulfur dioxide	10	0.026	1	-10
VIII A	Radon	10 pCi/liter; Alpha decay			-61.8

LEGAL RESPONSIBILITY, LACK OF LIMITS, AND ENFORCEMENT

The DEIS is deficient in several instances regarding the question of legal responsibility for potential environmental damage. The DOE should also recognize that in a number of areas there are no quantitative limits to polluting effects at either the State or the Federal level.

For instance, on p. 2-3, the disposition of drilling muds is discussed. As these muds consist of caustic materials, what laws are there to ensure the fact that these substances will not find their way into local surface waters?

Are there any regulations guaranteeing that the reseeding of disturbed areas along the transmission line route will in fact be carried out, as is said will be on p. 2-28?

On p. 3-92, we find that there is no protection for the citizen against industrial noise, only some "generally accepted guidelines".

The much-mentioned State ambient air standard for H_2S has itself not been traditionally enforceable against anyone. Rules make no sense unless there are built-in a means for enforcing them.

The DEIS also fails to discuss legal responsibility for potential damage resulting from cooling tower drift (p. 4-34), and erosion and siltation due to transmission line construction (p. 4-54). Additionally, no mention is made of legal requirements to restore the site should the plant be abandoned (p. 6-1).

The Los Alamos Chapter of NMCCA&W feels that the DOE, in spending public funds for this project, has an obligation to the public to include in the EIS a far more detailed discussion of how and by whom the citizen and the environment will be protected in those areas mentioned.

Addendum Not Presented At Hearing

As one minimal interim procedure for enforcement of the many provisions and actions for environmental protection described in the DEIS to be taken by the developers, we suggest the following: execution of the provisions and actions should be made a formal part of the contract, between the developers and the DOE, and the DOE should be legally responsible for enforcement. This might also be accomplished by means of a separate contract.

Response to Bob Watt

There is no reason to believe that the H_2S which is associated with the geothermal fluid would have an equilibrium relationship to the sulfate concentration in Redondo Creek. Sulfate is often abundant in all natural aqueous systems; hydrogen sulfide however is found only in specific reducing environment. Therefore the logic for assuming the presence of any reduced gas such as arsine (H_3As) or hydrogen selenide (H_2Se) which is based on sulfate/H_2S relationship is invalid.

As for the selenium, the concentrations in the geothermal fluid are at or below the drinking water standard of 10 ppb and a toxic concentration of gas from that low a concentration in the fluid is not expected to occur.

RECEIVED VIA FACSIMILE

THE BACA
LAND AND CATTLE COMPANY
P. O. BOX 2378, ABILENE, TEXAS 79604

September 5, 1979

Mr. Bennie G. DiBona
U. S. Department of Energy
Division of Geothermal Energy
Room 3122C
Washington, DC 20585

RE: Response to Draft of
Environmental Impact Statement
DOE/EIS 0049-D
Geothermal Demonstration Program
50 MWe Power Plant
Baca Ranch

Dear Mr. DiBona:

My name is James P. Dunigan and I represent the total ownership of the surface and minerals of the Baca Ranch. I was extremely disappointed that the people preparing the Environmental Impact Statement did not see fit to contact me in connection with their studies nor to furnish me a copy of the Environmental Impact Statement. This courtesy should be extended to any land owner, and especially to one who has always cooperated with every agency of the U.S. Government as well as the utility company and Union Oil Company who are participating in the demonstration plant.

I wish to take particular exception to statements on pages 1-3, 3-14 and 4-1 in which the general theme is that "over the 30-year life of a power plant approximately 746 acres of land within Redondo Canyon will be committed solely to geothermal acitivity..."; and additionally to the statement to the effect that "no competing use of land is present within Redondo Canyon." These two statements are not correct in that as land owners we are entitled to use the land for any purpose, such as grazing cattle, recreation or hunting. We certainly recognize our obligation not to interfere with the particular site occupied by the geothermal development. I am particularly concerned with these statements because they tend to suggest that this land is withdrawn from any use other than geothermal. Such statements are not true, and could well be prejudicial to our position as regards the efforts of the U.S. Government to acquire the entire ranch. Printed statements which are contrary to the facts could definitely have a bearing on the value of these acres.

We welcome you to inquire about the contracts that exist between ourselves and Union Oil Company and also welcome other inquiries you care to make to satisfy yourselves as to the correctness of our statements.

Sincerely,

James P. Dunigan

James P. Dunigan
for
Dunigan Enterprises, Inc.
Baca Land & Cattle Companies

JPD:jmw

Response to J. P. Dunigan:

The text has been modified to better clarify the present status and private ownership of the proposed project area (Section 3.1.1.5). The 746 acres of land referred to as being devoted to geothermal activities encompasses the entire well field and plant site for the 50 MW plant. Except for some livestock grazing practiced by the private owner, geothermal exploration by Union, with the landowner's permission, has been the major use of this land in Redondo Canyon in recent years. The land on which the well field and project site are located will remain under the current ownership of Mr. Dunigan and the Baca Land and Cattle Company. Primarily for the purposes of safety, there are lease provisions between the geothermal operators and the current landowner which control access to the project area to preclude casual use by other than the landowner or his guests. As the landowner, Mr. Dunigan has access to the project area for any purpose permitted by the lease agreement. However, experience at the Geysers, the only operating geothermal plant in the U.S., indicates that uses of the well field area for general hunting or recreational purposes would be impractical and incompatible for safety reasons. Other low-presence uses of the project area, such as livestock grazing, are more compatible with the geothermal operation.

New Mexico Citizens for Clean Air and Water

P.O. Box 5
Los Alamos
New Mexico 87544
5 September 79

Mr. Bennie G. DiBona
U.S. Department of Energy
ET-57
Division of Geothermal Energy
Mail Stop 3122C
20 Massachusetts Avenue, NW
Washington, D.C. 20585

Dear Mr. DiBona:

In response to your request for written comments on the DEIS for the Baca Ranch 50 MWe Power Plant Geothermal Demonstration Program, I am submitting the enclosed material for your information. This material is substantially that which I presented at the August 30 public hearing in Albuquerque. Please note, however, that Reference 1 has been added to the article on H_2S emissions.

I was questioned on two points at the hearing, the first involving air dispersion models. Other high terrain models which should be considered in the DEIS, besides the "Valley Model", are the "Airplane Model" (which uses TVA parameters) and the "Modified Turner Model". More detailed information on these models may be had by contacting Mike Williams, who is a member of our Chapter. He can be reached at FTS 843-2112 or at his residence, (505) 455-7321. Information on the various models may also be had through the Air Quality Section of the New Mexico State Environmental Improvement Agency, and the Federal EPA.

The second point upon which I was questioned was in regard to the letter addressed to you from Bob E. Watt (also a member of our Chapter), dated August 25, 1979. As I understand the question posed by Mr. Art Wilbur, he sought additional information regarding the possibility of the hydrides of selenium (Se), tellurium (Te) and arsenic (As) being released from the cooling towers along with H_2S. Based upon their heats of formation, he appeared to doubt that this was possible. In reply to this, may I say first that geologic and chemical associations among the elements S, Se, Te and As, and their hydrides, are relatively well known (Handbook of Chemistry and Physics, Handbook of Chemistry, A Field Guide to Rocks and Minerals -- Peterson Field Guide Series, etc.). There are certainly no assurances that the highly toxic hydrides of Se, Te and As would decompose once emitted to the atmosphere. These compounds can and do exist at STP; in Dangerous Properties of Industrial Materials (N. Irving Sax, 1960), for example, we see that the MAC (Maximum Acceptable Concentration) for H_2Se, accepted by the American Congress of Government and Industrial Hygienists, is given as "0.05 parts per million in air". Even if these hydrides were broken down, the question remains as to their fate. The reference quoted above states, in regard to selenium compounds, "its compounds are all more than moderately toxic" and, further, "all tellurium compounds are probably toxic, especially those that are soluble". The whole point is that the DEIS is far from adequate in treating this entire issue. More in-depth monitoring is obviously called for. I might mention also that Mr. Watt is presently preparing additional information on this point and he promises to provide your office with this material by September 15, 1979.

Sincerely,

G.J. Biggs

G.J. Biggs
Board Member for Geothermal Energy
Los Alamos Chapter
NMCCA&W, Inc.

POTENTIAL CONTAMINATION OF LOCAL SURFACE WATERS BY SPILLAGE OF GEOTHERMAL FLUID

The DEIS treats the possible pollution of Redondo Creek and San Antonio Creek as equally damaging to the environment. Given a choice between preserving the status quo in either stream, we would opt to divert Redondo Creek (a mere trickle which passes through the plant site) in order to protect San Antonio Creek and the Jemez River (into which Redondo Creek eventually flows near Battleship Rock). A culvert could be laid through the length of the plant site to effectively isolate the creek from spillage of geothermal fluid. Such spillage could be contained by dams and reinjected without entering the downstream watershed. A disadvantage would be alteration of the Redondo Creek micro-environment, but we feel this is preferable to exposing the Jemez River to relatively unimpeded geothermal spillage.

THREAT TO VALLES CALDERA NATIONAL NATURAL LANDMARK

The Valles Caldera is of national significance because it is one of the largest volcanic calderas in the world. It has been described in reports to the National Park Service as being a scenic wonderland, as anyone who has visited the area can attest to. Most of the Valles Caldera lies within Baca Location No. 1 Land Grant, which became a National Natural Landmark in 1975. In reports to the National Park Service, geothermal development activities were identified as being <u>the</u> major threat to the integrity of the Landmark.

The Landmark is presently privately-owned, though the Caldera may be viewed in large part by the public from NM-4. The view gives the impression of an undisturbed landscape, despite some rustic ranch buildings being within sight.

Since the Landmark is privately-owned, it enjoys no protection by government from private uses of the land. Currently, three Federal agencies show an interest in procuring Baca Location No. 1 or portions thereof for its geologic, biologic and historic features: these are the U.S. Fish and Wildlife Service, the National Park Service and the Forest Service. In addition, the State of New Mexico is interested in both Redondo Peak and the Valles Grande as potential State Natural areas. It is obvious that the Valles Caldera National Natural Landmark is of prime interest both nationally and statewide. Such interest is a reflection of citizens values and desires. We recommend that ownership of the land be resolved before any geothermal development beyond the 50 MWe stage be permitted.

NMCCA&W calls attention to the fact that all Federal agencies, including the DOE, are required to take cognizance of National Natural Landmark status. This is a form of protection not only to the land but also to the citizen.

Regarding this point, therefore, we ask that the DOE resolve more exactly, beforehand, to what extent future development, let us now say to 400 MWe, will effect the Baca Landmark. The purpose of the Baca 50 MWe geothermal plant is obviously to explore potential futher development. We of NMCCA&W want to know what plans follow. The DOE has at this time no legal responsibility beyond the 50 MWe stage. Therefore, in this EIS, we ask that you give full justification to the environmental impacts of this use of public funds within a recognized national landmark.
I conclude this portion of our statement with a quote from the DEIS, p. 4-66: "Development associated with the 400 MWe expansion will alter the character of the Valles Caldera/Baca Location National Natural Landmark to the extent that its status would surely be threatened or even revoked."

VISUAL IMPACT OF TRANSMISSION LINES

Two transmission line routes have been proposed for bringing geothermally-generated power from the Baca Plant to PNM's TA-3 substation on the Los Alamos Scientific Laboratories site. These are the Baca Corridor (Corridor 1) and the southern corridor (Corridor 2).

The DEIS devotes considerable attention to the various environmental characteristics of the two corridors (with the exception of archaeologic resources) and concludes that the southern corridor would have a much greater impact upon the environment than the shorter, more northern, Baca route. The southern route, besides being some 20% longer than the Baca route, also crosses three times more public recreation land, including Bandelier National Monument. The southern corridor has greater erosion and stream sedimentation potential, as stated in the DEIS; it also crosses more travel routes.

Thus, indications are that the Baca route is the more desirable choice. A major disadvantage of the Baca corridor is, however, that it traverses twice as much of the Valles Caldera National Natural Landmark then does the southern corridor. It is our understanding that the current owner of Baca Location No. 1 wishes the transmission lines to exit his land in the shortest distance possible, quite likely to avoid loss of National Landmark status. This would naturally favor the southern corridor.

A second disadvantage of the Baca corridor is that it is the one more likely to be seen from the Los Alamos townsite. We of the Los Alamos Chapter of NMCCA&W believe that the DEIS is lax in addressing the question:

"What will we who live and work in Los Alamos see of transmission lines on the mountains west of town?" At this time, we feel that this question reflects our major concern regarding transmission lines emanating from the 50 MWe Baca Demonstration Plant.

HYDROGEN SULFIDE EMISSIONS AND THE REQUEST BY PNM TO WEAKEN THE AMBIENT AIR STANDARDS

According to the draft EIS (p. 2-1), a major purpose of the geothermal demonstration plant is to demonstrate the "environmental acceptability" of electrical generation from liquid-dominated geothermal resources. With this declared purpose, we find it inconsistent that PNM should now be asking the State of New Mexico for a fifty-fold relaxation of the State ambient air standard for H_2S from the present 3 ppb (1-hour average) to 140 ppb for geothermal areas.

Energy developers at public forums have described the H_2S ambient standard as "strict", which it is, and as "arbitrary", which it is not. The law does not permit the adoption of any standard that is arbitrary. The H_2S standard is based on protecting the population against malodors. The concentration of H_2S that can be smelled by the sensitive portion of the public is 4.7 ppb (Ref. 1). While malodors are not directly destructive of human, animal or plant life, they clearly can be, and have been, destructive of the "environmental acceptability" of geothermal energy development. The principal cause of individual and organized citizen complaints against geothermal operations at The Geysers in northern California has been malodors due to H_2S emissions (Ref. 2). These widespread complaints have resulted from H_2S levels which in general are very much below 140 ppb This fact demonstrates that "environmental acceptability" and ambient concentrations of H_2S of 140 ppb (1-hour average) are clearly incompatible.

What alternatives are available besides weakening the standard or aborting the project? Technical options available for reducing H_2S emissions are not adequately addressed in the draft EIS. The source of virtually all uncontrolled H_2S emissions from the proposed plant is the cooling system. These emissions could be reduced by up to 98% by use of dry or wet/dry cooling towers in place of th open cooling towers. However, in the draft EIS, this option is dismissed with disquietingly simplistic arguments and explanations. The document says "many" dry cooling towers are quite noisy (p. 10-7). Are there some that are not? The document says dry cooling towers are "expensive" for most applications (p. 10-7). The relatively low ambient temperatures at the mountain location of the Baca Ranch make dry towers more attractive there than at other sites. What does "expensive" mean? What are the relative costs for different types of cooling systems? What fraction of geothermal power production cost is due to cooling system cost? How much would production costs and consumer costs be increased by using cleaner cooling towers in the Geothermal Demonstration Program?

These questions do not prove that cleaner towers are economically feasible, but neither does calling them "expensive" prove infeasibility. The real economics of this important issue of "environmental acceptability" must be addressed fully and publicly.

<u>REFERENCES:</u>

1. Leonardos, G., <u>et</u> <u>al</u>. "Odor Threshold Determinations Of 53 Odorant

Chemicals" Journal of the Air Pollution Control Association, Volume 19, No. 2, pp. 91 ff (February 1969).

2. Ellickson, P.L., *et al*. "Balancing Energy and the Environment: The Case of Geothermal Development" R-2274-DOE, Rand Corp. for DOE, pp. 116 ff (June 1978).

AIR QUALITY: MONITORING AND MODELING

On p. 3-59 of the DEIS, under the Description of Existing Environment, are given results of a three-month program of monitoring particulates near Redondo Creek. The reported average reading is 40 micro g/m^3. This value is far too high to be truly representative of ambient particulates in that area before the advent of geothermal activities. Average readings of 15 to 20 micro g/m^3 are typical for relatively undisturbed or remote areas of New Mexico. Even monitors in populated areas such as Los Alamos (at the Medical Center and the White Rock sewage treatment plant) give average readings of 20 to 25 micro g/m^3. If particulates are found to average 40 in the fall (which is not a windy season) near Redondo Creek, clearly the monitors are measuring effects of existing geothermal activities, which cannot fairly be used to describe representative pre-project conditions.at the Baca Ranch.

A second shortcoming in the DEIS discussion of air quality is that dealing with air dispersion modeling (pp. 4-22 to 4-32). The model used does not adequately take into account the effect of high terrain in the vicinity (approximately 10 kilometers to the SSE) of the proposed plant. Several other high terrain models (such as the widely used "Valley Model") will predict 1-hour average ambient H_2S concentrations for Baca Plant emissions of over twice the New Mexico standard. Some of these other commonly used high terrain models should be used to calculate expected concentrations of H_2S and the results included in the final EIS.

Response to New Mexico Citizens for Clear Air and Water (Los Alamos)

The comments in the letter from G. J. Biggs, with attachments, were also presented at the public hearing and have been addressed in the Responses to Hearing Board Summary (Appendix H).

Air quality evaluations were based on "modified flat terrain models" while the comments suggest the use of "high terrain" models or "complex terrain" models. Since complex terrain models tend to be based on flat terrain models it is probably true to say that the majority of complex terrain investigations use "modified flat terrain models". As suggested, models are available for the prediction of dispersion in mountainous areas (complex terrain). One model used in the DEIS is based on a formulation due to Egan which is generally considered to represent about the best possible approach to the problem at the present time. Not all available models can be similarly characterized, however. For instance, the model "VALLEY" which purports to be applicable to complex terrain situations has been strongly criticized recently and the DEIS staff did not chose to use this model in the work. For the nocturnal drainage flow the assumptions and caveats which apply to the calculations have been clearly stated in the DEIS. The resulting concentration should be analyzed with these statements in mind.

Although the DEIS addressed the question of reliably predicting dispersion in the project situation, it did not discuss the matter in any detail. It was felt that a long technical discussion of this matter would do little other than to arrive at the conclusion that the subject is not well understood. This point was made in the DEIS together with pointing out the fact that there was a scarcity of data. The subject of dispersion in complex terrain is being studied intensively at the present time. The calculations reported in the DEIS represent what is considered to be a "state-of-the-art" effort. It was decided to proceed in that manner after a thorough study of the situation involving discussions with researchers in the area and following a review of the data which were available to the staff.

Particulate concentrations of 40 $\mu g/m^3$ may not be representative of undisturbed areas of New Mexico. Thus these data may be reflecting the impact of activity in the area of the site. However, background concentrations for New Mexico vary widely and it should be kept in mind when speculating on the Los Alamos figures that much of that area is paved.

Section 4.2.3 has been rewritten for better clarity.

Appendix J

ADDITIONAL COMMENTS RECEIVED DURING CONSULTATION PROCESS

IN COMPLIANCE WITH

THE AMERICAN INDIAN RELIGIOUS FREEDOM ACT

PUEBLO of ISLETA

P.O. Box 317
Isleta, New Mexico 87022

Office of the Governor

Telephone
(505) 869-3111
(505) 869-6333

November 30, 1979

Mr. Arthur C. Wilbur
Geothermal Project Office
U.S. Department of Energy
600 Second Street , N.W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

In answer to your letter on the Geothermal Demonstration Power Plant Project and the statement contained here in on Indian cultural impacts, I am responding as before in my letter of August 10, 1979.

From the view point of the Non-Indian cultural, I am sure that you are only looking at the advantage that the project has without any consideration that it has on the Indian way of life. The comments made by the Indian people at your recent hearings should really indicate the true feelings that the Indian people have of the project. The encroachment and disruption of the Indian religion is the true reason that we are against the project.

It also seems that the Constitution of the United States is also forgetting at times where it also gives the people of the United States the freedom of Religion, but yet, this is being overlooked to give due respect to the Indian religion which is the [illegible] of Indian Life.

The Governor and Tribal Council are still taking a firm stand against the Baca Geothermal Project.

Sincerely,

Alvino Lucero

Alvino Lucero
Governor, Isleta Pueblo

AL/la

cc: Al Yelaire

DEC 3 1979
7 8 9 10 11 12 1 2 3 4 5 6

J-4

PHONE (505) 867-3304

PUEBLO OF ZIA

IN REPLY REFER TO:

SAN YSIDRO, NEW MEXICO 87053

December 4, 1979

Arthur C. Wilbur
Geothermal Demostration Project
U.S. Department of Energy
Plaza Del Sol Bldg. Room 712
600 Second Street , N.W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

This is in reference to your letter which deals with the proposed addition to the Final Environmental Impact Statement in which you asked the Pueblo of Zia to make comments. After some discussion with the key people here in the Pueblo, we feel that the Pueblo of Zia can't fully accept the proposed addition to the Final Environmental Impact Statement.

There were several reasons for our action, the first being the amount of time allotted to the Pueblo on which to make comments. The Pueblo of Zia feels that two weeks is not adequate time for us to comment on an issue of this importance and come up with a decision which will effect or alter the ways and conditions of our culture. If we accept the comments as they are written or attempt to respond to the proposed addition we would in essence be signing off our religion in that region. If adequate time could be given we feel the Pueblo could comment in greater detail on the proposed addition.

Secondly, Pueblo concerns are not addressed when certain individuals are used as "spokespeople" for the Pueblo.. We would like to mention the fact that the proposed addition doesn't use Pueblo input but instead utilized the comments of a few individuals who don't have the authority to speak for the Pueblo. Throughout the section you refer to people like J. Sando, A. Ortiz and F. Ellis, though these people are professionals within their chosen field they can't really express the true feelings of the Pueblo. These people can express their thoughts as individuals but these people do not live on a day to day basis within the respective Pueblos.

The use of only certain individuals will cause conflicts with the Pueblos when the true Pueblo feeling is disregarded. Therefore, if the comments can't express the feeling of the true Pueblo leadership then we reject the proposed addition.

The final reason is that the proposed addition to the Final Environmental Impact Statement reflects on the theory that minimal impact will occur. We feel that we addressed this theory back in August when the Pueblo of Zia went on record stating that man and machine can't predict what impact the project will have on Mother Earth. Therefore, we as Indian people depend on this area for our religion and to accept that only minimal impact will occur is only defeating our cause and survival, we must stand on the principle that more than maximum impact will occur.

These are but a few concerns and if additional meetings can be of some benefit please feel free contact us.

Thank you.

Sincerely yours,

Moses Shije

Moses Shije
Governor

MS:pp

J-6

PUEBLO OF ZUNI

P. O. BOX 339
ZUNI, NEW MEXICO 87327

ROBERT E. LEWIS
Governor

THEODORE EDAAKIE
Lt. Governor

SEFFERINO ERIACHO, SR.
Head Councilman

PESANCIO LASILOO
Councilman

MILO OWALEON
Councilman

ROGER TSABETSAYE
Councilman

FRED BOWANNIE, SR.
Councilman

ALEX BOONE
Councilman

In reply refer to:

DEC 6 1979

U. S. Department of Energy
San Francisco Operations Office
Geothermal Project Office
Plaza Del Sol Building, Room 712
600 Second Street, N.W.
Albuquerque, New Mexico 87102

Attention: Arthur C. Wilbur

Dear Sir:

Regarding your letter of, on or about, November 18, 1979, and the information which you enclosed, we have reviewed it and find it entirely true and acceptable as it is written except for the location description of Zuni in Section 3.1.10.1. Geographical Setting. The Pueblo of Zuni is one of the nineteen pueblos, but it is not in the Rio Grande Valley, it is west of the Continental Divide, lying in the Zuni Mountain watershed on the Zuni River, which is a contributary of the Little Colorado River system. Please correct this reference in the report.

It appears that the Native American Religious Freedom Act is forcing the Indian tribes to locate, describe, and reveal areas, religious rites, and sacred areas and objects to the various federal agencies in order to accrue to the "protections" intended under the law.

This kind of information becoming a matter of public record in an EIS was not the intent of the so-called

> "to protect and preserve for Native Americans their inherent right of freedom to believe, express, and exercise the traditional religious of the American Indian, Eskimo, Aleut, and Native Hawaiian, including, but not limited to access to sites use and possession of sacred objects and the freedom to worship through ceremonial and traditional rites".

These things should be worked out between the Secretary of the Interior and the other various federal agencies through memoranda of agreement "as to the desired confidentiality of such information.

Sincerely yours,

for Robert E. Lewis
Governor, Pueblo of Zuni

RECEIVED
DEC 8, 1979

Pueblo of Jemez

OFFICE OF THE GOVERNOR
P. O. BOX 78
JEMEZ PUEBLO. NEW MEXICO 87024

December 6, 1979

Arthur C. Wilbur
Project Manager
Room 712, Plaza Del Sol Bldg.
600 2nd St. N. W.
Albuquerque, New Mexico 87102

Dear Mr. Wilbur:

In review of the Baca Geothermal Demonstration Project, we are submitting our comments to the section dealing with the Pueblo Indian culture and religion.

In essence, the Pueblo does not accept the report as submitted, therefore, we reject the entire document. After careful analysis we have found the document in conflict and a lack of understanding with our religious values and way of life.

As previously stated by the Jemez traditional leaders in the two public hearings, the Pueblo is eminently against the geothermal development project in the Jemez Mountains. It is a direct threat to our culture, life and way of expressing our religious beliefs.

Therefore, the religious leaders and the Jemez Tribal Council rejects the document and the entire project.

Sincerely,

Henry Mora

Henry Mora
Governor of Jemez

SANTA CLARA
POST OFFICE BOX 580
(505) 753-7326

INDIAN PUEBLO
ESPANOLA, NEW MEXICO
87532

December 7, 1979

Arthur C. Wilbur, Project Manager
Geothermal Demonstration Power Plant Project Office
Room 712, Plaza del Sol Building
600 2nd Street, N.W.
Albuquerque, New Mexico 87102

Dear Art:

We have been reviewing the EIS regarding the Indian Religious and Cultural Concerns. Although I am sure we can argue and comment on specific areas in the document, we cannot afford to jeopardize those values and beliefs in order to satisfy the Department of Energy's participation.

We have continually rejected and opposed any direct participation to date, and I believe that we will do so, so long as it directly confronts our Indian culture and way of life.

This is just a reassurance and recommitment in behalf of Santa Clara Pueblo and its people that we will continue to fight against the proposed Baca Location Geothermal Power Generation Plant in the Jemez Mountains region.

In conclusion, this summarizes our feelings and concerns regarding the supplement to the EIS dealing with our religions and cultures.

Thank you for allowing us this time.

Sincerely,

Walter Dasheno

Walter Dasheno, Governor
Santa Clara Pueblo

WD/gy

RECEIVED
DEC 8 1979

LAW OFFICES

BRUCE J. TERRIS
1526 18TH STREET, N.W.
WASHINGTON, D.C. 20036

(202) 332-1882

BRUCE J. TERRIS
ELEANOR M. GRANGER
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EDWARD H. COMER
TARA HARVEY
DELMAR KARLEN, JR.
KAREN H. EDGECOMBE
NORMAN L. DEAN

December 7, 1979

Marty Rogowsky
Office of General Counsel
Department of Energy
Room 6D 033, Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20024

Dear Mr. Rogowsky:

The Santa Clara Pueblo has reviewed DOE's supplemental materials on the potential impacts of the Baca Demonstration Geothermal Power Plant on Pueblo culture and religion. The supplement concludes that the plant would infringe on the free practice of the Pueblo religion and proposes a mitigation plan in an attempt to minimize that infringement. The Pueblo strongly believes that the proposed mitigation plan will not eliminate that infringement. The Santa Clara Pueblo therefore believes that its religion and culture can only be protected from serious infringement through rejection of the project.

The supplemental materials contain several errors and deficiencies. Our analysis has been aided by Dr. Florence Ellis, an anthropologist who has specialized in the study of Pueblo culture. Her observations and conclusions have been conveyed to us both orally and in writing (Attachment A) and are used freely throughout our comments. In addition, we have used published writings by other Indian scholars. Those materials are attached.

The Supplement correctly states that Pueblo religious beliefs and practices permeate every aspect of their day to day living (§3.1.10.2, ¶2). That principle cannot be emphasized too strongly. Pueblo religion, however, not only permeates their entire life, but integrates it as well. It is not simply a form of worship or a set of philosophical beliefs, as is the case with most Western religions. It is that and much more. It is a pattern for living. Furthermore, in these days when Western culture is constantly encroaching on all aspects of Pueblo life, it represents one of the areas of Pueblo life which has remained most intact. It therefore provides an essential means for the Pueblo Indians to affirm their distinctive identity. Any threat to their religion is thus a threat to their cultural integrity.

Marty Rogowsky
December 7, 1979
Page Two

There are several important concepts which underlie Pueblo religion and which have not been clearly and completely presented in the supplemental materials. The concepts are those of balance, place, and secrecy. Each has a special relevance to the present controversy.

In the section on the Pueblo concept of reality (§3.1.10.3), there are several statements which recognize the fundamental importance of the concept of balance to Pueblo religion. Thus, the Pueblos believe that nature is supposed to be in balance, and that man should conduct his life in a manner that maintains that balance (§3.1.10.3, ¶s 4, 6). However, there are several corollaries to this principle which have been omitted. The first is that if man upsets the balance of nature, that damage is permanent and cannot be reversed. The second is that any such imbalance necessarily has negative repercussions on the world at large. Those repercussions can include events that conventional Western thought would not place in the same chain of causation, such as droughts, accidents, and sickness.

The Pueblo Indians believe that the drilling and other activities associated with geothermal energy production upset the balance of nature. Those activities invade the underworld, which as the supplement correctly describes, is the most important level of nature in Pueblo cosmology (§3.1.10, ¶4). In addition, those activities contaminate the underground water supply, alter its nature flow, and possibly reduce its surface abundance. That impact is particularly serious because, as the supplement recognizes, water has "pre-eminent importance" in Pueblo religion, is the medium by which spirits travel to and from the underworld, and is used in ceremonies for worship of those spirits (§3.1.10.4, ¶2; §3.1.10.3, ¶6). See Ellis, Anthropological Data Pertaining to the Taos Land Claim, p. 106 (Attachment B). Thus, geothermal activities strike at the very heart of Pueblo religion and cause a serious interference with the natural hydrological balance. That interference is perceived as having very far-reaching and negative repercussions throughout the Pueblo world (Ellis Letter, Attachment A, p. 1).

The second concept which needs to be emphasized concerns the importance of place in Pueblo religion. The Pueblo Indians are still living today on the same sites where the Spaniards found them in the 16th century. Sando, The Pueblo Indians, p. 23, Attachment C. More importantly, they are still using many of the same shrines that their ancestors did. Those shrines cannot be moved, just as the holy places in Bethelehem and Mecca cannot be moved. Similarly, when Pueblo Indians gather sacred objects or perform sacred rituals, they must be done in a special setting in order to be effective. The rituals "must be performed by special persons at stated times and places, in the presence of certain powerful fetishes and to the accompaniment of set prayers, songs and other ritual acts." Parsons, Pueblo Indian Religion, p. 269, note, Attachment D. And when sacred branches are collected for a ceremony, "[n]ot just any tree, but a suitable tree must be found." Tyler, Pueblo Gods and Myths, p. 252, Attachment E. Thus, the religious power residing in shrines or sacred objects is intimately connected to the physical location of those phenomena. Shrines and sacred objects cannot be replaced with substitutes in another location. Not every mountain or place is equally powerful. Tyler, supra, p. 251.

Consequently, the statement in section 4.1.7, ¶6, that "a sacred object has greater significance for purposes of the ritual than its collection area" is fundamentally wrong. The value of a sacred object is tied to its collection area. If the geothermal project displaces significant gathering areas or shrines, it will destroy the power of the rituals and objects associated with them.

The third important concept which is not fully explained in the supplemental materials is the Pueblo need for religious secrecy. The materials suggest that secrecy evolved partly in response to religious persecution by early Spanish invaders, and continues because of the need to prevent desecration of sacred sites by non-natives (§4.1.7, ¶s 7, 8). There is another basic reason for secrecy. The Pueblo Indians believe that when religious ceremonies are improperly revealed through words to, or sight by, non-Indians, the power of those ceremonies is lost. Parsons, supra, pp. 82-83. This belief explains in part why Pueblo religion does not proselytize. Sando, supra, p. 23. It also means that revelation of a secret can be an infringement of religion in and of itself, regardless of any subsequent use of that secret by non-Indinas. Consequently, if the project increases the potential that Indian ceremonies will be viewed by non-Indians, it poses a threat to the integrity of Pueblo religion.

With these three concepts in mind, we turn to a discussion of the probable infringements on religion which have been identified in the supplement. The first potential infringement is the destruction of religious sites. The most important religious site near the project area is Redondo Peak. The top of that Peak contains a main shrine for at least six Pueblos, including Jemez,

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Zia, Santa Ana, San Felipe, Cochiti, and Santa Clara. Pueblo shrines such as this one have much the same significance as altars in the Catholic church. The shrine at the top of the peak is the altar, and the area surrounding the peak is the church. Religious spirits are believed to concentrate at these shrines. The Pueblo Indians make offerings and perform ceremonies at the shrines to persuade these spirits to help them maintain a harmonious balance in the world. There are also other religious shrines in the project area.

The supplement incorrectly states that adverse impacts to these sites would be minimal. On the contrary, the project would be a major infringement. The plant would undermine the integrity of a major shrine and the church which surrounds it. The supplement admits that Redondo Peak is likely to be affected by the sight, sound, and smell of the project, but classifies these impacts as only an "invasion of privacy." This characterization is gross underestimate. These impacts destroy the very essence of the shrine. It is nearly impossible to establish or maintain one's focus of devotion and worship in the natural church-like setting when only a short distance away there is the visible ugliness of plant technology, the audible shock waves of drilling operations, and the occasional smell of noxious hydrogen sulfide fumes. The situation is comparable to operating a jackhammer in the interior of a Catholic church.

The noise impacts alone are totally unacceptable. The supplement states that "the noise reaching Redondo Peak from the nearest project facilities is computed to be 50 to 60 dBA during drilling and construction and 40 to 50 dBA during operation" (§4.1.7, ¶2). A recent study of noise impacts of geothermal development demonstrates that these noise levels are a serious problem just for ordinary residential communities. P. Leitner, An Environmental Overview of Geothermal Development: The Geysers-Calistoga KGRA, Vol. 3, August 16, 1978, Attachment F. That study found that geothermal noise intrusion "can be particularly disturbing to people who have chosen to live in the KGRA region because they place a high value on quiet and serenity." Id. at 4. Furthermore, it found that while "the most vigorous and widespread complaints came from receptor sound-pressure levels of 60-70 dBA or higher," "levels as low as 40-55 dBA have drawn a more vigorous response than would be expected in a typical urban or suburban community." Id. at 5. The Baca project will impose those same levels in an area of major religious importance. It is readily apparent that these levels will be equally or even more disruptive to the Pueblo Indians than they are to ordinary suburbanites.

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The second potential infringement discussed in the supplemental materials is the destruction of sacred objects. This entire section operates on the premise that sacred objects are fungible. It finds that any collection areas displaced by the project can be amply replaced by areas outside the project area and therefore concludes that the project will have "minimal adverse impact" on sacred objects (§4.1.7, ¶7). As we have demonstrated earlier, this analysis is fundamentally wrong. Sacred objects gain their power in large measure from the kind of place where they are gathered. Any destruction of a collection area therefore causes irreparable and irreversible harm to sacred objects.

The third type of infringement is invasion of privacy. The supplement evaluates the likelihood of such disturbances for two areas -- the project area itself and Redondo Peak. For the first area, the supplement is inconclusive, because DOE has been unable to ascertain whether any ceremonies are practiced within the project area. We can state emphatically that the Santa Clara Pueblo does observe religious ceremonies within the project area. DOE has been unaware of these ceremonies because the Pueblo religious societies come to that area and pray in secrecy in order to preserve the power of their religious ceremonies. The Pueblos have had to be particularly secretive because of the increased presence and activity of non-Indians in that area who are associated with preliminary drilling activities. This need to conduct exceptionally furtive ceremonies is an infringement of religion.

For the Redondo Peak area, the supplement finds less chance for unauthorized viewing of religious ceremonies, because project personnel would have no reason to leave the project area to visit the Peak and because "the strategic location of the project at the base of the mountain may help to discourage trespassers and curiosity-seekers from trying to reach the summit" (§4.1.7, ¶ 10). We are at a loss to understand this last statement. The increased activity in the area and the new access road to the plant will bring more people to the area. The plant operators cannot directly control access to the summit, because it is outside the project area. Consequently, the presence of the plant will encourage, not discourage, access to the nearby area.

The fourth section discusses potential interference from transmission lines. It states that "the two alternative transmission routes will avoid all known religious sites" (§4.1.7, ¶ 3). This statement is inconsistent with an earlier section of the supplement which reports that reliable non-Indian sources have

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identified two sacred sites within Baca Location which are "within view of an alternative transmission corridor" (§4.1.7, ¶3). These sites would therefore be directly threatened by the visibility of transmission lines. This specific impact must be added to the general conclusion that the sacred nature of the entire Baca location is undermined by the visible intrusion from man-made structures.

The next section of the impact analysis is particularly important because contamination or loss of water is a vital concern of the Pueblo. The supplement correctly emphasizes that water has "preeminent importance" in Pueblo religion (§3.1.10.4, ¶2) and that it is also "an essential cornerstone of the Indian way of life" (§3.1.10.1, ¶ 3). However, it underestimates the impact of the project on water uses by the Pueblo.

The section initially assumes that surface water reductions due to geothermal fluid extraction will be quite small. In our November 9, 1979, letter, we transmitted a hydrological analysis by a Bureau of Indian Affairs (BIA) employee which seriously questions that assumption. That report found that the project was likely to have much greater hydrological impacts, in the form of decreased geothermal additions to, and increased surface leakage from, surrounding streams, including Santa Clara Creek. Later in November, we sent DOE an even more recent hydrological analysis, which was performed by Geological Services of Tulsa (GST) for the Santa Clara Pueblo (Attachment G). The GST study confirms the results of the BIA study, again finding that the project will have "very significant impacts on surface water" substantially beyond the project area (p. 21) and that "the proposed project will have an impact on total water quantity many times greater" than what DOE has acknowledged (p. 23). Given these studies, the statement in the supplement that "the project should have no effect on the amount of water needed for religious purposes" is not scientifically supportable.

The section on water impacts next states that the expected changes in water quality should be minor and that those changes should have little or no effects on Indian lands (§4.1.7, ¶16). It states that the Baca plant will increase the turbidity of surface streams, and that there will be accidental spills of "short duration" (<u>ibid</u>.). It then provides the weak reassurance that there will be <u>no</u> "long-term" impact on religious practices from such an accident (<u>ibid</u>.).

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Any reductions in water quantity and quality would infringe on Indian culture and religion. The Pueblo Indians believe that any such reductions disrupt the natural balance, thereby leading to negative impacts in the world at large. More specifically, those reductions may disrupt the Pueblo agriculture, which is an important part of the Pueblo religious system. Thus, underground displacements appear to pose a threat to water quality and associated religious values.

The supplement's assessment of the impact of the project on sacred springs contains the same flaws as does its general discussion of water impacts. These impacts are likely to be greater than the supplement predicts, based on the studies we have cited. In addition, the geothermal fluids which are reinjected will be cooler and more concentrated in dissolved solids than those which are withdrawn. DEIS, p. 4-21. Therefore, the quality of the waters at surface springs will also be affected. DEIS, p. 4-22.

These impacts will infringe on Pueblo religion. According to Dr. Ellis, the Pueblo Indians regard all springs in the Jemez Mountain region as sacred shrines. See also Tyler, supra, p. 182. Those springs provide access to spirits of the underworld and the waters from these springs are believed to have great curative value. Those waters are often carried to the Pueblos in ceremonial jugs for use in different religious ceremonies, such as those designed to alleviate droughts. Therefore, the supplement's statement that "[t]he religious impact from the depleition or loss of a sacred spring is unknown," should be replaced with a conclusion that serious religious infringement will result from such impacts.

The final impact discussed in the supplementary materials is potential interference with access to religious sites (§4.1.7, ¶ 20). The materials offer no assurances of such access, except the possibility of a negotiated arrangement with private landowners and plant operators. Dr. Ellis has addressed this issue of access in connection with land claims of the Taos Pueblo (Ellis, supra, p. 106, Attachment B):

> Water and other materials still must be brought from sacred springs for ceremonial use even if such springs now are in lands owned by non-Indians, and the fact that the sacred lakes and springs no longer belong to Taos long has been not a mere theoretical thorn in the side of Taos but almost a traumatic injury.

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Consequently, any increased difficulty in reaching sacred sites in the project area due to any additional property restrictions imposed by the plant operators will also be infringement on Indian religious freedom.

In its summary of the impacts section, the supplement concludes that the project will cause some infringement on Pueblo religion, but that the full extent of that infringement is unknown (§4.1.7, ¶ 21). We have demonstrated above that infringement will occur in every one of the impact areas identified in the supplemental materials and that in many cases those infringements go to the heart of the Pueblo religion because they disrupt sacred shrines and essential water sources.

The supplement also suggests that any damage to Pueblo religion has already been done by preliminary construction activities. That suggestion is blatently erroneous. The amount of noise, water impacts, and human activities in the area will increase greatly if the project is approved. The Santa Clara Pueblo strongly believes that the religious significance of the area is one of continuing importance and will be harmed far more if the project goes forward.

Section 4.5 of the supplemental materials analyzes the impacts of future project expansion on Pueblo religion. That section makes it clear that a 400 MW expansion is totally incompatible with the maintenance of Indian religious values. The entire southwest quadrant of the Baca Location "would assume a greater industrial character" and "the overall appearance of this part of the Jemez Mountains would be greatly changed" (§4.5.2.6). We submit that decision to go forward with the present 50 MW plant must be based on an analysis of the effects of full 400 MW development on Pueblo religion, because it is clear that the project operators intend to only proceed with the project on an all-or-nothing basis.

In August 1979, Public Service Company of New Mexico (PNM) withdrew its state construction application for the plant, explaining that it would not build a 50 MW plant unless New Mexico raised its hydrogen sulfide emissions standards to permit greater geothermal development. The Energy Daily, August 16, 1979, p. 2 (Attachment H). In his testimony before the State's Environmental Improvement Board, PNM's vice president made clear his intention to build a 400 MW plant, stating that "[a] standard that permits construction potential of up to 400 MW is essential * * *." Testimony of C.D. Bedford, p. 4 (Attachment I). Furthermore, in its

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closing argument to the Board, PNM stated that "[g]eothermal development will not proceed on a unit by unit basis due to the economic unknowns of attempting to change [an air quality] standard each time a new unit is attempted to be built." Closing Argument of Public Service Company of New Mexico in Support of Adoption of Its Proposed Amendment ot Air Quality Coontrol Regulation 201, p. 12 (Attachment J). From these statements, it is clear that PNM only intends to proceed with the 50 MW plant if it can construct a 400 MW development. In these circumstnaces, the decision to build a 50 MW plant must be measured by the likely effects of full-scale development on Pueblo religion.

We now turn to the proposed mitigation plan to protect Pueblo religious freedom. First, we note that a mitigation plan is not a part of the four-step process which DOE proposed in the Report to Congress on the American Indian Religious Freedom Act. In that report, DOE recognized that before it proceeds with a proposed action, it must do four things: (1) investigate to determine whether a religious site is affected; (2) if a site is affected, consult with Native traditional religious leaders to determine whether religious freedom would be infringed; (3) if an infringement is found, prepare alternate plans which avoid the infringement; and (4) if avoidance is not feasible, weigh the impact on religious freedom against the importance of the project. Report, pp. 27-28. DOE has completed steps one and two, and has found that there will be an infringement. However, it has not proposed any alternate plan which will avoid the infringement. Instead, it has prepared a mitigation plan which will minimize the infringement. We assume therefore that DOE has concluded that no completely protective alternatives within the Baca Location are available, and the best that DOE can offer is a reduction in the potential infringement from a project in that region.

This conclusion suggests that DOE is now at step four, where it must weigh the impact on religious freedom against the importance of the project. In order to carry out a meaningful balancing process, it is appropriate for DOE to propose a mitigation plan which will allow it to weigh the post-plan infringement on religious freedom against the value of the project. Unfortunately, however, the mitigation plan is wholly inadequate to perform this function. See §11.3. The plan is in fact not a plan at all. It is nothing more than a proposal to develop a mitigation plan in the future, after consultations and negotiations between Indian leaders, DOE and the plant operators. As such, it offers no specific measures which will be made part of the decisionmaking process.

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DOE must analyze specific mitigating measures pursuant to NEPA. Since these are important alternatives, they must be analyzed in an environmental impact statement. After such analysis, a mitigation plan must be adopted. Only then can DOE decide whether the residual harms to religious freedom which remain after those measures are applied are outweighed by the importance of the project.

The need for this particularized analysis of mitigating measures was recognized in State of Alaska v. Andrus, 580 F.2d 465 (C.A.D.C. 1978). In that case, the State of Alaska and others challenged a decision by the Secretary of the Interior to sell oil and gas leases in the Outer Continental Shelf of the Gulf of Alaska. One of plaintiffs' arguments was that the Secretary had violated the National Environmental Policy Act by failing to prepare a detailed evaluation of the environmental impact of the United States Geological Survey's Operating Orders, which were designed to mitigate environmental harms resulting from drilling operations on the leased tracts. 580 F.2d at 477. Plaintiffs argued that the Secretary had merely described those orders in the environmental impact statement and treated them as a given, without evaluating their environmental impact. Ibid. The court of appeals agreed with the plaintiffs that a fuller evaluation of the Orders was required. Id. at 478. It characterized those Orders as a "central mechanism" by which the Secretary carried out his duty to minimize the adverse environmental impacts of the lease sale. Ibid. The court of appeals concluded that (id. at 479):

> When forthcoming operating orders are expressly viewed by the Secretary as part of the basic premise for the kind of consideration of adverse environmental impact that is mandated by NEPA, then the completion of the undertaking -- issuance of protective operating orders -- must be conducted with full consideration of environmental consequences and alternatives.

We submit that the principles establihsed in State of Alaska v. Andrus apply with full force here. DOE has done nothing more than list a set of possible mitigation measures which will be applied to reduce the projected impact on Pueblo religious values. Those measures are clearly intended to be a "central mechanism" and "basic premise" by which the adverse religious impacts of the project will be minimized. In those circumstances, DOE has a duty to evaluate fully the mitigation plan and to determine what the impacts will be on Indian religious practices and the environment despite this plan.

Finally, assuming that this analysis is carried out, it is very unlikely that the residual religious infringements will be acceptable. Unlike environmental harms, infringements of religious principles are rarely susceptible to compromise. Since alternative sites are available outside the Jemez Mountains and because the DEIS admits that the present site has more environmental conflicts than any other site (p. 10-6), it is clear that alternatives which do not infringe on Indian religious practices do exist. We therefore believe that, if the Department follows its own procedures under the American Indian Religious Freedom Act, this project must be rejected.

Up to this point, our comments have been concerned with the content of the supplemental materials. However, the supplement is also inadequate because the procedures which were followed are also inadequate.

The supplemental materials were not released as part of a new draft environmental impact statement. In our September 7, 1979, comments on the original DEIS, we explained in detail why it is essential that new materials omitted from the DEIS be issued in this form (pp. 11-12). A new draft EIS ensures that all government agencies and private groups and persons will have an opportunity to appraise and comment critically on the new materials. In the present case, the supplemental materials have only been circulated to the Pueblo tribes. This limited distribution does not satisfy NEPA requirements. For example, these materials should have been available to the members of the Interagency Task Force on Indian Religious Freedom, which prepared the detailed report to Congress which outlines the policies and procedures to be followed by the various Federal agencies to protect and preserve Indian religious rights and practices. The views of these expert agencies might have been especially helpful in suggesting alternatives or modifications to the project.

CONCLUSION

We therefore request a draft Environmental Impact Statement or Supplement be prepared adequately analyzing the effects of the project on the Indian religion, culture, and environment. Such a statement should remedy the extremely serious deficiencies which we have described above and in an earlier submission to DOE. We further request that DOE prepare a detailed mitigation plan and that this mitigation plan and alternatives to it be analyzed in a draft Environmental Impact Statement or Supplement.

If this is not done, based on the present record, we submit that DOE must refuse approval of the project.

Respectfully submitted,

James M. Hecker

BRUCE J. TERRIS
JAMES M. HECKER

Attorneys for Santa Clara Pueblo

Dec. 2, 1979

Mr. Jim Hecker
Bruce J. Cherris Law Firm

Dear Mr. Hecker,

Unfortunately I could do nothing about getting this into the mail for you via express tomorrow (through Alb. office) because neither of us thought about my not having your address other than name of your firm, and I could not reach the Santa Clara governor on Sat. or Sun. So this may be of little use to you other than as a reference for what I told you over the phone. I have not heard anything from Santa Clara yet re the meeting on Thurs. of which I told you but I will call the Pueblo tomorrow.

We started with the church concept in our telephone conversation. The best statement, I think, is that of the shrines being like altars (of which there sometimes are several) in a big Catholic church, and nature provides the church itself in such a spot as the top of Redondo Peak. It is not just the fairly small major shrine itself which is sacred but the area around it also, "the church" in which one worships. There is one general shrine at the top of the peak shared by all 6 Pueblos and quite possibly more. But there also are shrines belonging to individual pueblos in this area. We do not yet have any of their locations; whether they will be given to any of us is a question; it is hard for a Pueblo to bring itself to be specific about such things but under the duress which is going to ensue in this matter, unquestionably, as soon as full realization of the dread situation takes place, I think such revelation likely. But no Pueblo person could do it without the full backing of the trabal government which, in turn, could not do that without permission of the religious units and personages primarily concerned.

I am reminded, in their concept of altars and church, of the lines from our poem

> The groves were God's first temples-
> Ere man learned to hew the beam and lay the architrave-

Perhaps Wordsworth, or Bryant; neither my husband nor I can place it at the moment. But the Pueblo concept is thus.

The Pueblos say their religion is the one last thing which they retain. They do not share it with outsiders and think that revealing its secrets takes their value out of them. They finally took over Catholicism but changed it appreciably and managed to see parallels in a great deal of it and their own old religion, so that now they consider the two are one. Protestantism is another matter. In Catholicism and the Pueblo religion you find God (Father Sun), Mary the mother (Mother Earth), saints (the major kachinas or spirits with individual characteristics), angels (spirits of the dead who become generalized kachinas, water spirits), and there also is parallelism in importance of the shell in the two religions, importance of the cross, and various other things. Katcinas and some other spirits such as those of the directions live on high mountain tops. Their religion is basic to Pueblo living; it pervades life even if some of the details are not as strong as in the past.

The Indians strongly believe in the balance of nature. Removing such balance brings automatic reprisals from nature. Drilling upsets that balance. This is a most important concept.

Items taken fron specific areas for religious use must come from those
[redacted]

areas because their power does not lie only in themselves per se but has to do with where they come from. The concept of sacred water or clay having power to cure or otherwise aid an individual or group parallels that held in Mexico and in parts of Europe where water or soil from shrines, or even rosaries or pictures or other little items purchased at a shrine, carry power to alleviate ailments, give strength, protect one, etc. Plain soil or water from just anywhere does not have any such power. The shrine which these things come from is where the V rgin Mary or Christ or a saint appeared or spoke or did something which gives that spot special meaning and provides it with power for those who believe. And it is well known that some so-called miraculous cures, etc. have taken place, psychological cures , obviously, but still real. The Pueblos use water from specific sacred water sources for various ceremonies for which they prepare a "floor altar" consisting of sacred objects set out upon something of a sand painting (simpler than those sand paintings of the Navajo) on the floor of a ceremonial room, and the herbs and minerals, etc. in many cases must have been collected from specific spots, though herbs used in the household cures, those of herbalists, may be merely plucked here or there. That sort of curing is non-religious, but the religious cures and the other ceremonial affairs depend on items which take their "power" from the areas which they specifically must come from.

This covers the generalized religious picture. There are different types of ceremonies for different important purposes, and they are carried on by different religious societies. Each society is supposed to go into retreat to do its ceremony for that season 4 times per year. This keeps nature functioning correctly: man does his part and then nature does its part. If man is remiss, so is nature. In Pueblo thought, then, when something goes wrong, it is ipso facto certain that some individual or some group such as a religious society has done something wrong or has failed to do what it is supposed to have done. Such a responsibility to carry! When something goes wrong, individuals first examine their consciences and then quickly begin to wonder if their neighbors or someone who is a deviant in the Pueblo has been responsible for the damage. Even the idea of witchcraft has not disappeared among the older Pueblo people.

Pueblo shrines never can be moved, even as our shrines can not be moved because they are at spots significant for some important reason. The Pueblo people themselves know that when they place offerings on some shrines close to roads, etc., whites may steal those offerings. It has happened enough times so that the Pueblos have real reason to keep location of shrines a secret. And they keep their visits to shrines a secret so that they will not be watched and the dates of relig. matters not known. It is the pueblos of New Mex. other than Zuni which have cultivated secrecy ever since the Spaniards gave them so much trouble in the 17th and 18th centuries. We whites are permitted to see the ceremonies they have on saints days, celebrating for a Catholic saint, because we share their being Christian. But we may not see the ceremonies given for their own old religion and are not supposed to know that they are celebrating for native spirits even at the same time they do so for a Catholic saint. They put some of the saints into their pantheon when they took on Catholicism, especially, of course, the patron saint given each village by the old Spanidh priests. They make prayer offerings for their own spirits and also for the saint, marking his prayer stick with a cross to identify it. Nice gesture!

The problem of contamination of water is feared for Santa Clara Cr. which heads in a spring right at the edge or into the Baca Location. Its water is a basic necessity for the camping-fishing trade in beautiful Santa Clara Canyon, as well as to the 10 or so farms along it and the 30 familes (Spanish Americans and Indians) living at Guachapange on the edge of Santa Clara who irrigate from it. Santa Clara takes in something under $100,000 per year from the Santa Clara Canyon and Puye cliff house site trade; it is their main economic asset as a town (not money to individuals but the public moneys by which the pueblo runs). But the farming is another matter and at present they have been planning a reservoir to manage more water for gardens in the new housing development. What would contamination of this water do? Kill fish? Destroy or slow plant growth? Aside from such possibilities, the general idea of contamination of water, which they always have recognized as of ultimate importance in our dry Southwest, is thought sinful, if I may use that word.

There also is the entimely unsolved water rights problem, spoken of as the Amodt case, which all the Pueblos have worried about. It is thought by some of the wiser persons in the Southwest that 25 or 50 yrs. from now, the water rights will be one of the most important assets in the countryside, because we are running ever shorter on water as population increases. As I told you, I have been working on an Amodt case for 4 of the Tewa-speaking Pueblos, but none of the other Pueblos have had their problem taken up at all yet. And there also are all the other non-Pueblo tribes clamoring to have their rights seen to. Some Pueblos have already been objecting to the spread of Albuquerque because "their" water is being depleted when more people move in, water lawns, etc. Redondo Peak is at the top of the watershed for the 6 pueblos I mentioned the other day and I think also for Santa Domingo.

And then there is the matter of cutting out trees and building up houses, destroying natural beauty which these Indians so revere and increasing the number of people working or living around their major shrine area. Desicration of the shrine is sure to result; could you imagine anything else? And who would want to go up there to pray with noise and probably stench and certainly people around? Praying and contemplation are most important for the good of the Pueblo and Pueblo religion is intended for the good of the world, even if kept secret in its performance.

Monday: The governor was out of his office today, so I have received no further news.

Your papers arrived this afternoon.

Sincerely

Florence H Ellis

Pueblo Indians I

ANTHROPOLOGICAL DATA PERTAINING TO THE TAOS LAND CLAIM

Florence H. Ellis

SPANISH AND MEXICAN LAND POLICIES IN THE TAOS PUEBLO REGION

Harold H. Dunham

STUDY OF LAND USE OF THE TAOS PRIOR TO 1848

Harold H. Dunham

COMMISSION FINDINGS

Garland Publishing Inc., New York & London
1974

Attachment B

J-25

there were large numbers of burros used as draft animals. In the spring the War Chief collected the burros and then designated men to herd them, each owner taking his turn in watching the animals in the pasture and making sure they kept away from the young crops and the sacred spring Shipapun, believed to be connected to Blue Lake. (Parsons, 1926: 109, n. 221).

Donaldson reports the Taos grant as of 17,360 acres of which one-half "is inaccessible and about one-third of the remainder is unavailable either for grazing or agriculture." (Donaldson, 1893: 92, 100, 101.)

Miller (1896: 21, 22, 23) gives corn and wheat as principal crops, with an occasional field of oats, and a few beans, peas and melons. Oxen and horses pulled home-made Mexican type or American type plows. Miller states that the Taos kept no sheep or goats at this time, but hired a
138 Mexican with his flock to trample out the grain on a packed floor within a circle of tall poles. Several Taos farms toward Fernandez de Taos were being worked on shares by Spanish Americans in 1890.

There was a communal rabbit drive 6 or 8 miles distant on the mesa before saints' day dances, as in other pueblos, with participation mandatory, the rabbits being given to the officers and to the "saints' godchildren" who serve them to the dancers. A ceremonial hunt fire was built some distance south of town (according to modern data at Sun Stone). (Miller, 1896: 37). Jackrabbit fat was used to grease the stone used for baking paper bread (Parsons, 1936:23). Red paint was used by the hunters, the pigment being taken from the Giant's cave near Questa, 30 miles north. (Parsons, 1936: 19, 111). Deer drives formerly were held, the slayer being given a

hind leg, the hide, and antlers, the next man to come upon the kill being given a shoulder, and all the other hunters some share. Deer hunters pray and sprinkle pollen to the sun and drop some of the blood or flesh of the slain animal onto the ground for Earth Mother. Deer bones, deer hair, and turkey bones were deposited in two spots, one on the north and one on the south side of town. In the past eagles were pit-snared or taken as young birds from the nest. Buffalo were hunted in Marino Valley across the mountains to the north and in Pony Valley. Some carefully hoarded buffalo fat was used to grease the flat stone on which paper bread was baked as late as 1936, and drum heads and bags for ceremonial objects were made of buffalo hide (Parsons, 1936:20; Miller 1896: 26). The last big hunt is said to have taken place in 1884 when the Taos men went into the panhandle of Texas and found buffalo grazing with cattle!
The last big antelope hunt came two years later when a large number were 139 J-26
surrounded in the ~~Canada del Agua~~ Arroyo Aguaje near Tres Piedras and Lower Arroyo Hondo. (Grant, 1925: 84-5). Many bears are shot for meat (Parsons; 1926: 20); a bear hunt in Moreno Valley and beyond to the east is described by Grant for the late 1880's, and another tale speaks of a bear hunt in the Rio Grande country (Grant, 1925: 97, 98). Turkeys were shot for food and so that the feathers might be used ritually. (Parsons, 1926: 23).

Baskets were made as late as 1926 by an old woman and in a folktale we learn that shoots of the squawberry bush were used for this craft at Taos, as in the other pueblos. (Parsons, 1926: 24). Pottery continues to be made today, though only in small amounts.

Religion — Because of the intense and consistent conservatism of the Taos people, little is known of their ceremonialism. Before the solstices the sun is

watched at sunset to see where it sets over Tres Orejas Peak; this dating system is fundamental to keeping the ceremonial and planting calendar accurate. The solstices are periods for religious observance in all the pueblos. The famous trek to Blue Lake is scheduled for the last week in August. All adults at this time go by horse or foot to the Blue Lake area; there are offerings of prayer-feathers and pollen. Certain initiates must bathe ceremonially in the lake. Flowers and sand are taken back to the pueblo. At night there is a round dance and other dancing goes on in the daytime in the canyon. The Blue Lake ceremonial is not entirely concluded until October 2 or 3. In general it might be said to be involved with the Katcina - rain - fertility cult common to all the pueblos. Some of the young people must ascend Taos Peak for a sunrise ritual. In the spring, some of the kiva societies conduct a spring ceremony in which
140 they go into the mountains to spend the night and next morning ritually bathe in the creek, wash their hair, and use herbs as additional purification materials. Others of the groups go into the hills to spend the night and bathe and wash their hair in the stream next morning, before performing a ritual. There are other visits to the mountains and to the various sacred lakes, as hinted in the data obtained by the councilmen for the present land claim, but detail is lacking.

A race for the Sun and the Moon, in order to give them power to travel, is held very early in the morning on certain occasions. This is a relay race in which the runners are said to run from the pueblo, up the canyon, and over the mountain to the mound marking the end of the track, ten or fifteen miles distant, as indicated on our map. There is one mountain shrine referred to as "where the stone men are", where offerings are made by all

societies in connection with the races and buffalo and deer dances. (Parsons, 1926: 104). There are also many sacred springs scattered over the Taos area, as described in the data given by the Taos council. <u>All</u> springs are more or less involved with katcina concept in pueblo thought. The katcina are thought of as the supernaturals from whom all good things come (a general fertility concept), and although they are not represented in dances at Taos, they are venerated deeply. Ideology concerning the sacred lakes of Taos mingle the concepts of the original emergence of the Taos ancestors, the katcina, and purification; these ideas are but more attenuated in relation to the other sacred locations involving water. Water and other materials still must be brought from sacred springs for ceremonial use even if such springs now are in lands owned by non-Indians, and the fact that the sacred lakes and springs no longer belong to Taos long has been not a mere theoretical thorn in the side of Taos but almost 141
a traumatic injury.

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THE PUEBLO INDIANS

Joe S. Sando

The Indian Historian Press
San Francisco

[redacted]

Attachment C

of Jemez have many references in their songs to Stone Lake on today's Jicarilla Apache reservation, and to some shrines around Largo Canyon in Rio Arriba County. The area is one from which the Towas migrated to the present Jemez country, in the tenth or eleventh century A.D. Other references made in songs of the societies are to the Sierra Blanca area near the Mescalero Apache reservation in Otero County. Jemez legends say that the Arrow Society was evicted from the main Jemez group, and the members journeyed toward the southwest until they settled with the Tampiros who lived in the area at that time. Some of the references in the songs are entirely foreign in the Towa dialect, so the deities described may be Tampiro words and songs. The Arrow Society eventually returned to the Jemez country and established a village on the ridge, east of today's Ponderosa, before they were welcomed back into the community of several Jemez villages in the mountains north of Jemez Pueblo.

Areas along the Mogollon Rim of the New Mexico-Arizona border contain many ruins of former Pueblo Indian sites. Many of these sites and the higher mountain ranges have Zuni names, and it is with these Zuni names that other Pueblos refer to the area. In many instances, Pueblo people make songs for their dances and refer to the areas that have gone into non-Indian ownership many long years ago.

Religion

The Pueblos have no word that translates as "religion." The knowledge of a spiritual life is part of the person twenty-four hours a day, every day of the year. In describing the beliefs and practices of today, the traditional religion may also be understood. There is little basic change. The tradition of religious belief permeates every aspect of the people's life; it determines man's relation with the natural world and with his fellow man. Its basic concern is continuity of a harmonious relationship with the world in which man lives. To maintain such a relationship between the people and the spiritual world, various societies exist, with particular responsibilities for weather, fertility, curing, hunting, and pleasure or entertainment of the people. Even today, most Pueblo people belong to a religious society, and have an important place in the Pueblo, with time set aside on the Pueblo calendar of religious events. The calendar is so full that there is no time left for any new or innovative religious practices as is sometimes possible with

non-Pueblo Indians who accept, as one example, the Peyote Way. Many tribes that espouse new religions that are a combination of the old with the new beliefs, suffered many defeats, had lost their land to white invaders, and lost a great part of their culture as well. Certainly they could not remove their sacred artifacts nor their religious shrines at the point of a bayonet. Thus they had to revive their religion in a new homeland.

But the Pueblos are still living today upon the sites where the Spaniards found them in the 16th century. This is the principal reason for their religion being practically intact. The people took their religion underground around 1692, due to harassment by the Spaniards in their attempt to substitute another religion for the native one. This fear still persists, and it generally explains why a non-Indian is not permitted to observe a religious ceremonial dance in the Pueblos, and why no cameras or sketching are allowed.

The religious practices themselves, maintained by the Pueblos today, are the same they have carried on since their ancestors lived in pit houses. The oratories, prayers and songs are the same. These observances are not spontaneous outpourings, or outbursts of the troubled heart, but are carefully memorized prayerful requests for an orderly life, rain, good crops, plentiful game, pleasant days, and protection from the violence and the vicissitudes of nature. To appease or pledge their faith to God, they often went on sacrificial retreats, often doing without food and water as penance or cleansing of body and soul for the benefit of man throughout the world.

In the dominant society of America, religion is largely an exclusive property. Usually a certain set of beliefs and rituals is identified, written into sacred books and religious manuals, and maintained by a certain sect. It is presumed to be the one and only true, if not the first, religion. Belonging to different religions or sects simultaneously is discouraged, but proselytizing is a virtue. Contradictions such as these lead one to suspect the particular belief system. Pueblo religion does not proselytize. It is not w. ten, but is enshrined in the heart of the individual. Although me Pueblo people have been nominally Catholic for more than three hundred years, the native religion is the basis of their system of belief. The two systems are maintained by a process which Pueblo scholar Alfonso Ortiz once described as "compartmentalization." Each of the two religions are mutually distinct socio-ceremonial systems; each contains patterns or ways of worshipping not present in the other. Of the two systems of religion, one is the native or indigenous, the other is the Spanish-introduced Roman Catholic.

Elements of Catholic rituals that have been accepted are: worship on Sundays and receiving the various sacraments, confirmation, baptism, weddings and the native social dances of the Saints' days, Christmas and Easter. These rituals are now accepted as traditional Pueblo social and cultural patterns. In the end, all people throughout the world look to one personification, though they may address Him in different ways. As a writer from another continent said, "All paths lead to the same summit."

Some observers have said that the Pueblos "dance all the year round." This may be true, and more so was this the case in the past, since their ceremonial calendar covers the whole year. Through dancing and song one can realize a sense of rebirth and rejuvenation. The great summer corn dances of the Pueblos have caused many non-Indians to rejoice over the wonderful feeling of spiritual rebirth they have experienced.

The Pueblos believe that the Great One is omni-present. They ask for permission to use the physical form of an animal before it is killed. They believe that animals have an inner spiritual component. This is the spiritual life they invoke with a short prayer. It is not a new idea; other natives throughout the Americas have this ritual. In taking branches from the sacred Douglas fir tree, the Pueblo men will inform the Creator that the intent is not to

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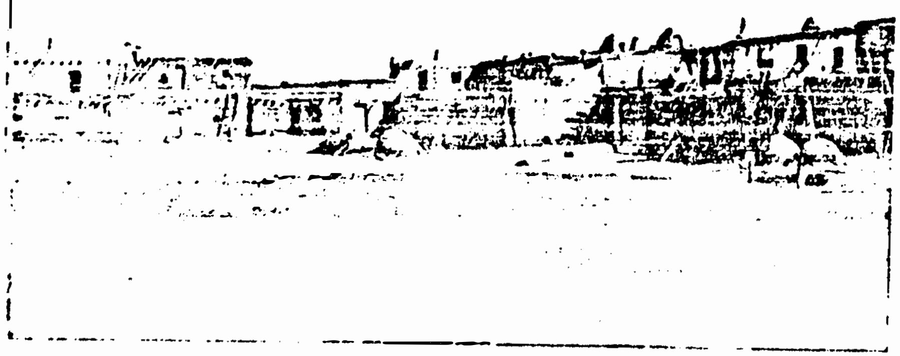

[illegible] of Tesuque, looking across plaza.

Smithsonian Institution photo, by A.C. Vroman, [illegible]

mutilate the tree, but that it will be used to decorate the human being in the performance of a sacred ritual or dance in His honor. In Pueblo religion, the Douglas fir is used to adorn most dancers, male and female. It is also used to decorate the altar and shrine where a likeness of a patron saint is kept during the day of the feast. For many years many Pueblo families did not have Christmas trees, since the purposes were not native. The dominant society often uses fir trees for Christmas trees. An unsold fir on a sales lot is a sad sight indeed, and is considered sacrilegious. This tree is not used to decorate a front yard either, since tradition has it that one is changing nature when a fir tree is dug up and moved to the yard in a Pueblo or a village.

After a fir branch has been used during a dance, ceremonial or social, the branches are taken away and disposed of in the river. Often some are kept in the home until dry. They are then burned in the open fireplace to furnish the fresh smell of the fir tree in the room, or taken to the garden or farm where it will decompose and thus serve as fertilizer while returning to Mother Earth.

Among the Christian concepts and observances adopted by the Pueblos are feast days for the patron saints. Every Pueblo village has a Catholic church named after a patron saint. On their patron saint's name day the "fiesta" is held annually. This day generally begins with holy Mass. Following the Mass, the first dance of the day is performed in front of the church in most villages. The statue of the saint is then carried in a procession to the "plaza" or center of the village. Here it is placed in an evergreen-covered bower. A dance is then performed throughout the day on the plaza, and spectators often numbering into the thousands observe the event from rooftops and around the plaza. At day's end the saint's statue is returned to the church in another procession. (For dates of the fiestas see appendix.)

Zuni does not celebrate a similar feastday for a patron saint, but holds the Shalako ceremony as an annual event in early De- cember. The ceremony takes place according to the time sch[illegible] set by the religious leaders of the Pueblo and not on a ca[illegible] basis.

Based upon their economy and fortified with their religious learning and observances, the Pueblos developed their society. Two types of social structure have existed in Pueblo history, and indeed still exist today in many instances. Anthropologists describe such societal types in many scholarly works. What is being related here, however, is an explanation of the evolving Pueblo society which is even now based upon the family. Since the Pueblos

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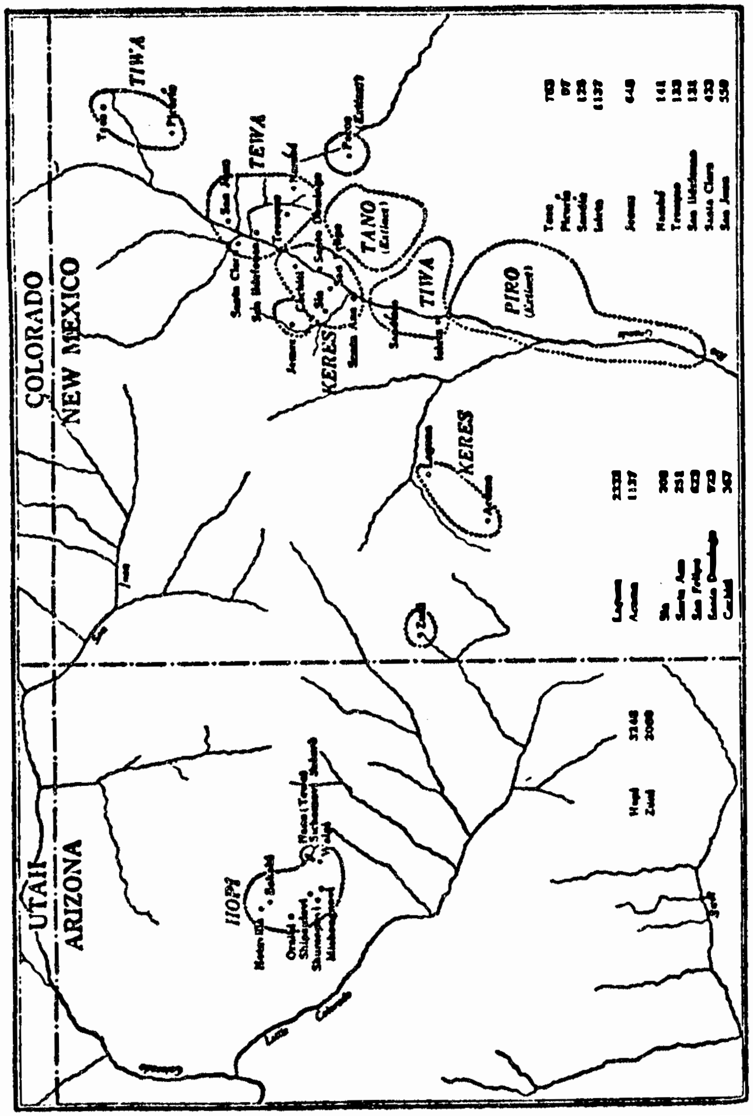
Attachment D



MAP I

PUEBLO INDIAN RELIGION

Volume I

By

ELSIE CLEWS PARSONS

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directions),* his horse threw him, and he became a stone image.[243] The Isletan tale of the Sun's kick-stick shows even more pointedly how failure results from incontinence or the mere thought of it. Blue Corn Girl and Yellow Corn Girl have heard the song of the kick-stick runner, their hearts are happy, and they would marry him. The next day, "because of the wishes and hopes of the girls," the youth's kick-stick falls short of its goal, the sunrise, and reaches only the middle of the sky.[244]

Fasting from food or drink, from sleep or from speech, are mainly ritualistic practices, but there are instances in daily life of such abstinence. Mishongnovi children are taught to dip into the food bowl only four times at the first meal of the day, and party manners for a bridegroom or a guest prescribe tasting only four times of a dish.[245] It is mannerly not to drink until the end of the meal (First Mesa, Acoma, Laguna).[246] A woman in labor is warned not to drop asleep lest she die (Taos), or lest the sex of the child be changed (Zuni). Should the Sia woman fail to concentrate upon the birth, "the child would not care to be born and would lie still and die."[247] The Hopi bride and her women connections have to stay up all night making wafer-bread the night before the marriage is consummated, an effort that possibly may signify more than just providing for a feast. In the San Juan tale of the Yellow Snake Girls who send the man back to his people to become a shaman, the girls lay a taboo of silence upon him, saying, "If no words come from your mouth for twelve days, you will prove yourself a good man."[248] In something of the same spirit Crow-Wing refers to a search by the Hopi Snake clan for "a good woman," a close-mouthed woman "who will not tell anybody," to take the position of medicine-maker.[249] During their ritual hunt the snake-hunters have to observe a taboo on speech, as did, in general, salt-gatherers. Speechlessness is required almost always of kachina impersonators, and not merely to conceal identity. Secretiveness about the kachina may be a remotely related rule. Various factors enter into the secretiveness of the Pueblos in regard to their ceremonial life, but one which is certainly strong with them is the belief that their ceremonies, their *costumbres* or *ofisi*, will lose their potency if told, a common Indian attitude. Even as in witchcraft, power talked about is power lost.

* But compare Mishongnovi, Beaglehole 2:9, for the danger to hunter and horse from an antelope running, *in a circle*, an albino antelope.

Personal potency or efficacy is enhanced through tranquillity. When the paternal grandmother or kinswoman is summoned to take charge of a newborn Hopi infant and its mother, she is supposed to be in a happy frame of mind, so anything at all disturbing is removed from the house.[250] If parents quarrel, a nursing infant may become sick (it may indeed), since its mother is not "all right inside." The parents should confess to the doctor who is called in or to the woman's uncle.* In announcing a Hopi ceremony, the Crier exhorts people to live in kindness, to be good to one another. "Until that many days [sixteen], we, all the people, without having any contentions, must live."[251] As Voth discernedly comments: "Any worry, sorrow, or anger disqualifies a Hopi, as a rule, to participate in a ceremony, and contentions and quarrels in the village are supposed to interfere with the efficacy of a ceremony." The Antelope chief of Shipaulovi tells Stephen that Cloud has come to Shipaulovi and heavy rain has fallen during his ceremony because peace and love prevail at Shipaulovi, whereas Cloud does not care for the ceremony at Walpi where there is no unison.[252] "Our grandfathers used to love one another," comments a Zuni critic, and, ignoring many a tale of drought she might have heard from grandfather or greatgrandfather, she adds, "therefore the rain never failed them."[253] Here is as close an approximation to the sense of virtue or its opposite, the sense of sin, as was ever achieved in Pueblo circles.

Hunters and their families are expected to remain in amiable

* Eggan. A remarkable parallel to modern Mayan (Quiché) practice (Bunzel, Lothrop) and to early Salvador confession in protracted labor (Strong), and suggestive of the early Aztec-Mayan practice of confession. Confession also occurs among Papago (as exorcism) (Underhill) and among northern Athapascans, Eskimo, and Iroquois (Lowie 1:106). The Athapascan Carriers hold that you must confess to get well (Bourke 1:465, n. 8).

Yellow Corn of Isleta told me that, if she fell sick from giving me information, she would have to confess it. Lucinda also remarked: "What I am telling you I am going to confess it before I die. I am not going to carry it away with me."

Pueblo ritual is kaleidoscopic. There are many ritual patterns or rites, and, almost as accommodating as tale incidents, they combine in many ways. Thus ritual is both fixed and mobile. Mobilized into a comparatively constant combination, a group of rites may form a ceremony, sometimes with, sometimes without, a dramatic idea. These ceremonies we shall consider in a following chapter, taking up now each rite or ritual element in itself, as a separable element or unit, in an order partly logical, partly suggested by the extent the rite is used, more particularly

in the West; opportunity for observation in the East has been limited.

In logical order we may consider the ritual of making offerings or giving pay to the Spirits; the fetishes and representations of the Spirits, those images or effigies which the Spirits invest when properly invoked, and which convey power or title;* the assemblage of fetishes and other sacrosanct things to form an altar; mimetic weather or crops ritual, including running and dancing and throwing gifts, rites which express with peculiar vividness the feeling or ideation of mimetic magic, of performing in little or representatively as a form of compulsive magic† what is desired on a large scale; and finally purificatory ritual to prepare for or to conclude ceremonial, cleansing for or after contact with sacrosanct and dangerous things.

It is more difficult to classify medicine which is used in many ways and for different ends, or that part of ritual which is ever the most precious and secret—prayer and song. Is the feather deposit a gift of hair feathers or clothing or a message, "like a letter" or a passport? Flagellation by kachina I had always thought of as a purificatory rite, in view of Zuni explanation, until Crow-Wing wrote that in the kachina races on First Mesa the more runners the kachina overtook and whipped, the more rain the kachina would have to send in compensation, implying an entirely different theory of ritual flagellation. Interpretation by the observer must be open to revision, and he must realize that just as "that's why" varies for the same tale, so varying explanations are given or held, within narrower limits, for rites; contemporaneously or from period to period. Interpretation of

* Pauwatiwa tells Stephen that all the domestic animals, even those in the hands of other peoples, are virtually his because he holds their Mother (a wooden star effigy). All these animals came through the Hopi and through this Mother. Hence it is very wrong of Navaho to steal Hopi animals. (We wonder how the Hopi War chief himself came to be connected with domestic animals unless by raids.)

† As Bunzel has admirably pointed out, the magical mechanistic techniques of the Pueblos belong to Pueblo religion, since they require a special setting to be effective. They must be performed by special persons at stated times and places, in the presence of certain powerful fetishes and to the accompaniment of set prayers, songs, and other ritual acts (Bunzel 2:492).

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Chapter Eight

THE GODLINESS OF PLACE

Alosaka, or Germinator

Andrew Hermequaftewa, the Bluebird chief of the Second Mesa pueblo of Shongopovi, expressed simply an opinion that must be common to all Pueblo groups. "The Hopi land is," he said, "the Hopi religion. The Hopi religion is bound up in the Hopi land."[1] In Zuñi tales the Pueblo land is referred to as the "terraced plain," or as the "sacred terrace," and this design, derived from the visible mesas, is by analogy carried into the sky where there are "cloud terraces" that are often represented on altars.

In one tale a gambler suggests that the land is a kind of gaming table for the gods. "Forever upon the floor of his house there lay spread a great buffalo robe, the skin upward dressed soft and smooth, as white as corn-flour, and painted with the many-colored symbols of the game, even as our own. But he delighted to call it his sacred terraced plain, bethinking himself of the robe-spread of the gods, which is even the outspread earth itself, bordered by terraced horizons, and diversified by mountains, valleys, and bright places, which are the symbols and game marks whereby the gods themselves count up the score of their game."[2]

The thought that one's homeland is the playground of the gods is but a poetic statement of a relationship that is otherwise taken as a fact in divine cosmography. While the landscape as an entity may be regarded as sacred, there are always particular spots, whether mountains, lakes, rivers, springs, or groves, which have particular meaning and sacredness. These are often the haunts of gods and lesser spirits. The feeling is so strong that it persists long after people have forgotten magical or supernatural associations. One who has always lived within a metropolis will find himself drawn to certain places,

[1] Andrew Hermequaftewa, *The Hopi Way of Life Is the Way of Peace*, 8.

[2] Cushing, *Zuñi Folk Tales*, 386–87.

to one corner in a park, or a certain chair in a library, despite the fact that he knows there are many others equally as good. The hunter or the fisherman who returns inexorably to the same place time after time has added another element; he has not only established a place of comfort and security, but has as well established an area where environmental response is to some extent controlled by his knowledge of what can be expected to happen there.

In the Pueblo cosmos the village is the center, but to have meaning a center must have a number of points of reference outside the center. Most importantly there are mountains. We have already observed that mountains provided horizon calendars which served to orient a number of pueblos within the time span of the year. The value of the range in this instance is probably more sacred than practical, but very often the value attached to a particular place is an inextricable mixture of the practical and the divine.

Let us consider some of the sacred mountains which give one kind of structure to the Pueblo world. The world has to be particularized to some extent, since under mountains one may include whole ranges, notable peaks, certain hills, flat topped mesas, buttes, needles, cones, and particular rock formations which are identified with mythological characters, or serve as shrines. The peaks of the directions and their "chiefs" have already been mentioned. These are mythical mountains rather than real ones, and they are often represented by stone or clay objects set about altars, but they may also become identified with actual peaks. For example, to the people of Laguna the mountain of the west is the peak of Mt. Taylor, 11,334 feet high. Since it lies northeast of Zuñi and southeast of the Hopi mesas, it can hardly serve as a common directional point, but many people make pilgrimages there.

The Pueblo world is fairly well confined as an entity by the Sandía Mountains—the Keresan home of the War Twins—on the east, and the San Francisco Mountains—home of the Kachina—on the west. For north and south confines one may borrow from the Navaho account of the Pueblo War, and accept Hesperus Peak in Colorado for the north and Mogollon Baldy, in the White Mountains, for a south marker.

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Some mountains had a very practical value in orienting the foot traveler in a rather confusing topographical world. To take one certain example, there is Cabazon Peak which lies on the trail between the Rio Grande of the Keres and the western pueblos of Acoma and Zuñi to the south. Cabazon is called a neck by geologists, and a needle by others. The aptness of the latter is illustrated by the fact that it rises 2,160 feet from the floor of the valley, but has a diameter of only 1,400 feet. In historic times a path passed by this peak and down the Puerco on the east to Acoma; doubtless it was centuries old then. Another route probably went north of Mt. Taylor toward Hosta Butte, and thence to Zuñi, or pueblos farther west.

On the route between Acoma and Zuñi there is a rock of no great size, but of great fame: El Moro. The fame derives from the Spaniards, "paso por aqui," but for several centuries before they passed that way it must have been a refuge for those who journeyed between Acoma and the Zuñi area. At the foot of this cliff there is a water hole; and that it has long been there is attested by the fact that on the top of the mesa there is a ruined pueblo, not of historic time. The place was a refuge for travelers, and the idea of refuge is closely related to the divine. In ancient Greece one who took refuge in a temple was in theory safe, for if he were dragged forth and killed, the god to whom the temple was devoted would avenge him. The same idea persisted into the Middle Ages with the contention that a cathedral was a refuge, even for criminals. Probably this concept is based upon the root idea of water, and physical protection that certain sites afforded the traveler. In the Pueblo world most springs and dependable cisterns are in some way sacred. Many are associated with a particular society, or with an individual kachina. Some of these are a solace and refuge to everyone who treats them with proper respect, while others are so sacred that their comfort must be refused, except by specified individuals on ceremonial occasions.

There are some ranges and high peaks which are more closely related to the spirit world than to practical affairs; they are eternal and are nearer to the unknown reaches of the cosmos than man cares to go very often, unless he is prescribed to do so. A Hopi ritualist may run to the San Francisco Mountains and back again, as swiftly as

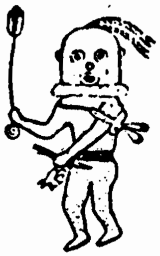
possible, to complete a rite. His mission is practical only in the sense that it establishes and confirms a relationship between the Hopitu and the gods of those mountains.

At other times and to other places the speed may be less, and the goals may contain a larger practical element, but the trips, or pilgrimages, are nevertheless thoroughly involved with the spirit world. I shall describe two mountains—one being a mountain and a lake—in which the practical, the beautiful, and the divine are well mixed. These two places have an added interest in that they are pan-Pueblo in importance, and in that way tie the Pueblo world together in space. They also join the Pueblos in time, for trips were made to these places by the vanished peoples of Mesa Verde and Pueblo Bonito, and doubtless from a great number of other towns which are now in ruin, or level with the ground.

The earth is a goddess, and her most essential products belong to spirits representing aspects of her "flesh." Corn is of course the essence of that flesh, because mankind subsists upon it; its flesh becomes their flesh. Since man cannot live by corn alone, even when squash and beans are added, two other things must be found. Salt is necessary to season food, and jewelry is necessary both in rites and for personal adornment. Unusual objects, such as quartz crystals, often are used in connection with ritual. The Pueblos knew that by rubbing two of them together a glow would be produced in the dark: the so-called lightning stone. However, above all other objects in importance was the turquoise. Sometimes the turquoise is a gem of great beauty, but even when it is not, it has great value.

Castañeda mentioned that the Zuñis offered flowers, plumes, and turquoise of an inferior sort at their sacred springs. The superior stones, one may assume, went into fetishes, or into gems for personal adornment. Since the sources of turquoise are very limited, the mountains which bore them became the seat of extensive pilgrimages to gather the stones. The extraction of turquoise from the earth-mother was not as simple as picking up an occasional crystal on the surface; it involved extensive mining from prehistoric times.

The most notable mines were in the Cerrillos area, which is about fifteen miles southwest of Santa Fé and lies just beyond the present



Chapter Twelve

THE FACE OF ANIMISM

Shulawitsi, the Zuñi firebrand-youth

ACCORDING TO the dictionary definition, animism is the belief that all objects possess a natural life or vitality, or are endowed with indwelling souls. To this it adds the possibilities that each object may have a conscious life and that the soul may be capable of a life outside the object. To that classic picture one may add the popular conviction that the world of animism is pantheistic. In order to face Pueblo animism honestly we must qualify and particularize general views. Since this book is concerned with gods—or rather with supernatural powers—it is necessary to distinguish between such powers, however small, and mere consciousness. It is also necessary to examine again man's place in the cosmos—world order, or harmony.

Let us begin with a simple statement of Pueblo animism: "To the Zuñi the whole world appears animate. Not only are night and day, wind, clouds and trees possessed of personality, but even articles of human manufacture, such as houses, pots, and clothing, are alive and sentient. All matter has its inseparable spiritual essence. For the most part this spiritual aspect of things is vague and impersonal."[1]

While that statement is true, it leaves out a number of concepts. To begin with, everyone will agree that living things are alive and that they, along with non-organic phenomena, possess "personality," which is to say, changing conformation, response to stimuli, and the like, and changes, including dissolution, which are easily equated in the human mind with one's own vital element. There is also a contemporary scientific point of view that grants considerable life to inorganic matter. The biologist Sir Charles Sherrington wrote: "Natural science has studied life to the extent of explaining away life as any radically separate category of phenomena. The categories of living

[1] Bunzel, "Introductions to Zuñi Ceremonialism," *loc. cit.*, 483.

and lifeless as regards science disappear." Or again: "The distinction between them is convention. This deletes 'life' as a scientific category; or, if you will, carries it down to embrace the atom. The vanishing point of life is lost."[2]

In this sense all matter has an inseparable scientific essence, if not a spiritual one. In the Pueblo universe there is a harmony of the whole, which will appear often in this chapter, and toward the end of this chapter Pueblo views will be considered in relation to various contemporary attitudes in Western thought. First, however, we need to understand the Pueblo view. Pueblos are not pantheists in either a mystical or in a scientific sense; their gods stand apart from the physical and biological world and have considerable, if variable, power to influence the course of events.

A related, if lesser, power resides in many insensate things, as well as in animals and men, but it by no means has an equal distribution throughout the world. Some things have special power, otherwise any object would do for a fetish; not every mountain is equally powerful. To learn of this supernatural power, and it limitations, let us examine a tree, an artifact, a stone, and an animal.

When a dance is to be held, one of the most frequent essentials for the dancers is a collar of spruce twigs, whether the dancers be masked or not. The spruce, which is actually Douglas fir, is the directional tree of the north for all three tribes. That is the region from which winter storms come, and the tree hence has a rain bringing potential at any season. The Zuñi name for this tree is translated "water comes out arms." "The breath from the gods of the undermost world is supposed to ascend through the trunks of these trees and form clouds behind which the rain-makers work."[3]

When the branches of this tree are to be gathered its blessing, or

[2] William K. C. Guthrie, *In the Beginning*, 19, 46.

[3] See M. C. Stevenson, "Ethnobotany of the Zuñi Indians," B.A.E. *Thirteenth Annual Report* (1908–1909), 97. According to Stephen, *Hopi Journal*, I, 395, "The spruce boughs gathered for kachina purposes in the spring of the year, if of glossy green, betoken absence of bad winds and that rains will prevail in the summer. If the spruce is dull (ma'si), it is an evil prognostication."

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power, must be sought. When the people of Keresan Santa Ana and San Felipe need spruce boughs, men are selected to ride up into the Jémez or the Sandia Mountains. (Hopis go to the San Francisco Mountains.) They take with them prayer-feather bunches, one of which is to be planted for the spirits of the mountains, since there they are losing a part of themselves. These spirits do not seem to be particularized, or even localized. It is not surprising to learn that one Acomite opined that even an airplane could be considered as belonging to this friendly group of spirits. Not just any tree, but a suitable tree must be found. The gatherers from San Felipe carry turkey feathers wrapped in corn husks, and when the right tree has been located, "the feather-bearer approaches. After praying, he climbs as high as he can and ties one of the feathers to the highest point: 'that brings out the rain and the Shiwannas from the mountains.' " After this rite the feather bearer and the other gatherers take as many branches as are needed.

The one who "plants" the feathers on the tree top is the war priest's helper. An idea of the content of his prayer comes from the pueblo of Santa Ana. When he alone approaches the spruce tree: "He says, in effect, 'Let the ianyi (power, blessing) of the spirits go to the pueblo with the spruce boughs; let them send rain on the 26th to the growing crops all over the world."[4] Other feathers are planted in the ground with their tips facing back toward the village.

Ianyi, somewhat similar to the word mana, which has become general in our language, is interestingly translated as both power and blessing. Blessing implies that the power has to some extent separated itself from that in which it resides and tends toward the pueblo. The branches here seem to be the bearers of the power, and they are special, because they have been selected as a medium of communication between the spirits and man. There is no concept of the tree as an independent, personified, spirit, such as a Dryad who can slip out of the form of the tree which incases it. As a qualification, there are personifications in the Pueblo spirit world: "Salt Old Woman, giver of herself," and the Hopi *chama'hia* or Stone people. These are celts

[4] Leslie A. White, *The Pueblo of San Felipe*, 37, and White, *The Pueblo of Santa Ana*, 248.

said to have been left from the days when stones had speech, and life, and traveled about the world.

Stones have a particular power. In the first chapter the boundary stone was discussed in relation to Masau'u. The Zuñis, who have no such god, likewise set up crudely sculptured columnar stones to mark the fields they have cleared. Even after the field is abandoned, and after the death of one who has cleared it, these stones protect and assert the right of his clan to the land. The protective power of this stone may be personified in the form of an animal, in which case it indicates the reverse value of the stone fetish carried by a hunter.

Another type of stone, which is to become a household utensil, is cut out of the mother rock in secrecy, and apparently with more elaborate ritual and taboo than in the cutting of spruce boughs. The grinding-stone is the central piece of household equipment and making one is not to be taken lightly. A special priest supervises the work in the field. It is likely that cooking stones are made at the same time, since one reaction of a stone to improper procedure is to crack upon first heating. Not only must the newly made artifact be treated properly to appease its spirit, but the rock from which it was cut has to be considered. "When cutting out mealing-stones they make prayers and cast meal to the 'flesh of the rock.' "[5] The prayer is not to the soul or spirit, but to the substance; the harmony—or perhaps one should say the *status quo*—of the Pueblo world has been disturbed, and amends must be made lest this small change effect greater changes.

The power involved in both the boundary stone and in cutting the rock might be called negative power, since the wish is to maintain things as they are, or restore them to what they had been but a short time before. On the other hand, an artifact, or even a part of one, may also have positive power, as this note from Keresan Laguna shows. "To cure childhood illnesses, a reliable medicine consists of potsherds gathered from old ruins, ground fine, and drunk in water. The sherds are impregnated with power because they were made in one of the four epochs of the distant past, in each of which people were created by 'Our Mother' but later destroyed (not having proved entirely satisfactory), and replaced by a presumably better group.

[5] Cushing, *Zuñi Breadstuff*, 328.

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AN ENVIRONMENTAL OVERVIEW OF GEOTHERMAL DEVELOPMENT: THE GEYSERS-CALISTOGA KGRA
Volume 3
Noise

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[redacted]

Attachment F

PREFACE

This preliminary environmental and socioeconomic assessment of The Geysers–Calistoga Known Geothermal Resource Area (KGRA) is part of the Department of Energy's (DOE) Geothermal Overview Project. The purpose of that project is to identify, summarize, and assess the environmental issues of KGRAs currently identified by DOE as having strong possibilities for commercial development. Project results are reported to the Assistant Secretary for Environment of DOE and provide a basis for selecting those geothermal areas having the most critical need for regional environmental studies.

The Geothermal Overview Project addresses issues pertaining to air quality, ecosystems quality, noise effects, geological effects, water quality, socioeconomic effects, and health effects. At each KGRA under study, the key issues are identified and all available data are collected and analyzed. Finally, recommendations for future research and data collection are made.

The Geysers–Calistoga KGRA study was the first to be undertaken in the overview project. In this effort, the Lawrence Livermore Laboratory worked cooperatively with the Geothermal Resources Impact Projection Study (GRIPS), a regional body consisting of the counties of Lake, Mendocino, Napa, and Sonoma. Vital to the approach used in this study, and all the overview studies, is the free flow of information and the early involvement of all interested parties including local, state, and federal agencies, electrical utilities, resource developers, universities, and other private and public groups. With all interested parties involved from the onset of the project, the overview reports should reflect a consensus of these groups.

This report is intended to serve as the basis for planning future research, field studies, and assessments addressing critical environmental and socioeconomic concerns associated with the development of geothermal resources in The Geysers–Calistoga region.

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ABSTRACT

Noise from geothermal resource development at The Geysers–Calistoga Known Geothermal Resource Area (KGRA) will cause community annoyance unless noise-level standards are set and adhered to. Venting of steam is the loudest source of noise and can reach 100 to 125 dBA at 20 to 100 ft; most of the other noise sources fall below 100 dBA and are those usually associated with construction and industrial projects. Enough data exist for assessment and decision making, but it is scattered and must be compiled. In addition, communities must decide on their criteria for noise levels. Residential areas in The Geysers–Calistoga KGRA will require more stringent controls on noise than will the open space of which the KGRA is primarily composed. Existing technology can reduce noise levels somewhat, but more effective silencing devices are needed, particularly on steam venting systems.

INTRODUCTION

Geothermal energy development in The Geysers–Calistoga Known Geothermal Resource Area (KGRA) was, for many years, confined to a remote, almost uninhabited mountainous area. Since the early 1970s, however, geothermal development projects have been moving much closer to residential districts, and citizen complaints about noise emissions have become an issue. This is particularly true in Lake County, where small recreational/retirement communities are located within one-half mile of existing or planned geothermal wells, power plants, and other facilities. The same potential for conflict exists in other parts of The Geysers–Calistoga KGRA, particularly Sonoma and Napa counties.

The geothermal industry is actively involved in a program to reduce noise emissions and a number of important technological improvements in noise control have become standard practice in recent years. In spite of these advances, at times large quantities of geothermal steam must still be vented to the atmosphere without effective silencing. This is, by far, the most serious noise problem remaining, and its solution should be given a high priority.

This report deals exclusively with the impact of geothermal industry noise on adjacent communities and the extent to which it may reduce the public acceptability of this promising energy source. It is based, in part, on findings of the Geothermal Noise Workshop held on November 14 and 15, 1977, at the University of California (Davis) under the sponsorship of Lawrence Livermore Laboratory and the Geothermal Resources Impact Projection Study (GRIPS). Additional discussions with knowledgeable individuals in regulatory agencies, industry, and acoustical consulting firms provided valuable supplementary information.

GEOTHERMAL NOISE SOURCES

The noise sources that accompany the development and utilization of geothermal energy in The Geysers–Calistoga KGRA are summarized in Table 1. Except for the operations involving the venting of geothermal steam, these sources are typical of many construction or industrial projects.

Site Preparation/Road Construction

Heavy earthmoving equipment is generally used to construct access roads, well pads, and generating unit sites. Noise conditions during site preparation for Geysers Power Plant Unit 13 were investigated in 1977 by the PG&E Department of Engineering Research; a report will be available by the end of 1978. A general reference source for noise emissions from construction equipment is the EPA document PB 206 717. [1]

Geothermal Well Drilling

Extensive data are available for both mud and compressed-air drilling phases. Union Oil Company and Republic Geothermal, Inc. have both conducted noise monitoring at a well site during the entire drilling process. All developers, as well as the Lake County Air Pollution Control District and Sonoma County Planning Department, have routinely taken sound-level readings to confirm adherence to use-permit requirements. Sound-level measurements for both mud and compressed-air drilling operations have been published in a number of references. [2-7]

Geothermal Well Clean-Out and Testing

After a successful geothermal well has been drilled, loose rocks and other particulates are cleared from the bore by venting the steam to the atmosphere at full production rates. A conventional muffler often cannot be used during this initial clean-out process because of potential damage from ejected debris. Extended production testing following clean-out is usually conducted with commercial mufflers of limited effectiveness. A-weighted sound pressure levels have been collected during these operations by developers as well as county and state agencies. Octave band frequency analyses are available from several sources. [2,3,5,7,8]

Table 1. Noise sources associated with geothermal development in The Geysers–Calistoga KGRA.

Site preparation/road construction
Geothermal well drilling
Mud drilling
Compressed air drilling
Geothermal well clean-out and testing
Geothermal steam venting
Muffled
Unmuffled
Construction of facilities
Steam pipeline
Transmission line
Generating unit
Generating unit operation
Turbine/generator building
Steam-vent gas ejector
Cooling tower
Vehicular traffic

Geothermal Steam Venting

After the initial completion and testing of geothermal wells, steam venting occurs during many different operations. These include the long-term bleeding of steam from partially shut-in wells, additional production testing, commissioning of steam pipelines, venting at the wellhead or generating unit during outage conditions, venting at the wellhead and along the steam pipeline during unit startup, and replacement of wellhead valves. Some of these sources can be adequately silenced with present technology, but others cannot. The highest sound pressure levels are associated with the relatively infrequent unmuffled venting at wellhead or pipeline installations. Data are available to describe the A-weighted levels and frequency spectra of all major sources of steam-venting noise. [2-9]

Construction of Facilities

Steam-pipeline, transmission-line, and power-plant construction requires many standard types of heavy machinery. Several generating units are now under construction at The Geysers and noise at these sites has recently been studied by the PG&E Department of Engineering Research. These data will be made available in the near future. While no site studies of other construction activities have been conducted at The Geysers, extensive published data on noise levels from construction equipment can be found in the EPA document PB 206 717. [1]

Generating Unit Operation

Three major operational noise sources can be identified within the generating unit complex: the turbine/generator building, the steam-vent gas ejector, and the cooling tower. Sound pressure levels and octave-band frequency spectra are available for all sources. [7,8]

Vehicular Traffic

Geothermal development activities result in increases in vehicular traffic. This traffic may constitute a significant noise source, especially when vehicles such as large, diesel-powered trucks must be operated on steep grades. No field measurements of traffic noise related to geothermal development seem to have been made at The Geysers; nevertheless, standard references provide an adequate description of vehicular noise sources. [10]

Data Adequacy and Recommendations

Existing data adequately characterize the sound pressure levels, frequency spectra, and duration of the various geothermal industry noise sources. Thus, it is possible to readily identify the sources that can cause the greatest concern in the adjacent communities. No further collection of geothermal noise-source data appears to be necessary for environmental assessment or decision making.

However, much of the existing noise-source information has been gathered very recently and is available only in scattered reports or is not yet published. To facilitate the preparation of more accurate environmental impact documents, it would be useful to have all of these data brought together in a handbook for convenient reference; such a handbook would also be valuable to noise assessment studies in other geothermal resource areas.

GEOTHERMAL NOISE PROPAGATION

Methodology

To predict the impacts of geothermal noise emissions, we must be able to accurately forecast should pressure levels and frequency spectra at various distances from the nosie source. This issue must be considered in all environmental impact documents, and it can become a very important factor in decision making.

Although methods exist for making these predictions, no noise propagation model has been generally agreed upon or systematically evaluated for accuracy by comparison with field measurements. There are presently two basic methods to predict the propagation of geothermal noise from source to receptor—an analytical method based on wave divergence plus excess attenuation factors and an empirical approach using noise propagation data recorded at various distances from geothermal sources.

The analytical approach to noise propagation starts with the basic phenomenon of wave divergence. Wave divergence reduces the sound pressure level by 6 dB every time the distance from the source doubles. In addition, excess attenuation occurs from such factors as molecular absorption, physical barriers, wind, temperature inversions, vegetation, and ground surface properties; this attenuation can be calculated from generally accepted and verified sources.* A worst-case prediction would only take account of the combined attenuation from wave divergence and molecular absorption. A more realistic prediction would also have to count the contributions of several of the other excess attenuation factors mentioned.

The empirical approach would use data on noise propagation from actual geothermal sources in The Geysers terrain. A large series of sound pressure level measurements and one-third octave frequency spectra have been taken at distances up to 1 mi from various geothermal operations.† A predictive empirical model could be derived from these data and tested in field situations.

In addition, a semiempirical A-weighted attenuation curve has been developed by R. C. Bush. [4] This curve is based on a combination of theoretical acoustics and field measurements made on noise sources at The Geysers and elsewhere. [11] It has been used to predict sound pressure levels at receptor sites near a proposed geothermal generating unit. [12] Union Oil Company recently carried out a field test of this attenuation curve that predicted sound pressure levels up to several miles from a venting well with reasonable success. [13]

*One such source is "Sound Propagation Outdoors," by U. Kurze in *Noise and Vibration Control*, L. L. Beranek, ed. (McGraw-Hill, New York, 1971).

†Unpublished data, P. Leitner, Biology Department, St. Mary's College, Moraga, California.

Adequacy of Available Methodologies

Methods currently available seem reasonably accurate in their predictions of geothermal noise propagation. The effects of site-specific terrain factors such as barriers or elevation differences between source and receptor can be calculated on the basis of known theoretical and empirical relations. Local meteorological conditions such as winds and temperature inversions can also be taken into consideration when making predictions. Unfortunately, there have been few field studies to test the the accuracy of predictions made with different methodologies. No existing noise propagation model has been generally agreed upon and accepted as appropriate for use under local terrain and meteorological conditions at The Geysers.

Recommendations

The alternative predictive approaches need to be systematically evaluated by a committee of knowledgeable individuals directly involved with geothermal resource development and impact assessment. This working group should include representatives of steam-supply companies, utilities, regulatory agencies, and consulting firms. All existing data on noise propagation should be assembled and a family of propagation curves generated. Field measurements should be conducted, as agreed upon by the committee, to confirm and/or modify these curves. Such a model-validation procedure, would provide a standard predictive methodology useful in both planning and impact assessment. A thoroughly validated noise propagation model could greatly assist evaluation of noise impact in other geothermal resource areas and in other energy technologies.

COMMUNITY NOISE CRITERIA

In making decisions concerning proposed geothermal development projects, it is not enough to know the characteristics of geothermal noise sources and accurately predict the values of important noise parameters at receptor sites. Community noise criteria adequate to protect against annoyance and activity interference must be established and accepted before it is possible to judge project acceptability or to set source standards.

A number of factors must be considered in determining community noise criteria, including the existing noise environment, current land use patterns, the prior history of community response to noise, and general standards and guidelines.

Existing Noise Environment

Baseline noise levels unaffected by geothermal industry noise sources have been measured at many locations in The Geysers-Calistoga KGRA.[3,9] In recent years, most environmental impact documents prepared for geothermal development projects in Sonoma and Lake counties have included field measurements of baseline noise conditions.[2-7] Data usually consist of A-weighted sound pressure levels, although occasionally octave-band, statistical, or energy-equivalent levels have been taken. Sampling procedures usually involve short-term measurements at a few sites on and adjacent to the project area over a single day-night cycle. Long-term monitoring is rarely conducted. As expected in an essentially rural area, measured noise levels at most sites are very low and are dominated by natural sounds.

The Community and Its Response to Geothermal Noise

The most noise-sensitive land use within The Geysers-Calistoga KGRA is clearly residential, and it is the residents of rural areas and small communities in Lake and Sonoma counties who have reacted adversely to geothermal noise intrusion. Critical receptor sites where residents could be affected by geothermal noise are well known or easily determined. However, much of the KGRA is private land remote from residential development, and quite different criteria may apply in these areas.

Because of the low ambient-noise levels throughout much of the KGRA, residents are readily aware of geothermal noise intrusion. This can be particularly disturbing to people who have chosen to live in the KGRA region because they place a high value on quiet and serenity. Some individuals' response to noise may be partly conditioned by a negative attitude toward other impacts of geothermal development including odor

(H_2S) and visual aesthetics. Citizen complaints in Lake County communities adjacent to geothermal development have been analyzed by the Lake County Air Pollution Control District and by Long/Davy/Associates for the Noise Element of the Lake County General Plan.[14] They found that most community annoyance is related to noise from steam venting, well drilling, and truck traffic. Community response appears to follow fairly well a typical curve relating severity of public reaction to the magnitude of the outdoor day/night average sound level.[15] The most vigorous and widespread complaints come from receptor sound-pressure levels of 60-70 dBA or higher. However, in some cases, levels as low as 40-55 dBA have drawn a more vigorous response than would be expected in a typical urban or suburban community. It is not clear whether such complaints are related to the low ambient-noise levels of the region or to nonacoustic factors, such as opposition to geothermal development in general.

General Standards and Guidelines

Regulatory authority over noise from geothermal industry sources is shared among federal, state, and local levels of government. Federal and state legislation governs occupational exposure and applies to geothermal noise as it affects industry employees. Trucks and other motor vehicles operated on public highways are subject to the noise standards of the California Motor Vehicle Code. Local government holds the responsibility for regulating all other aspects of geothermal noise.

State law requires that a Noise Element be included in the General Plan for each county. The Noise Element provides the basis for local programs to control environmental noise and protect the community from excessive noise exposure. It does not set standards, but rather describes existing noise conditions, develops criteria for noise-compatible land-use planning, and outlines techniques for achieving an acceptable noise environment. A draft Noise Element has been prepared for Lake County,[14] and a noise ordinance may follow. Sonoma County has adopted a Noise Element for its General Plan.

Geothermal noise emissions are usually regulated on a project-by-project basis in Lake and Sonoma counties. A variety of noise standards have been applied to geothermal projects as conditions on county use permits. Those standards have not always been adequate to prevent community annoyance and complaints.

A number of studies that have attempted to specify the relationship between noise level and community annoyance or activity interference are summarized in Appendix D of Ref. 15. This EPA document identifies an outdoor day/night average sound level (L_{dn}) of 55 dB as a reasonable protection in residential areas. It points out that this level should satisfy most people but will not completely eliminate annoyance and complaints. It also cautions that an L_{dn} of 55 dB is not to be construed as a federal standard and that the economic and technological feasibilities of reaching this level were not considered.

While the noise exposure of residential communities within The Geysers–Calistoga KGRA is a prime issue, much of the KGRA is uninhabited open space. The EPA "Levels Document" suggests that an appropriate noise limit for open space is an equivalent A-weighted sound level of 70 dB averaged over 24 hours.[15] Any proposal for noise standards for the geothermal industry should clearly consider separate standards for areas where no residential or other sensitive receptors would be affected.

The draft Noise Element of the Lake County General Plan has proposed land-use/noise-level compatibility criteria for Lake County, taking into account the conclusions of the EPA "Levels Document"[15] as well as the State of California Noise Element Guidelines.[16] These criteria would, of course, apply to all land uses, not just geothermal industry activities.

Data Adequacy

Available background information seems adequate to establish acceptable noise levels for both residential and open space areas within The Geysers–Calistoga KGRA. Ambient noise has been measured at a number of locations; existing land-use patterns and the location of critical receptors, such as small residential communities, are well known. The pattern of citizen complaints about geothermal noise has been analyzed and can be related in a general way to the type and energy level of noise intrusions. There is considerable local experience in Lake and Sonoma counties with the relative effectiveness of various geothermal project noise standards in reducing complaints. By comparing this experience to EPA noise criteria for residential and open space areas, it should be possible to arrive at reasonable standards that will protect the public welfare without imposing unrealistic conditions on the geothermal industry.

Recommendations

Ambient noise conditions should be determined before permitting geothermal development projects so that appropriate noise criteria can be selected. This is best accomplished on a project-by-project basis. When a specific project is under consideration, noise sources and their locations will be known and critical receptor sites can then be identified with accuracy. Regional baseline noise surveys are not recommended.

In general, community response to noise intrusion seems well defined and predictable enough that criteria can be chosen to minimize annoyance and complaints. However, the factors that lead to annoyance when geothermal noise is barely audible (40-55 dBA) are poorly understood. Additional study should be directed at identifying these factors and incorporating then into noise-impact assessment procedures.

Local regulatory agencies with authority over geothermal development projects should establish uniform and acceptable noise criteria for residential and open space areas. These criteria should not apply just to the geothermal industry, but to all activities that may impact local communities, such as logging, mining, resort operations, and off-road vehicles. Although the criteria should minimize complaints, the elimination of all adverse public reaction is not a realistic goal.

Once acceptable levels are identified and reasonable standards established, responsibility for noise control falls on the developer. Permits for particular projects would be issued on the basis of the developer's demonstrated ability to control noise and meet community criteria.

Elaborate noise-monitoring systems are not recommended as a general rule. Occasional checking by regulatory agencies should be sufficient to establish compliance with standards. Agencies must be provided with adequate resources to carry out this function.

GEOTHERMAL NOISE CONTROL

Venting large quantities of geothermal steam at the wellhead, along pipelines, and at the generating unit is clearly the loudest source of industrial noise at The Geysers. Measured sound pressure levels at distances of 25 to 100 ft range from 100 to 125 dBA. All other noise sources are well below 100 dBA in intensity. Although large-scale steam venting does not occur frequently or for long periods, it can be audible at three miles and can produce annoyance at two miles. Furthermore, it is not restricted to early project stages but occurs periodically throughout the entire life of a geothermal field. If more effective silencing devices cannot be developed, use of geothermal energy may be restricted in areas of The Geysers–Calistoga KGRA that are close to residential development.

Existing Control Technology

In recent years, the geothermal industry has improved control of the noise generated by venting steam with advances in such areas as compressed-air drilling procedures, steam discharge during a power-plant outage, and wellhead and pipeline venting during power-plant start-up.

Compressed-Air Drilling

Drilling in a steam-bearing zone is accomplished with compressed air rather than mud. Compressed air is forced down the drill pipe and returns carrying rock cuttings and any geothermal steam produced. The steam, air, and cuttings are vented through a pipe known as a blooie line. All developers currently operating at The Geysers use a large cyclonic separator/muffler at the end of the blooie line to control particulate and noise emissions. Control is particularly effective when water is injected into the blooie line upstream from the cyclonic muffler. Noise levels from air drilling can be reduced from about 120 dBA at 50 feet with only a blooie line expander tube to below 90 dBA with the cyclonic muffler.

In many cases, the cyclonic muffler can also control noise during the initial clean-out and production test at a newly completed well when the drill rig and related equipment are still on location.

Steam Discharge During Power Plant Outage

It is not practical to shut in the wells in a steam supply field during a short-term outage at the generating unit, and large quantities of steam may have to be released to the atmosphere. Rock mufflers have recently been constructed adjacent to several of the existing generating units. These large rock-filled pits replace conventional metal mufflers, which were relatively ineffective and corroded quickly. They have reduced sound pressure levels from more than 100 dBA at 75 ft to 72 dBA at 25 ft. Most generating units will be equipped with rock mufflers in the near future.

Wellhead and Pipeline Venting During Power-Plant Start-up

Previously, during a long-term outage at a generating unit all wells in the steam supply field had to be completely shut in. The start-up procedure is extremely noisy because all wells must be vented to the atmosphere to clean out rocks and other debris that could damage the turbine. Venting is also necessary at various points along the steam pipelines to clear condensate that had accumulated during the outage. Sound pressure levels as high as 125 dBA can be measured 50 ft from these steam vents.

Although no effective mufflers have been developed, certain improvements have been made to reduce the frequency of well shut-in. New V-ball throttling valves have been installed on many high-production wells and, during an outage, can reduce the steam production from a field to 50-60% of normal. A portion of the rest can be sent to other units via intertie pipeline systems or can be vented through the rock muffler near the power plant. These new developments can, in some situations, avoid the necessity of complete well shut-in and the subsequent large-scale venting during power-plant start-up.

Requirements for Additional Control Technology

Steam-Vent Noise

In spite of these recent advances in noise control, procedures during both the development and operation of a geothermal field still require venting large quantities of steam under conditions that preclude effective silencing. Extended production testing of new wells and clean-out of previously shut-in wells are the most common noise sources that can exceed 100 dBA at 50 to 100 ft. A muffling system is required that can attenuate this steam-venting noise by at least 20 to 30 dBA.

Drilling Noise

Although the sound pressure levels associated with mud and compressed air drilling are much lower (80 to 90 dBA at 50 ft), complaints are sometimes received from persons living within 1000 to 3000 ft of a drill site. This is due, in part, to the continuous round-the-clock operation and, in part, to occasional noise peaks occurring when the drill string is raised or lowered. Inexpensive methods of attenuating the low-frequency components of noise from large diesel engines and compressors would be very useful.

Recommendations

Steam-Vent Noise

The highest priority should be given to developing a system to muffle the free venting of steam wells to the atmosphere.

One developer has used a rock-filled muffler mounted on a flat-bed semi-trailer. While it can be moved by truck tractor from one well pad to another, it is extremely heavy and difficult to maneuver, especially on mountain roads. Such mufflers do not seem practical for short-term venting procedures because of the cost and the time required for hookup. However, improvements on this design might be effective in certain applications.

As an alternative, a rock-filled muffler similar to that developed for the generating units could be constructed on some well pads for use during venting. While these installations are quite expensive, they might provide a practical means of noise abatement for venting occurring close to residential areas, especially if several wells on the same pad could be served by a single muffler.

In addition, some large metal test mufflers of conventional design are capable of attenuating venting noise to about 100 dBA at 50 ft. Investigating the possibility of new designs might be worthwhile to achieve an additional reduction of 10 to 20 dBA during extended production tests.

There is, however, real need for a light-weight, easily portable silencing device for use during well clean-out when conventional mufflers would be damaged by ejected rocks and debris. Various jet nozzle configurations have been investigated by NASA to reduce the sound pressure levels from aircraft and rocket engines and to shape the frequency spectrum. Applying this research to geothermal steam venting, as well as developing techniques for directing the steam flow away from receptors, could help achieve a satisfactory level of noise reduction.

A feasibility study should be initiated as soon as possible to determine the most promising approaches to reducing steam-venting noise. This should be followed by the design, construction, and testing of prototype and standard muffling devices.

This effort should be carried out in close cooperation with geothermal developers at The Geysers. Such a program can probably be completed within one year.

Drilling Noise

Second priority should be given to the control of drilling noise. Techniques are available for developing acoustic enclosures and better exhaust noise control for large engines and compressors, as well as improvements in cyclonic muffler design. Some of these advances are currently being implemented by geothermal developers. Further reduction of drilling noise can probably be accomplished by the industry and will not require an extensive research and development effort.

REFERENCES

1. U.S. Environmental Protection Agency, *Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances*, Rept. PB 206 717, prepared by Bolt, Beranek, and Newman (Dec. 31, 1971).
2. Atlantis Scientific, *Environmental Impact Report, Castle Rock Springs Geothermal Steam Area, Lake County, California*, prepared for Burmah Oil and Gas Co. (Aug. 22, 1975).
3. Atlantis Scientific, *Environmental Impact Report, Ford Flat Geothermal Steam Area, Lake County, California*, prepared for the County of Lake Planning Department (Jul. 5, 1976).
4. ECOVIEW Environmental Consultants, *A Draft Environmental Impact Report for Union Oil Company Unit #17 Development Area, Lake County, California*, prepared for the County of Lake Planning Department (Dec. 15, 1977).
5. Environmental Impact Planning Corporation. *Long Ridge Geothermal Leasehold—Draft Environmental Impact Report*, prepared for the County of Lake Planning Department (Apr. 1977).
6. Gennis and Associates, *Draft Environmental Impact Report: McCulloch Oil Corporation Cobb Valley Geothermal Leasehold*, prepared for County of Lake Planning Department (Feb. 1977).
7. Sociotechnical Systems, Inc., *Draft Environmental Impact Report, Northern California Power Agency/Resource Funding Limited, Cobb Valley Geothermal Project*, prepared for County of Lake planning Department (Sept. 20, 1977).
8. R. C. Bush, "An Overview of PG&E's Audible Noise Measurement Program at The Geysers," *Geothermal Environmental Seminar—'76*, (Lake County, California, Oct. 27-29, 1976).
9. R. R. Illingworth, "Factors Contributing to Annoyance by Geothermal Steam Well Venting at The Geysers," *Geothermal Environmental Seminar—'76* (Lake County, California, Oct. 27-29, 1976).
10. U.S. Environmental Protection Agency, *Transportation Noise and Noise from Equipment Powered by Internal Combustion Engines*, Rept. NTID 300.13 (Dec. 1971).
11. R. C. Bush, "Plant and Equipment Noise Treatment," *in Proc. of Pacific Coast Electrical Association Engineering and Operation Conference*, (Los Angeles, California, Mar. 17-18, 1977).
12. Pacific Gas & Electric Company, *Environmental Data Statement, Geysers Unit 16* (Aug. 19, 1977).
13. A. S. Timmons and O. D. Whitescarver, *Geysers Simplified Noise Model, Unit 17 Geothermal Development Area*, Union Oil Company of California, Santa Rosa, California (Mar. 15, 1978).
14. Vibron West, *Noise Element of the General Plan, Lake County, California*, prepared in cooperation with Sociotechnical Systems, Inc. (Feb. 11, 1977).
15. U.S. Environmental Protection Agency, *Information on the Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, Document No. 550/9-74-004.
16. California Department of Health, *Guidelines for the Preparation and Content of Noise Elements of the General Plan*. Office of Noise Control, California Department of Health in cooperation with the Office of Planning and Research (1976).
17. S. L. Hester, *et al.*, *Ambient Sound Level Anderson Springs-Cobb Valley, Lake County, North Bay Division*, prepared by Pacific Gas & Electric Co. (Mar. 13, 1974).

KJM

HYDROLOGIC/GEOLOGIC REVIEW

OF

ENVIRONMENTAL IMPACT STATEMENTS

FOR

GEOTHERMAL DEVELOPMENT

submitted to

SANTA CLARA PUEBLO

Espanola, New Mexico

by

Geological Services of Tulsa, Inc.

Tulsa, Oklahoma

November, 1979

GEOLOGICAL SERVICES OF TULSA

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November 7, 1979

Mr. Walter Dasheno, Governor
Santa Clara Pueblo
Post Office Box 580
Espanola, New Mexico 87532

Re: Critique of Environmental Impact Statements
Geothermal Leasing and Demonstration Project

Dear Mr. Dasheno:

As you requested on October 15th, Mr. Tom Aley and myself have critiqued two environmental statements concerning geothermal leasing in the Santa Fe National Forest and the geothermal demonstration program on Baca Ranch. Our comments are attached.

Our critique is limited to the geological and hydrological portions of the assessments. Because the current concern of the Santa Clara Pueblo is the effect of geothermal development activity on water supplies, Mr. Aley, the hydrologist, is responsible for, and deserves the credit for, the major portion of this critique.

If you have any questions, please call me and we will try to answer them.

Very truly yours,

Wilgus B. Creath

WBC:db

Attachment

CRITIQUE OF ENVIRONMENTAL IMPACT STATEMENTS GEOTHERMAL LEASING AND DEMONSTRATION PROJECT

In our opinion the Final Environmental Statement, Geothermal Leasing, Santa Fe National Forest is totally inadequate for assessing any impacts beyond the most preliminary exploratory work; however, it does point out there is no indication that the energy to be produced by the Jemez Mountain Geothermal Resource is really needed in the region. The Baca Ranch Program is a demonstration project. The Draft Environmental Impact Statement for Geothermal Demonstration Program, 50 MWe Power Plant, Baca Ranch, New Mexico is of much better quality but it is more self-serving. In our opinion, the statement should have devoted more effort in evaluating the effects of full-scale development. The demonstration project is just the camel getting his head in the tent -- Santa Clara should insist on a look at the rest of the animal.

Neither Environmental Statement makes a serious attempt to incorporate public opinion in the assessment. Public participation in both instances appears to be limited to after-the-fact comments after the assessments were written. This, in our opinion, is not pursuant to the intent of the National Environmental Policy Act of 1969.

Both environmental documents are deficient in the area of impact analysis. The Forest Service utilizes an elementary matrix to graphically display a qualitative summary of environmental impacts. The Department of Energy utilizes no assessment methodology whatsoever. Sophisticated methodologies have been developed for assessing impacts of proposed projects on water resources. We believe that some of these methods should have been employed in both the Forest Service and Department of Energy statements.

A more detailed review of each of the documents follows:

FINAL ENVIRONMENTAL STATEMENT ON
GEOTHERMAL LEASING, PREPARED BY
THE SANTA FE NATIONAL FOREST, UNDATED

COMMENT 1

The environmental impact statement considers major activities on substantial amounts of land where conditions are varied. As a result, it is lacking in the site specifics necessary to realistically evaluate the proposed action. The data and the assessments are very incomplete.

The primary reason that this document was prepared was to permit exploratory work while also complying with the

National Environmental Policy Act. Although this impact statement may be adequate for the exploratory phase of the work, it is totally inadequate for evaluating the impacts of any work beyond exploratory work. It is our conclusion that the technical content of this EIS is totally inadequate for assessing any proposed development of geothermal resources which may occur in the area.

COMMENT 2

Considerations of impacts on water quality are based upon only a few chemical parameters. These are (pages 33,34, and 56) total dissolved solids, pH, sulfates, sodium, and chloride. Other parameters should have been included to provide an adequate environmental assessment. The list of water quality parameters should have included arsenic, boron, barium, beryllium, bromide, cadmium, chromium, copper, iron, mercury, manganese, nickel, lead, selenium, zinc, silver, rubidium, and fluoride.

The Forest Service EIS considers water quality impacts on fish, and ignores impacts to other aquatic fauna and flora. Many invertebrates are far more sensitive to toxic compounds in water than are fish; many of these invertebrates provide essential food for fish. Furthermore, waters produced from National Forest lands are used for agricultural irrigation; the Forest Service should have considered the impacts of water quality changes upon agriculture and other current water uses.

In addition, only the thermal impact on aquatic life is considered. Other parameters, such as those listed in the preceding paragraph would have more permanent deleterious effects.

COMMENT 3

The EIS generally recognizes that the extraction of large volumes of water from thermal aquifers would affect the available quantity of water on the surface. However, the writers (and some of the reviewers) of the EIS do not have a clear picture of the mechanisms through which these water quantity impacts would occur.

The extraction of more water from the thermal aquifers than is re-injected would rapidly lead to major dewatering of the thermal aquifers. This dewatering would induce groundwater recharge from overlying groundwater supplies, which in turn would divert waters from surface water supplies. Based upon our work to date, we believe that induced groundwater recharge would have major impacts on surface water supplies. A substantial amount of the work in conjunction with our proposed geologic and hydrologic studies will be directed toward this issue.

It is our opinion that the following statement from page 30 of the final Forest Service EIS represents a logical and prudent course of action:

"In a statement made at a public meeting on a geothermal leasing, a spokesman (Mr. Donald Eugene Gray) for the State Engineers Office commenting on water rights said, 'It is the State Engineer's position that in the Valle Grande area there is an interfingering of formations and all are interconnected and hydraulically connected; that all formations are one hydrologic unit; and that the appropriation of water, either in gaseous or liquid state, will have some effect on the Rio Grande Stream system and that it will be necessary for the appropriator to offset that effect so that existing rights will not be impaired.

If the appropriator takes exception to this position it will be his burden to show that the appropriation will not have an effect on the stream system'."

At several points in the EIS, the Forest Service discusses the issue of whether or not the thermal aquifers are hydrologically connected with other aquifers in the area (for example, page 90). It sometimes appears that the Forest Service is willing to assume that the aquifers are not connected unless proof to the contrary is developed. We believe that this position is improper for four reasons:

1. In nature, it is an extremely rare occurrence for superimposed aquifers not to be hydrologically integrated. There may be zones which restrict the quantity of hydrologic integration, but these generally only retard (and do not prevent) such vertical hydrologic integration.

2. In view of the tectonic history of the area, it is highly improbable that the thermal aquifer is totally isolated from hydrologic connections with overlying aquifers and/or surface waters.

3. The potential heavy net extraction of water from thermal aquifers would greatly accelerate the quantity of water moving into the thermal aquifers from overlying groundwater and from surface waters.

4. A presumption that the aquifers are not connected is prejudicial to the interests of existing resource users (water users), while being beneficial to the interests of those seeking to develop the use of thermal aquifers for electrical energy production. From our hydrologic view point, electrical energy production will result in a decrease in water quantity. In New Mexico, water is probably a scarcer commodity that electricity.

COMMENT 4

On several occasions in the EIS the Forest Service raises the issue of whether or not the thermal aquifer is a replaceable resource (pages 19, 44, and 79). It would be a replaceable resource if:

1. Extraction of water from the thermal aquifers induced recharge from overlying groundwater systems and ultimately from the surface.
2. Requirements were made that the volume of water reinjected into the thermal aquifer had to equal the quantity of water extracted from the thermal aquifer.

The reason that the U.S. Forest Service raises the issue of management of the thermal aquifer as a replaceable resource is probably because of federal laws governing the management of national forest lands. In particular, the Forest Service places great emphasis on the Multiple Use Act. This act specifies that National Forest lands shall be managed to produce a sustained yield of resource commodities. By not permitting the overdrafting of the thermal aquifer, the Forest Service could apply the sustained yield concept to the production of electrical energy from the thermal aquifer. Santa

Clara Pueblo may wish to encourage the Forest Service to adopt this line of logic with respect to the thermal aquifer resource.

COMMENT 5

Alternate number 1, the no-leasing alternate, should have been considered for a reason not listed on page 82 of the EIS. The no-leasing alternate would have been prudent if an unacceptable trade-off exists between the quantity of water which would be consumed by potential thermal energy projects and the quantity of electrical energy which would be produced. The Forest Service should have considered the values involved in this trade-off. If the analysis indicated that the value of water was greater than the value of electrical energy which might be produced, adoption of the no-leasing option would have prevented waste of, or damage to, other resources which will occur as a result of thermal exploration activities.

COMMENT 6

On page 62 it is stated that earthquakes can result from hydrologic lubrication of a fault line but that this is not likely because drill logs will detect faults and that these wells will then not be used for reinjection. The probability that mechanical logs will accurately detect faults in a geologic section dominated by ash falls and ash flows is remote.

COMMENT 7

Active faults and seismicity are mentioned in several places in the document but no historical data are presented.

DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR GEOTHERMAL DEMONSTRATION PROGRAM, 50 MWe POWER PLANT, BACA RANCH, NEW MEXICO, 1979

As a result of our review of this draft EIS, we have identified six major issues of concern:

1. The conclusions in the draft EIS are often not based upon adequate data.

2. The choices of units and measures employed in the assessment indicate a lack of hydrologic expertise on the part of the people making the assessment. An adequate assessment requires thorough involvement by people with professional expertise in the technical fields involved.

3. There are major water rights issues involved in the proposed project. The proponent has ignored this issue by making illogical hydrologic assumptions which are unsupported by data.

4. The question of whether the upper part of the Bandalier Tuff is an aquiclude or an aquitard is of vital importance. The proponent includes some data indicating that substantial water flow would occur from overlying units into the thermal aquifer with dewatering of the thermal aquifer. However, elsewhere in the draft EIS, the proponent says there would be no recharge. This is a self-serving assumption lacking both a factual and logical basis.

5. The proposed project would trade the consumption of water for the production of energy. The draft EIS

does not determine the value of the water which would be consumed by the proposed project. This value may exceed the worth of the energy which would be produced even if the plant functioned as proposed.

6. The document does not satisfactorily address the ramifications of full-scale (400 MWe) development if the pilot project is found to be commercially feasible. The financial projections of Union Geothermal Company and Public Service Company of New Mexico are almost certainly based on full development.

COMMENT 1

There appear to be serious water rights problems in conjunction with the proposed project. We have no legal expertise in water rights, yet water rights issues involve both legal and hydrologic considerations. Therefore, we will outline the hydrologic conditions as we see them to help the attorneys involved in their consideration of the matter.

The proposed 50MW plant would extract approximately 9,665 acre feet of water per year from geothermal supplies, and would re-inject approximately 6,856 acre feet of water (values derived from page 2-25, draft EIS; other pages of the report give slightly different values). A total of 2,809 acre feet of water would be consumed per year by the single proposed plant.

The proponents propose to operate the 50MW plant with an annual water right of 15.93 acre feet. Based upon our preliminary hydrologic assessment of the proposed project, it is our conclusion that this water right is insufficient to cover the hydrologic impacts of the proposed project on other water users. In the following paragraphs, we have considered five separate water right quantities which might be appropriate for the proposed project; this consideration includes the 15.93 acre feet suggested by the proponent. Again, our emphasis is on the hydrologic (rather than the legal) suitability of each of the possible quantities of water right.

Annual water right of 9,665 acre feet

This volume represents the annual amount which would be extracted for a beneficial use (in this case energy production). Water rights in the western United States are generally based upon the quantity of water extracted, and a credit against the extraction volume is commonly not given for return flows. However, return flow credit might be given if the quality of the return flow water was essentially the same as the quality of the water which was extracted. This is not the case at the proposed power plant, since about 29% (proponent calculates 27%) of the water extracted is evaporated. Because of the evaporation, the concentration of total dissolved solids in the return flow water (injection water) is about 29% greater than the concentration in waters extracted from the ground.

The water to be extracted is of poor chemical quality for drinking water or agricultural purposes. Page 4-12 of the report indicates that the mean concentration of total dissolved solids is 6,093 mg/l (or parts per million, ppm). The U.S. Environmental Protection Agency proposes classification of underground waters having less than 10,000 ppm total dissolved solids as drinking water (Reproposed Rules for State Underground Injection Control Programs, Federal Register Vol. 44, No. 78, pp. 23738-23767). The 10,000 ppm total dissolved solids concentration limit is found on pages 23742 and 23743.

The State of New Mexico or other federal agencies may have definitions of drinking water which would exclude the Baca thermal waters; however, our point is that the quality of the water, while not good, is not so poor as to automatically exclude it from all uses other than geothermal energy production.

<u>Annual water right of 2,809 acre feet</u>

This volume represents the volume of water which would be consumed through the operation of the proposed plant. This is also the volume of makeup water which would need to be injected into the thermal aquifer to prevent overdrafting of the groundwater system.

On page 9-13 of the report the statement is made that geothermal developers considering operations at the Heber site in California would be required to inject a volume of fluid equal to that withdrawn. This is a prudent requirement to insure long term productivity of geothermal resources as well as to insure that geothermal developments do not deplete surface water or groundwaters already allocated to other users.

Annual water right of 2,056 acre feet

Use of an alternate cooling system design would require the use of 2,056 acre feet of non-thermal water per year (page 9-20). The EIS states that this would be legally impossible because water rights are already appropriated. However, it should be noted that this design would conserve about 750 acre feet of water per year over the design proposed in the draft EIS. In a region where all water rights are appropriated, all water evaporated are lost to other water uses. Furthermore, because of return flow, some water can be used more than once; once water is evaporated, it cannot be used again.

It is our view that the draft EIS is deficient in not considering the impacts of the proposed selection of a cooling system which is not the most water efficient. Based upon data on pages 4-18 and 4-19 of the draft EIS, irrigated cropland near the Jemez River in San Diego Canyon requires a water right of approximately 1.14 acre feet of water right for each acre irrigated. Conservation of 750 acre feet of water per year would permit the continued use of about 658 acres of irrigated land along the Jemez River. This is a significant impact.

Annual water right of 312 acre feet

Based upon data included on page 6-1 of the draft EIS, this value represents the mean annual rate of groundwater recharge to the overdrafted thermal aquifer. This recharge would cause diversion of shallow groundwaters and surface waters from their present flow patterns into flow patterns which would recharge the depleted thermal aquifer. As a result, this recharge represents a diversion from present surface and shallow groundwater supplies of 312 acre feet of water per year for an anticipated period of 270 years.

The proposed rate of extraction of geothermal waters (9,665 acre feet per year) is far more rapid than the mean rate of groundwater recharge to the thermal aquifer as anticipated by the proponent (pages 6-1). As a result of this, pressures on recharge waters would vary significantly with time, and the annual quantity of groundwater recharge would sometimes be larger than 312 acre feet. The largest quantities of natural recharge to the thermal aquifer would occur near the end of the 30 year lifespan of the project.

The proponent does not include in the draft EIS an explanation of how this natural recharge rate was calculated. This data should have been included. The nature of the recharge areas is described on page 3-53:

"Ultimate recharge areas for the Valles Caldera geothermal system are probably the same as those for the shallow groundwater system. Isotope data show a meteoric origin of undertermined age (Union Oil Co., 1978). Groundwater contained within the Valles Caldera aquifers slowly recharges the geothermal system at depth by leakage through confining layers such as the altered caprock and by percolation downward through joints, fractures, and fault zones. The recharging waters move downward and laterally through the geothermal reservoir. During their residence, the meteoric waters are chemically altered by wall-rock and perhaps juvenile water contribution and are heated by the underlying magma body."

Estimation of the annual rate of groundwater recharge to the thermal aquifer after the start of pumping will require a substantial amount of geologic and hydrologic work. This is discussed elsewhere. However, in view of the existing data included with the draft EIS, we anticipate that annual recharge rates resulting from the proposed project frequently will be larger than the 312 acre feet per year value included in the draft EIS. We emphasize that this recharge would be produced from waters in shallow groundwater and surface water supplies.

<u>Annual water right of 15.93 acre feet</u>

This is the proponents suggestion (see pages 4-18 through 4-20 of the draft EIS). This estimated volume is in conflict with statements and estimates made elsewhere in the draft EIS (in particular, pages 3-53 and 6-1). Furthermore, the estimate of 15.93 acre feet as the quantity needed to offset water quantity impacts is based upon faulty technical logic.

On page 4-19 the proponent states:

"The shallow groundwater system should not be impacted, since (1) fluids will neither be withdrawn nor injected into shallow aquifers and (2) shallow aquifers will be protected from surface infiltration by the use of impermeable pits (sumps) with high freeboard to contain vented and/or drilling fluids."

The proponent neglects to consider the quantity of induced recharge resulting from the extraction of water from the thermal aquifer. The proponent recognizes that induced recharge will occur (see pages 3-53 and 6-1 of the draft EIS and the above discussions on an annual water right of 312 feet).

The proponent's estimate of annual water consumption of 15.93 acre feet is poorly documented on pages 4-18 through 4-20. It appears, however, that a "best fit" streamflow depletion analysis was conducted, and provided the basis for the derivation of this value. We fail to see the technical applicability of this technique (particularly when used under non-pumping conditions) to the questions at hand.

The proponent's suggestion that their proposed actions would reduce surface flow by 15.93 acre feet per year shows a total lack of understanding of the hydrologic difficulties involved in determining quantitative impacts of land use actions on surface streams. On page 7-2 of the draft EIS, the statement is made that Union must demonstrate to the New Mexico State Engineer's Office that they control sufficient irrigated land to retire water rights equal to the amount of impairment detected by monitoring streams. Let us consider the technical feasibility of this approach.

Any method of flow depletion estimation used must insure that existing water rights are not jeopardized by underestimation of the quantity of water lost from the surface system. The nearest long-term stream gaging station which could be used to assess the quantitative hydrologic impacts of the proposed project is on the Jemez River at Battleship Rock. Based upon data on pages 3-40 and 3-41 of the draft EIS, the mean annual flow for this station averaged 30 cubic feet per second (cfs) for the period from 1960 to 1975. Annually, this value ranged from 16 to 65 cfs.

In mountainous terrain (such as the area in question), precipitation, evaporation, transpiration, sublimation, and water detainment as soil moisture storage vary widely from point to point. In such an area, prediction of streamflow through hydrologic models is subject to great errors (particularly when one looks for short-term changes). Calculated streamflow (using hydrologic models) is commonly 10 or 20% different from the actual quantity of streamflow measured. Changes in the water flow of the Jemez River at the Battleship in his planning. The proponents apparently own and would willingly retire water rights for only 50 acres of irrigated farmland. It is our conclusion that this represents only a tiny portion of the water right which would need to be retired to offset the water quantity impacts of the proposed project.

SUMMARY OF COMMENT 1

Pages in the draft EIS which relate to water rights and groundwater recharge of the thermal aquifer are as follows: 1-2, 1-3, 2-24, 2-27, 3-33, 3-34, 3-38, 3-40, 3-41, 3-47 through 3-54, 4-12, 4-18 through 4-22, 4-65, 6-1, 7-1, 7-2, 9-13, and 9-20.

Based upon hydrologic considerations alone, requiring a water right of 9,665 acre feet per year for the operation of the proposed plant appears more restrictive than is necessary to protect other water users. We believe that requiring a water right of 2,809 acre feet per year would be a more reasonable approach _if_ this volume of water were actually injected into the thermal aquifer. We realize that the location of the site would create significant problems in the development of adequate water supply sources. Furthermore, such requirements would probably make it more difficult to construct additional geothermal power plants in the area.

From a hydrologic viewpoint, the minimum amount of water right which should be held by the proponents of the project should be equal to the maximum rate of groundwater recharge expected to be induced by the proposed project. The proponents have not determined this quantity, but based upon data presently available, we believe it represents substantially more than 312 acre feet per year. Our proposed studies will help determine this quantity.

The final environmental statement prepared by the U.S. Forest Service for geothermal leasing on Santa Fe National Forest lands includes the following statement (page 30):

> "In a statement made at a public meeting on a geothermal leasing, a spokesman (Mr. Donald Eugene Gray) for the State Engineers Office commenting on water rights said, 'It it the State Engineer's position that in the Valle Grande area there is an interfingering of formations and all are interconnected and hydraulically connected; that all formations are one hydrologic unit; and that the appropriation of water, either in gaseous or liquid state, will have some effect on the Rio Grande Stream system and that is will be necessary for the appropriator to offset that effect so that existing rights will not be impaired.
>
> If the appropriator takes exception to this position, it will be his burden to show that the appropriation will not have an effect on the stream system'."

On pages 7-1 and 7-2 of the Department of Energy draft EIS, the statement is made that the commercial partners of the venture have reached tentative agreement with the New Mexico State Engineer's Office regarding the potential for surface stream flow impairment caused by stream withdrawls from the reservoir (thermal aquifer). This is apparently based upon the 15.93 acre foot per year volume which we have already discussed. The draft EIS further states (page 7-2) that Union must demonstrate to the New Mexico State Engineer's Office that they control sufficient irrigated land to retire water rights equal to the amount of impairment detected by monitoring of streams. Based upon our understanding of the situation, this should have presented a difficult hydrologic problem for the proponents of this power plant.

COMMENT 2

The proposed project would induce groundwater recharge of the thermal aquifer. This induced recharge would affect water supplies in overlying groundwater systems by depleting these waters and by altering flow routes. Recharge of the thermal aquifer by more shallow acquifers would result in more groundwater recharge occurring from the surface of the land. This would result in a decrease in the quantity of surface runoff from the area.

In addition to impacts on other water users, less surface water flow would affect aquatic life and non-consumptive uses of the streams of the area. These impacts were not assessed in the draft EIS.

The geologic and hydrologic work which Geological Services of Tulsa has proposed will help assess the impacts of the proposed project on the surface water and shallow groundwater supplies. Based upon our present understanding of the situation, we believe that the proposed project will induce substantial groundwater recharge, and that this will have very significant impacts on surface waters and shallow groundwaters in the area. These impacts will extend substantially beyond the area to be occupied by the proposed development. Our proposed work will identify as accurately as possible the area which will be impacted by the proposed project. Such as assessment was not made by the proponent, although we believe it should have been and that it should have been included with the draft EIS.

COMMENT 3

The proponent proposes to extract thermal water from 14 to 17 wells, and to inject cooled water through three non-producing wells (see page 2-8). The ratio of extraction to injection wells seems high; we should consider the reasonableness of this relationship in our future work. Our concern is that an inadequate number of injection wells could lead to possible catastrophic failures with resulting discharge to surface waters and/or shallow groundwaters. Furthermore, we wonder why the wells to be used for injection were not suitable for extracting waters from the thermal aquifer.

COMMENT 4

Some numerical values for the same feature vary from one part of the report to another. For example, on page 1-2, the volume of the reservoir fluid is shown as 4×10^{12} pounds of fluid. On page 3-33, the value is shown as 4.7×10^{12} pounds of fluid. For purposes of uniformity, we have used the latter value. The total water consumption of the plant also varies from one part of the report to another; for purposes of uniformity, we have used values on page 2-24. Although the differences are generally small, and are undoubtedly less than the error the the estimates, it would help reviewers if values were uniform throughout the document.

It would also have helped reviewers if more conventional units were used to express water quantities (for example, acre feet of water rather than pounds of water). Non-conventional units tend to obscure the significance of the quantities involved unless the reviewer converts all the units. In addition, the sporadic use of metric units (sometimes with and sometimes without English equivalents) was not of much help to reviewers, and tended in increase numerical errors in the report. As an example, it was interesting to note (page 4-1) that diesel trucks and heavy construction machinery en route to the project site would pass less than 300 km from some residences in the area. The typist and proof reader probably did not realize that this equals 186 miles. The writer probably had 1,000 feet in mind for this value.

Rock gaging station would need to exceed 10 to 20% of total flow (or 3 to 6 cfs) before changes in the flow regime could (in the short term) be attributed to the extraction of water from the thermal aquifer. Three to six cfs represents 2171 to 4344 acre feet per year.

The proponents project would result in a net extraction of 2,809 acre feet of water per year from the thermal aquifer. Even if all of this water were replaced by induced groundwater recharge from surface streams, this quantitative change would (in the short run) either be undetectable or only marginally detectable at the Battleship Rock gaging station through the comparison of predicted flow with actual gaged flow. Since the actual quantitative impacts could well be less than 2,809 acre feet per year, changes in stream flow would be statistically undetectable for a number of years. It could well require 20 or 30 years of detailed data to show that the power plant operation had caused a decrease in stream flow of about 1,000 acre feet per year. If water rights are fully appropriated, this is an unjustifiable period of time to wait for a determination of the quantity of water which was diverted by the proposed power plant.

It is our conclusion that the proposed project will have an impact on total water quantity many times greater than the 15.93 acre feet per year which the proponent has acknowledged

COMMENT 5

The statement is made on page 2-28 that wells drilled into the thermal aquifer will be abandoned using standard well abandonment practices. The "standard" practices which we have seen in the past are not always successful, and some of them are not appropriate to chemically aggressive thermal waters.

The abandonment practices should be described. The likelihood of leakage or failure of the sealings should be discussed, and the impacts of such failures should be assessed.

COMMENT 6

The proposed geothermal energy project involves cost-sharing between the Department of Energy and private firms; the firms and site were selected by DOE as a result of a Program Opportunity Notice (PON) issued on September 30, 1977. One of the specific objectives included in the PON (see page 2-2 of draft EIS) was to demonstrate the validity of reservoir engineering estimates of reservoir productivity (capability and longevity). This objective could not be met without accurate calculations based upon adequate data. Based upon estimates found in the draft EIS, we question whether this proposal meets the objective.

The thermal aquifer is described (page 3-33) as being primarily in the pumicey basal portions of the Bandalier Tuff;

these portions are described as being 1,000 feet thick. On page 3-34, the statement is made that the reservoir is not restricted to the Bandalier Tuff, but extends to depth in underlying volcanic and sedimentary rocks. On page 3-33, the area underlain by the thermal aquifer is calculated to be 40 square miles, and the estimated volume of water in the aquifer is calculated to be 1.73 million acre feet. On page 4-22, the porosity of the aquifer is presumed to be 10%.

Some (or all) of the above values are incorrect. An aquifer with an areal extent of 40 square miles and a 10% porosity would have 1.73 million acre feet of water storage if it were 675 feet thick. However, according to the draft EIS, the aquifer is substantially thicker than this. Since the derivation of values is not given in the report, all we can tell in our review is that at least some of the values are in error (or possibly values which were not explained were used in the calculations). Perhaps the value relates to the volume of water which could be yielded to wells rather than the actual volume of water in the aquifer.

Some of the units and measures found in the hydrologic portions of the draft EIS are different from those commonly used in the practice of hydrology; this indicates that experienced hydrologists have not been adequately involved in the assessment of impacts. For example, water extraction rates are often given in pounds per hour rather than cubic feet per second. The volume of water in the thermal aquifer is expressed in pounds rather than acre feet. Good assessment work requires professional evaluation.

In calculating the volume of water in the thermal aquifer and the potential life of the aquifer under fully developed use (see page 4-65), calculations are based upon porosity. Porosity is a measure of the pore space within the aquifer, and is an important parameter. However, water can be extracted from only a portion of this pore space; this value should have been determined in order to calculate the rate of reservoir depletion. According to the report, the primary aquifer consists of the pumicey basal portions of the Bandalier Tuff. In such a material, we would anticipate that a substantial amount of the porosity would not yield water to wells.

COMMENT 7

The proposed project would result in the annual evaporation of approximately 2,809 acre feet of water for 30 years. This evaporation would ultimately result in an equal decrease in the quantity of water in shallow groundwater and surface water supplies. Data included in the draft EIS is inadequate to determine the rate at which this decrease would be detectable on the surface, yet it is obvious that there would ultimately be an equal volume trade-off.

The draft EIS should have compared the value of the electrical power resource with the value of the water resource which would be consumed by the project. Based upon data in the draft EIS, 2,809 acre feet of water is consumed to produce each 320 million killowatt hours of electricity. At a value of 2 cents per kwhr., an acre foot of water would produce a commodity with a wholesale value of $2,290. When used for agricultrual purposes, the wholesale value of the commodity produced by an acre foot of water might equal or exceed this amount. A detailed calculation and consideration of these costs is beyond the scope of our work, yet we believe that such calculations should have been included in the draft EIS.

The Department of Energy proposes to trade water and other natural resources for electrical energy. The Department of Energy has failed to show that such energy is needed, and has failed to show that the value of this energy justifies the consumption of water resources and the degradation of other natural resources. In reality, the purpose of the project is not to generate electricity, but instead to demonstrate that it can be generated through the use of an incompletely proven technology. In view of the proven value of water resources in the State of New Mexico plus the values of other natural resources in the area, it is our conclusion that the proposed project is not a prudent use of natural resources. An adequate EIS would have made this apparent.

COMMENT 8

Very little documentation is presented concerning seismic events in the area of interest. The statements made on page 3-27 are confusing and subject to diverse interpretations. If increased seismic activity is a possible adverse impact of geothermal development, then reliable baseline data on seismic activity is needed.

COMMENT 9

The surface water monitoring system to be installed needs elaboration. A system (11-6) which monitors water velocity, discharge, temperature at intervals greater than once a month seems less than adequate to us.

COMMENT 10

The summary (1-1) states that DOE has contacted tribal representatives and exchanged information on the project and the religious significance of, and potential impacts on, American Indian lands nearby. During our meeting on October 15th, Santa Clara representatives repeatedly emphasized the religious importance of certain hot springs and other geographic/geologic features to their culture. These areas are not identified in the draft statement and there is little indication that the DOE has given the subject any attention.

COMMENT 11

It is stated on page 2-1 that this is to be a demonstration plant to demonstrate the reliability, economic feasibility and environmental acceptability of electrical generation from geothermal resources. If this is a demonstration project, then the assessment should be especially complete. It is also stated (2-1) that the potential consequences of further commercial development of geothermal energy, beyond 50 MWe (to 400 MWe is indicated elsewhere) will be discussed in the draft in a general way. It may reasonably be assumed that if the demonstration project is feasible then full commercial development of the Valles Caldera will become a fact. For this reason, we believe that the DOE document should address in detail the impact of full-scale development.

It will be erroneous to assume that the deleterious effects of a 400 MWe plant will simply be 8 times those of a 50 MWe plant. A thorough analysis is needed to assess the effects of losing 6,000,000 lbs/hr of geothermal fluid from the hydrologic regime and the release of 400 lb/hr of hydrogen sulfide to the atmosphere. 3,504,000 pounds of hydrogen sulfide released to the atmosphere each year is a problem worthy of more than passing comment. Will this cause acid rains which in turn may leach nutrients from the soils and have an adverse effect on farming in the region? Is the DOE assuming that full-scale development from 50 MWe to 400 MWe will increase adverse effects by only a factor of 8? This is an erroneous assumption. Many of the adverse effects can be expected to rise exponentially rather than arithmetically. Not enough data is presented in the document to satisfy any impartial reviewer as to how much geothermal development your area, with existing cultural patterns, will tolerate.

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New Mexico Geothermal Project Threatened By Hydrogen Sulfide Standard

By Burt Solomon

Environmental problems — namely, the rotten-egg aroma of hydrogen sulfide — could put a crimp in the planned development of New Mexico's extensive geothermal resources.

After seven months of haggling, Public Service Company of New Mexico (PNM), Union Oil Co. and the federal Department of Energy finally signed last week a formal contract to build a $124.6 million 50-megawatt demonstration geothermal power plant in the scenic Jemez Mountains 60 miles north of Albuquerque. It is believed that the site's geothermal resources could generate 400 megawatts of power for 30 years, and it is only one of an estimated six or eight potential geothermal sites in the state.

However, on Friday PNM told the state's Environmental Improvement Board that the demonstration plant will not be built unless New Mexico's strict hydrogen sulfide emissions standard is modified. According to a recent federal environmental impact statement, the utility noted, the state's current H_2S standard of three parts per billion (ppb) would allow only a single 50 MWe plant at the Jemez Mountains site.

PNM and Union Oil "are not willing to build 50 megawatts unless we can build more," a utility spokeswoman explained. PNM's interest in the project "is not just to give science a helping hand. We're in it to sell electricity, and Union is in it to sell steam" to the power plant that PNM will build and operate.

Hydrogen sulfide "is not a health hazard, but a nuisance odor," she said. "How much is too much? It's a question of aesthetics. . .Unless the state of New Mexico is willing to compromise, there won't be any geothermal development in the state, because if we can't build, no one else will be able to build." PNM has withdrawn the construction application it had filed with the state and does not intend to resubmit it until the hydrogen sulfide issue is resolved.

New Mexico environmental officials, for their part, scheduled a September 13 hearing on the H_2S standard and have indicated that alterations may be forthcoming — though not necessarily as great as the utility would like. "On the one hand, we would like to encourage geothermal development," Cubia Clayton, deputy director of the state's Environmental Improvement Department, said on Wednesday. "On the other hand, a lot of this would be occurring in areas of high recreational value to the state. We must try to find a level" that meets both needs.

With tourism the third leading industry in New Mexico, "it gets to be a nice little problem," Clayton said. "I'm not sure exactly how it works out, though in the past we've generally been able to strike a reasonable balance." In 1973, he recalled, state officials altered the hydrogen sulfide standard to 100 ppb in the oil- and gas-rich Pecos-Permian Basin in New Mexico's southeastern corner, although the standard has since been tightened to 30 ppb in and around municipal areas. Clayton also noted that some geothermal areas, including PNM's site, have sulfur springs which by themselves push the "natural ambient level probably above the state [H_2S] standard."

One reason that Clayton terms this problem "a toughie" is that "odor is hard to quantify. You can't measure it with an instrument like other air pollutants. It's so subjective." According to Clayton, there is some (though not decisive) evidence that an H_2S level of 30 ppb is above the "odor threshold" for 10 percent of the population — who would be able to smell but would not be overwhelmed by the aroma — though not for the remaining 90 percent. In some local jurisdictions, Clayton added, hydrogen sulfide emissions are judged by "odor panels" of citizens who sniff and decide how bad it is.

According to state officials, PNM has suggested that the present standard of three parts per billion (on a one-hour average) be changed so that — within a 10-mile radius of geothermal sites — 50 ppb couldn't be exceeded more than three times a day and 140 ppb couldn't be exceeded more than twice a year (both as one-hour averages). The state's Environmental Improvement Department staff plans to counter with its own proposal early next month.

Attachment H

H_2S AMBIENT STANDARD

TESTIMONY OF C. D. BEDFORD

Q. PLEASE STATE YOUR NAME AND PRESENT OCCUPATION.

A. My name is C. D. Bedford and I am a Vice President of Public Service Company of New Mexico (PNM).

Q. HOW LONG HAVE YOU BEEN EMPLOYED BY PNM?

A. Since 1963.

Q. WHAT IS YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND?

A. I received a Bachelor of Science degree in Electrical Engineering from Virginia Polytechnic Institute in 1962. From 1962 to 1964, I attended graduate school at the University of New Mexico. I am a Registered Professional Engineer in New Mexico and a member of the National Society of Professional Engineers (NSPE) and the Institute of Electrical and Electronic Engineers (IEEE).

Q. WOULD YOU SUMMARIZE YOUR PROFESSIONAL EXPERIENCE?

A. My work experience is shown on Appendix A, attached.

Q. WHY HAS PNM REQUESTED THAT THE NEW MEXICO ENVIRONMENTAL IMPROVEMENT BOARD AMEND REGULATION 201 CONCERNING THE HYDROGEN SULFIDE STANDARD?

A. PNM, along with Union Geothermal Company of New Mexico, a wholly-owned subsidiary of Union Oil Company of California (Union), and the United

States Department of Energy (DOE) have entered into an agreement which will be discussed later in more detail, so as to develop initially a 45 MW geothermal power plant. From a planning standpoint, the option of having geothermal resource generation available is substantial. For, in addition to this alternative energy resource, the short lead times for construction of geothermal plants is invaluable due to the added flexibility it provides a utility such as PNM in meeting its demands. Additionally, as you are all aware, the ability of utilities to generate electricity by use of gas and oil is becoming much more limited, due not only to scarcity of these fuels but to the substantial increase in their cost. Fortunately, use of geothermal resources will significantly displace the need for gas and oil.

If the first unit proposed to be developed in the Baca, is successful, and due to the relatively small size of each generating unit (50 to 100 MW per unit) the construction of further units can be accomplished in a relatively short time when compared to the long lead times necessary for construct-- of either coal-fired plants or nuclear generation plants. For example, those later type units require 8 to 12 years to build while a geothermal unit is anticipated to take 3 to 4 years. This allows us, along with other resources, to meet our load requirements in a much shorter time frame.

Analysis to date also indicates that geothermal generating plants will require less initial capital investment than other types of base load generation. For as in the case of the Baca development, the development cost of the well field, is not initially borne by PNM, and as a result a capital cost per kW is lower for geothermal compared to coal. The capital cost of Baca Unit 1 is estimated at $779 per kW while the capital cost for San Juan Unit 4 is estimated at $1,146 per kW.

Finally, due to the location of the Baca, PNM will be able to use the Baca Project to alleviate the need for power in northern New Mexico which will add capacity to serve load in that area and save substantial transmission losses.

Another benefit of development of this resource is that the Baca Unit 1 45 MW will add diversity to PNM's generation resources. A diversified generation mix has the advantage of making a utility less dependent upon any one single fuel source. The effect of a disruption in a fuel supply, such as oil, during the 1973 embargo, strikes in the coal industry and similar events indicate that diversity is a substantial benefit to a utility in maintaining continuity of service at a reasonable price. The capacity of the first unit at the Baca (In 1982) will give PNM the following diversity:

A.	coal:	1224 MW	77.9%
B.	gas-oil:	302 MW	19.2%
C.	geothermal:	45 MW	2.9%

By the year 2000, geothermal could account for up to 10 percent of PNM's capacity. PNM's options for base load generation are coal or nuclear unless geothermal resources become feasible. Baca Unit 1 is the key to having the geothermal option available to PNM in the near future. The success of this unit will be a substantial step in giving PNM the option of building more geothermal units. If the expected cost reductions in the areas of steam production and plant construction and operation can be achieved by this demonstration project, subsequent units are anticipated to be economically feasible without DOE's participation. Therefore, the Baca geothermal field, which has a potential to supply at least 400 MW of generation capacity, can be fully developed if this Board adopts a standard which, while protecting the visibility and the health and welfare of the citizens of the state of New Mexico, will also allow for the resource's full development. This development will provide an alternative to scarce fuel resources, an alternative to the use of coal with its high environmental costs, and to use of nuclear, which is uncertain as to being developed, based on present national concerns.

Q. MR. BEDFORD, ARE THERE ANY OTHER BENEFITS THAT ARE DERIVED FROM DEVELOPMENT OF THIS GEOTHERMAL RESOURCE?

A. Yes, the Baca Unit 1 will not use fresh water for cooling. Instead, the design of the Baca Unit 1 Geothermal Plant incorporates the use of the condensed geothermal steam for cooling water. An annual cost savings of $200,000 to $400,000 per unit per year could be anticipated. The exact savings in water consumption, however, will depend upon final detailed design and a quantifiable analysis of make-up water cost.

Q. ASSUMING THAT THE BACA PROJECT IS NOT BUILT NOW, MR. BEDFORD, WHAT EFFECT WOULD THIS HAVE ON GEOTHERMAL DEVELOPMENT IN NEW MEXICO?

A. PNM is unfortunately caught in a dilemma. If we do not demonstrate the feasibility of this resource now, we most likely will not be able to utilize geothermal energy in the next decade. DOE's backing of this project (over $50 million) makes the project presently feasible, and without it, the project will not go forward. Union would most likely lose its investment of nearly $10 million, and geothermal development, therefore, in New Mexico will be adversely affected. In fact, the New Mexico Environmental Improvement Division in its initial review of our construction permit for the Baca Unit 1 found that based on the unrealistic existing standard that even one unit developed at the Baca could result in emissions that exceed that standard. Although our modeling results did not concur with the state's, we felt it imperative at this time to attempt to establish a reasonable standard in the State of New Mexico rather than arguing modeling results with the Environmental Improvement Division when future units are attempted to be sited.

The Baca location 1 is the most extensively studied geothermal area in the State of New Mexico and is, in fact, believed to be one of the best geothermal reservoirs within the United States capable for being developed for geothermal power generation. If this location cannot be developed into a viable project by construction of future units, then even the near-term outlook for development of geothermal energy is doubtful. A standard that permits construction potential of up to 400 MW is essential, while, once again, protecting the visibility and health and welfare. The public interest of New Mexico, including the social and economic value of development of this resource, should be obvious. Additionally, the exact emission limitations on each unit can be evaluated as the technological practicability of control of H_2S is improved, should the Board choose to do so. However, the standard should be set now at a reasonable level so as to control air pollution while not discouraging or limiting development of this resource. Indeed, our Air Quality Control Act in the State of New Mexico only allows this Board to set standards necessary to prevent or abate "air pollution" and not to pass a standard that is more stringent than necessary to meet that requirement. We believe that our proposal which will be discussed in more detail later by Mr. Richard Jordan, not only is a realistic standard, but enables not only PNM, but also other utilities and developers interested in geothermal resources to proceed with development of this resource.

Q. MR. BEDFORD, HAS PNM CONSIDERED THE EFFECTS ON HEALTH AND ODOR EFFECTS OF H_2S UNDER ITS PROPOSED STANDARD?

A. Yes, PNM has in great detail studied the effects that would result on both health and odor detection under the standard as proposed. Dr. Thomas Milby, a medical consultant for PNM, and President of Environmental Health Associates, Inc., will present his findings as to those impacts under the standard as proposed. We are satisfied, based on this review, that our standard will not result in either ill health effects or bothersome odors for persons either residing in or passing through the Baca area.

Q. MR. BEDFORD, WHAT OTHER WITNESSES WILL TESTIFY ON BEHALF OF PNM?

A. In addition to Dr. Milby, and Richard Jordan, PNM will present testimony by Mr. Arthur Wilbur. Mr. Wilbur will present a description as to the Department of Energy's involvement in the development of the Baca Geothermal Demonstration Power Plant Project. Additionally, Mr. Jack Maddox of PNM, the Baca Geothermal Demonstration Participant Manager, will give an overview as to the actual development of this project as well as the respective roles between DOE and the participants. Mr. Lloyd Aker will discuss the control technology that PNM intends to use for the first unit to be built in the Baca location. I might note that the process that PNM has selected can have removal efficiencies of H_2S as high as 99 percent.

Mr. Russ Erbes of PNM will present PNM's modeling review showing the support and the basis for the development of the standard that we have proposed. Finally, Mr. Joel Robinson of Union Oil Company will provide testimony concerning Union Oil Company's participation in this project as well as their initial exploration in the Baca location as well as the emissions that can be expected from the well field operation.

. MR. BEDFORD, ARE YOU AWARE THAT THE PRIVATELY OWNED BACA LOCATION IS IN AN AREA THAT IS PRESENTLY BEING CONSIDERED FOR PURCHASE BY THE UNITED STATES FOREST SERVICE AND WILL, THEREAFTER, LIKELY BE OPEN TO THE PUBLIC?

Yes. PNM has followed very closely the discussions between the existing owners of the Baca location and interested federal agencies. However, the lease agreements as they presently exist will enable both Union and PNM to continue development of this location of the geothermal resources even in the event that the United States Forest Service purchases this property. The impact that would result, however, is that the public would have access to much of the Baca, however, we have designed our standard as such that we do not believe even in the event this land becomes subject to public access, there will be any health or bothersome odor effects that will occur under the standard as proposed. The standard should more than adequately prevent and abate air pollution as required under New Mexico's Air Quality Control Act.

By adoption of a realistic standard at this point in time, we believe, that the New Mexico Environmment Improvement Board can determine how these resources are to be developed while still protecting the New Mexico environment. We believe this action should be taken now, so that the Federal agency will be fully aware of the state's position before they acquire the land for the public domain.

Q. MR. BEDFORD, YOU EARLIER INDICATED THAT BY ADOPTION OF THIS STANDARD AS PROPOSED, THE BOARD WOULD STILL HAVE THE FLEXIBILITY TO REVIEW TECHNOLOGY IN THE FUTURE AS IT BECOMES MORE REFINED AND NECESSARY TO ADOPT EMISSION REGULATIONS FOR SPECIFIC UNITS, AS NECESSARY, THAT REFLECT THAT FUTURE TECHNOLOGY. IS THAT CORRECT?

A. Yes, I believe that the Board, by adopting this standard, will indicate that these types of resources can be reasonably developed and will give that signal to persons who intend to attempt to develop these resources. However, the Board will not be precluded at a later date, from passing emission regulations for all or specific units based upon that future technology. PNM intends to install on all future units control technology at least equivalent with that which it now considers BACT for installation on the first unit.

Installation of this BACT, in our opinion, goes beyond the existing requirements on PNM for construction of this unit, but is in accord with our continuing obligation to see that the environment of New Mexico is protected, while enabling us to meet our obligation to provide service at just and reasonable rates.

Q. MR. BEDFORD, DOES THAT CONCLUDE YOUR TESTIMONY.

A. Yes, however, I would like to thank the Board for holding this hearing in a timely manner due to our requirement to proceed with this project as well as the efforts that have been required by the New Mexico Environmental Improvement Division in their evaluation of our proposal.

APPENDIX A

Public Service Company of New Mexico

1. Vice President, Administration: November 1973 to present (responsible currently for Information Systems/Data Processing, System Planning, Generation and Transmission, Engineering and Construction, RD&D, Environmental Affairs, Procurement and Contracting, Inter-Utility Sales and Purchases, and until May 1977, the Rate Department).

2. Vice President, Corporate Planning: April 1973 to November 1973 (responsible for System Planning, Environmental Affairs, Rates, and Contracts departments).

3. Manager, Corporate Planning: December 1971 to April 1973.

4. Manager, Engineering: April 1970 to December 1971.

5. Assistant Manager, Engineering: December 1969 to April 1970.

6. Senior Engineer, System Studies: July 1967 to December 1969.

7. Special Projects Engineer: December 1963 to July 1967.

Sandia Corporation

1. Technical Staff Member: July 1962 to December 1963.

I have also been a member of the following committees or forums:

1. Western Systems Corordinating Council.

   Technical Studies Subcommittee

   Planning Coordination Committee

   Environmental Committee: 1973 to 1975

2. New Mexico Power Pool.

   Engineering Committee: 1969 to 1974

   (Chairman: 1971 to 1974)

3. EEI Rate Research Committee and EEI Construction Committee.

4. Western Energy Supply and Transmission Associates (WEST).

   Engineering and Planning Committee: 1973 to 1978

   (Chairman: April 1976 to April 1978)

   Management Committee: 1978

BEFORE THE NEW MEXICO ENVIRONMENTAL IMPROVEMENT BOARD

IN THE MATTER OF THE APPLICATION OF
PUBLIC SERVICE COMPANY OF NEW MEXICO
TO AMEND NEW MEXICO AIR QUALITY CONTROL
REGULATION 201-HYDROGEN SULFIDE.

CLOSING ARGUMENT OF PUBLIC SERVICE COMPANY OF NEW MEXICO IN SUPPORT OF ADOPTION OF ITS PROPOSED AMENDMENT TO AIR QUALITY CONTROL REGULATION 201

On behalf of Public Service Company of New Mexico (PNM), Keleher & McLeod, P.A. hereby submits closing argument as requested by the New Mexico Environmental Improvements Board at the close of the hearing held September 13th and 14th, 1979.

INTRODUCTION

Adoption of PNM's proposed standard will allow for the reasonable development of geothermal resources within the State of New Mexico. Failure to adopt the proposed standard will preclude any development of geothermal resources as the cost of development with additional control equipment, such as ~~any~~ dry cooling towers, will not be competitive with other forms of energy. A utility cannot develop a generation unit unless the New Mexico Public Service Commission finds that such unit is economically competitive with other forms of energy developments. Development of these resources will provide substantial

[redacted]

social and economic benefit to the citizens of the State of New Mexico.

The proposed standard will prevent with reasonable probability any injury to human health, animal or plant life and will prevent any unreasonable interference with the public welfare (including bothersome odors) visibility and will provide for the reasonable use of property within the State of New Mexico.

HEALTH AND ODOR EFFECTS

Dr. Thomas H. Milby was the only witness at the hearing with a background sufficient to enable him to give his expert opinion on both health and odor effects of H_2S under the standard as proposed by PNM. Dr. Milby's conclusion after review of the standard proposed by PNM is that there is absolutely "no valid scientific evidence to suggest that even at the highest concentration mentioned, there is any danger of injury to anyone exposed. At 0.01 ppm, an odor will likely be detectable to most people, but only at somewhat higher levels will the characteristic rotten egg-like nature of the gas maybe identifiable. . . . Thus, in my opinion, other than occasionally perceiving the characteristic odor of hydrogen sulfide, individ als passing through or residing in the area will suffer neither ill affects nor especially bothersome nuisance."

Dr. Milby testified that although certainly there is unclarity within the literature concerning the exact odor threshold of H_2S, that generally the odor threshold of detection is in the range of 0.01 to 0.03 ppm. Mr. Russell Erbes of PNM testified that he was able to monitor natural H_2S emissions in the Baca Location of 0.05 to 0.6 ppm, which levels are far above the levels set for the annual concentrations that will be allowed under PNM's standard.

INSTALLATION OF BEST AVAILABLE CONTROL TECHNOLOGY

New Mexico Air Quality Control Act does not allow the Board to install stringent control technology just for the sake of it. Only control equipment necessary to prevent air pollution can be required. Notwithstanding that limitation, however, in the design of the proposed standard, PNM has incorporated use of the Stretford Control Process which is presently the best available control technology for removal of H2S gas from geothermal projects. Other technology that can potentially have application on commercial units is being developed but has no commercial application to date. However, to date and as indicated by even the State's witness, Dr. Conrad, the Stretford is the best process available. The legal requirement of the Air Quality Control Act allows the Board to consider the technical practicability of reducing air contaminants from the sources involved. However, the Board must consider additionally the economic reasonableness of that technology. It is PNM's position that no further control is necessary to prevent air pollution and if the Board requires installation of additional technology, such as dry cooling towers, this makes the cost of development of geothermal operation clearly non-competitive with existing sources. Dr. Mike Williams of the New Mexico Citizens for Clean Air and Water, testified that PNM should be required to install either dry cooling towers or dry-wet cooling towers. Mr. Lloyd Aker, PNM's witness on technology, indicated that use of dry cooling towers could increase the cost of the fuel annually (i.e. additional steam requirements) by approximately thirty million dollars on a present worth basis. Additionally, the cost to install and operate a dry cooling tower would be approximately thirteen million dollars more than use of a wet cooling tower. The cost of installing and operatjng this dry cooling tower would therefore increase the cost of H_2S removal from the Stretford process by approximately forty times compared to the Stretford cost per pound of H_2S removed. The requirement of that additional cost will undoubtedly make geothermal development infeasible, as testified to by Mr. Bedford of PNM, more likely than not for the next decade. Even with Department of Energy's backing of over fifty million dollars, this project must still be competitive economically with other sources of energy development so as to enablee Public Service Commission to determine it is in the best interest of the rate payers of the State of New Mexico to enable this development to proceed.

The Board must consider that the intent of the Air Quality Control Act is to provide for development of resources within New Mexico with standards that are necessary to avoid those concentrations that will with reasonable probability injure human health, animal or plant life, or may unreasonably interfere with the public welfare, visibility or the reasonable use of the property. The evidence is that with installation of the Stretford process the proposed development at the Baca Location No. 1, will not injure health or unreasonably interfere with public welfare, etc.

Again, the New Mexico Air Quality Control Act does not allow this Board to adopt standards which eliminate any odor of any kind but only to consider odors that will interfere with the public welfare. Certainly an odor level substantially above that odor threshold of detection is required prior to an odor becoming obnoxious and in fact interfering with the public welfare. Dr. Milby also testified (and as shown on PNM exhibit no. 6), that for most of the general population, H_2S odor does not become offensive (however not intolerable) until the range of three to five ppm is reached. Again, a level substantially above that expected under PNM's proposed standard. The comparison of a standard initially adopted by this Board in the Permian Basin of 0.10 clearly indicates that this Board has previously been of the opinion that odor levels in that range are acceptable and do not unreasonably interfere with public welfare.

AMBIENT CONCENTRATIONS

Under PNM's proposal, except for the Pecos - Permian Basin Region, the one hour average of allowed H_2S concentrations, not to be exceeded more than once per year, is 0.010 ppm. This is also in accord with the EID's proposal.

The next major change is under Paragraph E provides that within known geothermal resource areas (KGRA's) and a three mile perimeter, the annual average shall be 0.010 ppm. This is substantially more stringent than the standard that presently exists in the Permian Basin Region. Under Paragraph F, on a one hour average within KGRA's and a three mile perimeter, concentrations shall be 0.035 ppm not to be exceeded more than once per twelve hours and 0.120 ppm not to be exceeded more than twice per year. Finally in Paragraph G, a one hour average within corporate limits of a municipality that is within a KGRA or a three mile perimeter, the maximum concentrations cannot exceed 0.010 ppm. This also is in accord with the EID's proposal.

Mr. Richard Jordan of PNM testified that the existing standard was drafted as never to be exceeded and is in fact the most stringent H_2S standard in the United States. That standard was passed without any discussion on whether in fact a source could met it but was only a goal as testified to by Mr. Ken Hargis of the EID. In fact the standard was passed prior to the adoption of the permit regulation 702 of the EID and which regulation requires that a source cannot be constructed if it will emit air contaminants that violate Federal or State standards. Indeed, based upon that regulation the EID rejected PNM's application for construction of the first unit in the Baca Location based on their predicted emissions that indicated that source might violate the State's extremely stringent standard.

All the Federal ambient air standards and numerous State standards provide that the standard set cannot be exceeded more than a certain number of times within a given period. This type of standard can provide, therefore, for unique meteorological conditions for short duration in which a larger ambient concentration might occur and yet still protect, due to the short averaging period for which a standard cannot be exceeded, both the health and welfare as required for the adoption of a standard. The State must recognize in the adoption of standards that there is no magic number which should never be exceeded. A reasonable regulation will allow for exceedances for short periods as long as the standard itself is not exceeded more than a given frequency. Mr. Russell Erbes of PNM addressed concentrations that can be predicted under PNM's proposal and under a one hour average felt that the highest concentration that would be allowed and still protect that one hour standard was a 0.154 ppm prediction. This number not significantly above the one-half hour standard that was allowed in the Permian Basin from 1972 through 1976. Even under the EID's proposal which allows for the standard to be exceeded once per year the standard would more than sufficiently protect health and welfare notwithstanding that once exceedance may occur.

PROPOSED STANDARD OF PNM EXCLUDING VENTING EMISSIONS

PNM proposed standard included predicted emissions from well venting from Union Oil Company's operation. However, as indicated in the cross-examination if in fact the EID is not going to consider emissions from venting operations in permitting of geothermal units, which appears to be a reasonable approach, then PNM's proposed standard could be significantly changed, specifically Paragraph F. Paragraph F could be changed to provide for 0.030 ppm one hour average not to be exceeded more than once per twelve hours and a 0.075 ppm one hour average not to be exceeded more than twice per year.

CONCLUSION

Geothermal generated electricity can provide up to fifty percent of New Mexico's energy requirements. The substantial benefits to the citizens of the State of New Mexico both socially and economically are obvious and this Board should be encouraging the development of this alternate energy source. The short lead times for construction and the reduction of requiring utilities to primarily rely on coal fired generation or nuclear generation are benefits that should also be encouraged by this Board. The existing standard was set as a goal without any reference to whether in fact it can be obtained. It was adopted prior to the Permit Regulation 702 which requires that new sources must show that they will not violate State or Federal standards. This Board, in adopting the proposed standard of PNM, will set the standard at a level at which the emissions of H_2S in the ambient atmosphere will prevent with reasonable probability any injury to human health, animal or plant life, and will not unreasonably interfere with the public welfare visibility or the reasonable use of property. The development of geothermal resources require that they be economically competitive with other existing forms of energy. The proposed standard, while assuming installation of presently acknowledged best available control technology on all proposed units at the Baca, will allow for the development of this resource on a cost competitive basis. However, a standard, which is unjustified from a health and welfare viewpoint, but requires installation of dry cooling towers will make geoth●rmal development totally uneconomic compared with other sources of energy and no Certificate of Public Convenience and Necessity could be obtained thereunder from the New Mexico Public Service Commission.

The Board must balance the technical practicability of removing H_2S with the economic reasonableness of removing H_2S from the source involved. The proposed standard makes such a balance. The New Mexico Air Quality Control Act does not provide for standards to be adopted so on the basis of forcing technology. Standards only can be adopted sufficient so as to prevent air pollution. Any standard that requires control beyond that level necessary to protect welfare and property, etc. is unlawful.

The standard that was adopted in the Pecos - Permian Basin by this Board in 1972, although providing that it cannot be exceeded, set a level at 0.100 ppm and which was obviously determined to be at a level that would not unreasonably interfere with public welfare (i.e. odor). To now set a standard more stringent than that unduly discriminates against geothermal development while giving substantial preference to the oil and gas industry of the State of New Mexico. This discrimination cannot be justified or permitted under the laws of the State of New Mexico.

PNM's proposed standard will protect against nuisance odors or offensive odors for most of the population and in fact is set at merely the threshold of odor detection, which is far below levels normally required by the population before they find it offensive. No testimony distinguished the difference between the standard in the Pecos - Permian Basin from that proposed by PNM except on the basis that it was economically infeasible to clean up emissions in the Pecos area. The need to make geothermal developments economically competitive with other forms of energy development probably require the economics of H_2S control to be more thoroughly considered in this hearing than was done in the Pecos - Permian Basin hearing.

Adoption of the EID's proposal only delays and merely avoids making a decision as to the level at which the standard must be set to protect welfare, etc. As indicated by Mr. Hargis, even under the EID's proposal, one or two geothermal plants could be developed prior to once again the ambient concentrations being at a level at which no further plants could be built under the Permit Regulation 702. The evidence presented in this hearing indicated that the standard of PNM's will allow for reasonable development and still protect against unreasonable ambient concentrations. Geothermal development will not proceed on a unit by unit basis due to the economic unknowns of attempting to change a standard each time a new unit is attempted to be built. This Board must decide now what is required for the standard so, while protecting human health etc., providing that this resource can be developed and which will provide substantial social and economic benefit to the citizens of the State.

Respectfully submitted,

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