DOE/ET/27041--T5

DE82 013321

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DOE/ET/27041--T5
EL CENTRO GEOTHERMAL UTILITY
CORE FIELD EXPERIMENT
ENVIRONMENTAL-IMPACT REPORT
AND
ENVIRONMENTAL ASSESSMENT

Prepared For:

City of El Centro
Planning Department

and

United States
Department of Energy
Division of Geothermal Energy

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE. It has been reproduced from the best available copy to permit the broadest possible availability.

Environmental Data
Prepared and Submitted By:

WESTEC Services, Inc.
3211 Fifth Avenue
San Diego, CA 92103

950 6920

August, 1979

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

INTRODUCTION

The City of El Centro is proposing the development of a geothermal energy utility core field experiment to demonstrate the engineering and economic feasibility of utilizing moderate temperature geothermal heat, on a pilot scale, for space cooling, space heating, and domestic hot water. The proposed facility is located on part of a 2.48-acre (1 hectare) parcel owned in fee by the City in the southeastern sector of El Centro. Geothermal fluid at an anticipated temperature of about 250F (121C) will heat a secondary fluid (water) which will be utilized directly or processed through an absorption chiller, to provide space conditioning and water heating for the El Centro Community Center, a public recreational facility located approximately one-half mile north of the proposed well site.

In order to initiate this demonstration project, a Conditional Use Permit for its construction and operation will have to be granted by the City of El Centro. As approval of the CUP will represent a discretionary action by the City Planning Commission and City Council, and because the proposed project may significantly (adversely) affect the environment, the California Environmental Quality Act (CEQA) requires the preparation of an Environmental Impact Report (EIR). The United States Department of Energy will participate by providing the majority of funding for the project. This involvement by a Federal agency necessitates preparation of an Environmental Assessment (EA) as required by the National Environmental Policy Act (NEPA). Under the Council on Environmental Quality's regulations implementing NEPA, preparation of a joint EIR/EA is permitted (Section 1506.2).

An EIR/EA is an informational document which is intended to inform public decision-makers (in this case, the City of El Centro Planning Commission and Council, and U.S. Department of Energy), other responsible or interested agencies, and the general public of the environmental effects of a proposed project. The environmental review process has been implemented to enable public agencies to evaluate a project in terms of its environmental consequences, to examine and implement methods of eliminating or reducing any adverse impacts, and to consider alternatives to the project as proposed. While CEQA and NEPA require that major consideration be given to avoiding environmental damage, the responsible public agencies remain obligated to balance possible adverse effects against other public objectives, including economic and social goals, in determining whether and in what manner a project should be approved. Accordingly, this EIR/EA has been prepared in compliance with the City of El Centro's Guidelines for Implementation of the California Environmental Quality Act of 1970, and with the U.S. Energy Research and Development Administration's Guidelines to the Preparation of Environmental Reports for Geothermal Development Projects.

A draft of this report was circulated for public review in April of 1979. Following the public review period clarifications and additions were made to the draft, as requested by the three State agencies submitting comments. Subsequently, the City of El Centro Planning Commission held a public hearing on the EIR in June of 1979, and certified the EIR as being accurate and complete and in accordance with the requirements of CEQA. The City Council, the City's final discretionary authority, held a public hearing on July 5, 1979, and also certified the EIR. Thus, for the purposes of satisfying CEQA, this document is considered a final EIR. For the purposes of complying with the requirements of NEPA it is considered a draft EA.

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
	EXECUTIVE SUMMARY	xii
I	PROJECT DESCRIPTION	1
1.1	Project Objectives	1
1.2	Project Location and Setting	2
1.3	Project Characteristics	7
1.3.1	Overview	7
1.3.2	Drilling Activities	10
1.3.2.1	Drill Site Preparation	10
1.3.2.2	Drilling Operations	10
1.3.2.3	Well Cleanout and Testing Operations	17
1.3.3	Additional Facilities at the Well Site	18
1.3.4	Hot/Chilled Water Distribution System	23
1.3.5	Installation of Geothermal Equipment at the El Centro Community Center	25
1.3.5.1	Design and Equipment Installation	25
1.4	Project Schedule	30
1.4.1	Development and Operation	30
1.4.2	Regulatory Process	32
II	DESCRIPTION OF BASELINE ENVIRONMENT/ANALYSIS OF IMPACTS/DISCUSSION OF MITIGATION MEASURES	33
2.1	Geology	33
2.1.1	Landform and Topography	33
2.1.2	Geology	34

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
2.1.3	Geothermal Resources	35
2.1.4	Geologic Hazards	35
2.1.4.1	Fault Displacement	37
2.1.4.2	Seismic-Induced Ground Shaking	37
2.1.4.3	Induced Seismicity	42
2.1.4.4	Soil Liquefaction	42
2.1.4.5	Subsidence	42
2.1.5	Soils	43
2.1.6	Geology and Soils Impacts	43
2.1.6.1	Landform and Topography	43
2.1.6.2	Geothermal Resources	44
2.1.6.3	Fault Displacement	45
2.1.6.4	Seismic-Induced Ground Shaking	45
2.1.6.5	Induced Seismicity	48
2.1.6.6	Soil Liquefaction	48
2.1.6.7	Subsidence	48
2.1.6.8	Soils	49
2.1.7	Mitigation Measures	49
2.1.7.1	Topography	49
2.1.7.2	Geothermal Resources	50
2.1.7.3	Fault Displacement	50
2.1.7.4	Seismic-Induced Ground Shaking	51
2.1.7.5	Induced Seismicity and Subsidence	52

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
2.1.7.6	Liquefaction	52
2.1.7.7	Soil Related Impacts	52
2.2	Hydrology	53
2.2.1	Groundwater	53
2.2.2	Surface Water Systems	54
2.2.3	Hydrology Impacts	56
2.2.3.1	Groundwater	56
2.2.3.2	Surface Water	57
2.2.4	Mitigation Measures	57
2.2.4.1	Groundwater	57
2.2.4.2	Surface Water Quality	58
2.3	Climatology and Air Quality	59
2.3.1	Existing Conditions	59
2.3.1.1	Meteorology and Climatology	59
2.3.1.2	Air Quality	60
2.3.2	Air Quality Impacts	62
2.3.2.1	Emission Sources	62
2.3.2.2	Emission Quantification	64
2.3.3	Mitigation Measures	68
2.4	Noise	69
2.4.1	Ambient Noise Level	69
2.4.2	Noise Standards	70
2.4.3	New Levels of Noise	75

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
2.4.4	Impacts	75
2.4.4.1	Compliance with Adopted Standards	75
2.4.4.2	Residential Impact	79
2.4.5	Mitigation Measures	83
2.5	Biology	86
2.5.1	Vegetation and Wildlife	86
2.5.2	Impacts	86
2.5.3	Mitigation Measures	86
2.6	Archaeological and Historical Resources	87
2.6.1	Site Reconnaissance	87
2.6.2	Impacts	87
2.6.3	Mitigation Measures	87
2.7	Visual Resources/Aesthetic Quality	88
2.7.1	Visual Overview	88
2.7.2	Impacts	88
2.7.3	Mitigation Measures	91
2.8	Socioeconomics	92
2.8.1	Population Characteristics	92
2.8.1.1	Imperial County	92
2.8.1.2	City of El Centro	95
2.8.2	Community Attitudes	97
2.8.2.1	County-Wide Attitudes	97
2.8.2.2	Neighborhood Attitudes	98

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
2.8.3	Employment	99
2.8.4	Agricultural Base	99
2.8.5	Housing	101
2.8.6	Public Services and Utilities	101
2.8.6.1	Overview	101
2.8.6.2	Solid Waste Disposal	102
2.8.6.3	Water Use	103
2.8.6.4	Revenue	104
2.8.7	Impacts	104
2.8.7.1	Employment/Population/Housing	104
2.8.7.2	Public Services and Utilities	105
2.8.7.3	Solid Waste Disposal	106
2.8.7.4	Water Use	106
2.8.7.5	Revenues	107
2.8.8	Mitigation Measures	107
2.9	Land Use	108
2.9.1	Relevant Land Use Programs and Goals	108
2.9.1.1	Geothermal Objectives and Principles	108
2.9.1.2	Industrial Objectives and Principles	109
2.9.2	Project Area Land Uses	110
2.9.3	Project Area Zoning	112
2.9.4	Transportation Systems	112
2.9.5	Impacts	115

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
2.9.5.1	Land Use	115
2.9.5.2	Transportation Systems	118
2.9.6	Mitigation Measures	119
2.9.6.1	Land Use	119
2.9.6.2	Transportation Systems	120
2.10	Energy Consumption	120
2.10.1	Overview	120
2.10.2	Impacts	120
2.10.3	Mitigation Measures	122
III	UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS	123
3.1	Air Quality	123
3.2	Noise	123
3.3	Public Utilities (Water Supply)	124
3.4	Visual Quality/Aesthetics	125
IV	ALTERNATIVES TO THE PROPOSED PROJECT	127
4.1	Alternate Locations	127
4.1.1	Alternate Drill Site Within City of El Centro	127
4.1.2	Alternate Drill Site Within Designated Parcel	129
4.2	Alternate Operational Procedures	132
4.3	No Project	133
V	GROWTH-INDUCING IMPACTS	135

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
VI	RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY	137
VII	IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES	139
VIII	AGENCIES AND ORGANIZATIONS CONSULTED	141
8.1	Public Agencies	141
8.1.1	Federal	141
8.1.2	State of California	141
8.1.3	County of Imperial	141
8.1.4	City of El Centro	141
8.1.5	Other Agencies	141
8.2	Private Organizations	141
IX	CERTIFICATION OF ACCURACY AND QUALIFICATIONS	143
9.1	Report Contributors	143
9.1.1	Principal Investigator	143
9.1.2	Project Description	143
9.1.3	Impact Analysis	143
9.1.4	Unavoidable Adverse Environmental Effects	144
9.1.5	Alternatives to the Proposed Project	144
9.1.6	Growth-Inducing Impacts	144
9.1.7	Short-Term Uses vs. Long-Term Productivity	145
9.1.8	Irreversible and Irretrievable Commitments	145

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Title</u>	<u>Page</u>
9.2	Certification	144
X	REFERENCES CITED	147

LIST OF FIGURES

<u>Number</u>	<u>Title</u>	<u>Page</u>
1-1	Map of Imperial County Showing Location of Proposed Geothermal Field Experiment	3
1-2	Map of El Centro Showing Location of Proposed Geothermal Utility Core Field Experiment	5
1-3	Vicinity Map Showing Location of Well Site, Pipeline Route, and Community Center in Southeastern El Centro	6
1-4	Imperial Valley Known Geothermal Resource Areas (KGRAs)	8
1-5	Drill Site Layout During Drilling Operation	11
1-6	Production Well Drilling Schedule and Milestones as a Function of Well Depth	12
1-7	Injection Well Drilling Schedule and Milestones as a Function of Well Depth	13
1-8	Well Drilling and Construction Schedule	19
1-9	Layout of Facilities at Well Site During Project Operation	20
1-10	Piping and Instrument Diagram Showing Interface Between Production and Reinjection Wells and the Hot/Chilled Water Distribution System	22
1-11	El Centro Community Center Master Plan	26
1-12	Architectural Rendering of El Centro Community Center Showing Location of Roof-top Air Conditioning Units	27

TABLE OF CONTENTS

LIST OF FIGURES (Continued)

<u>Number</u>	<u>Title</u>	<u>Page</u>
1-13	Schematic Flow Diagram Showing Integration of El Centro Community Center with Facilities at the Well Site	29
1-14	Overall Design and Construction Schedule for Geothermal Utility Core Field Experiment	31
2-1	Map of Heber KGRA Showing Pattern of Geothermal Gradients	36
2-2	Geologic Map of the Imperial/Mexicali Valley Showing Proximity of Faults to the Project Site	38a
2-3	Earthquake Epicenters in the Imperial Valley, June 1, 1973 to May 31, 1974	40
2-4	Recurrence Intervals for Large Earthquakes in Imperial Valley Region, Based on Seismic Record for the Period from 1934 to 1963	47
2-5	County of Imperial Initial Geothermal Development Class I and Class II Noise Standards and El Centro Noise Regulation	74
2-6	A-Weighted Sound Levels for Various Project Activities as Functions of Distance from Source	76
2-7	Parcel Boundary Noise Spectra for Each Phase of Project Development and Operation	78
2-8	Community Noise Levels for Various Project Activities as Functions of Distance from Source	81
2-9	El Centro Geothermal Well Site	89
2-10	Geothermal Well Drilling Rig Operating in the North Brawley Area of Imperial County	90a
2-11	Existing Land Uses in the Vicinity of the El Centro Geothermal Utility Core Well Site	111
2-12	Zoning Pattern in the Vicinity of the El Centro Geothermal Utility Core Well Site	113
2-13	Regional Transportation Routes in the Imperial Valley Area	114

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

<u>Number</u>	<u>Title</u>	<u>Page</u>
4-1	Map of El Centro Showing Location of Alternative Well Sites	128

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
2-1	Anticipated Bedrock Accelerations Due to Maximum Credible Earthquakes on Pertinent Local and Regional Faults	41
2-2	Analysis of Colorado River Water, Water Year 1972-1973	55
2-3	El Centro Monthly Air Quality Summary, 1976, and Annual Summary, 1977	61
2-4	El Centro Field Experiment Project Pollutant Emissions	65
2-5	H ₂ S Concentrations and Distance of Maximum Ground-Level Impact from Geothermal Well Flow Testing	67
2-6	El Centro Project Pollutant "Savings"	69
2-7	Ambient Noise Levels in A-Weighted Decibels	71
2-8	Imperial County Noise Element Standards and Limits	73
2-9	Octave Band Sound Pressure Levels at 100 ft (30 m) for Various Phases of the Project	77
2-10	Operation Assumptions	80
2-11	Estimated Community Noise Levels (CNEL/L _{dn}) at Nearest Sensitive Receptors (dB)	82
2-12	Imperial County Population Trends	93
2-13	Selected Socioeconomic Characteristics - 1970	94
2-14	Income and Poverty Status - 1970	96
2-15	September 1978 Imperial County Labor Statistics	100

TABLE OF CONTENTS (Continued)

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
2-16	Energy Consumption for the City of El Centro by Non-Industrial Sector	121
2-17	Total Energy by End Use for City of El Centro	121
4-1	Noise Levels at Sensitive Receptors From Two Alternative Well Sites	131

LIST OF APPENDICES

<u>Letter</u>	<u>Title</u>	<u>Page</u>
A	El Centro Geothermal Utility Core Field Experiment Project Climate and Air Quality Study	A-1
B	El Centro Geothermal Utility Core Field Experiment Noise Impact Analysis	B-1
C	Archaeological Clearances	C-1
D	Geothermal Well Neighborhood Survey	D-1

EXECUTIVE SUMMARY

PROJECT DESCRIPTION

The City of El Centro is proposing the development of a geothermal energy utility core field experiment to demonstrate the engineering and economic feasibility of utilizing moderate temperature geothermal heat, on a pilot scale, for space cooling, space heating, and domestic hot water. The proposed facility is located on part of a 2.48 acre (1 hectare) parcel owned in fee by the City in the southeastern sector of El Centro in Imperial County, California. Geothermal fluid at an anticipated temperature of about 250F (121C) will heat a secondary fluid (water) which will be utilized directly or processed through an absorption chiller, to provide space conditioning and water heating for the El Centro Community Center, a public recreational facility located approximately one-half mile north of the proposed well site.

The geothermal production well will be drilled to 8,500 feet (2590m) and an injection well to 4000 feet (1220m) at the industrially designated City property. Once all relevant permits are obtained it is estimated that site preparation, facility construction, the completion and testing of both wells would be finished in approximately 26 weeks. The environmental impacts requiring most mitigation would take place within this period. An operations/evaluation period of 18 months will follow the start up of the geothermal heating and cooling system.

ENVIRONMENTAL EFFECTS

As summarized below, implementation of the proposed El Centro Geothermal Utility Core Field Experiment could result in some adverse environmental effects. However, most of these effects are of a minor nature, or their probability of occurrence is extremely low. In addition, measures have been incorporated into the project of attached as conditions of approval by the City of El Centro to either completely mitigate or reduce the magnitude of these impacts to insignificant levels.

Landform

Prior to the commencement of drilling, the drillsite will be modified by grading to create a flat pad, a reserve pit (sump), and a permanent six-inch berm along the eastern and western perimeters of the project site. Since the proposed drilling site is essentially flat and served by existing roads, the small amount of grading required will not result in significant impacts to the landform.

In resolution 79-87 the City Council of El Centro certified this EIR as adequate and complete, and determined that the impacts identified by the EIR have been adequately mitigated by the conditions of its approved conditional use permit.

Geology

Geology-related impacts normally considered to be of potential significance for a geothermal well drilling and testing project include: seismic-related ground rupture, ground shaking and soil liquefaction; and land subsidence and increased seismicity induced by withdrawal of fluids from the geothermal reservoir. Analysis indicates that

adverse impacts resulting from induced subsidence or seismicity are not expected due to the very small volumes of geothermal fluid removed for the demonstration project, as opposed to full-field production pumping for power generation. Significant impacts resulting from seismic ground shaking or soil liquefaction are also considered unlikely during the duration of the proposed project. Further, should strong ground shaking occur, wellhead braces and normal operational safety procedures would be adequate to prevent significant damage to drilling rig, wellhead and casing components in all but extreme cases.

It is conceivable that one or more of the proposed drillholes could intersect a fault plane within the project area. Should an earthquake occur along such a fault, movement and subsequent rupture of the well casing could result. However, an uncontrolled discharge of geothermal fluid from the well site is unlikely because of the low pressure, non-artesian nature of the well.

Soils

Native soils underlying the proposed project site exhibit some adverse engineering characteristics, such as low bearing capacity and moderately high shrink/swell potential. It is expected that the standard, conservative engineering practices used in site and foundation preparation will be adequate to alleviate any significant problems.

Groundwater

The geothermal well drilling procedures proposed by the project applicant includes several features designed to avoid potential adverse groundwater impacts. Possible shallow aquifer contamination (due to the loss of drilling or geothermal fluids through weak formational materials in the borehole) will be avoided by setting the well casing to protect such formations. The reserve pit or drilling sump will be lined with impervious clays to minimize potential seepage of geothermal fluids. In addition, possible upward movement of reinjected brines is not expected to be of major importance due to the already poor (as far as is known) quality of deep groundwater in this part of the Imperial Valley. However, it is possible that the proposed well drilling program will encounter relatively less saline groundwater in zones likely to be affected by injection; in that case, the injection program will be revised to assure that such zones are avoided.

Surface Water

Significant impacts to surface water from a spill of geothermal brine is highly unlikely. The proposed well will be drilled into a low-pressure reservoir, and a continuously operating downhole pump will be required to lift the fluid to the surface. Also, it is anticipated that the regulatory controls and enforcement that will be imposed on the project by the Regional Water Quality Control Board and the California Division of Oil and Gas (with respect to the provision and operation of blowout protection equipment) will essentially eliminate the potential for significant adverse effects.

Air Quality

Sources of air pollutants from the proposed project include: fugitive dust generated during site grading; diesel construction and well drilling equipment exhaust emissions; employee vehicle exhaust emissions; drift from the cooling tower used to cool drilling mud; and noncondensable gas emissions (primarily hydrogen sulfide) from flashed steam during well testing. Total emissions from the above sources will not constitute significant contributions to regional pollution levels.

A detailed analysis of potential H₂S concentrations, based on very conservative (worst-case) assumptions, indicates that the ambient air quality standard of 30 parts per billion (ppb) would not be approached, the anticipated hourly H₂S concentrations being less than 2 ppb. Although instantaneous H₂S concentrations may be momentarily detectable during flow testing (which will require only from one to ten days) there is little or no probability of H₂S standard exceedance, even at the closest residences to the proposed project. As an additional measure of approval the City has required that performance of well testing and maintenance operations be conducted whenever possible during wind conditions favorable to dispersing the plume away from nearby homes.

The fact that geothermal energy replaces energy from electrical generation by combustion of fossil fuels is expected to result in an air pollutant "savings" of over nine tons per year.

Noise

Noise associated with the proposed geothermal exploration project will result primarily from: drill site preparation; well drilling; well cleanout activities; well flow testing; and facility operation. Without adequate mitigation measures, these operations would result in noise levels exceeding the limits stipulated in the City of El Centro's noise ordinance and in the County of Imperial's "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial Valley."

To ensure that the noise level will not create an impact or annoyance to the nearest residences, the City has adopted strict mitigation measures as conditions of approval. Specifically,

- Site preparation, well cleanout, flow testing and facility construction are restricted to daylight hours.
- Well drilling operations must be adequately mitigated to achieve a 55 dB noise level (60 dB during daylight hours) or less at the City-owned property line. Pipe stacking and line section assembly will be restricted to daylight hours. Well drilling noise levels will be monitored by City staff and any residential complaints recorded. If the noise attenuation program is incapable of mitigating noise levels to 55 dB at the property line during evening hours then drilling will be prohibited between the hours of 10 p.m. to 7 a.m., unless a variance allowing 60 dB 24 hours per day is approved by the Planning Commission and City Council.

- A 6 feet or higher block wall fence will be constructed along the eastern 120 feet of the southern property line.

The use of special mufflers on drilling equipment and the construction during drilling of sophisticated sound barriers will protect nearby residents from significant noise intrusion.

Biology

The proposed project site is devoid of vegetation except for scattered, adventitious weedy species. No rare and/or endangered plant or animal species were observed on or are expected to utilize the subject property. Because of the foregoing, no significant biological impacts are anticipated as a result of the proposed project.

Archaeology and Paleontology

Although it is known that prehistoric peoples did utilize the land in and around the proposed project site, past agricultural activities have totally impacted the area. Based on a study of the subject property by personnel from the Imperial Valley College Museum, it is not considered possible that extant archaeological (or paleontological) resources exist on the ground surface, and it is not likely that they exist in the subsurface.

To fully assure that the proposed project activities do not adversely affect heretofor unknown cultural resources, all project activities should cease if any unusual specimens of bone, stone or ceramic are discovered. A qualified archaeologist should be contacted to evaluate these discoveries, and, as warranted, either remove them in a scientifically acceptable manner or, depending on the scientific value of the discovery and time restrictions, assure that they are preserved in-place. If this latter option is implemented, it should be possible to transfer drill site activities to an immediately adjacent location and proceed with the proposed geothermal exploration and evaluation program.

Land Use

The proposed field experiment conforms with the existing zoning and the General Plan land use designation, and no inconsistencies have been identified between the plan's geothermal and industrial principles and project development. No mitigation measures are therefore considered necessary. Barring extenuating site-specific circumstances which warrant a variance, project implementation will follow guidelines contained in the Imperial County Geothermal Element and the "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial County."

Socioeconomics

The proposed project is not particularly labor-intensive, and is not expected to significantly affect local employment, population or housing. No significant impacts to existing public services and utilities are anticipated, with the exception of the demand for water during well drilling. The level of water required, while not constituting an

overall water supply problem to El Centro as a whole, could seriously exacerbate existing water delivery/pressure problems to some northern sectors of the City. As a means of mitigating the impact to insignificance, the City is requiring on-site water storage tanks capable of providing six hours of water demand, to be utilized during peak usage periods in coordination with El Centro public works employees.

The project will not result in significant changes in either local revenues or increased costs for public services.

Visual Resources

The geothermal well drilling rig on the project site will constitute a significant aesthetic impact during the drilling operations. However, because the drilling rig will be required at the site for no longer than about nine weeks, the impact is of only short-term significance. The long-term visual impact of the field experiment will not be significant, and the permanent facility will be of a scale and character consistent with the industrial use of the area.

Energy

Project development will result in the expenditure of energy for construction-related vehicle and equipment operation. The completed project will rely mainly on geothermal energy for its daily operation, with the exception of several electric motors required to operate process equipment and the cooling tower. Viewed in isolation, the field experiment will have no significant effect on the local or regional energy consumption and supply picture. When considered as a future energy utility core, however, the project presents the potential for a substantial beneficial effect. To the extent that geothermal energy is utilized in residential, commercial and industrial activities, the field experiment will assist in decreasing the region's reliance on oil and natural gas.

SECTION I

PROJECT DESCRIPTION

1.1 PROJECT OBJECTIVES

The overall objective of the project applicant is to demonstrate the engineering and economic feasibility of utilizing moderate temperature geothermal heat on a pilot scale for space cooling, space heating and domestic hot water. This field experiment in the City of El Centro is intended to provide evidence of the profitability of direct heat applications to residential/commercial space conditioning, particularly in the southwestern United States.

A primary goal of the project is to obtain technical, economic, institutional and environmental data under field operating conditions that will facilitate decisions on the utilization of geothermal energy by prospective developers and users. As the project evolves, this field experiment will foster the formation of working relationships between the City of El Centro, Chevron Resources Company (the geothermal resource consultant), WESTEC Services, Inc. (the program/manager), and applicable regulatory agencies that will serve as an example to encourage the adoption of geothermal energy by industry and other prospective users.

Specifically, by using a geothermal resource to cool and heat the El Centro Community Center, the City of El Centro will:

- Provide a "core" for geothermal heat utility supply within the City to be utilized 1) in space cooling and heating for commercial and government buildings, business complexes and residences, and 2) as process heat for industry and agribusiness. Approximately 78 percent of the total energy consumed in the residential and commercial sectors of the City is potentially replaceable by geothermal energy.

- Provide the first demonstration in the United States of low grade hydrothermal resources being utilized to cool buildings as well as heat them.
- Provide a demonstration of the availability of low grade geothermal heat on the periphery of a well-defined geothermal resource presently scheduled to be utilized for electric power production.

The choice of the El Centro Community Center as the building to be cooled and heated will provide a high level of public visibility and has the essential elements for wide publicity at the national level. In addition to this immediate user, prospective user groups for a core geothermal energy utility system have been identified. They include general categories of commercial and industrial users, as well as specific firms which have indicated an interest in utilizing geothermal energy for their operations. Approximately 54 ac (22 ha) of land directly east of the project drill site have been proposed by the City as an industrial park. During implementation of the field experiment, a marketing and public relations program will advise local and state-wide businesses of the opportunities for utilizing geothermal energy in commercial and industrial enterprises, and encourage their relocation to the proposed industrial park.

1.2 PROJECT LOCATION AND SETTING

The proposed field experiment is located within the City of El Centro in Imperial County, California (Figure 1-1). El Centro is located in the heart of the Imperial Valley agricultural district, lying approximately 120 mi (192 km) east of San Diego, 90 mi (144 km) south of Indio and 14 mi (22 km) north of the International Border.

The project site consists of three related areas. The first is the geothermal well site, occupying part of a 7.4-ac (3.0 ha) parcel owned in fee by the City in the

Map of Imperial County Showing Location of Proposed Geothermal Field Experiment

**FIGURE
1-1**

eastern portion of El Centro (Figure 1-2). The property is composed of three lots described as Blocks 47, 48 and 49, Second Addition. Each lot is 180 ft by 600 ft (54 m by 180 m) with an area of 108,000 sq ft (9720 sq m). The well site, presently vacant, covers the eastern 400 ft (122 m) of Block 47 (Figure 1-3). A City recycling center consisting of a mobile office and compacting machinery covers the western portion of Block 47.

The well site is situated within an industrial area and is zoned for manufacturing use as are all surrounding abutting properties. Second Street borders the property to the west, beyond which are located various industrial uses such as a lumber yard, department store, warehouse, and ceramic tile company. A railroad spur forms the northern boundary, beyond which are Blocks 48 and 49, also owned by the City. These lots are being used by the Public Works Department for open storage of gravel, soil, concrete, pipes, wooden poles, and two oil storage tanks. Abutting these uses to the north is a privately-owned cement storage facility for geothermal wells. Further north is a block of eleven single-family residential units, approximately 700 ft (214 m) from the northern lot boundary of the well site. A seed processing plant and wholesale paper and supply company are located east of First Street, which forms the eastern extent of the site. A single-family residential block with about ten units is situated to the northeast, with the closest dwelling unit about 550 ft (168 m) away. The western 210 ft (63 m) of the well site is bounded to the south by a block wall and a Pacific Telephone Company equipment yard. Immediately south of the eastern 120 ft (36 m) of the lot are two single-family residences, nonconforming uses in the industrial zone.

The second component of the sites encompassing the field experiment extends approximately 2500 ft (750 m) along and under First Avenue from the eastern boundary of the well site to the El Centro Community Center. Pipelines of the hot/chilled water

Map of El Centro Showing Location of Proposed Geothermal Utility Core Field Experiment

**FIGURE
1-2**

FIGURE
1-3

distribution system would be constructed here. The community center occupies the third and final location (Figure 1-3).

1.3 PROJECT CHARACTERISTICS

The following description of the technical characteristics of the proposed project is divided into five subsections. The first (Section 1.3.1) provides an overview of the geothermal reservoir and project operation. The second (Section 1.3.2) is a discussion of drilling activities to be undertaken at the well site. Section 1.3.3 describes the permanent facilities to be constructed at the well site, and Section 1.3.4 details the construction of the hot/chilled water distribution system. Finally, Section 1.3.5 discusses modification of the existing utility system at the community center and installation of the necessary equipment for geothermal utilization. In this report it is assumed that the well will be productive and capable of supplying the requisite "fuel" for project use.

1.3.1 Overview

The geothermal reservoir which is the energy source for this field experiment is embodied in a 13.5 sq mi (35 sq km) area known as the Heber Known Geothermal Resource Area (KGRA) in the Imperial Valley (Figure 1-4). The area of maximum temperature gradient is centered around the township of Heber which is approximately 4.5 mi (7.2 km) south of the City of El Centro. The southeast corner of the City is within the boundary of the Heber KGRA, as designated by the U.S. Geological Survey (White and Williams, 1975). The prevailing geothermal gradient at the drilling site is expected to be in the range of 2.0 to 3.3F (1.1 to 1.8C) per 100 ft (30 m). This is based on data published by the USGS and the California Division of Mines and Geology, and data gathered by Chevron Resources Company in the Heber KGRA. The high gradients (>3.0F per 100 ft) were only observed at shallow depths of less than

WESTEC Services, Inc.

Imperial Valley Known Geothermal Resource Areas (KGRAs)

**FIGURE
1-4**

1000 ft (305 m), while lower gradients (around 2.0) prevail at greater depths. Therefore, unless geothermal anomalies are encountered, it is highly probable to find 250F (121C) brine at about 8500 ft (2590 m), and it is moderately probable to find that temperature at about 6500 ft (1980 m).

Based on flow tests and core and log analyses done by Chevron at Heber, it is estimated that a well drilled within the City and completed in 1000 ft (305 m) of sand at 8500 ft (2590 m) will have a productivity index of 110 bbl/day/psi ($17.5 \text{ m}^3/\text{day-psi}$). This is more than adequate to support the proposed production rate of 100 gal/min (378 l/min), or 3428 bbl/day ($545 \text{ m}^3/\text{day}$).

If initial evaluation testing at the project site confirms the productivity of the well, a reinjection well will be drilled approximately 30 ft (9 m) away. The used brine will be reinjected into a shallower zone than that from which it was produced. Continuous production from the production well will result in depletion of reservoir pressure over time if vertical communication is not established between the reinjection and production well. For an assumed continuous aquifer of 5000 ac (2025 ha), the maximum cumulative production is estimated at 32 million bbl (5.1 million m^3) over the estimated project life.

The reservoir life, however, could be extended if the reservoir is replenished by brine encroachment from a larger aquifer or by brine imbibition from overlying and underlying strata. Reinjecting brine may also help replenish the reservoir if there is any vertical communication between injection and production zones. The actual extension of project life due to one or more of these factors will depend on their contributed brine volume relative to the volumes produced.

1.3.2 Drilling Activities

1.3.2.1 Drill Site Preparation

Site preparation will involve grading operations to remove any existing vegetation, to create proper drainage, and to develop a reserve pit (cuttings pit) of 5344 bbl (855 m³) overflow capacity. Though the proposed drill site is essentially level in its present condition, some grading may be necessary to develop a flat drill pad. Since the drill site borders First Street, no new roads will be required. An asphalt parking lot on the northeast corner of the site will be constructed after completion of drilling operations.

Site preparation, including drill rig assembly, should require approximately one to two weeks and employ a maximum of 12 to 15 persons at any one time.

Construction of the reserve pit will be in accordance with approved engineering practices. This pit and its embankment will be covered with a mixture of native soils and bentonite clays such that its permeability will not exceed 10⁻⁶ centimeters per second (cm/s). The inner slope of the finished reserve pit will be at an approximate slope ratio of 1 vertical to 3 horizontal, whereas the outer slope will not exceed a ratio of 1 to 1.75. The thickness of the reserve (mud) pit lining will depend on the permeability of the clay used. Plans for the reserve (mud) pit will, as a matter of normal course, be submitted for approval to the Regional Water Quality Control Board.

1.3.2.2 Drilling Operations

The proposed drill site layout during drilling operations is shown on Figure 1-5. The relative locations of the well heads, drilling equipment, cuttings pit, and ancillary features are illustrated. Figures 1-6 and 1-7 detail the drilling milestones for the production and injection wells as a function of well depth.

Drill Site Layout During Drilling Operation

**FIGURE
1-5**

Production Well Drilling Schedule and Milestones as a Function of Well Depth

FIGURE 1-6

Injection Well Drilling Schedule and
Milestones as a Function of Well Depth

**FIGURE
1-7**

a. Drilling Equipment

The proposed production and injection wells will be drilled with a rotary drilling rig operating 24 hours per day. An estimated nine weeks will be required to drill both wells. Approximately six workers will be on duty at any one time, but occasional special operations, such as electric logging or cementing, can require as many as 12 workers. Approximately 25 workers will be involved with drilling operations, depending on work loads and scheduling. A rotary drilling rig is normally equipped with a 300 hp drawworks driven by a 335 kw motor (powered by diesel-generating facilities). An independently-powered 500 hp mud pump will supply the hydraulics needed to drill efficiently. The mast and substructure are typically rated at 125 tons, or sufficiently overrated to provide a reasonable margin of safety.

Well drilling operations are regulated by the California Division of Oil and Gas (CDOG). CDOG regulations cover the drilling program, the casing program and the provision of blowout protection equipment (BOPE).

b. Casing Program

The production well will be drilled to a depth of 8,500 ft (2590 m). This will consist of a 20 in (51 cm) diameter conductor casing, run to a depth of 100 ft (30 m) and cemented to the surface, and a 13.4 in (34 cm) diameter surface casing, running from 1000 ft (305 m) to the surface and cemented its entire length. Prior to drilling below 1000 ft (305 m) a mud logger will be installed. An 11-in hole will be drilled from 1000 ft to 7000 ft and an 8 5/8 inch casing cemented to the surface. A 7 5/8 hole will be drilled from 7000 ft to 8500 ft to collect additional regional geological data and assess the potential resource at that depth. If a suitable resource is found at 7000 ft, a cement plug will be installed across the shoe of the 8 5/8 inch casing and the lower portion of the well abandoned. If the lower portion of the well must be utilized

for geothermal fluid production or offers a significantly improved resource temperature, a 5 1/2 inch pre-slotted steel liner will be hung from the shoe of the 8 5/8 inch casing across the interval of interest.

The injection well will be drilled to a total depth of 4000 ft (1220 m). As with the supply well, the injection well will consist of a 20-in (51 cm) diameter conductor casing, run to a depth of 60 ft (18 m) and cemented to the surface. A 17.5 in (44 cm) hole will be drilled to 800 ft (244 m) and cemented with a 13.4 in (34 cm) diameter casing to the surface. From this depth, the injection well will be drilled to a depth of 4000 ft (1220 m) and cemented to the surface utilizing an 8.6 in (22 cm) casing. Both the supply and injection wells will be perforated at selected intervals with two jet holes per foot.

The geothermal well drilling program was developed by Chevron Resources Company based on their experiences as the major leaseholder on the Heber KGRA. Chevron's experience to date at Heber, which can be applied directly to the El Centro area, indicates that the water salinity and quality between 4000 and 10,000 ft of depth are the same. Therefore, it follows that the production fluid will be compatible in water quality with the water in the injection zone. Electric logs will be taken during the well drilling to determine injection zone water quality and the injection well will be backflowed upon completion to obtain injection zone water samples directly. In the unlikely event that any freshwater is encountered near the proposed injection zone, the reinjection program will be revised to ensure that the fluids produced are injected into a zone with water comparable in quality to that of the reinjected brine.

c. Drilling Fluid

Drilling fluids, usually referred to as drilling "mud," serve the following nine major functions:

1. Remove drill cuttings from the hole.
2. Control subsurface pressure.
3. Cool and lubricate drill bit and pipe.
4. Prevent borehole walls from caving.
5. Release drill cuttings at surface.
6. Prevent formation damage.
7. Provide maximum information from formations penetrated.
8. Suspend cuttings when circulation stops.
9. Suspend weight of drill string and casing.

The mud is circulated through a closed loop system. After coming out of the drillhole, the mud passes through a desilter and across a fine screen shale shaker, which separates cuttings from the mud. The mud then passes through a cooling tower, which reduces the temperature by about 40F (22C), and is returned to the drillhole via mud pumps. The cuttings are stored in the reserve pit (cuttings pit) until they are transported to an approved sanitary landfill, or neutralized and made arable. The former option will probably be followed.

Drilling fluid is primarily a mixture of water and clay (sepiolite and/or bentonite), containing varying quantities of additives depending on the particular drilling conditions. For the proposed drilling program the applicant tentatively expects to use a clay base fluid to 1000 ft (305 m) and a gel-lignite mud from 1000 ft (305 m) to total depth. The gel-lignite mud will include neither chrome nor any other heavy metal.

The project applicant estimates that the drilling fluid pH will not exceed 11.0 at any time, and that the caustic hydroxide content will range from 200 lb to 2500 lb (90 kg to 1125 kg) per well.

1.3.2.3 Well Cleanout and Testing Operations

After drilling is completed and the blowout protection equipment removed from the surface casing, annulus wellhead valves (the Christmas tree) are installed on the wellhead. The well is then flowed to clean out drilling fluids (see following paragraph), and production-tested from 24 hours to up to 10 days. This test is performed to determine the production rate, quality, composition and characteristics of the geothermal resource. The discharged fluid from the production well during the test period will be continuously conveyed by pipeline to the injection well.

Cleanout flowing of the proposed El Centro wells involves the following quantities of fluids: (1) at least 1000 bbl (159 m^3) but not more than 5000 bbl (795 m^3) of displacement water, which is essentially either fresh water or fresh water containing up to 0.2 percent (2000 mg/l) of dissolved potassium and/or sodium chlorides mixed with residual drilling fluid; (2) not more than 5000 bbl (795 m^3) of reservoir fluid mixed with formation detritus and filtrate; and (3) not more than 90,000 bbl ($14,300 \text{ m}^3$) of reservoir fluid, which may contain varying amounts of formation detritus. Thus, the total amount of cleanout fluids per well will be no more than 100,000 bbl ($15,900 \text{ m}^3$). All of these fluids will be discharged into steel tanks and/or a leak-proof reserve pit.

Samples of reservoir fluid and steam phase constituents will be collected during cleanout flowing for chemical analysis. However, due to the presence of drilling fluid contaminants during early cleanout operations, these analyses are often inconclusive. Samples collected during the latter phases of cleanout operations may be representative because of the substantial quantities of reservoir fluid produced — up to 90,000 bbl ($14,300 \text{ m}^3$). Additional sampling of the noncondensables would be conducted

during the testing program if information obtained during cleanout operation is inconclusive or indicates potential problem levels of such constituents as hydrogen sulfide.

The complete well drilling and construction schedule is described in Figure 1-8.

1.3.3 Additional Facilities at the Well Site

A concrete pad, approximately 3200 sq ft (288 sq m) in size, will be provided at the drill site as a foundation for the mechanical equipment required for the field experiment. A prefabricated steel shade structure will be built over that portion of the pad which requires protection from direct sun and weather elements.

The equipment located on the pad will include the sand separator and heat exchanger and a liquid chiller, cooling tower, and miscellaneous pumps and motors (see Figure 1-9). The sand separator will eliminate entrained solids upstream of the heat exchanger. A totally submersible, electric-driven downhole pump, with a setting depth of 500 ft (152 m), will pressurize the production system to prevent brine flashing. An electric-driven centrifugal reinjection pump will pressurize the reinjection system to provide adequate flow through the 8.6 in cement-cased reinjection well, which extends to a depth of 4000 ft (1220 m). Temperature, pressure and flow recorders will provide a permanent record of geothermal fluid production rates and well flow characteristics.

The reason the chiller plant (absorption unit) is not located at the Community Center is that the modular concept of district heating and cooling developed in the initial feasibility study (Multi-purpose Utilization of Hydrothermal Resources Within the City of El Centro) will be evaluated in this demonstration. Under the modular concept, the area of a city to benefit from district heating and cooling would be divided into small districts in which one modular plant would serve a particular district. This demonstration plant is conceived as a modular plant serving

Well Drilling and Construction Schedule

**FIGURE
1-8**

WESTEC Services, Inc.

20

Layout of Facilities at Well Site During Project Operations ,

**FIGURE
1-9**

not only the Community Center but, hopefully, other consumers in the area — residential and industrial alike.

An interface between the geothermal fluid production/reinjection and the closed hot water distribution system will be provided by a counterflow shell and tube heat exchanger as shown in Figure 1-10. The closed, forced circulation hot water loop will be heated directly by the geothermal fluid heat exchanger. This closed hot water loop provides heat for space heating and domestic hot water at the community center as well as heat to operate an absorption chiller at the well site.

The absorption chiller will be used at the well site to cool water in the closed chilled water loop prior to its return to the community center. The absorption chiller will be a 100-ton packaged, automatic liquid chiller which is operated using the heat from the closed hot water loop as the energy source.

The absorption chiller is itself a closed refrigeration system which operates under a partial vacuum and utilizes water as a refrigerant and lithium bromide as an absorbent in a continuous chemical process. In addition, the absorption refrigeration system has internal process cooling and heat rejection requirements which must be satisfied by cooling water supplied to internal heat exchangers from a cooling water system.

The cooling water system will utilize a packaged wet mechanical-draft cooling tower of the induced draft cross-flow type. A motor-driven, induced draft fan will be employed to provide a positive air flow through the tower fill. The cooling tower operates on the basic principle of bringing the water to be cooled into intimate contact with a moving airstream where about 75 percent of the water-cooling process takes place by evaporation and the remainder by conduction to raise the dry-bulb temperature of the air. The airstream usually leaves the tower very close to saturated condition. Drift eliminators, consisting of baffles arranged to change the direction of

WESTEC Services, Inc.

22

Piping and Instrument Diagram Showing Interface Between Production and ReInjection Wells and the Hot/Chilled Water Distribution System

**FIGURE
1-10**

air flow and catch most of the water droplets entrained in the airstream by impingement on the baffles, will be employed. A circulating pump will provide the necessary cooling water flow to the absorption refrigeration unit.

Evaporation losses, drift losses, and blowdown from the cooling tower will be made up utilizing water from the municipal water system. The cooling tower will be in operation primarily during the summer months, when the rate of evaporation is greatest. Aside from the air conditioning season which generally extends from April to October, there is little foreseeable need to utilize it in other months when the absorption chiller unit is not in use. Cooling tower blowdown will be discharged to an on-site evaporation pond. The solids remaining after dewatering will be transported to an approved solid waste disposal site. Blowdown from the cooling tower, because of high salinity, cannot be drained to the sewer system because the sewage treatment process will be chemically disturbed if high salinity liquids are allowed to enter the treatment plant. Blowdown could be diluted with clean water but since fresh water is limited in the Valley this method was eliminated from consideration. Thus the requirement of an evaporation pond seemed most feasible.

Some chemical treatment utilizing non-chromate additives will be required in the cooling water system to prevent corrosion and the growth of organic material. Similarly, some chemical treatment of the closed, forced circulation hot and chilled water loops may also be required for the same reasons.

1.3.4 Hot/Chilled Water Distribution System

A preinsulated pipe will be used for transporting the hot or chilled fresh water between the well site and the community center. This pipe has an epoxy-lined, asbestos-cement inner core with polyurethane foam insulation and an asbestos-cement outer casing. The polyurethane foam insulation is bonded between a lined casing and

core, and capped at both ends with water and heat resistant end seals to ensure complete encasement. The nonmetallic material makeup of this pipe precludes any corrosion problems.

The chilled water distribution system will consist of one 4-in (10 cm) supply line and one 4-in (10 cm) return line. The hot water distribution system will consist of one 1-in (2.54 cm) supply line and one 1-in (2.54 cm) return line. These four pipelines will be buried along the west side of First Street from the well site to Orange Street, and then along the east side of First Street to the community center, a total distance of approximately one-half mile (760 m) (see Figure 1-2). The procedure for the laying of pipe to the El Centro Community Center from the proposed well site basically entails the following. The street's asphalt surface will be cut along the pipe's route of some 2400 feet. The trenching operation will require 1 backhoe operator, 2 truckdrivers, and 1 laborer. The trench depth will be about 4 feet deep and about 3 feet wide. The open trench length at any one time will be no longer than can be completed in one day (600 feet). The laying of the pipe will require 2 pipe fitters, 1 crane operator to lift and drop pipe, 1 laborer and 1 foreman. Thrust blocks for the pipe, which are poured concrete foundations, will require open trench areas during the period when the concrete is curing. Traffic will be diverted to the opposite side of the street or diverted around the excavated areas. The trench filling operation will require the same manpower and equipment as the trench excavation operation. Thrust blocks will be located underground at locations where the pipeline changes directions, such as at the well site and at the community center. The pipeline will be installed within the same right-of-way as an existing 12 in (30 cm) water line under First Street. No relocation of existing utilities will be required. Construction, which will be conducted during normal working hours only and will require only about two weeks, will thus have minimal noise and traffic-related effects.

Temperature of the fluid in the pipe will vary from 100F to 200F (38C to 93C) in the winter and from 42F to 50F (6C to 10C) in the summer. Maximum heat flux would occur during the winter with a heat loss from the fluid to the ground not to exceed 10 BTU/hr per foot length of pipe. Internal pressure along any portion of piping will not exceed 150 psi.

1.3.5 Installation of Geothermal Equipment at the El Centro Community Center

The El Centro Community Center will be the facility used in the testing of space heating, cooling, and hot water based on a geothermal resource. The center is located on a site of 2.7 ac (1.1 ha), about 360 ft by 320 ft (110 m by 98 m) at the corner of First Street and Brighton Avenue. The building is of concrete block wall construction with steel supported roof and fire resistant construction throughout. The total square footage of enclosed area is approximately 13,200 sq ft (1188 sq m), with an enclosed roofed-over shaded area of approximately 3000 sq ft (270 sq m).

Figure 1-11 is a Master Plan for the El Centro Community Center. The parking area, access road, showers and creative play structures are still in the planning stages. Figure 1-12 shows an architectural rendering of the community center along with the location of the roof-top air conditioning units.

1.3.5.1 Design and Equipment Installation

The project design plans were generated from calculations which yielded the following resource and equipment parameters:

Wellhead temperature	250F (121C)
Peak geothermal fluid flow	46,800 lb/hr (21,228 kg/hr)
Heat exchanger area	490 sq ft (44 sq m)
Absorption unit rated capacity	100 tons
Chilled water pipe size	4 in (10 cm)

WEST ELEVATION

SOUTH ELEVATION

EAST ELEVATION

NORTH ELEVATION

SECTION

ALL ELEVATIONS & SECTION
SCALE 1" = 20'

Architectural Rendering of El Centro Community Center
Showing Location of Roof-top Air Conditioning Units

**FIGURE
1-12**

Hot water pipe size	1 in (2.54 cm)
Distribution pipe insulation thickness	3.5 in (8.9 cm)
Peak space cooling requirement	744,000 BTU/hr
Peak space heating requirement	130,000 BTU/hr
Average domestic hot water demand	108 gal/day (408 l/day)

The schematic flow diagram for the community center's integration with the field experiment is shown in Figure 1-13. To implement these improvements the modifications to the community center will be minimal, with the only visible evidence of change being the addition of some piping on the building exterior leading from the base of the building to the roof. The modifications to the building will be made on the roof-mounted air conditioning equipment to accept hot and chilled water for space conditioning, and in the hot water heater to accept a hot water source for sanitary water heating.

The hot and chilled water distribution systems will interface with the existing rooftop air handling units and zone heating coils at the community center. Separate rooftop air handling units will provide variable volume supply air for each building exposure and loading type to prevent the necessity for zone reheat. The air handling unit will have a chilled water coil and will either cool or ventilate. Supply air will be distributed to each zone through heating coils for zones requiring heat. Each zone has a thermostat which modulates the supply air quantity, thereby maintaining space temperature. Heating and cooling stages are cycled by the space thermostats requiring the most cooling or heating and by the relationship between the outside air temperature and preset control temperatures. The heating and cooling system controls are interlocked to prevent cooling in the air handling unit when any zone is heating.

Schematic Flow Diagram Showing Integration of El Centro Community Center with Facilities at the Well Site

FIGURE
1-13

1.4 PROJECT SCHEDULE

1.4.1 Development and Operation

Figure 1-14 provides the overall work schedule and milestones. The project applicant anticipates commencement of drill site preparation and drilling operations in mid 1979. The supply well will be completed within the first 10 weeks in order to permit assessment of project viability before material procurement begins. Assuming initial favorable results from this well, an injection well will be drilled in a two-week period. Construction of surface facilities will follow. Further tests, equipment installation and injection well completion will consume the remaining time allocated for well drilling and construction. Concurrently with installation of improvements at the well site, the necessary equipment will be installed at the community center.

An operations-evaluation period of 18 months will follow startup of the system. At the end of the operations-evaluation period, this proposed project will be concluded. During or after this period, the project applicant may decide to utilize production from the well which is not required for the community center for other non-electric applications. This action would constitute a separate project, and would necessitate the completion of an additional environmental study beyond the scope of this document. The possible ultimate life of this project or of any other which utilizes the geothermal resource depends upon the life of the reservoir underlying the drill site. Reservoir life is a function of the ability to establish vertical communication between the production and reinjection wells. One of the primary objectives of this demonstration will be to determine if effective well communication can be established based on the lithology encountered beneath the drill site. Without this communication, large scale development of the geothermal resources beneath the City of El Centro is doubtful.

NOTE 1. AN OPERATIONS-EVALUATION PERIOD OF 18 MONTHS FOLLOWS START UP OF THE SYSTEM.

NOTE 2. PRODUCTION WELL WILL BE COMPLETED IN FIRST TEN WEEKS ALLOWING PROJECT VIABILITY TO BE ASSESSED BEFORE SYSTEM MATERIAL PROCUREMENT BEGINS.

Overall Design and Construction Schedule
for Geothermal Utility Core Field Experiment

FIGURE
1-14

The Geothermal Energy Office of the California Energy Resources Conservation and Development Commission (1979) and the California Division of Oil and Gas (1979) have not formulated an opinion or estimate on the projected energy production capacity or lifespan for the Heber KGRA, but do not disagree with the estimated electrical energy and wellhead thermal energy capacity reported by Brook et al. (1979). Brook et al. have estimated that the Heber KGRA has a potential lifespan of 30 years at a power production of 650 MW and a wellhead thermal energy of 7.7×10^{18} joules. Thus, from all evidence available to date, the reservoir capacity is clearly able to accommodate the modest energy requirements of the demonstration project.

1.4.2 Regulatory Process

Before commencement of drilling several permits and approvals must be obtained by local, state, and federal agencies. The City of El Centro has already issued (July 5, 1979) a conditional use permit to construct and operate the facility. The State Division of Oil and Gas must also issue a permit to drill and operate the well. A permit, "Report of Waste Discharge Requirements," must also be secured from the Regional Water Quality Control Board (RWQCB) prior to the time a project is started. This permit covers the quality and quantity of any surface discharge of fluid including quality and disposal methods of fluids from drilling operations and wastes from on-site sanitary facilities. The local Air Pollution Control District (APCD) issues two permits, one granting authority to construct and another granting permission to operate, for all activities which discharge air pollutants into the atmosphere. Finally, the U.S. Department of Energy must approve the funding needed to implement the project.

SECTION II

DESCRIPTION OF BASELINE ENVIRONMENT/ANALYSIS OF IMPACTS/DISCUSSION OF MITIGATION MEASURES

2.1 GEOLOGY

2.1.1 Landform and Topography

The site of the proposed El Centro geothermal energy demonstration project is located in the southern portion of the nearly featureless Imperial-Mexicali Valley (the Salton Trough), which comprises the northern, landlocked portion of the Gulf of California rift. Elevation of this broad, alluviated plain ranges from approximately 47 feet (14.2 m) above sea level at the Colorado River delta to minus 230 ft (-70 m) at the Salton Sea. This extensive plain is interrupted by the channels of the New and Alamo Rivers, and by several volcanic hills near the north (Obsidian Buttes) and south (Cerro Prieto) ends of the valley.

The New and Alamo Rivers originate to the east and west of Mexicali, respectively, in Estado de Baja California, Mexico. These rivers meander across the length of the Imperial sub-area of the Imperial-Mexicali Valley, flowing northward to their terminus in the south end of the Salton Sea. The Salton Sea has occupied the lowest portion of the valley since the 1905 flooding of the Colorado River. This flooding continued for nearly two years, carving channels as much as 40 ft (12 m) deep.

Located at the south end of the Salton Sea are five small volcanic domes, composed of obsidian-intruded, pumiceous rhyolite. The maximum height of these features is about 100 ft (30 m) above the surrounding area, reaching a minimum height of about minus 130 ft (-40 m).

The El Centro field experiment site is approximately equidistant from and between the New and Alamo Rivers, at an elevation of approximately 45 ft (14 m) below sea level.

2.1.2 Geology

This potential geothermal resource area lies near the axis of the Salton Trough, the sediment-filled northern extension of the Gulf of California rift (Elders et al., 1972, Figure 1). The Salton Trough is filled with lacustrine and deltaic sands and shales of Tertiary age, overlain by Quaternary-age alluvial, lacustrine and, to a lesser extent, volcanic materials (Dutcher et al., 1972, Figure 3). The trough is bordered by mountains of late Mesozoic and earlier granitic rocks and metasediments, underlying a thick sedimentary sequence. The major lithographic units are the Split Mountain (Miocene), Imperial (upper Miocene to Pliocene), Palm Spring (Pliocene), and Borrego-Brawley (Plio-Pleistocene) formations (California Division of Mines and Geology, 1977; Dibblee, 1954).

Various faults of the San Andreas system extend into the Salton Trough from the northwest (Dutcher et al., 1972). The trough appears to be part of a zone of en echelon adjustments in the San Andreas fault system along the San Andreas-Sand Hills (Banning-Mission Creek), Imperial, Brawley, Calipatria, Westside, Superstition Hills, Superstition Mountains, Cucapa, Elsinore-Laguna Salada, and San Jacinto faults.

Individual stratigraphic features encountered in any particular well in the Salton Trough are usually of limited horizontal extent. Some generalized stratigraphic features, however, are consistent throughout the trough. One of these features is the thick sequence of clay-dominated (greater than 75 percent of the total volume) rocks between about 1000 to 2000 ft (300 to 600 m) beneath the surface. This lithologic feature forms the clay "caprock" which has "sealed" the geothermal system, resulting in a limited vertical circulation which has allowed the abnormal buildup of excess heat. Some researchers have considered this clay caprock to be a facies of the Borrego-Brawley formation.

Underlying the clay-dominated sequence are sections with dominant arkosic and quartz sandstones, which have been considered as a Colorado River delta facies of the Palm Spring formation (Helgeson, 1968). Additional valley-wide consistencies are compaction and mineralogic similarities, with attendant bulk density increases accompanying deep burial.

2.1.3 Geothermal Resources

The geothermal resources of the Imperial Valley are incorporated into six known geothermal resource areas (KGRAs): Salton Sea, Brawley, Heber, East Mesa, Dunes, and Glamis (Figure 1-4). Four of the KGRAs have been drilled and are considered to be economically viable: Salton Sea, Heber, East Mesa and Brawley. The geothermal reservoir which is the energy source for the El Centro field experiment is located on the periphery of the 13.5 sq mi (35 sq km) Heber KGRA, which is estimated to contain 12.4 percent of the Imperial Valley's total geothermal resources (VTN, 1978). The area of maximum temperature gradient in the Heber anomaly is centered around the township of Heber, approximately 4.5 mi (7.2 km) south of the City of El Centro.

The prevailing geothermal gradient at the drill site is expected to be in the range of 2.0 to 3.3F (1.1 to 1.8C) per 100 ft (30 m). This is based on data published by the U.S. Geological Survey and the California Division of Mines and Geology, and data gathered by Chevron in the Heber area. The high gradients (>3.0) were only observed at shallow depths of less than 1000 ft (305 m) while lower gradients (around 2.0) prevail at greater depths (Figure 2-1). Therefore, unless geothermal anomalies are encountered, it is highly probable to find 250F (121C) brine at about 8500 ft (2590 m) and it is moderately probable to find that temperature at about 6500 ft (1980 m).

2.1.4 Geologic Hazards

Potential geologic hazards at the El Centro site include the following:

WESTEC Services, Inc.

36

- a. Seismic activity resulting in effects due to:
 - (1) Fault displacement
 - (2) Ground shaking
- b. Potential induced seismicity created by withdrawal and reinjection of geothermal fluids.
- c. Potential seismic-induced soil liquefaction
- d. Potential subsidence due to withdrawal of geothermal fluids.

Each of these potential hazards is discussed below.

2.1.4.1 Fault Displacement

Movement along a fault plane can result in the displacement of a portion of the earth's crust at the ground surface and/or at depth. Such displacement can be either rapid, as occurs during an earthquake, or relatively slow and gradual, as associated with fault "creep." Fault displacement involves such great forces that the only means of avoiding damage to man-made structures is to abstain from building over active fault traces or design structures to accommodate or withstand the expected displacement.

No faults are known to break the ground surface on the site. As shown in Figure 2-2, no known faults pass through the City of El Centro, although the Superstition Mountain fault lies directly northeast of the city limits.

2.1.4.2 Seismic-Induced Ground Shaking

The Imperial-Mexicali Valley is an area of high seismic potential. As shown on Figure 2-2, several known faults pass within 25 mi (40 km) of the project site. Some of these faults have been the source of intense activity within the last few decades (Lamar et al., 1973).

SOURCE: DUTCHER et al, 1972

Geologic Map of the Imperial/Mexicali Valley Showing Proximity of Faults to the Project Site

FIGURE
2-2

Expansion of the U.S. Geological Survey-California Institute of Technology seismic monitoring network early in 1973 has led to an accumulation of data concerning small magnitude earthquakes, earthquake swarms and microearthquake activity in the Imperial Valley. Information from this monitoring network resulted in the addition of the Brawley and Calipatria faults to the list of known faults in the Imperial Valley, just as the El Centro earthquake of 1940 added the Imperial fault.

Results of seismic monitoring from June 1, 1973 to May 31, 1974 are shown in Figure 2-3 (Hill et al., 1975). Epicenters are concentrated primarily along the previously unknown Brawley fault and along the Imperial fault. The frequent, low magnitude earthquakes are believed to result in strain release which averts the occurrence of a very large magnitude event.

Table 2-1 lists the distances from the field experiment project site to pertinent local and regional faults. Also listed on the table are the estimated maximum credible earthquake magnitudes for each fault, and the corresponding anticipated bedrock acceleration at the project site for each of the earthquake magnitudes given. It should be noted that the maximum induced ground acceleration in stiff soil (Column 4 in Table 2-1) is usually higher than in rock (Seed et al., 1968).

Active faults nearest to El Centro include the Imperial and the Superstition Hills faults. These faults are part of the San Andreas and San Jacinto fault zones which trend along northwest axes through the southern portion of the state. The Imperial fault is located approximately 3.7 mi (5.9 km) east of El Centro. Major earthquakes which occurred in 1940 and 1966 are associated with this fault. The Superstition Hill fault lies about 2 mi (3.2 km) to the northeast of El Centro and is associated with a major earthquake that occurred in 1951. These active faults have had surface rupture and fault creep slippage (slow ground displacement) (MSA, 1978).

FIGURE 2-3

Table 2-1

**ANTICIPATED BEDROCK ACCELERATIONS DUE TO MAXIMUM CREDIBLE
EARTHQUAKES ON PERTINENT LOCAL AND REGIONAL FAULTS**

Fault	Minimum Distance to El Centro Geothermal Field Experiment (mi/km)	Maximum Credible Earthquake Magnitude ¹	Maximum Credible Bedrock Acceleration at Minimum Distance (% of gravity) ²
Brawley	10.7/17.2	6	23
Imperial	3.7/5.9	7	58
Calipatria	15.2/24.5	6	17
Superstition Hill	2.0/3.2	7	70
Superstition Mountain	0.6/1.0	7	>70
San Andreas-Sand Hills	26/41.8	7.5	24
San Jacinto	7.0/11.3	7.5	50
Elsinore-Laguna Salada	19/30.5	7-7.3	23-26
Cucapa	21/33.6	6	12

- Notes:
1. Primarily from Greensfelder (1974). Those not listed by Greensfelder assumed to be consistent with other faults, i.e. Richter Magnitude 6.
 2. From Greensfelder (1974, Figure 3).

2.1.4.3 Induced Seismicity

Current experience does not allow a complete evaluation of the effects of large-scale withdrawal of geothermal fluids on the accumulated strain within the reservoir area. In the decade or so that water-dominated geothermal systems have been under production, both with and without reinjection, no increase in seismic activity has been noted. However, only long-term seismic monitoring programs will provide any information regarding this potential hazard.

2.1.4.4 Soil Liquefaction

The soil types beneath the project site are known to be capable of supporting perched water tables between 36 and 60 in (91 to 152 cm) in depth under condition of extensive irrigation. During periods of heavy irrigation, the groundwater table may rise to within 18 in (46 cm) of the surface. In addition, leakage from the cuttings pit or evaporation pond can, if not minimized, contribute to shallow groundwater conditions. However, because the project site is not irrigated agricultural land, and because the cuttings pit will be lined to minimize leakage, the potential for seismic-induced soil liquefaction should be insignificant.

2.1.4.5 Subsidence

Extensive withdrawal of geothermal fluids can result in subsidence of the land surface. However, the low volumes associated with the proposed field experiment should not be sufficient to result in subsidence. An evaluation of the potential subsidence associated with possible large volume geothermal production in the future is beyond the scope of this EIR. If early exploratory conditions suggest that further project expansion may occur, a more extensive subsidence monitoring network than currently exists in the area should be established to provide a baseline for further studies.

2.1.5 Soils

The soil type covering the proposed well site is classified by the U.S. Department of Agriculture Soil Conservation Service (SCS) as "Vint loamy fine sand, wet." The SCS provides the following description of the soil:

Typically this is a deep soil with slopes of 0 to 2 percent on basin floors and flood plains at elevations of 35 ft (10.5 m) above to 230 ft (70 m) below sea level. It formed in alluvial and aeolian sediments from diverse sources. Irrigation has caused perched water tables at depths of 36 to 60 in (91 to 152 cm). Characteristically, the profile to a depth of 60 in (152 cm) is stratified light brown and pink loamy fine sand with several thin lenses of heavy silt loam at depths between 10 and 40 in (25 to 100 cm). Permeability is moderately rapid. Runoff from bare soil is slow with a slight erosion hazard. Unprotected surface soil has a slight wind erosion hazard, with some abrasion hazard to young plants. Available water capacity is about 5.5 in (14 cm) for a rooting depth of 60 in (152 cm).

This soil has potential for use as home sites and urban areas. The sandy texture of the soil and high water tables are basic features that affect use. House slabs and footings need to be designed with enough strength to compensate for the low bearing strength of this soil. Metal should be protected from contact with corrosive soil moisture. Drainage may be needed to maintain salt sensitive landscaping plants.

2.1.6 Geology and Soils Impacts

2.1.6.1 Landform and Topography

As previously described, site preparation will involve minimal grading operations and the construction of a reserve pit (cuttings pit) in accordance with approved engineering practices (see Section 1.3.2.1). An approximate 18-in (46 cm) high enclosing berm will also be constructed around the perimeter of the well site (see Figure 1-5). Because of the flatness of the site, and because it is served by existing roads the topographical impacts will be minimal.

2.1.6.2 Geothermal Resources

As previously mentioned, the well is expected to have a maximum production rate of 730 gal/min (2760 l/min) or 25,000 bbl/day (4000 m³/day) with pump and well casing modification. The proposed project, however, requires a maximum production rate of only 100 gal/min (378 l/min) or 3428 bbl/day (545 m³/day), roughly 14 percent of its unmodified production capacity. The production rate will vary considerably with the space conditioning demand resulting in a minimum annual production requirement of approximately 103,000 bbl/yr.

With the assumption that the used brine will be reinjected into a different zone, the annual production will result in a slow depletion of the reservoir pressure. For an assumed continuous aquifer of 5000 ac (2025 ha), the maximum cumulative production is estimated at 32 million barrels (5.1 million m³). Consequently, assuming no vertical replenishing of the reservoir, reservoir life for this field experiment according to the proposed usage could be as high as 310 years. Production rates in excess of the minimum usage would, of course, significantly lower the reservoir project life. For example, an annual production rate of 515,000 bbl/yr (82,400 m³/yr) could deplete the reservoir in only 62 years.

The actual project life, however, could be extended if the reservoir is replenished by brine encroachment from a larger aquifer or by brine imbibition from overlying and underlying strata. Reinjected brine may also help replenish the reservoir if there are any vertical communications between injection and production zones. The actual extension of project life due to one or more of these factors will depend on their contributed brine volume relative to the produced volumes.

The calculation of the net production of 32 million barrels was done by Chevron Resources Company based on their experience as the major leaseholder on the

Heber KGRA. It was assumed that the production well would be fed by a finite aquifer of 5000 acres (although evidence indicates nearly continuous aquifers in the Heber area). Therefore, it was also assumed that the aquifer would experience pressure decline as fluid is removed during production. An allowable pressure decline of 415 lb was assumed, at which time the reservoir pressure would no longer left the reservoir fluid to the minimum pressure required at the downhole pump station. Assuming the production well is completed in 1000 feet of net sand (assuming 2000 feet of sand exposed) and a 20 percent reservoir porosity, calculations of the compressibility of rock and fluid shows that 32 million barrels can be removed from the assumed finite aquifer by such time that the reservoir pressure declines 415 lb.

2.1.6.3 Fault Displacement

The proposed project facilities are located approximately 0.6 mi (1 km) from the known nearest fault, the Superstition Mountain, and thus should not be directly affected by fault displacement. The potential for project damage due to displacement along any currently unknown faults in the area cannot be evaluated at this time. However, if one of the proposed drill holes were to intersect a fault plane, and movement on the fault were to occur, subsurface rupture of the well casing could result. In such an instance some geothermal reservoir fluid could reach the surface or shallow subsurface, but probably not in an uncontrolled manner. Because of the low pressure, non-artesian nature of the reservoir, the minor losses of fluid which in the worst-case could occur would not present a water quality problem.

2.1.6.4 Seismic-Induced Ground Shaking

Table 2-1 in Section 2.1.4.2 lists the anticipated bedrock accelerations at the proposed field experiment site due to the estimated maximum credible seismic activity in the region. As shown, either the Superstition Mountain or Superstition Hill

faults, which lie 0.6 and 2.0 mi (1.0 and 3.2 km) from the project site, are considered capable of generating an earthquake that would result in peak bedrock accelerations of at least 70 percent of gravity at the subject property. Five additional faults in the region, ranging from 3.7 to 19 mi (5.9 to 30.5 km) from the site, could generate peak bedrock accelerations from 23 to 58 percent of gravity in the study area.

The frequency of occurrence of large earthquakes in the Imperial Valley has been plotted by Evernden (1970) to reflect the repeat interval for earthquakes in a $10,000 \text{ km}^2$ area (see Figure 2-4). As shown, a Magnitude 7 seismic event would be predicted to occur an average of 0.025 times per year, or once every 40 years. A Magnitude 6 event is expected an average of 0.17 times per year, or once every 6 years. Within the $10,000 \text{ km}^2$ area, the probability of a large magnitude event occurring at or near the proposed field experiment site is relatively low; hence, the repeat intervals cited above represent worst-case assumptions. Nevertheless, there is a finite possibility that the proposed geothermal core facilities may be subjected to an occurrence of significant seismic ground shaking during the project life. Further, the evidence suggests that the peak bedrock acceleration could exceed 50 percent of gravity. It is estimated that such an event would have a predominant period of 0.35 seconds (Seed *et al.*, 1968), and a duration of strong shaking of approximately 24 seconds (Housner, 1970).

The City of El Centro has adopted the 1976 edition of the Uniform Building Code (UBC) as the City Building Code. The UBC places the proposed field experiment facility site in Seismic Zone 4, which requires the use of design criteria that provide reasonable assurance that structures and facilities will safely withstand the most severe earthquake predicted.

Source: Evernden, 1970.

Recurrence Intervals for Large Earthquakes in
Imperial Valley Region, Based on Seismic Record
for the Period from 1934 to 1963

FIGURE
2-4

2.1.6.5 Induced Seismicity

Earthquake hypocenter depths and the accumulation of crustal strain in KGRAs generally appear to be confined to shallow depths relative to areas outside KGRAs. This suggests that extensive accumulation of strain (and, hence, an increased potential for large-magnitude earthquakes) is less likely within a geothermal area. However, the phenomenon of induced seismicity due to large-scale withdrawal of fluids and heat from a geothermal reservoir is poorly understood.

Fluid injection operations in other parts of the country (Colorado) have been shown to induce seismic activity. Such injection, however, occurred at very high pressures and in geologic settings significantly different than the Imperial Valley. The reinjection of fluids at the site of the El Centro field experiment will be at depths of at least 4000 ft (1220 m), considerably above the depth of the noted seismic activity (SDG&E, 1976). Thus, reinjection of spent geothermal fluids does not appear to represent a significant impact, although confirmation of this will not be possible until large-scale injection operations are implemented and changes in the seismic regime monitored.

2.1.6.6 Soil Liquefaction

Soil and shallow groundwater conditions are such within the proposed project site that soil liquefaction due to seismic ground shaking may be possible. If site-specific soil and foundation engineering investigations for the proposed project confirm this possibility, appropriate foundation design measures will be necessary to avoid potential adverse effects.

2.1.6.7 Subsidence

Extensive withdrawal of geothermal fluids can result in subsidence of the land surface. However, the relatively low volumes associated with the proposed

project, coupled with complete reinjection of produced fluids, should not be sufficient to result in subsidence. An evaluation of the potential subsidence associated with possible large volume geothermal production in the future is beyond the scope of this EIR. While the proposed field experiment could be more closely tied into the existing Imperial County subsidence monitoring network to provide a baseline for further studies, this would probably be appropriate only if production is increased to a level substantially above that presently planned. Likewise, it should be noted that natural, tectonic-related subsidence in the Imperial Valley is progressing at a rate which is only beginning to be understood (Elders et al., 1972; Crow and Kasameyer, 1978). For example, natural subsidence in some portions of the valley amounted to 7.5 in (19 cm) between 1972 and 1977, whereas other areas have risen by as much as 3 in (7.6 cm) (Crow and Kasameyer, 1978).

2.1.6.8 Soils

As described in Section 2.1.5, the project site contains soils classified as Vint loamy fine sand, wet. Permeability is moderately rapid for this soil, thus prohibiting its use in lining brine retention ponds. Low bearing capacities and generally high water tables will require added attention for the construction of concrete foundations and the selection of landscaping plants.

2.1.7 Mitigation Measures

2.1.7.1 Topography

No substantial landform alteration is necessary for the implementation of the proposed field experiment. In the event of project abandonment after partial progress, the land will be returned to its original condition by cleaning the fluid storage sump and backfilling with native soil materials.

2.1.7.2 Geothermal Resources

It is currently unknown to what extent reservoir replenishment, if any, will occur. During the drilling of the production well, core samples will be taken and a reservoir analysis will be conducted based on lithologic evidence. These samples will be analyzed in an attempt to determine at what depth vertical replenishment can take place. This evidence will then be used to determine optimum depths for reinjection and in monitoring the actual results of the field experiment.

The geothermal well drilling program was developed by Chevron Resources Company based on their experience as the major leaseholder on the Heber KGRA. Chevron's experience to date at Heber, which can be applied directly to the El Centro area, indicates that there are no barriers in the Valley floor to restrict vertical permeability. All shale formations have been found to be broken and non-continuous to date. Only actual well operation will provide the final answer; however, all indications to date point to the establishment of effective well communication through vertical permeability for this field experiment. If this production/reinjection technique proves successful in El Centro it could result in cost savings for future expansion by requiring less land for well sites and lower costs for well drilling. Since ultimate recovery of the resource is not required for this field experiment the potential benefits from this reinjection scheme far outweigh the risks.

2.1.7.3 Fault Displacement

In the event of damage due to fault rupture of well casing, the severity of the damage must be taken into consideration in assessing corrective measures. Casing washout may necessitate the berming, at worst, of a small area within the project site surrounding the well. Containment of the spill within the bermed area should involve little difficulty. Given the low pressure, non-artesian nature of the reservoir, corrective measures to plug the hole with cement would be rapidly implemented.

2.1.7.4 Seismic-Induced Ground Shaking

In essence, the City Building Code (the UBC) incorporates the Recommended Lateral Force Requirements published by the Structural Engineers Association of California (SEAOC, 1975). In the commentary on the SEAOC recommendations, the philosophy behind these criteria are stated as follows:

More specifically with regard to earthquakes, structures designed in conformance with the provisions and principles set forth therein should, in general, be able to:

1. Resist minor earthquakes without damage;
2. Resist moderate earthquakes without structural damage, but with some non-structural damage;
3. Resist major earthquakes, of the intensity of severity of the strongest experienced in California, without collapse, but with some structural as well as non-structural damage.

In most earthquakes it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. This, however, depends upon a number of factors, including the type of construction selected for the structure.

In the same commentary is a discussion of the method used to establish the boundaries between UBC Seismic Zones 3 and 4. This involved plotting the major fault systems within California, and locating the boundary of Zone 4 twenty-five miles (40 km) from fault systems considered to have the potential for generating a Richter magnitude event of 7.0 or greater, and fifteen miles (24 km) from those systems with a potential from magnitude 6.0 to less than 7.0. The above was based on studies from California Mines and Geology Bulletin 198 (Alfors et al., 1973) and usage of an arbitrary 30 percent of gravity bedrock acceleration as the boundary between Zones 3 and 4. A study of this part of the commentary indicates bedrock accelerations in Seismic Zone 4 as high as 75 percent of gravity are contemplated by the SEAOC recommendations. As

indicated earlier herein, 70 percent of gravity is the maximum bedrock acceleration projected in the vicinity of the proposed project (Table 2-1).

In view of the above, it is considered that design of the demonstration facility in accordance with provisions of the City Building Code or the UBC (Seismic Zone 4) will result in structures and components adequate to safely resist the strongest earthquake anticipated. Further, since neither the proposed improvements nor the project site present unusual features or complex structural problems, a site-specific response analysis should not be necessary.

2.1.7.5 Induced Seismicity and Subsidence

Induced seismicity and subsidence are not expected to be a significant problem on the small scale of the field experiment. However, the experiment, if deemed necessary by any of the regulatory agencies, will be tied more closely into the existing Imperial County seismic and subsidence monitoring network, and included in the periodic leveling surveys carried out in the Valley. Other mitigation measures for these phenomena are not considered necessary.

2.1.7.6 Liquefaction

Adverse effects due to soil liquefaction during project drilling and construction operations are considered to be unlikely. However, the liquefaction potential to the various project elements will be addressed during the engineering design phase for all required foundations.

2.1.7.7 Soil-Related Impacts

Because the permeability of the on-site soil may not be low enough to allow its use for lining the brine retention pond, it will be necessary to line the pond with bentonite or another impermeable clay. The adverse engineering qualities of the natural soil (sandy texture, low bearing strength and potentially high water table) will

require that the drill rig and ancillary drilling and flow testing facilities be set up with care to avoid foundation stability problems. Likewise, careful attention shall be given to the need for adequate foundations and drainage.

2.2 HYDROLOGY

2.2.1 Groundwater

The California Department of Water Resources (1970) and Loeltz et al. (1975) presented information on groundwater of the Imperial Valley. Hardt and French (1976) presented selected data on wells, including drillers logs, construction details, water level measurements, and chemical analyses. The following discussion of regional and local groundwater conditions is derived from these sources.

Deep exploration holes in the central part of the Imperial Valley have shown that the underlying lacustrine and playa deposits may contain high salinity water in some zones and fresh water in others. Low vertical permeabilities inhibit mixing from various depth zones. The extent of good quality groundwater in the central Imperial Valley is limited. Early attempts to construct wells for municipal water supply at Brawley and El Centro were failures. Records indicate that wells west of the Alamo River have water of very poor chemical quality. A 500-ft (152 m) test well at Imperial yielded only a small amount of water, which had a total dissolved solids content greater than 10,000 mg/l. However, artesian wells east of the Alamo River often yield water with a total dissolved solids content between 1,000 and 2,000 mg/l.

In the Imperial Valley, groundwater generally moves toward the axis of the valley and, thence, northwestward toward the Salton Sea. The major sources of groundwater recharge are seepage of excess applied irrigation water from the Colorado River and canal seepage. The principal area of groundwater discharge is the central, cultivated part of the valley. Here, groundwater moves into the Alamo and New

Rivers, as well as numerous drains. Many years ago, widespread waterlogging developed as a result of repeated irrigation. Networks of ditch and tile drains were constructed throughout the cultivated area. Waterlogging is now virtually ended and shallow groundwater levels have been stabilized at depths ranging from 5 to 20 ft (1.5 to 6.1 m) below the land surface.

Although the extent to which usable groundwater occurs in the central Imperial Valley is unknown, it is believed to be greatly limited, as evidenced by small well yields and poor chemical quality. In the central part of Imperial Valley, the transmissivity of the fine-grained deposits is likely less than 10,000 gallons per day per ft (125 m^2 per day) to depths of 500 ft (152 m). Geologic data indicate that at greater depths, the materials are of even lower permeability.

2.2.2 Surface Water Systems

El Centro receives its water from the Colorado River via the All American Canal and associated canal system network. The quality of the incoming Colorado River water is shown in Table 2-2. The high total dissolved solids (TDS) level of the raw water requires extensive subterranean tiling of agricultural land to provide adequate draining of the soils and prevent salt accumulation. Coagulation, sedimentation and filtration are required before the incoming water is suitable for drinking. This is accomplished at the El Centro Water Purification Plant which has the capacity to process approximately 12 million gallons of water per day.

Agricultural drainage and treated municipal wastewater flow to the Salton Sea along drainage canals and the New and Alamo Rivers. Regional water quality has been discussed extensively in several environmental documents (see WESTEC Services, 1979; VTN, 1978); that information is incorporated herein by reference.

Table 2-2

ANALYSIS OF COLORADO RIVER WATER
WATER YEAR 1972 - 1973

Constituent or Characteristic	Units	Imperial Dam	
		Maximum	Average
Sodium (Na)	mg/l	173.0	145.0
Potassium (K)	mg/l	5.1	5.0
Calcium (Ca)	mg/l	95.0	88.0
Magnesium (Mg)	mg/l	36.0	34.0
Chloride (Cl)	mg/l	152.0	128.0
Carbonate (CO ₃)	mg/l	0.0	0.0
Bicarbonate (HCO ₃)	mg/l	188.0	174.0
Sulfate (SO ₄)	mg/l	370.0	336.0
Nitrate (NO ₃)	mg/l	2.2	1.6
Boron (B)	mg/l	0.21	0.18
Fluoride (F)	mg/l	0.7	0.5
Total Dissolved Solids	mg/l	962.0	856.0
Conductivity	Micromhos	1403.0	1306.0
pH	Scale	8.1	8.0

Source: Electric Power Research Institute, 1976.

2.2.3 Hydrology Impacts

2.2.3.1 Groundwater

The primary adverse impacts to groundwater that could occur at the project site include: shallow aquifer contamination due to the loss of drilling or geothermal fluids through a weak formation in the borehole; seepage from the reserve pit; or upward movement of injected brines. The primary adverse impact that could occur off-site would be due to improper drilling waste disposal or practice, or disposal at an unsuitable site.

The quality of groundwater beneath the site is believed to be poor. Electric logs run during well construction could provide an indication of groundwater salinity in this zone. Shallow groundwater can be of less saline to poor quality depending on local drainage conditions. In areas of poor drainage the shallow groundwater may be of very high salinity. Actual conditions can only be determined by field sample of water from drains or shallow holes.

If such data indicate the presence of less saline groundwater, particularly in the lower portion of the 200 to 2000 ft (61 to 610 m) interval, then monitoring of groundwater would be advisable. This could be done through installation of a specially designed monitor well at an appropriate depth, based on interpretation of geologic and electric logs. Such monitoring would be more important during actual production-level operation of the geothermal well over long periods, when much larger volumes would ultimately be injected.

Seepage from the reserve pit could affect local groundwater quality. Permeability of materials comprising the bottom and sides of the pits depends not only on the thickness and character of the material (such as laboratory permeability), but on characteristics of the liquid disposed in the pits. In turn, this depends on the

temperature and chemical composition of the brines produced. High salinities and brine temperatures could markedly affect the permeability of native clays and/or bentonite.

2.2.3.2 Surface Water

The most direct surface-water-related effect of the proposed geothermal field experiment will be a consumptive requirement of water for use in drilling operations. This requirement and its resulting impact are discussed in detail in Section 2.8.7.4 of this report.

Surface water quality impacts due to a spill of geothermal brine are conceivable but improbable. While a well blowout or natural causes could bring brine to the surface, an uncontrolled discharge of geothermal fluid from the drill site into nearby City streets and gutters is unlikely. The proposed well will be drilled into a low-pressure reservoir, and a continuously operating downhole pump will be required to lift the fluid to the surface. Thus, in the event of operator error or mechanical failure which created an opening in the otherwise closed production/injection system, the loss of brine would be very small. No water bodies lie near the well site, and even in the worst conceivable case where brine flowed into the street, it would deposit into the storm drain inlet at the corner of Hope and Main Streets. These streets slope at 0.001 degrees and provide approximately 6 cu ft per running foot of flow capacity without overflowing the curb.

2.2.4 Mitigation Measures

2.2.4.1 Groundwater

The proposed casing program, described in Section 1.3.2.2b, is prescribed by the CDOG to, among other reasons, assure that casing is set to protect weak formation materials and to minimize the potential for contaminating shallow subsurface waters with drilling or geothermal fluids.

Seepage from the reserve pit or sump should not be significant and should not require mitigation. However, if any of the regulatory agencies involved consider it necessary, seepage could be monitored by a specially designed shallow monitor well. Also, after the exploration phase is completed and fluid is removed from the pits, shallow holes could be drilled and testing performed to determine the extent of seepage. This would be done after any seepage had occurred and, thus, could serve as a guide for future operation.

Adverse impacts to local groundwater, due to possible upward movement of injected brines, are not expected to be of major importance. This is due to the poor quality of groundwater in a regional sense, i.e. groundwater in the El Centro area is of poor quality, as far as is known. However, the chemical quality of groundwater in deep zones, those most likely to be affected by injection, is unknown. If subsequent exploration indicates the presence of less saline water, a suitable monitoring program will be instituted.

2.2.4.2 Surface Water Quality

Numerous project characteristics and regulatory controls will significantly aid in preventing possible adverse surface water impacts. Principally, an 18-in. (46 cm) high berm will be constructed around each drilling site, and the sites will be graded to drain into a 5344 bbl (855 m³) reserve pit. This pit will serve to contain all but very large spills within the confines of the drilling site.

Waste discharge requirements, containing very specific water quality control measures, must be obtained from the Regional Water Quality Control Board, Colorado River Basin, prior to commencement of drilling or testing operations. In addition, the California Division of Oil and Gas prescribes and rigorously enforces the adequate provision and operation of blowout protection equipment for all geothermal

wells drilled in the State. These regulatory controls, along with the low flow characteristics of these low temperature pumped wells, will serve to substantially reduce the potential for large, uncontrolled discharges of geothermal fluid from the drill site.

2.3 CLIMATOLOGY AND AIR QUALITY

A complete analysis of the air quality and climatologic effects of the geothermal energy utility core is presented in Appendix A to this EIR, and pertinent portions of that study are summarized below.

2.3.1 Existing Conditions

2.3.1.1 Meteorology and Climatology

The combination of the semi-permanent high pressure system over the Pacific Ocean and the blocking action of the Southern California coastal mountain ranges create a characteristic desert climate in El Centro. Strong heating by day and cooling under clear skies create large diurnal and seasonal temperature oscillations. Average summer maxima reach 108 F (42 C) and winter minima drop to 38 F (3 C). Most summer days exceed 100 F (38 C), whereas subfreezing temperatures are unusual. Humidities are very low with a mean annual humidity of 38 percent that reaches a maximum in January and a minimum in June. Rainfall is extremely low with an annual average of 2 to 3 in (5.1 to 7.6 cm) per year. Light precipitation from winter storm systems and occasional destructive summer convective storms occur from 5 to 10 days per year.

Winds and the vertical stability structure over the desert are generally conducive to good air quality. Daytime winds of 7 to 10 mph (11 to 16 kph) created by convection cells and complex terrain around Imperial Valley do not allow for significant localized pollution buildup. Emissions from El Centro are usually carried eastward on

prevailing westerly winds, but a summertime "gulf breeze" blows from the southeast toward the Salton Sea.

Nighttime radiation inversions with light winds create a potential for localized stagnation of low-level pollutants, but the instability of each following day minimizes any day-to-day carryover effects. Imperial County does not experience the low level trapping subsidence inversions common in coastal environments. When inversions form aloft, they are usually so high as to not affect local air quality. With a good dispersion climate and limited pollutant sources, Imperial County has some of the best air quality in California.

2.3.1.2 Air Quality

Without heavy industry or a high population density, the principal Imperial County pollution source is related to its agricultural operations. Although mobile sources dominate the region's emissions inventory, the one pollutant that usually violates ambient air quality standards is total suspended particulates. Standards for other pollutant species are usually met, even for ozone, the problem pollutant throughout much of the rest of California. The dry desert soil and soil disturbance from farming operations combine with moderate wind speeds to elevate dust levels throughout all of the Imperial Valley.

Air quality monitoring is conducted at El Centro, and additional dust measurements are made in Brawley and Calexico. A very comprehensive program by Lawrence Livermore Laboratory (LLL) at various potential geothermal development sites is providing site-specific baseline air quality data. As shown in Table 2-3, the 1976 and 1977 El Centro air quality monitoring summary, standards are met for all pollutants measured except particulates. Standards for particulates are exceeded by a factor of three or more. Even higher dust levels occur in more agriculturally intensive

Table 2-3

EL CENTRO MONTHLY AIR QUALITY SUMMARY, 1976,
AND ANNUAL SUMMARY, 1977

(Maximum Monthly Values for Given Averaging Times)

<u>Pollutant</u>	<u>OZONE</u>	<u>SULFUR DIOXIDE</u>	<u>TOTAL SUSPENDED PARTICULATES</u>	<u>ATMOSPHERIC LEAD</u>
<u>State Standards</u>	.10 ppm - 1 HR	.50 ppm - 1 HR	100 $\mu\text{g}/\text{m}^3$ - 24 HRS	1.5 $\mu\text{g}/\text{m}^3$ - 30 DAY AVG
January	0.03	0.01	178	0.77
February	0.08	0.02	260	1.02
March	0.06	0.02	372	0.49
April	0.03	0.02	156	0.56
May	0.04	0.02	393	0.39
June	0.05	0.02	193	0.33
July	0.06	0.02	271	0.32
August	0.08	0.02	155	0.31
September	0.06	—	161	0.46
October	0.07	—	151	0.35
November	0.05	0.09	207	0.80
December	0.05	0.05	124	0.85
1976 ANNUAL MAXIMA:	0.08	0.09	393	1.02
1977 ANNUAL MAXIMA:	0.09	0.09	328	1.06

Source: California Air Resources Board (1976).

areas such as Brawley and Calexico. Because of the dry soil and desert climate, it is often difficult to separate out the natural contribution from the man-made fraction of this particulate burden. Much of this dust is also in the large particle range that is effectively filtered out by the respiratory tract. Thus the health effects of the heavy dust exposure are difficult to assess, but it nevertheless constitutes an aesthetic problem as well as having potential health implications. Except for particulates (and hydrocarbons as a means of ozone control) the County is in a position to achieve and maintain most ambient air quality standards. Standards for hydrogen sulfide (H_2S) the pollutant species of main concern in geothermal applications, have also been exceeded on rare occasions near current geothermal resource development operations. Based on present and projected air quality in Imperial County, the emissions of particulates and hydrogen sulfide are the two areas requiring a detailed analysis of ambient air quality impact.

2.3.2 Air Quality Impacts

2.3.2.1 Emission Sources

Air pollutant emissions from the proposed project will be confined mainly to the pre-operational phase rather than from operational conditions. Since the completed system is a closed cycle, there will be little impact once the system is constructed and operating.

Although the overall emissions from drilling two wells and constructing the demonstration project are comparatively small, two factors require careful attention. One, the site preparation and on-site traffic during drilling will create heavy local dust levels and exacerbate the existing dust problem. Secondly, the close proximity of two existing residences on First Street will make these receptor sites particularly sensitive to any locally generated emissions.

The sources of pollutant emissions from each phase of project development and operations are discussed individually below, followed by a quantitative assessment of impacts in Section 2.3.2.2.

a. Drill Site Preparation

Before drilling the production and injection wells, the drill site will require surface grading. This disturbance of the soil not only generates fugitive dust from earthmoving activities such as excavation of the cuttings pit, but also leaves the earth susceptible to further erosion by lowering the wind threshold for soil movement, until such time that the soil becomes restabilized.

b. Well Drilling

During drilling, emissions from the diesel drives on the drilling equipment will release combustion emissions (principally oxides of nitrogen and carbon monoxide) that may create locally significant pollutant concentrations at the adjoining residences to the south. Additional minor vehicular emissions from drilling crew traffic will also be added to the local airstream. If there is a high level of H_2S encountered during drilling, small amounts may occasionally escape with the drilling mud or cuttings, but neither the nature of the resource nor normal drilling procedures have much potential to create problems during actual drilling.

c. Flow Testing

By far, the most probable adverse impact of the El Centro project will occur during well cleanout and flow testing. When the brine is flashed at atmospheric pressure, a portion of the liquid vaporizes and will be carried away by the wind. If the wind direction is toward local residences and plume buoyancy is relatively small (with minimum initial plume rise), then any noncondensable gases such as H_2S may be noted at nearby locations. The magnitude of the impact, which has been determined to be very low, is quantified below in Section 2.3.2.2.

d. Operational Emissions

During operation of the heating/cooling system, the only release to the atmosphere will be from small amounts of drift in the cooling tower or during temporary upset or system venting during scheduled maintenance. Once the amount of H_2S in the El Centro steam has been determined during initial testing, the impact of future well venting may be better identified.

2.3.2.2 Emission Quantification

Specific details of how each of the various emission sources was quantified are presented in the air quality appendix (Appendix A). Table 2-4 shows the total emissions from the principal sources. Total project emissions for the preoperational phase are less than 10 tons for all pollutants, including the NO_x from the diesel drilling rig power units, the main pollution source. Compared to the already low Imperial County pollution burden, these represent a very small increase in regional emission levels; any concomitant air quality impact would be correspondingly small.

Because of the diverse spatial and temporal distribution of these pollutants, it is very difficult to translate these emissions into a precise ambient air quality impact. Since the total project-related pollutant levels are small, somewhat diffused, and from multiple sources, an explicit treatment of dispersion from these sources is generally not possible or even necessary. Hydrogen sulfide, however, because of its definite source and extremely low threshold of odor nuisance, does lend itself to a definitive source/receptor analysis. By applying a Gaussian diffusion equation to a wide scenario of meteorological conditions and input characteristics, the probable "envelope" of potential H_2S impact during well flow testing can be defined. For any typical set of conditions experienced in El Centro, the hourly H_2S levels in Table 2-5 are less than 2 parts per billion (ppb), or well below the hourly standard of 30 ppb. Although

Table 2-4

EL Centro Field Experiment Project Pollutant Emissions

SOURCE	TOTAL SUSPENDED PARTICULATES	CARBON MONOXIDE	TOTAL HYDROCARBONS	OXIDES OF NITROGEN	OXIDES OF SULFUR	HYDROGEN SULFIDE
	(TSP)	(CO)	(THC)	(NO _x)	(SO _x)	(H ₂ S)
Fugitive Dust During Site Preparation	1200					
Heavy Duty Site Preparation Equipment Emissions	23	80	33	345	26	
Diesel Drive Drilling Equipment Emission	720	2240	840	10,320	680	
Employee Vehicle Emissions		1671	213	172		
Well Testing						48
TOTAL (POUNDS)	1943	3991	1086	10,837	706	48
(TONS)	0.97	2.00	0.54	5.42	0.35	0.02
IMPERIAL COUNTY ANNUAL TOTAL (TONS)	18,300	44,100	10,600	5,700	100	—
PERCENT OF ANNUAL COUNTY EMISSIONS INVENTORY	0.005%	0.005%	0.005%	0.09%	0.35%	—

Note:

Minimal additional emissions will also result from:

- Drift from drilling mud cooling tower
- Fugitive dust from on-site vehicular activity during drilling, flow testing, and equipment installation
- Drift from heat rejection cooling tower
- System venting during periodic well cleanout and maintenance
- Accidental emissions during upset conditions

Table 2-5

H_2S Concentrations and Distance of Maximum
Ground-Level Impact from Geothermal Well Flow Testing

Pasquill Stability Class	DAYTIME		TRANSITIONAL		NIGHTTIME	
	$U^1 = 3 \text{ msec}^{-1}$ $H^2 = 10 \text{ meters}$		$U = 1.5 \text{ msec}^{-1}$ $H = 20 \text{ meters}$		$U = 1 \text{ msec}^{-1}$ $H = 30 \text{ meters}$	
	Distance (m)	Maximum Concentration (ppb) ³	Distance (m)	Maximum Concentration (ppb)	Distance (m)	Maximum Concentration (ppb)
"A"	62.9	0.57 ● ⁴	108.0	0.35	148.3	0.27
"B"	64.2	0.95 ●	133.6	0.49	204.9	0.34
"C"	95.2	1.23 ●	203.9	0.62 ●	318.3	0.41
"D"	161.8	1.46	360.5	0.70 ●	544.9	0.45 ●
"E"	218.1	1.79	504.2	0.78 ●	954.0	0.43 ●
"F"	388.0	1.62	980.8	0.64	1912.3	0.34 ●

Notes:

- ¹ U = wind speed
- ² H = plume rise
- ³ California standard = 30 ppb
- ⁴ most probable stability classes for day, transitional and night conditions

instantaneous H_2S concentrations may be momentarily detectable during flow testing at maximum brine flows, there is little or no probability of any H_2S standard exceedance, even at the closest residences to the proposed project.

2.3.3 Mitigation Measures

Although the cumulative project impact is small, especially during the operational phase of the program when emissions are essentially negligible, certain specific actions will help minimize the air quality impact. Both for the benefit of nearby residents as well as the comfort of equipment operators, regular watering during construction, drilling and testing will reduce local dust levels. By restricting access to the site or preparing an oiled access and parking area, fugitive emissions from vehicle access during the operational phase will also be minimized. Since the timing of testing and maintenance is somewhat discretionary, the work, whenever possible, will be performed when winds carry the plume away from populated areas.

Besides these specific steps, the fact that geothermal energy replaces energy from electrical generation by combustion of fossil fuels results in a net air quality improvement. Assuming that the average system energy savings is 100,000 Btu/hr, the annual energy replacement is about 200,000 Kwh/year. If that energy were to come from burning oil in a power plant, the resulting pollutant savings is shown in Table 2-6. The project thus reduces total power plant emissions by a little less than one ton per year. Since additional facilities may use the geothermal resource, and since future project-related emissions create a negligible air quality burden, the expansion and continuation of service by the utility core will continue to accrue future air quality benefits.

Table 2-6

El Centro Project Pollutant "Savings" (tons/year)

	Estimated First Year Project Emissions	Subsequent Year Project Emissions	Annual Pollutant Savings By Replacement of 200,000 kwh/year
Total Suspended Particulates	0.97	neg.	0.07
Sulfur Dioxide	0.35	neg.	0.37
Carbon Monoxide	2.00	neg.	0.03
Oxides of Nitrogen	5.42	neg.	0.25
Total Hydrocarbons	0.54	neg.	neg.

2.4 NOISE

A description of the existing acoustic environment at the proposed El Centro Field Experiment project site and a detailed analysis of project-related noise impacts are provided herein as Appendix B. Pertinent portions of this analysis are summarized below; for further details please refer to Appendix B.

2.4.1 Ambient Noise Level

Ambient daytime noise conditions were measured at the southeast corner of the well site and along the eastern boundary of the second residence directly south of the site on February 8, 1979. Additional data were obtained in the vicinity for noise generated by surrounding industrial activity. Morning and afternoon measurements were performed using a General Radio 1945-7100 Community Noise Analyzer, which meets the Type 1 American National Standards Institute Specification S1.4-1971. Field calibration of the instrument was performed using a GR type 1562 Sound Level Generator.

Nighttime ambient noise was measured from 11:50 p.m. on July 18 to 12:10 a.m. on July 19, 1979. The ambient sound level (L_{10}) was found to be 55 dBA. Several factors contribute to a relatively high nighttime ambient level, including gusting wind, barking dogs, cattle in a nearby feedlot, loading and unloading of trucks at the Pacific Telephone operations yard, and light automobile traffic.

Table 2-7 presents the results of the noise measurement program. Ambient noise is presented in terms of L_{90} , L_{50} , L_{max} , L_{min} , and L_{eq} . The measured L_{eq} values were used to calculate the noise energy averages for the measurement period; these in turn were used to determine the existing Day-Night Sound Level (L_{dn}) and Community Noise Equivalent Level (CNEL). L_{dn} and CNEL are descriptors most commonly used to describe community noise.

As shown in Table 2-7, the ambient L_{dn} and CNEL values for the project site are each 55 decibels. Predominant noise sources influencing the ambient level are: the City recycling center immediately west of the well site, which operates an aluminum can flattener; the City materials storage yard north of the project; a telephone company operations yard south of the project location; general industrial activity surrounding the site at slightly greater distances; and vehicular traffic on First and Second Streets.

2.4.2 Noise Standards

A number of noise standards are used in Imperial County to regulate noise. The City of El Centro noise ordinance establishes a limit on the maximum sound pressure level allowable on the property line of the source. The City standard (see Figure 2-5) is applied without regard to the underlying zoning, and is equivalent to an A-weighted noise level of 55 dB.

The Noise Element of the County General Plan (County of Imperial, 1974) establishes standards and limits in terms of the Composite Noise Rating (CNR), Noise

TABLE 2-7

AMBIENT NOISE LEVELS IN A-WEIGHTED DECIBELS*

MEASURED LEVELS ON PROJECT SITE

Time	L ₉₀	L ₅₀	L _{max} L _{min}	L _{eq}
1010-1110 hours	50	55	80/47	58
1215-1315 hours	47	55	78/45	59

MEASURED LEVELS IN VICINITY

Time	L _{max}	L _{eq}	Source	Measurement Distance From Source (ft/m)
1020 hours	71	63	City Recycling Center	300/92
1030 hours	80	75	City Recycling Center	75/23
1100 hours	70	55	Ambient at Well Site	—
1323 hours	66	56	Southern Paper & Supply	300/92
1511 hours	74	57	Halliburton Company	300/92
1511 hours	65	63	Pacific Telephone	150/46

AMBIENT COMMUNITY NOISE LEVELS

L _{dn}	55
CNEL	55

*All measurements made on February 8, 1979.

Exposure Forecast (NEF), and U.S. Department of Housing and Urban Development (HUD) criteria. A summary of these standards is given in Table 2-8. Unfortunately, both the CNR and NEF descriptors are used primarily for evaluating transportation-related noise, and the HUD criteria are somewhat unwieldy for use in estimating sound levels when employing the noise modeling techniques necessary to describe a somewhat complicated noise source (such as the proposed field experiment).

The County of Imperial's (1971) "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial County" contains noise criteria specifically for geothermal projects. These criteria establish two classes of drilling and production noise standards, as shown on Figure 2-5. The Class I standards apply to areas well removed from sensitive receptors, while the Class II standards are much more limiting, depending on the type of land use in the project vicinity.

The City of El Centro is currently required to review the proposed project based on its own municipal noise ordinance. However, at its discretion the City may elect to amend its current ordinance and to review the project in terms of the County's criteria rather than in terms of its own noise standards. This may be a logical direction, since geothermal development is an activity not considered in the City ordinance, and the County's criteria differentiate between different zones or land use types, while the City's do not. Because it is not yet known what set of standards the City will use as a basis for review, the discussion of impact will consider each of the potentially applicable criteria.

As seen in Figure 2-5, any of five categories of the Class II standards could be applied to the subject project. Because of the area's industrial zoning and industrial General Plan designation, application of the Class II-Industrial standard may be likely.

TABLE 2-8

IMPERIAL COUNTY NOISE ELEMENT STANDARDS AND LIMITS

Critical

- HUD - Clearly Unacceptable; Exceeds 80 dB(A) for 60 minutes per 24-hour period, or exceeds 75 dB(A) for 8 hours per 24-hour period.
- NEF - Zone C, NEF greater than 40.
- CNR - Zone 3, CNR greater than 115.

Concern

- HUD - Normally Unacceptable; Exceeds 65 dB(A) for 8 hours per 24-hour period, or loud repetitive sounds on-site.
- NEF - Zone B, NEF greater than 30 and less than 40.
- CNR - Zone 2, CNR greater than 100 and less than 115.

Caution

- HUD - Normally Acceptable; Does not exceed 65 dB(A) for more than 8 hours per 24-hour period.
- NEF - Zone Upper A, NEF greater than 20 and less than 30.
- CNR - Zone Upper 1, CNR $100 + \frac{1}{2}$ the distance between CNR 100 and CNR 115.

Allowable

- HUD - Clearly Acceptable; Does not exceed 45 dB(A) more than 30 minutes per 24 hours.
- NEF - Zone A, NEF less than 20.
- CNR - Zone 1, CNR less than 100.

Source: Imperial County Planning Department (1974).

County of Imperial Initial Geothermal Development Class I and Class II Noise Standards and El Centro Noise Regulation (based on preferred Octave Bands as defined by ANSI)

**FIGURE
2-5**

2.4.3 New Levels of Noise

Noise levels resulting from development and operation of geothermal projects are produced by the following activities: (a) drill site preparation; (b) well drilling; (c) well cleanout; (d) well flow testing; and (e) facility operation. Based on noise measurements taken at other geothermal operations in the Imperial Valley, on manufacturers' design standards for various components of the facility, and on data presented in VTN (1978) and U.S. Department of Energy (USDOE, 1978), sound levels from unmuffled equipment at various distances from the source were calculated for each of the project-related activities. Noise levels for the cooling tower and absorption chiller were obtained from product manufacturers. These predicted sound levels are shown in Figure 2-6, and octave band sound pressures at 100 ft (30 m) are shown in Table 2-9.

2.4.4 Impacts

2.4.4.1 Compliance With Adopted Standards

As described in Section I, the proposed drilling program will commence at the production well site, and progress to the injection well location about 30 ft (9 m) away, assuming favorable geothermal resource evaluation results during initial drilling. The distances from the proposed drill sites to the nearest boundary of the geothermal development parcel is 85 ft (26 m). By extrapolating the data shown in Table 2-9 (which shows octave band sound pressure levels for various project activities at 100 ft or 30 m) to 85 ft (26 m), the operation noise spectral data at the project boundaries can be derived. These data are illustrated on Figure 2-7. For comparison, the City of El Centro performance standard and the County of Imperial Class II-Industrial and Class II-Normal Residential standards are also shown on the figure.

WESTEC Services, Inc.

A-Weighted Sound Levels for Various Project Activities as Functions of Distance from Source

**FIGURE
2-6**

TABLE 2-9

OCTAVE BAND SOUND PRESSURE LEVELS AT 100 FT (30 M)
FOR VARIOUS PHASES OF THE PROJECT

<u>Octave Band</u>	<u>Drill Site Preparation</u> ¹	<u>Well Drilling</u>	<u>Well Cleanout and</u> <u>Flow Testing</u>	<u>Facility Operation</u>
63	84/57	86	50	59
125	92/72	82	49	59
250	76/66	75	47	59
500	71/59	69	47	56
1000	74/57	68	47	53
2000	68/55	67	43	50
4000	62/46	55	38	47
8000	54/42	44	34	42
Overall A-weighted Sound Pressure Level	79/64	75	51	59

NOTE: 1. Excavation equipment/truck noise.

Parcel Boundary Noise Spectra for Each Phase of Project Development and Operation (assumes the use of no special noise attenuation devices on noise-generating equipment)

**FIGURE
2-7**

As seen on Figure 2-7, noise from three of the five phases of project development and operation is in excess of the Class II-Normal Residential standard and City of El Centro standard across essentially the complete spectral band. Noise from well cleanout and flow testing exceeds these standards above 250 Hz. The Class II-Industrial standard is exceeded for frequencies less than 2000 Hz by well drilling and 4000 Hz during drill site preparation. Noise from well cleanout, flow testing, and operation of the facility drops below the standard across the spectral band.

2.4.4.2 Residential Impact

The operation and duration assumptions in Table 2-10 were used to calculate the CNEL and L_{dn} values shown in Figure 2-8. These values were used to generate Table 2-11, which quantifies the impact of each phase of project development and operation on nearby residences. The two closest homes are located just south of the well site at distances of 135 and 235 ft (41 and 72 m). Other sensitive receptors include residences to the northeast and north at distances of 550 and 700 ft (168 and 214 m) from the well site (see Figure 2-11).

Since the existing community noise level is a CNEL or L_{dn} of 55 dB, the proposed activities will be audible out-of-doors at receptors within 2000 ft (610 m) of the source. The maximum impact will be due to well drilling, which will raise the ambient exterior noise level by an estimated 26 decibels at the nearest home, 20.5 decibels at the next residence, and 13 decibels at the residential block beginning at the southeast corner of First Street and Hamilton Avenue. Operation of the facility, by contrast, would raise the ambient noise level in these locations by 6.5, 1.5, and 0 decibels, respectively.

Evaluating noise impact according to HUD criteria within the Imperial County Noise Element (Table 2-8) utilizes the A-weighted sound levels given in Figure 2-6. At the nearest receptor the maximum noise from drilling is over 72 dB(A).

Table 2-10

OPERATION ASSUMPTIONS

<u>Operation</u>	<u>Time of Day</u>	<u>Duration</u>
Drill Site Preparation	0600-1600 hours	30 min/hr
Well Drilling	0000-2400 hours	30 min without rotary/ 30 min with rotary
Well Cleanout	0600-1600 hours	30 min/hr
Flow Testing	0600-1600 hours	30 min/hr
Facility Operation	0000-2400 hours	60 min/hr

Note: Noise generated from project development and operation will be required to comply with the strict, City-imposed performance standards listed in Section 2.4.5.

Community Noise Levels for Various Project Activities
as Functions of Distance from Source

**FIGURE
2-8**

TABLE 2-11

ESTIMATED COMMUNITY NOISE LEVELS (CNEL/L_{dn})
AT NEAREST SENSITIVE RECEPTORS (dB)

<u>Receptor</u>	<u>Location 1^a</u>	<u>Location 2^b</u>	<u>Location 3^c</u>	<u>Location 4^d</u>
Distance from Drill Site (ft/m)	135/42	235/72	550/168	700/214
<u>Activity</u>				
Site Preparation	70.5	66	58.5	56.5
Well Drilling	81	75.5	68	66
Well Cleanout	55(ambient)	55(ambient)	55(ambient)	55(ambient)
Flow Testing	55(ambient)	55(ambient)	55(ambient)	55(ambient)
Facility Operation	61.5	56.5	55(ambient)	55(ambient)

NOTES:

- a. Single-family residence immediately south of well site.
- b. Single-family residence immediately south of "Location 1."
- c. Single-family homes at southeast corner of First Street and Hamilton Avenue.
- d. Single-family homes north of Hamilton Avenue between First Street and Second Street.

This level, which would continue 24 hours per day for the duration of drilling, exceeds the Element's "Concern" limit of 65 dB(A) for 8 hours per 24-hour period and approaches the "Critical" criterion of 75 dB(A) for 8 hours per 24-hour period.

The attenuation in noise afforded by normal construction in buildings with windows open is sufficient to reduce this level by 10 to 15 dB. Thus, the nighttime impact, which is most critical in terms of community response, would be reduced to an interior level of 57 to 62 dB at the nearest home, 52 to 57 dB at the adjacent residence, and 45 dB within the homes at the corner of First Street and Hamilton Avenue. An interior sound level of 45 dB is generally considered compatible with residential activity. Therefore, the sound reduction afforded by the buildings themselves is insufficient to fully mitigate the exterior noise impacting the two homes south of the drill site to an acceptable level.

2.4.5 Mitigation Measures

As mentioned above and described in detail in Appendix B, some activities associated with the proposed geothermal field experiment will result in significant noise impacts in terms of exceeding both ambient community noise levels (L_{dn} and CNEL) and applicable HUD noise criteria. Also, when compared to either the City of El Centro noise ordinance or the Class II-Industrial criteria in the "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial County," a significant impact is anticipated. This impact, unless mitigated, would be most noticeable to the residents in the two single-family homes immediately south of the well site, where the site preparation and well drilling phase of the project would have the greatest effect. Operational noise from the facility would also be discernable, but would cause a far less significant impact. The neighborhoods to the north and northeast of the project site (on Hamilton Avenue) would be significantly impacted only

by noise from well drilling. Since the attenuation provided by the walls of the affected homes is not sufficient to reduce the interior sound levels to an acceptable level, additional efforts are required. Project compatibility with applicable noise standards will require the implementation of sophisticated mitigation measures.

The City of El Centro is requiring as a condition of approval compliance with strict performance standards. These measures are as follows:

1. Site preparation, well cleanout, flow testing and facility construction are restricted to daylight hours.
2. Well drilling operations must be adequately mitigated to achieve a 55 dB noise level (60 dB during daylight hours) or less at the City-owned property line. Pipe stacking and line section assembly will be restricted to daylight hours. Well drilling noise levels will be monitored by City staff and any residential complaints recorded. If the noise attenuation program is incapable of mitigating noise levels to 55 dB at the property line during evening hours then drilling will be prohibited between the hours of 10 p.m. to 7 a.m., unless a variance allowing 60 dB 24 hours per day is approved by the Planning Commission and City Council.
3. A 6 feet or higher block wall fence will be constructed along the eastern 120 feet of the southern property line.

Throughout this report, the data used to predict project-related noise were derived by measuring noise generated by equipment having no special-purpose mufflers or other sound-attenuating features. Thus, to achieve the necessary noise reduction, all equipment used in drill site preparation and well drilling, especially diesel engines and generators, will be fitted with hospital-type mufflers to reduce exhaust noise. The use

of mufflers will be accompanied by construction of sound barriers around the facility. A temporary 20 foot high noise enclosure will be constructed around the perimeter of the drill site for the mitigation of noise impacts during 24-hour drilling operations. The noise enclosure will consist of 1½ inch fiberglass matting sandwiched into a quilted blanket and wrapped around a structural framework. The structural framework will consist of vertical telephone poles, anchored in the ground, attached by 2 x 4 lateral crosspieces and will include access-doors for the movement of heavy equipment as well as man-doors for the movement of project personnel on and off the drill site.

Aside from the block wall which must be constructed along the southern property line, only temporary barriers present during site preparation and drilling would be needed on the north and east to shield the homes on Hamilton Avenue. The combination of mufflers and solid wall barriers will have to achieve a minimum of 25 decibels noise attenuation over the frequency range of 63 to 8000 Hz. No permanent walls around the northern or eastern sides of the facility would be required to protect the homes along Hamilton Avenue, since the attenuation afforded by the walls of those homes will reduce the interior noise during normal project operations to an acceptable level. Implementation of these measures will bring the noise level into compliance with adopted standards, and will reduce the residential annoyance factor to an acceptable level, even at night, because of the high nighttime ambient of 55 dBA (L_{10}).

Several alternative methods of mitigation were considered but rejected in favor of the adopted mitigation program. One approach to mitigation would be for the City of El Centro to condemn the two homes to the south under its redevelopment program and relocate the residents to other homes. The property could then be utilized for industrial purposes as designated by the General Plan. Under this alternative, temporary sound barriers would still be required during well drilling to protect the residents along Hamilton Avenue.

A second feasible alternative would involve providing the two most affected families with alternative housing in an El Centro motel or hotel during well drilling. This measure would effectively avoid the noise problem during its most significant period, but sound attenuation of lesser stringency would be necessary to shield these homes during the life of the project.

A third and fourth means of reducing the significance of the impact would be to relocate the well site further west on the parcel toward the recycling center, or to restrict drilling to daylight hours. The effectiveness of these actions is discussed in Section 4.2, Alternate Operational Procedures.

2.5 BIOLOGY

2.5.1 Vegetation and Wildlife

The 63,000 sq ft (5670 sq m) project is largely devoid of vegetation, having been cleared of plant cover in the past. Only scattered, adventitious weedy species have returned. This lack of vegetation and the intrusive nature of industrial activity on surrounding properties prevents the opportunity for wildlife to become established on or utilize the site. No endangered, rare, or threatened floral or faunal species as listed by the California Native Plant Society or U.S. Fish and Wildlife Service are present on or use the site.

2.5.2 Impacts

The absence of biological resources will allow the project site to be developed without creating an adverse biological impact.

2.5.3 Mitigation Measures

Because no biological impact of any magnitude will result from implementation of the field experiment, no mitigation measures are considered necessary.

2.6 ARCHAEOLOGICAL AND HISTORICAL RESOURCES

2.6.1 Site Reconnaissance

The area in and around the proposed well site was surveyed for prehistoric and historic cultural resources by staff from Imperial Valley College (IVC) Museum in late 1978 (von Werlhof and von Werlhof, 1978). (The survey report is reproduced in its entirety in Appendix C of this EIR.) The site-specific reconnaissance determined that the property is devoid of archaeological and cultural resources. Nothing associated with the project site or vicinity is included in the National Register of Historic Places, the California Landmark Inventory, or California's list of Historical Points of Interest. It is possible, though highly unlikely, that subsurface archaeological resources will be discovered during development of the property.

2.6.2 Impacts

Because no prehistoric or historic resources are present on the surface of the field experiment site, and because it is unlikely that extant resources exist beneath the surface, no related impacts are anticipated.

2.6.3 Mitigation Measures

To fully assure that any excavation, drilling, equipment staging, or construction activities associated with the proposed project do not adversely affect cultural resources, all such activities will cease if any unusual specimens of bone, stone or ceramic are discovered. A qualified archaeologist will be contacted to evaluate these discoveries and, as warranted, either remove them in a scientifically acceptable manner or, depending on the scientific value of the discovery and time restrictions, assure that they are preserved in-place. If this latter option is implemented, it should be possible to transfer drill site activities to an immediately adjacent location and proceed with the proposed geothermal exploration and evaluation program.

2.7 VISUAL RESOURCES/AESTHETIC QUALITY

2.7.1 Visual Overview

The project site is completely flat and contains no dwelling units or other buildings (Figure 2-9). The only existing vertical element on the site is a pair of telephone poles and guy wire. No landscaping has been established on the property.

Visible from the project site are urban, largely industrial features. A soil/aggregate storage yard lies across the railroad tracks to the north. A recycling center and warehouses are seen to the west. Buildings occupied by a paper supply company are found immediately across First Street to the east, while two single-family homes and a telephone company operations yard are adjacent to the south. Although various criteria have been devised for the assessment of visual resources, evaluation of the scenic quality of an area is inherently subjective, and any form of comparison is tenuous at best. Given these limitations, however, the aesthetic qualities of the project area are considered low.

2.7.2 Impacts

The most significant visual impacts will occur during the nine-week drilling operation when an approximate 120 ft (35 m) high rotary drill rig will be on-site. During the drilling process, a significant aesthetic impact will result primarily from the high visibility of the drilling rig, which will be further reinforced by the need for nighttime site and drilling rig lighting. Figure 2-10 shows a rotary drill rig operating in the Imperial Valley.

The impact will most directly affect the single-family and duplex neighborhoods north and northeast of the industrial area in which the field experiment will be located. The essentially horizontal skyline currently presented to these residents will be interrupted by a dominant vertical element. However, because the drilling rig will

El Centro Geothermal Well Site. Looking from First Street, left side of photograph shows two single-family homes; center shows Pacific Telephone Operations Yard; right side shows City Recycling Center and Second Street (in distance).

**FIGURE
2-9**

Geothermal Well Drilling Rig Operating in
the North Brawley Area of Imperial County

FIGURE
2-10

(This page left intentionally blank)

be required at the site for no longer than about nine weeks, the impact is of only short-term significance.

A second short-term visual impact will occur during the approximate two week period devoted to well cleanout and flow testing. Small amounts of steam will be released to the atmosphere, resulting in a plume rising to heights of 50 to 120 ft (15 to 35 m) and extending approximately 100 to 300 ft (30 to 90 m) downwind, depending upon humidity and wind conditions..

The long-term visual impact of the field experiment, following removal of the drilling rig, will not be significant. As described in Section 1.3.3, the permanent facility, no component of which will be greater than approximately 15 ft (4.5 m) in height, will be of a scale and character consistent with the industrial use of the area.

Modifications necessary at the El Centro Community Center will also create no significant aesthetic impact. The only visible evidence of change will be the addition of some piping on the building exterior leading from its base to the roof. The residents within the viewshed of the center will therefore not be adversely affected.

Construction of the hot/chilled water distribution system will create a temporary impact associated with excavation under First Street for installation of the subsurface pipelines. This impact is short-term, since after construction the street will be returned to its previous condition.

2.7.3 Mitigation Measures

The range of temporary impacts associated with well drilling, flow testing, and excavation under First Street are unavoidable and essentially unmitigable. The low-level but long-term impacts created by the wellhead structures, cooling tower, absorption chiller, and other equipment can be minimized by fencing of the equipment and installation of full landscape screening around the perimeter.

If initial drilling indicates the absence of a viable geothermal resource, the drill site will be regraded and returned to its original condition.

2.8 SOCIOECONOMICS

2.8.1 Population Characteristics

2.8.1.1 Imperial County

The 1975 population of Imperial County was approximately 83,800, with 24,426 persons living in unincorporated areas (Table 2-12). The City of El Centro, in 1975, had a population of 21,295. The State Department of Finance 1978 population estimates for Imperial County indicate a population of 88,880 for the County as a whole, and 23,404 for the City of El Centro.

As shown on Table 2-12, population growth in the Imperial Valley occurred at a very active pace over the 1970 to 1975 period, with the County's population increasing at about twice the rate as that for the State. Holtville displayed the most rapid rate of growth percentage-wise (24.3%), followed by Calexico (22.5%) and Westmorland (20.6%). In absolute terms, Calexico gained the most population (2,395), followed by El Centro (2,023), then Holtville (849).

As can be seen in Table 2-13, Imperial County's overall population has a much higher percentage of youth (41.5%) than does the State of California (33.3%). This is reflected in the significantly lower median age of the County. Conversely, the number of elderly (over age 65) is lower than the State average. In terms of education, all of Imperial County tends to be somewhat below the State's statistical average.

Imperial County has almost three times the rate of Spanish-Americans than the State as a whole. Much of this is no doubt explained by the valley's labor-intensive agricultural base and its close proximity to Mexico. The City of Calexico, for example, had well over 90 percent of its 1970 population in the Spanish-American

Table 2-12

IMPERIAL COUNTY POPULATION TRENDS

	<u>1970</u>	<u>1975</u>	<u>1970-1975</u>		<u>Est. 1978¹</u>
			<u>Percent Increase</u>	<u>Actual Number Increase</u>	
Brawley	13,650	14,010	2.6	360	14,013
Calexico	10,625	13,020	22.5	2,395	13,341
Calipatria	1,824	2,074	13.7	250	2,360
El Centro	19,272	21,295	10.5	2,023	23,404
Holtville	3,496	4,345	24.3	849	4,463
Imperial	3,094	3,213	3.8	119	3,244
Westmorland	<u>1,175</u>	<u>1,417</u>	<u>20.6</u>	<u>242</u>	<u>1,550</u>
TOTAL:	53,136	59,374	11.7	6,238	62,375
Unincorporated Area	21,356	24,426	14.4	3,070	26,505
Imperial County	74,492	83,800	12.5	9,308	88,880
State of California	19,953,134	21,198,100	6.2	1,244,966	N/A

Source: Imperial County Planning Department.

¹Based upon State Department of Finance estimates provided by the Imperial County Planning Department.

Table 2-13

SELECTED SOCIAL CHARACTERISTICS - 1970

	1970 Population	% <18 yrs	% >65 yrs	Median Age	Median School Years	% Spanish ¹	% Negro
Brawley	13,650	41.2	7.6	23.8	10.4	48.0	3.3
Calexico	10,625	46.2	6.0	19.9	7.8	91.3	N/A
Calipatria	1,824	N/A	N/A	N/A	N/A	N/A	N/A
El Centro	19,272	40.6	6.1	24.7	12.2	34.5	7.1
Holtville	3,496	40.2	7.9	24.9	10.6	N/A	N/A
Imperial	3,094	41.9	6.0	23.2	11.7	N/A	N/A
Westmorland	1,175	41.5	7.4	24.0	N/A	N/A	N/A
Imperial County	74,492	41.5	7.4	24.0	10.8	46.0	3.4
State of California	19,953,134	33.3	9.0	28.1	12.4	15.5	7.0

¹Spanish-speaking persons only or persons
with Spanish surname.

Source: U.S. Department of Commerce, 1972a.

category. Negro population does not appear to be a significant factor, since the County's 1970 percentage was about half that of the State.

Overall, median family income of Imperial County's residents in 1969 (Table 2-14) was generally lower than for that of the State, although it should be recognized that somewhat of a dichotomy may exist between some of the valley's more well-to-do landowners and the seasonal farm labor population. According to the 1970 Census, Imperial County had almost double the rate of families below poverty level than did California as a whole. It can also be seen in Table 2-14 that the lower level of median family income for the Negro and Spanish-American groups was also proportionately lower when compared to the State as a whole.

2.8.1.2 City of El Centro

According to a 1977 special census (U.S. Department of Commerce), the population of El Centro is 22,660. This represents an average annual growth rate of about 2 percent per year since the 1970 census. The 1970 census portrayed an ethnic composition comprised of 56 percent Anglo-American, 35 percent Hispanic, 7 percent Black and 2 percent other.

El Centro has been the destination for much of the rural or urban migration within Imperial County. The proportion of Imperial County residents living in El Centro has grown steadily from about 12 percent in 1910 to about 26 percent in 1970. By the early 1970s, the two largest employment sectors in the El Centro labor market area were government and wholesale/retail trade, reflecting El Centro's role as a regional administrative and commercial center.

Based on its continued function as County seat and major shipping service center for the stable agribusiness economy of Imperial County, El Centro should continue to experience modest population growth. Geothermal development, tourism,

Table 2-14

INCOME AND POVERTY STATUS - 1970

	1969 Median Income	% Families Below Poverty Level ¹	Negro Median Income	Spanish Heritage ² Median Income
Brawley	\$8,330	16.9	\$4,714	\$6,634
Calexico	6,889	25.2	N/A	6,440
Calipatria	N/A ³	N/A	N/A	N/A
El Centro	10,011	12.2	6,035	6,885
Holtville	9,423	8.2	N/A	N/A
Imperial	N/A	N/A	N/A	N/A
Westmorland	N/A	N/A	N/A	N/A
Imperial County	8,257	16.1	5,069	6,592
State of California	10,732	8.4	7,484	8,791

¹As defined by the 1970 Census.

²Based upon the 1970 Census definition of persons of Spanish language or Spanish surname.

³Not available.

Source: U.S. Department of Commerce, 1972b.

proximity to the fast growing Mexicali border area and regional recreational opportunities should add to the population growth pressures of the El Centro area. Within this context of moderate but somewhat accelerated growth, it is projected that the population of the City of El Centro will increase by between 10,000 to 20,000 persons by the year 2000 (Urban Innovations Group, 1978).

2.8.2 Community Attitudes

2.8.2.1 County-Wide Attitudes

Public attitudes towards geothermal development in Imperial County have been surveyed and analyzed by Butler and Pick (1977). Briefly stated, a study conducted in connection with the preparation of the Imperial County Geothermal Element found that about 90 percent of the population of Imperial County is in favor or strongly in favor of geothermal development. Fifteen percent of those questioned believed there was opposition to geothermal development. Only 19 percent felt they had a good understanding of geothermal development, while three-fourths of the respondents advocated strong regulation of geothermal development. The conclusions drawn by this report and another by Green and Steinberger (1976) indicate that the potential of geothermal development is seen as a significant solution to the area's economic problems. Fostering the County's economic growth is of top priority to area residents who view bringing jobs to the area through secondary industries as the most helpful aspect of development for County residents.

The City of El Centro Geothermal Utility Core Field Experiment should provide visible evidence to residents and outside businesses of the applications of geothermal energy to space heating and cooling of buildings and hot water heating. During the project, a strong marketing and public relations program will be undertaken. Its objective is to advise local and state-wide businesses of the opportunities for

geothermal utilization in the commercial and industrial sectors. An information center in the community center itself and tours of the demonstration project will also further these program goals.

2.8.2.2 Neighborhood Attitudes

As a part of the environmental review process, the City of El Centro Planning Department conducted a community attitude survey toward geothermal energy in general and the field experiment project in particular. Several City staff members walked throughout the neighborhood north of the well site and interviewed the resident of every fourth household. The results of the survey, which are included as Appendix D, indicate that most of those surveyed (1) do not understand geothermal development; and (2) do not oppose the project. Nevertheless, opposition from at least one community group, the National Association for the Advancement of Colored People (NAACP), who purport to represent blacks and other residents near the project area, has recently surfaced. At the June, 1979 Planning Commission meeting at which the EIR was reviewed, residents and group spokesmen voiced disapproval, not of geothermal energy or the project itself, but of the City's decision to locate the project and thus bring another industrial operation to their sector of the City. Generally, they objected to the City's failure to evaluate fully potential drill sites in other sections of El Centro. The same objections were delivered at the City Council meeting on July 5, 1979; however, the Council adopted the Planning Commission's recommendations to approve the conditional use permit with mitigating conditions and the EIR. A lawsuit to stop the project has been publicly threatened but has not materialized. It is presently the City's position that it has adequately addressed the suitability of alternate sites. Nevertheless, it is currently evaluating additional areas outside the industrial zone in a good faith effort to resolve further conflict.

2.8.3 Employment

The employment base of the El Centro community labor market area, which includes the City of El Centro as well as that portion of Imperial County immediately surrounding the community, recorded strong growth over the past 10 years. In 1976, about 26,700 persons were employed in this labor market area in non-agricultural employment categories in contrast to a total of 8625 persons in the same categories in 1960. This represents a gain of over 18,000 jobs in the past 16 years. Gains occurred in all categories of non-agricultural employment. Wholesale-retail trade and government recorded the largest individual numerical increases.

However, a major problem facing the County of Imperial is its high rate of unemployment, averaging 18 to 20 percent for 1977 (Economic Development Department, 1977). This is due in part to declining employment opportunities in the major industry of farming, attributable to increased mechanization, and the lack of diversification in commercial and industrial businesses. Imperial County labor statistics for September 1978 showed 29 percent civilian unemployment (Table 2-15). At present, there are nine industries located in or near El Centro employing approximately 1400 persons.

2.8.4 Agricultural Base

The Imperial Valley is one of the most productive agricultural areas in the country. Within the boundaries of the Imperial Irrigation District approximately 457,600 ac (183,404 ha) are under cultivation out of 476,000 ac (190,600 ha) of farmable land (Imperial Irrigation District, 1977). Currently, there are approximately 300 ac (120 ha) of land in agricultural production within the El Centro city limits, in addition to 9530 ac (3810 ha) within the El Centro planning area (El Centro Planning Department, 1978).

Table 2-15

SEPTEMBER 1978 IMPERIAL COUNTY LABOR STATISTICS

Labor Force, Employment and Unemployment
Imperial County

	September	1978 August	July	1977 September
Civilian Labor Force ¹	42,750	43,900	44,400	41,800
Total employment	30,350	30,500	31,900	29,850
Total unemployment	12,400	13,400	12,500	11,950
Seasonally adjusted rate	INA	INA	INA	INA
Unadjusted rate ²	29.0	30.5	28.1	28.6

¹Total labor force (and components) by place of residence and including workers involved in trade disputes. Employment includes self-employed, unpaid family, and domestic workers.

²The unemployment rate is computed from unrounded data; therefore, it may differ from rates using figures in this table.

Source: Economic Development Department, September 1978.

More than 35 growers and shippers still operate in El Centro, while intense large-scale agriculture is practiced in the irrigated areas adjacent to the city. General field crops include cotton, alfalfa, wheat, barley, sugar beets, and grain sorghum; major horticultural crops include asparagus, cantaloupes, lettuce, onions, and carrots. The cattle feeding industry is very extensive, consuming more grain than is produced locally. In 1975, the value of Imperial Valley agricultural products exceeded \$500 million, an increase of almost \$170 million over 1972. Since 1969, the economy of Imperial County has undergone a degree of diversification.

2.8.5 Housing

City of El Centro building permit data since 1972 indicate an average of 205 new residential units per year. While the existing El Centro housing stock is primarily (65 percent) single-family residences, recent construction trends point toward a continuing upswing in new apartments, condominiums and mobile homes, representing approximately 60 percent of the new construction total. Although housing demands slacken during the summer and "slow" agricultural seasons, according to a January 1977 special census, the residential vacancy rate was low at only 4 percent. (Recent construction activity, however, may have raised this rate.) The average household size is estimated at 3.2 persons per dwelling unit. In 1977, the average mean assessed house value was \$28,654 and the monthly average mean rent was \$204 (Urban Innovations Group, 1978).

2.8.6 Public Services and Utilities

2.8.6.1 Overview

As previously mentioned, the project site is located in an existing urban area with complete access to such urban services as police, fire, hospital, etc. Public utilities, including a 12-in water line and an 8-in sewer line, are available at the First

Street frontage. The Southern California Gas Company has indicated the availability of natural gas service, and electrical power service is likewise available from adjacent Imperial Irrigation District power lines. Commercial size trash bins and service will be provided by the El Centro Sanitation Company.

2.8.6.2 Solid Waste Disposal

The drilling muds and other residual solids resulting from the proposed well drilling operations will be disposed of at one of three possible landfill sites. Although Imperial County maintains 10 landfills, only three possess adequate capacity and are tentatively approved by the Colorado River Basin Regional Water Quality Control Board (RWQCB) for geothermal waste disposal. Each of these three sites is a Class II-2 landfill, which can accept certain types of geothermal wastes on a limited basis if those wastes contain no toxic materials and the total dissolved solid (TDS) level of liquids is less than 6000 mg/l.

The three approved sites are as follows:

<u>Landfill</u>	<u>Location</u>	<u>Comment</u>
Calexico	Two miles west of Calexico, off State Highway 98	Currently accepting geothermal waste
Brawley	One-half mile north of Brawley, on Hovley Road	Currently accepting geothermal waste
Holtville	Six miles east of Holtville, on Norrish Road	May be considered acceptable

Due to a problem of decreasing capacity, the Imperial County Public Works Department, Solid Waste Division currently (February 23, 1979) feels that a fourth site, the

Imperial Landfill (six miles west of Imperial on Worthington Road), is no longer acceptable for geothermal waste.

The Calexico landfill site is the closest landfill approved for geothermal drilling solid wastes (9 mi/14 km from the drill site), and in all probability will be selected for the El Centro field experiment. However, testing of the drilling wastes by the RWQCB will be necessary to determine at which landfill site it will be disposed (Boyd, 1978). In addition, the County of Imperial is planning to develop a landfill site approximately 10 mi (16 km) west of Westmorland capable of accepting toxic materials (including some geothermal materials) not now accepted within the County of Imperial. Virtually all the drilling mud currently in use within Imperial County is acceptable, although heavy metal additives used in other areas could not be disposed of locally.

2.8.6.3 Water Use

Some 6800 ac-ft of water were delivered to El Centro in 1968, compared to 2.9 million ac-ft of water diverted per year for the farmland included in the Imperial Irrigation District. A long-term water supply to El Centro and the Imperial Valley is well protected by various laws and agreements over priority rights to the Colorado River. However, projected population growth and development within California, adjoining states and Mexico point to long-term excessive water demands, especially once the Central Arizona Project is completed. As a consequence, California cannot rely on more than its priority share which may result in a reduction to 2.6 million ac-ft in water rights for the Imperial Irrigation District (Imperial County, 1973).

Potable water within the City is stored in two 2.5-million gallon storage tanks and one 5-million gallon storage tank located at the filtration plant. There are also two elevated storage tanks of 100,000 gallons and 250,000 gallons located within the City. This storage capacity represents sufficient water to serve the needs of the City for about one day during peak demand periods.

2.8.6.4 Revenue

The City of El Centro's sources of income provided \$9.5 million in revenues received during FY 1977-78. State and federal funding accounted for 38 percent or about \$3.6 million of the total. Property taxes provided \$1.5 million or 16 percent. Revenues generated from all other sources including fees, fines, service charges, and nonproperty taxes, contributed the remaining \$4.4 million or 46 percent. In addition, total revenue carryovers from previous years provided an extra \$1.9 million.

Major items of public expenditures centered around public works activities including street, sewer and water system costs, and public safety expenses involving police and fire protection. Total public works expenditures were approximately \$4.2 million, or 43 percent of the budget, versus public safety costs at \$2.3 million or 24 percent. Total budget expenditures for FY 1977-78 were approximately \$9.7 million, which amounted to \$412 per capita based on a mid-1978 population estimate of 23,500 inhabitants.

Costs for the proposed project will be borne by the U.S. Department of Energy (DOE) and the City of El Centro. DOE costs are projected to be approximately \$1.9 million; the City of El Centro will contribute about \$740,000. These costs will occur over a 3-year period and will be phased in order to avoid a premature commitment of final funds prior to evaluating the resource. Most of the El Centro share consists of in-kind services and approximately \$600,000 in existing City-owned property and building values.

2.8.7 Impacts

2.8.7.1 Employment/Population/Housing

As explained in Section I, drill site preparation will require one to two weeks and a maximum of 12 to 15 workers. The actual drilling operation will last

approximately nine weeks and employ about 25 workers. Some of the required employees would be current residents of Imperial County. However, a large local labor pool of appropriately trained workers has not yet been established. Thus, it is expected that many, if not most, workers associated with the drilling operation will come from out of the area, and relocate in Imperial County only for the duration of the project.

In addition to the direct employment benefits of the project, the drilling of the proposed wells will create a slight "ripple" effect on the local economy, thus resulting in minor indirect socioeconomic effects to the community. Examples of these effects might be the creation of additional local jobs, particularly in the service industries, or the generation of additional local income as a result of local purchasing.

The primary housing needs will be for temporary accommodations for nonlocal workers. No significant problems are foreseen in meeting the temporary housing needs of the drilling crews.

In the long run, a successful direct use field experiment could influence the expansion or attraction of industry to the area. This scenario would provide additional employment opportunities and an increased demand for housing and supporting goods and services. Despite Imperial County's high unemployment rate, most geothermal development jobs will continue to go to specially trained workers from outside the area, unless appropriate job skill training programs are successfully implemented.

2.8.7.2 Public Services and Utilities

No significant impacts are anticipated to any of the City of El Centro's municipal services, except water supply which is discussed below. Neither the El Centro Fire Department nor the Imperial County Fire Department foresee any unique problems associated with the field experiment. The latter agency has indicated that no

fires related to geothermal well drilling have occurred in the County since the inception of such drilling (Medina, 1978).

The El Centro Police Department also expects no significant impacts to its operations.

2.8.7.3 Solid Waste Disposal

No significant impacts are anticipated to existing landfill facilities as a result of the disposal of residual drilling solids and sediment from blowdown discharge to the on-site evaporation ponds, assuming RWQCB approval for such disposal. To date, no significant problems have been experienced in this area (Boyd, 1978). During the testing of the well, it may become necessary to dispose of the geothermal brine produced, if such brine is not reinjected. In this situation, brine would be transported to a Class I or Class II-1 disposal site.

2.8.7.4 Water Use

Highest water usage will occur during the predicted nine weeks of drilling operations. On the order of 12,000 gal (45,360 l) of water per day with peaks of 20,000 gal (75,600 l) per day will be needed (Garrett, 1978). This level of water usage represents approximately 3 percent of the City's present daily consumption, a significant impact. While there are no overall water supply problems to El Centro as a whole, without proper mitigation, water usage of this magnitude would seriously exacerbate existing water delivery/pressure problems to some northern sectors of the City. These water delivery problems sometimes occur during hot weather (May through October), early evening peak water usage periods. Water delivery/pressure problems to the outlying northern sectors would require the project's ability to reduce or to withhold its water demands from the municipal system during times of peak demand.

In addition, the project operation will consume 676,800 gal/yr (roughly 2 ac-ft/yr) in evaporation and drift losses associated with the facility's water cooling

tower, or about 0.03 percent of the City's yearly consumption, which will have to be made up with water from the municipal water supply.

2.8.7.5 Revenues

Because the City of El Centro has overall responsibility for the project which will occur on municipally-owned lands, no increased property tax revenues will result. To a very small degree, local and California State sales and income tax revenues may increase as a result of project activities.

As previously mentioned, the major costs (\$1.9 million) for the project will be funded by the federal government via the U.S. Department of Energy (DOE). Most of the City of El Centro's costs (\$740,000) consist of in-kind services provided by the current staff and "credit" for existing property and building values. However, some minor additional street and property maintenance costs as well as administrative costs associated with the geothermal project (rather than other City business) will be borne by the City.

The proposed project is a feasibility study/field experiment. Thus, it is uncertain to what extent, if any, this or future applications may prove to be cost effective. The proposed project was not designed to attempt to recoup the almost \$2 million investment through utility savings at the El Centro Community Center. (During 1977, for example, the community center consumed 405,281 kwh of electricity at a cost of \$5,390).

2.8.8 Mitigation Measures

Except for water use, the proposed project requires no mitigation measures to offset adverse socioeconomic impacts. During the drilling operation, sufficient on-site water storage will be required to avoid heavy water demands upon the municipal water system at peak evening hours. The presence of two 8 ft x 8 ft water tanks will

provide up to six hours of on-site water use based on the projected 20,000 gal per day/833 gal per hour demand. This or similarly sufficient on-site water storage capabilities will permit the drilling activities to continue during peak hours without exacerbating existing City water delivery/pressure problems. The drilling crew will cooperate with the City's Public Works Department in coordinating and scheduling their water needs.

While not directly concerned with the immediate project, it is also recommended that project participants continue their supportive positions regarding the geothermal job training program now being offered in Imperial County. Local geothermal job training will be needed to aid in the reduction of Imperial County's high unemployment rate.

2.9 LAND USE

2.9.1 Relevant Land Use Programs and Goals

The project site and proposed field experiment fall within the planning purview of the El Centro General Plan. Public hearings on a draft 1978 amended General Plan are currently being conducted by the El Centro Planning Commission and City Council. Included in the Plan are several goals, objectives and principles related to geothermal and industrial development. While still pending official adoption, the following material from the proposed General Plan represents consultation between the City Council, Planning Commission, planning staff and consultants, and the general public.

2.9.1.1 Geothermal Objectives and Principles

The objectives for the conservation of geothermal resources are as follows:

- To develop these resources in a planned and efficiently managed manner, to discourage wasteful use, minimize adverse environmental impacts and prolong the economic production life of this resource.
- To encourage the direct utilization of geothermal resources to reduce the consumption of fossil fuels.

To accomplish these objectives, the following principles are proposed:

- To insure that the loss of productive agricultural lands due to geothermal development is minimized.
- To coordinate City interests and objectives with County and State regulatory agency plans, so that both the beneficial and adverse effects will be accounted for.
- To prevent geothermally-induced subsidence or seismicity.
- To promote the varied and experimental application of direct geothermal energy to activities within the city area.

2.9.1.2 Industrial Objectives and Principles

The industrial use objective is as follows:

- To provide for a variety and range of industrial sites so that it is economically feasible to manufacture and provide goods, services, and employment in attractive and convenient locations.

To accomplish the objective of the plan, the following principles are established:

- To encourage and promote El Centro as a regional center for general, agriculturally-oriented, and geothermal-related industry.
- To prevent the intrusion of all incompatible uses that would reduce the efficiency of the industries and their opportunities for growth.
- To protect adjacent residential areas from the intrusion of industry-related noise, light, and visual clutter by proper screening, landscaping and the use of buffers.
- To encourage and promote the general visual improvement of existing industrial areas.

2.9.2 Project Area Land Uses

According to the draft General Plan, current land use within the City consists of 33 percent residential, 6 percent commercial, 10 percent industrial/railroad right-of-way, 5 percent utility, 11 percent public/institutional, 3 percent mixed uses, 4 percent vacant, and 20 percent streets/highways/alleys. There are approximately 570 ac in the City limits zoned for medium and heavy industry; about 50 percent of these lands ranging in size from 1 to 60 ac are vacant or largely underutilized. These undeveloped industrial properties include the proposed project site.

The project site consists of 63,000 sq ft (5670 sq m) of City-owned property located in the eastern portion of the City. Land use types in the vicinity of the project site are specified in Figure 2-11. The proposed site is part of three lots which include 7.43 ac (3.0 ha) of municipally-owned property. The City-owned property to the north is currently used by the Public Works Department for open storage of gravel, soil and other aggregates. Two oil storage tanks used for mixing are also stored at the yard. Materials such as concrete, pipes and wood poles are also present. The City's Recycling Center is situated along the southwestern portion of these lots and consists of a mobile office and compacting machinery. A railroad spur crosses north of the site in an east/west direction and forms the boundary line between the project site and the adjacent City lots to the north. The site is bordered to the west by Second Street across from which are located a lumber yard, department store warehouse and a ceramic tile company. The property north and adjacent to the municipally-owned property is being utilized as a cement storage facility for geothermal wells. Further north of this site is a block of single-family residential units. These residences are about 700 ft (214 m) north of the project site and consist of about 11 older dwellings. There is also a 30 ft (9 m) wide alley along the southern perimeter of the block

separating it from the industrial uses. The area east of the site is bordered by First Street. A seed processing plant dominates the land use in this area, although a wholesale paper and supply company is also located there. A single-family residential block with about 10 units is situated northeast of the project site with the closest dwelling unit about 550 ft (168 m) away. The eastern 120 ft (37 m) of the site is bounded to the south by two lots containing older, nonconforming single-family residences. The western 230 ft (70 m) is bounded to the south by a block wall and the Pacific Telephone Company yard, with a trucking company situated further south.

2.9.3 Project Area Zoning

The site is situated within the City's industrial area and is zoned M-1, restricted manufacturing. The zoning is consistent with the City's adopted and proposed General Plans which designate the site as a "general industrial" area. The proposed usage would be allowed in the zone subject to conditional use provisions. Zoning in the vicinity of the proposed well site is shown in Figure 2-12.

2.9.4 Transportation Systems

The Interstate 8 freeway, located approximately 1 mi (1.6 km) south of the project site, provides primary east-west access through the southern portion of the Imperial Valley as it connects San Diego with Yuma, Arizona and points east. A number of State highways provide additional east-west access to the Imperial Valley (Figure 2-13), including Route 98, which closely parallels the U.S./Mexican border; Route 80, which parallels Interstate 8 north of the site; and Route 78 connecting Oceanside to Blythe. Primary north-south access to the Valley is provided by Routes 86 and 111. Several improvement projects for Route 86 have been scheduled by CALTRANS in its current 6-year program. However, a full-scale conversion to a limited-access 4-lane highway is not planned before 1984.

Zoning Pattern in the Vicinity of the
El Centro Geothermal Utility Core Well Site

**FIGURE
2-12**

Regional Transportation Routes in the Imperial Valley Area

**FIGURE
2-13**

Primary north-south access to the project site entrance on First Street is available by proceeding along Route 86 or Dogwood Road, designated an arterial street in the proposed El Centro Amended General Plan. Primary east-west access to the site entrance is along Ross Avenue. An interconnecting grid-like system of City and County thoroughfares provides a variety of directional options (Figure 1-2).

2.9.5 Impacts

2.9.5.1 Land Use

The proposed field experiment is consistent with the City's zoning and General Plan use designation; implementation will require issuance of a Conditional Use Permit (CUP) by the City. The CUP hearing process will consider the extent to which the project complies with applicable development principles of the General Plan. Those principles are discussed individually below:

a. Geothermal Principles:

- "To insure that the loss of productive agriculture lands due to geothermal development is minimized".

The project site is neither used nor designated for agriculture. Implementation of the field experiment will be in complete compliance with this principle.

- "To coordinate City interests and objectives with County and State agency plans, so that both the beneficial and adverse effects will be accounted for".

In development of the field experiment, an interagency review and analysis process will be conducted to identify all effects of the project, and ensure compliance with all applicable regulatory procedures. The City of El Centro

will use as a basis for regulation of this project the County of Imperial Geothermal Element. The California Division of Oil and Gas will supervise the drilling, operation, and maintenance of the well. The County's Air Pollution Control Board will require that emissions from the well and cooling tower comply with its regulations for stationary (non-vehicular) sources. The Colorado River Basin Water Quality Control Board will have jurisdiction over elements of well development that potentially affect water resources.

- "To prevent geothermally-induced subsidence or seismicity".

The design and scope of the project should ensure compliance with this principle. The field experiment proposes to withdraw relatively low volumes of geothermal fluid and to reinject all of the brine produced. ReInjection will be at depths considerably above the depth of seismic activity. In addition, to minimize the possibility of a problem, the pressure at which reinjection will take place will be carefully established and regulated by the CDOG.

- "To insure that the public is well informed about the effects of resource extraction and use".

The City will develop at the El Centro Community Center an information center which will visually display the project operation and provide information regarding geothermal utilization. This information center will be available to local residents and visitors who are interested in the actual application of geothermal energy.

- "To promote the varied and experimental application of direct geothermal energy to activities within the city area".

The proposed project will provide the first demonstration in the United States of low grade hydrothermal resources being utilized to cool buildings as well as heat them. In addition, it will provide a "core" for geothermal heat utility supply to be utilized in space heating and cooling for commercial and government buildings, business complexes and residences and process heat for industry and agribusiness.

b. Industrial Principles:

- "To encourage and promote El Centro as a regional center for general, agriculturally-oriented, and geothermal-related industry".

Because the proposed project is geothermally based, it clearly complies with this principle.

- "To prevent the intrusion of all incompatible uses that would reduce the efficiency of the industries and their opportunities for growth".

Because the field experiment is a compatible use located on a parcel designated for industrial use, it does not interfere with attainment of this goal.

- "To protect adjacent residential areas from the intrusion of industry-related noise, light, and visual clutter by proper screening, landscaping and the use of buffers".

These topics are analyzed in detail in Sections 2.4 (Noise) and 2.7 (Visual Quality), which describe how the project can incorporate appropriate mitigating measures to minimize the magnitude of these environmental effects. The particular development site chosen, however, is one which because of its location in an industrial area, poses few significant impacts.

- "To encourage and promote the general visual improvement of existing industrial areas".

The well site will be screened with both fencing and landscaping to enclose the starker visual elements and soften the visual image it presents to the surrounding area.

2.9.5.2 Transportation Systems

Traffic generated by the proposed project will come primarily from two sources: employee trips to and from the site, and the movement of trucks and drilling

equipment. It is estimated that a maximum of 25 workers will be employed at the project site over the nine weeks of project drilling. Due to the relatively low number of employees who will be at the project site at any given time, employee traffic impacts should be minimal. Additionally, a small level of visitor traffic may be generated by the proposed project. On-site parking facilities will be provided for employee, truck, equipment and visitor parking.

Truck and drilling equipment movement in and around the project site will constitute only a minor cumulative impact on the area's road system. Occasional oversize or overweight loads will be properly escorted and special drayage equipment will be used for proper axle weight distribution.

Minor traffic congestion may result during structural excavation and installation of the hot/chilled water distribution system under First Street. Traffic may be inconvenienced or may need to use alternate streets during the short-term construction period. Along most of its length, First Street serves residential areas only; this location outside of a major commercial area and the ready availability of alternate travel routes should minimize traffic flow problems.

2.9.6 Mitigation Measures

2.9.6.1 Land Use

The proposed field experiment conforms with the existing zoning and the General Plan land use designation, and no inconsistencies have been identified between the plan's geothermal and industrial principles and project development. No mitigation measures are therefore considered necessary. Barring extenuating site-specific circumstances which warrant a variance, project implementation will follow guidelines contained in the Imperial County Geothermal Element and the "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial County."

2.9.6.2 Transportation Systems

Due to the lack of significant transportation system impacts associated with operations at the well site, no mitigating measures are deemed necessary. With respect to pipeline construction activities, the City of El Centro Department of Public Works will ensure proper traffic diversion on First Street. The width of First Street may be sufficient for two-lane traffic during construction. In either event, appropriate safety measures will be taken.

2.10 ENERGY CONSUMPTION

2.10.1 Overview

Electricity and natural gas are the major sources of energy for the City of El Centro. Consumption of these two sources by the residential and commercial sectors is tabulated in Table 2-16. There are at present no industrial-level users of electricity or any industrial natural gas users with a potential for geothermal applications within the City limits. Table 2-17 lists the total non-industrial energy consumption for the City by end use. Approximately 78 percent of the energy consumed in the residential and commercial sectors is potentially replaceable by geothermal energy (City of El Centro, 1978).

2.10.2 Impacts

Project development will result in the expenditure of energy for construction-related vehicle and equipment operation. The completed project will rely mainly on geothermal energy for its daily operation, with the exception of several electric motors required to operate process equipment and the cooling tower. Viewed in isolation, the field experiment will have no significant effect on the local or regional energy consumption and supply picture. When considered as a future energy utility core, however, the project presents the potential for a substantial beneficial effect.

Table 2-16

ENERGY CONSUMPTION FOR THE CITY OF EL CENTRO BY
NON-INDUSTRIAL SECTOR

	<u>Electricity</u>		<u>Natural Gas</u>	
	<u>(KWH/yr)</u>	<u>(BTU/yr)</u>	<u>(Cu.Ft./yr)</u>	<u>(BTU/yr)</u>
Residential	104,279,960	3.56×10^{11}	233,521,500	2.34×10^{11}
Commecial	<u>75,364,079</u>	<u>2.57×10^{11}</u>	<u>135,962,700</u>	<u>1.36×10^{11}</u>
TOTAL:	179,644,039	6.13×10^{11}	369,484,200	3.70×10^{11}

Total = 9.8×10^{11} BTU/yr

Table 2-17

TOTAL ENERGY CONSUMPTION BY END USE FOR
CITY OF EL CENTRO

	<u>%</u>	<u>BTU/yr</u>
Air Conditioning	37	3.6×10^{11}
Water Heating	16	1.6×10^{11}
Space Heating	19	1.9×10^{11}
Commercial Refrigeration	5	0.5×10^{11}
Residential Refrigeration	6	0.6×10^{11}
Cooking	10	1.0×10^{11}
Residential Clothes Drying	2	0.2×10^{11}
Other	<u>5</u>	<u>0.4×10^{11}</u>
TOTAL:	100	9.8×10^{11}

Source: City of El Centro, 1978.

To the extent that geothermal energy is utilized in residential, commercial and industrial activities, the field experiment will assist in decreasing the region's reliance on oil and natural gas.

2.10.3 Mitigation Measures

The small amounts of energy consumed during the project construction are minor, unavoidable, and essentially unmitigable. Successful implementation of the project will itself act as a mitigating measure by assisting in the development of an energy alternative to fossil fuels.

This project will demonstrate the utilization of moderate temperature geothermal heat in the City of El Centro for space conditioning and domestic hot water, and will provide visible evidence of the profitability of direct heat applications of geothermal energy. The technical, economic, and environmental data obtained under field operating conditions will facilitate decisions by the City on the benefits of the utilization of geothermal energy by prospective developers and users. In addition, as the project evolves, this field experiment will foster the formation of working relationships between the City and applicable regulatory agencies that will serve as an example to encourage the adoption of geothermal energy by industry and other prospective users.

SECTION III

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

The foregoing analysis indicates that the proposed geothermal field experiment could potentially result in several adverse environmental effects. Such effects would lie primarily in the areas of water quality, air quality, noise, aesthetics and water consumption. However, for the most part, mitigation measures have been or easily could be included in project plans to either eliminate or substantially reduce these adverse effects.

Those aspects of the project which are not completely amenable to mitigation by any reasonable means are discussed below.

3.1 AIR QUALITY

Although the potential air pollution impacts will be minor, because of the small scale of the demonstration project, there still will be an overall reduction of air quality below current conditions. In addition to the introduction of noncondensables into the air during well flow testing and maintenance venting of the operational utility core system, a very small fraction of liquid drops will be entrained into the cooling tower airstream and lost as drift during the cooling process. The pollutant control measures to be incorporated into the project will insure that such impacts do not exceed the limits established by existing Federal and State ordinances, rules, and standards. However, there will still be sufficient residual effects to cause some minor, though insignificant, changes in air quality.

3.2 NOISE

The existing community noise level in the vicinity of the proposed field experiment is a CNEL or L_{dn} of 55 dB. Activities involved in project development will

be audible out-of-doors at receptors within 2000 ft (610 m) of the well site. The impact will be clearly significant, but the magnitude of impact will vary according to the receptor location and criteria or standard in question. The maximum impact will be caused by well drilling, which is relatively short term in duration (less than three months). Operation of the utility core over the life of the project will also create an unavoidable impact, although the only sensitive receptors close enough to be affected lie in one direction, to the south. The magnitude of impact will be substantially less than that from well drilling, however. Drilling would also adversely affect residential properties to the north and northeast. A variety of mitigation measures are available to substantially reduce the significance of the impact. The noise generated cannot be reduced to a level of inaudibility, however.

3.3 PUBLIC UTILITIES (WATER SUPPLY)

Drilling operations will require from 12,000 to 20,000 gal (45,360 to 75,600 l) of water per day from the municipal system. While this volume of water does not constitute a supply burden to the city system as a whole, it would strain an existing delivery/pressure problem to some northern sectors of the city. The demand created during peak usage periods (early evening, May through October) dictates that the project accommodate its needs within the constraints imposed by municipal requirements.

While the direct consumption of the required volume of water is unavoidable, its effect on the municipal system's existing pressure problem is mitigable by utilizing water storage tanks on-site during the drilling period. Tanks with capacity of up to six hours of water demand are readily available, and would permit the drilling activities to continue during peak hours without exacerbating existing water delivery/supply problems.

3.4 VISUAL QUALITY/AESTHETICS

An unavoidable impact will be created by the high visibility of the well drilling equipment during its presence on the project site. Urban development in the vicinity is of a small bulk and scale, with the prevailing height of structures being below thirty feet. Drilling equipment up to 120 ft (37 m) would present a dominant visual element during the nine-week drilling period.

SECTION IV

ALTERNATIVES TO THE PROPOSED PROJECT

Described below are several alternatives to the proposed El Centro Geothermal Utility Core Field Experiment. Included are discussions of alternate project site locations as well as potential alternate operational procedures. As required by the California Environmental Quality Act and National Environmental Policy Act, the "no project" alternative is also discussed. Of the three principal well sites considered, the proposed location was determined to have the least environmental impact and to best meet the engineering constraints of the experiment.

4.1 ALTERNATE LOCATIONS

4.1.1 Alternate Drill Site Within City of El Centro

Selection of the First Street site for development was based not only on the potential value of the underlying resource, but also on the suitability of the site for development. The City of El Centro reviewed two other candidate sites, and determined that use of the designated property would cause less disruption of surrounding land uses than would the other suggested sites.

Two alternate sites owned by the City of El Centro were initially considered. The first site is currently occupied by the El Centro City Shops. The shops are located on Orange Avenue directly west of the train station and close to the central business district (Figure 4-1). This location makes it attractive for a potential commercial heating and cooling project. Nevertheless, several factors eliminated this location from further study. A major factor was its unavailability in the near term, since it is currently in active use as a maintenance facility. The proposed parcel, in comparison, is vacant for two-thirds of its 600 ft (183 m) length. The City recycling

Map of El Centro Showing Location of Alternative Well Sites

FIGURE 4-1

center, which occupies the western 200 ft (61 m), will not be affected by the geothermal operations. An additional problem with the City shops site is its size — it provides insufficient space for construction and operation of the field experiment. Finally, its closer proximity to more densely populated areas and more heavily travelled roadways made it less desirable because of the greater noise and aesthetic concerns associated with it.

The second alternate site, located in the northwest portion of the City on Villa Avenue (see Figure 4-1), houses the City's outfall lift station and animal shelter. Sewage is collected at this point and transported therefrom to the City's sewage treatment plant. Proximate land uses in the vicinity are a commercial retail center and residential neighborhood, both of which are conforming uses as designated by the El Centro General Plan. Both areas would be impacted to a more significant degree than would the influence area of the selected site. A major land use constraint surrounds the Villa Avenue parcel. It has been designated by the General Plan as a future park site, and although not yet developed as such, there likely would be substantial public opposition to a suggested redesignation to a geothermal energy use.

The proposed project well site was selected as having the greatest potential for an underlying geothermal resource while being located near an immediate application, the El Centro Community Center. The Center offered the advantage of being a public building used by all segments of El Centro citizenry. The proposed drilling site was also situated near the proposed site for a geothermal energy industrial park presently under consideration by the City.

4.1.2 Alternate Drill Site Within Designated Parcel

Block 47, the parcel within which the field experiment is located, is 600 ft (183 m) in length. The eastern 400 ft (122 m) encompasses the proposed project, while

the western 200 ft (61 m) contains the City's recycling center. The reservoir underlying the property could be developed from anywhere within the block. The environmental effects of relocating the well site to two logical alternate locations are discussed below.

Consideration of an alternate drill site would be necessary only as an attempt to mitigate or avoid the noise impact, since this is the only location-variable effect of the project. None of the other environmental implications of the field experiment would be reduced or magnified by relocation, so these factors provide no motivation for such a move.

The two potential alternate locations for the drill site are at the western end of the 400 ft (122 m) subparcel (Site A), or at the spot where the recycling center now operates (requiring relocation of the center), Site B. The resulting distances between the drill site and nearest sensitive receptors are:

Site A: 330 ft (101 m) from homes south of Block 47.
700 ft (214 m) from homes to northeast on Hamilton Avenue.

Site B: 520 ft (159 m) from homes south of Block 47.
810 ft (247 m) from homes to northeast on Hamilton Avenue.

The noise levels at these distances for each phase of project operation and development are shown in Table 4-1.

The noise impact associated with these two sites would be reduced in magnitude if the HUD criteria (Table 2-8) were used as the standard of reference. Only well drilling, of the five major project activities, exceeds the level of "Concern" adopted in the Imperial County Noise Element at each of the sensitive receptors. For the other project activities the extra distance and attenuation provided by the homes themselves would adequately reduce the noise level everywhere but at the first home south of Block 47, for which mufflers or noise barriers would still be necessary during site preparation.

Table 4-1

**NOISE LEVELS AT SENSITIVE RECEPTORS FROM TWO ALTERNATIVE
WELL SITES (dBA)**

<u>Activity</u>	Distance from Well Site A to:		Distance from Well Site B to:	
	Homes south of Block 47:	Homes on Hamilton Ave.:	Homes south of Block 47:	Homes on Hamilton Ave.:
	<u>330 ft/101 m</u>	<u>700 ft/214 m</u>	<u>520 ft/159 m</u>	<u>810 ft/247 m</u>
Site Preparation	63	56.5	59	55 ¹
Well Drilling	73.5	65.5	69.5	65.5 ¹
Well Cleanout	55 ¹	55 ¹	55 ¹	55 ¹
Flow Testing	55 ¹	55 ¹	55 ¹	55 ¹
Facility Operation	55 ¹	55 ¹	55 ¹	55 ¹

NOTE: 1) Ambient noise level = 55 dB(A).

If the noise analysis is conducted using as a standard not the County Noise Element, but rather the City of El Centro noise ordinance, County Class II-Normal Residential criteria, or Class II-Industrial criteria, then no benefit derives from relocating the facility. Each of these establishes a performance standard which must be achieved at the parcel boundary. Since the well site at any of the preferred or alternative locations would be in the middle of the parcel's north-south dimension, the noise level generated and applicable performance standard are identical for each location. Thus, if the City ordinance or County Class II-Industrial criterion is selected by the City as the applicable standard of reference (as is likely), sound attenuation of at least 25 dB, as was discussed in Section 2.4.5 as necessary for the preferred site, will also be necessary for the alternate sites. Thus, even though the audible noise level generated from the alternate sites would be less, and would in the absence of any other standard require less rigorous mitigation, because the standard likely to be applied measures noise at the parcel boundary, attenuation equal to that necessary for the preferred site will be required at either of the alternates. No benefit therefore would accrue from relocating the well site to the west.

4.2 ALTERNATE OPERATIONAL PROCEDURES

The technical and engineering procedures proposed for project operations are among the most efficient and safe currently available for geothermal resource development and evaluation, and cannot be changed to any significant degree without compromising the primary objectives of the project applicant. In addition, with one exception, there are no technically viable alternate operational procedures available that would result in significantly reduced environmental impacts. The exception is to restrict drilling operations to the daytime hours. This would substantially reduce the potential noise impact and require considerably less extensive noise mitigation

measures. This restriction has not been proposed by the project applicants, because it would impose a very significant hardship in terms of completing the exploration project within the planned time frame and budget.

4.3 NO PROJECT

Implementation of the "no project" alternative (that is, denying or delaying approval of the Conditional Use Permit for the proposed project) would eliminate all potential adverse environmental effects discussed in Section II. However, the long-term economic benefits associated with the possible future development of the area for geothermal utilization would also be eliminated, or at least postponed, by this alternative. Further, the environmental benefits to be derived would also be lost. For example, the fact that geothermal energy replaces energy from electrical generation by combustion of fossil fuels results in a net air quality improvement. Table 2-6 in Section 2.3.3 quantifies the yearly tons of air pollutant "savings" anticipated.

The field experiment is intended to generate important new information on a direct use geothermal application. To the extent that such information could be utilized in other geothermal activities, the cumulatively significant savings in fossil fuels which can be achieved through continuing geothermal development would be lost by the No Project alternative.

SECTION V

GROWTH-INDUCING IMPACTS

Approximately 25 persons will be associated with the drilling operation, which will last about nine weeks. Construction and other auxiliary work activities will likewise require only a very limited number of subcontracted personnel for a short duration. Consequently, no significant, direct, growth-inducing impacts on employment, population or housing are expected.

The immediate purpose of the field experiment is to evaluate the feasibility of direct application of geothermal resources to space heating and cooling and domestic hot water systems. If these results are encouraging, long-term applications on a larger scale may ensue. Secondary growth-inducing impacts could occur, particularly if industrial applications prove promising enough to attract new or expanded industry to the area. The City of El Centro has proposed that 54 acres directly east of the drill site be designated as a solar and/or geothermal industrial park. Grant applications have been submitted to State and Federal agencies who are participating in acquisition and improvement of the property. During implementation of the field experiment, a marketing and public relations program will be conducted by City staff. Its goal will be to advise local and state-wide businesses of the opportunities in the utilization of geothermal energy in commercial and industrial enterprises. These actions will create a strong incentive for businesses to locate in the industrial park and utilize geothermal energy from the well site's utility core.

New commercial and industrial development would expand the city's employment base and indirectly provide additional jobs and revenues in sales and support services. The demand for housing would concurrently increase. Construction of new

geothermal-related facilities would draw on the local labor force and induce an immigration of workers and technical personnel possessing expertise not readily available locally.

A full identification of the environmental effects resulting from such induced growth is beyond the scope of this EIR, but it is nevertheless possible to generally assess the impacts. Automobile and truck activity would increase on city streets, and traffic-related noise would be magnified. Pollutant emissions from vehicles and industrially-based stationary sources would incrementally degrade the region's air quality. Municipal services and facilities may have to be expanded to adequately satisfy the requirements of intensified urban activity.

None of these impacts must necessarily become significant. Careful planning for the types and phasing of new development, and monitoring of its effects can provide the City with ample opportunity to anticipate and avoid potentially major problems before they occur.

SECTION VI

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Implementation of the proposed demonstration project is responsive to a national need to pursue and develop "alternative" energy sources. Operation of the field experiment would test the usefulness of geothermal fluid on the fringes of a KGRA for application to uses other than generation of electricity. Successful expansion of this use can minimize the region's dependence on fossil fuels, and avoid the environmental effects of burning oil and natural gas. All identified impacts of geothermal development have been found to be controllable, and even within a cumulative content to pose no long-term risks to health or safety if an assertive program of mitigation is instituted. Utilization of the geothermal fluid at the El Centro well site could continue over a period of several decades. Thus, the geothermal utility core will neither narrow the range of beneficial uses of the environment, nor sacrifice long-term objectives for immediate benefits.

No alternative uses of the peripheral resources around this geothermal anomaly have been identified which might themselves merit immediate utilization of the resource. Development is therefore justified at the present time; postponement would not preserve the resource for another foreseeable future use.

SECTION VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Development of the El Centro Geothermal Energy Utility Core will commit the consumption of surface and subsurface natural resources. Energy will be irreversibly and irretrievably committed in manufacturing, transporting, assembling, and maintaining the utility core facilities. No land resources will be so committed, however, since in the event that the geothermal reservoir under the well site cannot be feasibly exploited, the surface improvements will be removed and the site returned to its previous condition.

How the reservoir itself will be affected by withdrawal of fluid cannot be estimated with certainty. While highly unlikely, it is possible that equipment failure or faulty operational technique, unknown aspects of the reservoir or subsurface geology, or unanticipated problems in production, handling, or reinjection of the brine could "quench" the reservoir, cooling it to an extent where it would be no longer useful as an energy source.

A second potentially irreversible commitment and effect of the project involves the rate at which fluid is withdrawn from the reservoir. The field experiment will require a maximum flow of only about fourteen percent of the well's flow capacity. Additional application of the utility core to other potential industrial users and an increase in well production to its maximum rate could exhaust the portion of the resource tapped by this well in as little as three years. If there is no communication between the levels of production and reinjection and, thus, no reheating of the reinjected brine, a resource of potentially long-term value could be prematurely exhausted. However, it can be safely assumed that because of the large capital

investments involved, large-scale utilization of the resource will not proceed unless vertical communication is established between reinjection and production wells or, at a minimum, an acceptable project life can be assured to minimize the potential financial risks associated with geothermal utilization. Continuous monitoring of pertinent parameters of the well and reservoir will be necessary to establish the potential productivity and life of the well and reservoir.

For an assumed continuous aquifer of 5000 acres, the maximum cumulative production is estimated at 32 million barrels. The maximum expected production rate for a pump setting depth of 500 feet has been estimated to be 730 gal/min for the well casing sizes specified. If the initial field experiment were expanded to include additional users of the geothermal energy such that the maximum well flow rate were required continuously, without first establishing fluid communication between the injection and production wells, the aquifer could conceivably be depleted within three years. This situation is highly improbable.

The peak flow rate required for the field experiment is presently estimated at 100 gpm. At a continuous production rate of 100 gpm, a 32 million barrel aquifer would be depleted in approximately 25 years, assuming no injection/production communication. If the production well were pumped using a variable speed pump which would regulate the well flow rate to provide just enough energy to meet the fluctuating energy demand, the reservoir could last as long as 310 years without any injection/production fluid communication. Allowing for a reasonable margin of error in controlling the geothermal system, the life of the aquifer without well communication could be conceivably shortened from 310 years to 62 years. Therefore, one can conclude that all reasonable assumptions indicate that sufficient resource exists to complete the 18 month demonstration and thereby establish the existence or nonexistence of injection/production fluid communication.

SECTION VIII
AGENCIES AND ORGANIZATIONS CONSULTED

8.1 PUBLIC AGENCIES

8.1.1 Federal

United States Department of Energy
Oak Ridge National Laboratory

8.1.2 State of California

Regional Water Quality Control Board, Colorado River Basin
Division of Oil and Gas
Department of Transportation, District 11

8.1.3 County of Imperial

Planning Department
Office of the Agricultural Commission, Air Pollution Control
Health Department

8.1.4 City of El Centro

Planning Department
Public Works Department
Fire Department
Police Department

8.1.5 Other Agencies

Imperial Irrigation District
El Centro School District
El Centro Community Hospital
Southern California Association of Governments

8.2 PRIVATE ORGANIZATIONS

Chevron Resources Company
Southern California Gas Company

SECTION IX

CERTIFICATION OF ACCURACY AND QUALIFICATIONS

9.1 REPORT CONTRIBUTORS

This environmental impact report was prepared by WESTEC Services, Inc. of San Diego, California for the City of El Centro Planning Department. Members of the WESTEC Services, Inc. professional staff, consultants, and City of El Centro staff contributing to this report, and their areas of contribution are as follows:

9.1.1 Principal Investigator

Allen M. Jones; M.S. Environmental Biology

9.1.2 Project Description

Peter B. Sherwood; P.E.; B.S. Mechanical Engineering
Roger N. Yamasaki; P.E.; B.S. Mechanical Engineering
Sharon G. Province; J.D.

9.1.3 Impact Analysis

A. Geology

Frank A. Kingery; R.G.; M.S. Geology
Gary Lowe; M.S. Geology (in process)

B. Hydrology

Frank A. Kingery; R.G.; M.S. Geology
Gary Lowe; M.S. Geology (in process)

C. Climatology/Air Quality

Hans D. Giroux; Ph.D. Candidate Meteorology

D. Noise

Carol S. Tanner; P.E.; M.S. Mechanical Engineering
Edwin C. Kamps; B.S. Electrical Engineering; M.S. Business Science

E. Biology

Allen M. Jones; M.S. Environmental Biology

F. Archaeological and Historical Resources

Jay C. von Werlhof; Supervising Environmental Manager, Imperial Valley College Foundation Environmental Studies

G. Visual Resources/Aesthetic Quality

Sharon G. Province; J.D.

H. Socioeconomics

Alex Hinds; B.A. Applied Ecology; M.A. Urban Development, City of El Centro Planning Department

Sharon G. Province; J.D.

I. Land Use

Alex Hinds; B.A. Applied Ecology; M.A. Urban Development, City of El Centro Planning Department

Oliver Alvarado; B.A. Social Sciences; M.A. Urban Development, City of El Centro Planning Department

J. Energy Consumption

Peter B. Sherwood; P.E.; B.S. Mechanical Engineering

Allen M. Jones; M.S. Environmental Biology

9.1.4 Unavoidable Adverse Environmental Effects

Allen M. Jones; M.S. Environmental Biology

9.1.5 Alternatives to the Proposed Project

Allen M. Jones; M.S. Environmental Biology

9.1.6 Growth-Inducing Impacts

Allen M. Jones; M.S. Environmental Biology

Sharon G. Province; J.D.

9.1.7 Short-Term Uses vs. Long-Term Productivity

Allen M. Jones; M.S. Environmental Biology

9.1.8 Irreversible and Irretrievable Commitments of Resources

Allen M. Jones; M.S. Environmental Biology

9.2 CERTIFICATION

I hereby affirm that to the best of my knowledge and belief, the statements and information herein contained are in all respects true and correct, and that all known information concerning the potentially significant environmental effects of the project has been included and fully evaluated in this draft EIR.

Allen M. Jones
Principal Investigator

SECTION 10

REFERENCES CITED

- Alfors, J.T., J.L. Burnett, and T.E. Gay, Jr., 1973, Urban Geology - Master Plan for California, California Division of Mines and Geology, Bulletin 198.
- Biehler, S., 1971, "Gravity Studies in the Imperial Valley," Cooperative Geological - Geophysical - Geochemical Investigations of Geothermal Resources in the Imperial Valley of California, R.W. Rex, editor, University of California, Riverside.
- Boyd, James, 1978, Imperial County Department of Public Works, telephone conversation, August 11.
- Brook, C.A., R.H. Mariner, D.R. Mabey, J.R. Swanson, M. Guffanti, and C.J.P. Muffler, 1979, Hydrothermal Convection Systems with Reservoir Temperatures 90C: in, L.J.P. Muffler, editor, Assessment of Geothermal Resources of the United States, 1978, U.S. Geological Survey, Circular 790.
- Butler, Edgar and James Pick, 1976, "Public Attitudes Regarding Geothermal Development in Imperial County, California," Dry Lands Research Institute.
- California Air Resources Board, 1977, California Air Quality Data, "Summary of 1977 Air Quality Data," Vol. 1X, Annual Summary, Technical Services Division, Sacramento, California.
- California Department of Water Resources, 1970, Geothermal Wastes and the Water Resources of the Salton Sea Area, Bulletin 143-7.
- California Division of Mines and Geology, 1977, Mines and Mineral Resources, Imperial County, California, County Report Number 7.
- California Division of Oil and Gas, 1979, telephone conversation with Mr. Don Landy, July 18.
- California Economic Development Department, 1977, Imperial County Labor Market Bulletin, December.
- California Economic Development Department, 1978, Imperial County Labor Market Bulletin, September.
- California Energy Conservation and Development Commission, Geothermal Energy Office, 1979, telephone conversation with Mr. Edward Ennis, July 17.
- City of El Centro, 1978, Geothermal Energy Utility Core Field Experiment, Vol. 1 (Technical Proposal), July 14.
- City of El Centro Planning Department, 1978, Environmental Impact Report for the Amended General Plan, August.

- Crow, N.B., and P.W. Kasameyer, 1978, "Monitoring Natural Subsidence and Seismicity in the Imperial Valley as a Basis for Evaluating Potential Impacts of Geothermal Production," Geothermal Resources Council, Transactions, Vol. 2, pp. 125-128.
- Dibblee, T.W., 1954, Geology of the Imperial Valley Region, California, California Division of Mines, Bulletin 170, Chapter II, Part 2, pp. 21-82.
- Dutcher, L.C., W.F. Hardt, and W.R. Moyle, Jr., 1972, Preliminary Appraisal of Groundwater in Storage with Reference to Geothermal Resources in the Imperial Valley Area, California, U.S. Geological Survey, Circular 649.
- Elders, W.A., R.W. Rex, T. Meidav, P.T. Robinson, and S. Biehler, 1972, "Crustal Spreading in Southern California," Science, Vol. 178, pp. 15-24.
- Everden, J.R., 1970, "Study of Regional Seismicity and Associated Problems," Seismological Society of America, Bulletin 60, pp. 393-446.
- Garrett, B.D., Chevron Resources, Inc., 1978, personal communication, December 7.
- Green, Phyllis Strong and Maureen Farnan Steinberger, 1976, "Some Issues Regarding Regulatory Policy, Political Participation and Social Implications of Geothermal Resource Development in the Imperial Valley," University of California at Riverside, February.
- Greensfelder, R.W., 1974, Maximum Credible Rock Acceleration from Earthquakes in California, California Division of Mines and Geology, Map Sheet 23.
- Hardt, W.F., and J.J. French, 1976, "Selected Data on Water Wells, Geothermal Wells, and Oil Tests in Imperial Valley, California," U.S. Geological Survey Open File Report, Menlo Park, California, 251 pp.
- Helgeson, H.C., 1968, "Geologic and Thermodynamic Characteristics of the Salton Sea Geothermal System," American Journal of Science, Vol. 266, pp. 129-166.
- Hill, D., P. Mowinkel, and A. Lahr, 1975, "Catalog of Earthquakes in the Imperial Valley, California, June 1973 - May 1974," U.S. Geological Survey Open File Report, Washington, D.C.
- Housner, G.W., 1970, "Strong Ground Motion," Earthquake Engineering, Robert Wiegel, editor, pp. 75-92.
- Imperial County, 1971, "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial County," Public Works Department, May.
- Imperial County, 1973, Conservation Element of the Imperial County General Plan, Planning Department, December 18.
- Imperial County, 1974, Noise Element of the Imperial County General Plan, Planning Department, October 1.

- Imperial Irrigation District, 1977, "Annual Inventory of Areas Receiving Water" (mimeographed document).
- Lamar, D.C., T.M. Merrifield, and R.J. Proctor, 1973, "Earthquake Recurrence Intervals on Major Faults in Southern California," Geology, Seismicity and Environmental Impact, Association of Engineering Geologists, Special Publication, October.
- Loeltz, O.J., B. Irelan, J.H. Robison, and F.H. Olmsted, 1975, Geohydrologic Reconnaissance of the Imperial Valley, California, U.S. Geological Survey, Professional Paper 486-K.
- Medina, Rudy, 1978, Chief, Imperial County Fire Department, telephone conversation, August 11.
- MSA, Inc., 1978, Sandalwood Park Tentative Map for Development and Annexation to the City of El Centro, Final Environmental Impact Report, prepared for the City of El Centro, California.
- San Diego Gas & Electric Company, 1976, Final Report, Environmental Baseline Data Acquisition, Geothermal Environmental Studies, Heber Region, Imperial Valley, California, prepared for Electric Power Research Institute.
- Seed, H.D., I.M. Idriss, and F.W. Kufer, 1968, "Characteristics of Rock Motions during Earthquakes," Report Number EERC 68-5, Earthquake Engineering Research Center, University of California, Berkeley.
- Structural Engineers Association of California, 1975, Recommended Lateral Form Requirements and Commentary, 21 pages plus commentary (84 pages), plus appendices, SEAOC of Northern California, San Francisco.
- Uniform Building Code, 1976.
- Urbans Innovations Group, 1978, Amended General Plan, El Centro, California, August.
- U.S. Department of Commerce, 1972a, 1970 Census of Population, Characteristics of the Population: Sections 1 and 2, Bureau of the Census, April.
- U.S. Department of Commerce, 1972b, 1970 Census of Population, General Housing Characteristics: California, Bureau of the Census, April.
- U.S. Department of Commerce, 1972c, 1970 Census of Population, General Social and Economic Characteristics: California, Bureau of the Census, April.
- U.S. Department of Commerce, 1977, Special Census, Bureau of the Census.
- U.S. Department of Energy, 1978, Environmental Assessment, Westmorland Development Project, Imperial County, California, June.
- Von Werlhof, J., and S. von Werlhof, 1979, "Archaeological Examinations of a Proposed Geothermal Test Well in El Centro," Imperial Valley College Museum, January 2.

VTN Consolidated, Inc., 1978, Heber Geothermal Demonstration Project, Final Environmental Impact Report, prepared for the Imperial County Planning Department, March.

WESTEC Services, Inc., 1978, South Westmorland Geothermal Exploration Project, Draft Environmental Impact Report, prepared for the Imperial County Planning Department, October.

WESTEC Services, Inc., 1979, North Brawley Ten Megawatt Demonstration Facility, Draft Environmental Impact Report, prepared for the Imperial County Planning Department, January.

APPENDIX A
EL CENTRO GEOTHERMAL UTILITY CORE FIELD EXPERIMENT
PROJECT CLIMATE AND AIR QUALITY STUDY

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1	INTRODUCTION	A-1
2	DESCRIPTION OF EXISTING METEOROLOGY AND CLIMATOLOGY	A-1
2.1	General Climate	A-1
2.2	Temperature, Humidity, and Precipitation	A-2
2.3	Winds	A-3
2.4	Vertical Stability and Inversions	A-6
3	AIR QUALITY	A-8
3.1	Air Quality Standards and Rules	A-8
3.2	Air Quality Effects	A-10
3.3	Pollutant Emissions Inventory	A-11
3.4	Ambient Air Quality	A-14
4	AIR QUALITY IMPACT OF THE PROPOSED PROJECT	A-17
4.1	Field Experiment Emissions Sources	A-17
4.1.1	Site Preparation and Well Drilling Emissions Sources	A-19
4.1.2	Well Testing Emissions Sources	A-19
4.2	Project Emissions	A-20
4.2.1	Well Site Preparation Emissions	A-20
4.2.2	Well Drilling Emissions	A-21
4.2.3	Well Testing Emissions	A-22
4.2.4	Operational Emissions	A-22
4.3	Ambient Air Quality Impacts	A-22
5	MITIGATION	A-25
6	REFERENCES	A-27

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

<u>Number</u>	<u>Title</u>	<u>Page</u>
2-1	El Centro 1945-1960 Wind Directional Frequency Distribution (Wind Rose)	A-5
3-1	Imperial County Total Organic Gas Emission Projections Through 1997	A-15

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
2-1	Representative Climatic Parameters in El Centro, California A-4	
2-2	Annual Occurrence Frequencies for Six Stability Classes, El Centro, California, 1954-1958	A-7
3-1	Ambient Air Quality Standards Applicable in California A-9	
3-2	Imperial County Emissions Inventory (tons/day)	A-12
3-3	El Centro Monthly Air Quality Summary, 1976, and Annual Summary, 1977	A-16
3-4	Imperial County Total Suspended Particulate Summary, 1977	A-18
4-1	H ₂ S Concentrations and Distance of Maximum Ground-Level Impact from Flow Testing for Typical Atmospheric Conditions	A-24
5-1	El Centro Project Pollutant "Savings" (tons/year)	A-26

APPENDIX A

EL CENTRO GEOTHERMAL UTILITY CORE FIELD EXPERIMENT PROJECT CLIMATE AND AIR QUALITY STUDY

1.0 INTRODUCTION

The City of El Centro is proposing the development of a geothermal utility core field experiment to demonstrate the feasibility of utilizing moderate temperature geothermal heat for space heating, space cooling, and domestic hot water.

The proposed El Centro Community Center project provides an innovative application of energy extraction from geothermal brines for space conditioning in an environment given to large oscillations of ambient temperature. If this project can be demonstrated to be technologically and economically feasible, it may assist in a larger scale commercial exploitation of the resource at considerable energy savings for the region.

This air quality study assesses the air pollution impact of the proposed geothermal field experiment. Since the project involves a closed loop system with minimal release of materials into the atmosphere, much of the impact is expected to be temporary during well development, with little ongoing atmospheric impact during normal project operations. Periodic maintenance and minor cooling tower emissions constitute possible future impacts, but the major concern will be the potential for adverse impact to residents within several hundred feet of the well drilling site. If pollutant levels during drilling can be shown to be slight, the overall project impact will thus be within acceptable limits.

2.0 DESCRIPTION OF EXISTING METEOROLOGY AND CLIMATOLOGY

2.1 General Climate

The El Centro area of Imperial Valley is situated in a broad, V-shaped depression that forms the Mexicali, Imperial and Coachella Valleys. Along both sides of

the valley mountains restrict the free passage of air from other airsheds. Except for San Geronio Pass, which allows for the concentrated intrusion of air from the populated coastal area, the exchange of maritime and desert interior air is quite diffuse. The effective screening by topographical barriers and the fair skies due to the semi-permanent, subtropical high pressure center over the Pacific Ocean maintains high temperatures, low humidities and limited precipitation. The protective terrain barrier and vigorous daytime mixing also combine to give the lower desert good air quality. Except for dust from agricultural operations and lack of desert soil moisture, Imperial County has some of the "cleanest" air in the state.

2.2 Temperature, Humidity and Precipitation

Strong heating by day and nighttime radiative losses under clear, dry skies create large diurnal temperature oscillations of 30F (17C) or more. Seasonal variations between the mean winter minimum temperature of 38F (3C) and the mean summer maximum of 108F (42C) are similarly pronounced. Summer temperatures above 90F (32C) occur almost every day from July through September; subfreezing temperatures in winter, however, occur only infrequently.

Humidities are low throughout the year with a maximum of about 50 percent relative humidity in winter. June is the driest month with a slight increase during the hottest weather as slightly moister air from the Gulf of California enters Imperial County in July and August.

Precipitation is extremely low around El Centro. Very brief periods of precipitation in conjunction with weak winter storm systems and similarly weak summer convective thunderstorms supply about 2 to 3 in (5 to 7.6 cm) of rain each year. A few storms, especially in conjunction with tropical storms moving inland across Baja California in early fall, may create flash floods and cause extensive property damage and threaten lives.

Data from two weather stations near the proposed project (see Table 2-1) indicate the climatic homogeneity of the area and the annual distribution of climatic variables in the very pronounced desert climate around El Centro.

2.3 Winds

Winds, which control horizontal transport, and thermal stability, which governs vertical dispersion, are the critical factors in relating project-related emissions to ambient air quality. In general, both factors are conducive to good ventilation in the Imperial Valley.

Winds around El Centro, which affect both the initial rate of dilution of project effluents and their ultimate transport away from the area, are usually fairly brisk and thus prevent much localized pollution buildup. The deep vertical convection cells and complex terrain surrounding the valley lead to average speeds of 7 to 10 mph (11 to 16 kph) that carry emissions rapidly away from any pollutant sources. At night, winds become light and allow for temporary stagnation, but winds the following day are usually sufficient to preclude any day-to-day carryover effects.

Figure 2-1 shows the directional wind distribution at the El Centro Airport (Imperial County Airfield). Over half of the wind directions are confined to a 90 degree sector centered on winds from the west. A secondary directional maximum develops during the summer as a unique "sea breeze" is drawn in from the Gulf of California by the low pressure trough that develops over the hot interior of the desert. Typically, any emissions generated by the proposed development would be carried eastward out of El Centro and ultimately dispersed in the deep convective cells induced by solar heating. Given the normally strong winds and good mixing, Imperial County offers an excellent potential for favorable atmospheric dispersion that would minimize any possible adverse air quality effects of geothermal development.

Table 2-1

REPRESENTATIVE CLIMATIC PARAMETERS IN EL CENTRO, CALIFORNIA

	ABS. MAX. TEMP. (°F)	MEAN MAX. TEMP. (°F)	MEAN MIN. TEMP. (°F)	ABS. MIN. TEMP. (°F)	MEAN DAYS T > 90°F (DAYS)	MEAN DAYS T < 32°F (DAYS)	MEAN REL. HUM. (%)	MEAN PRECIP. (IN.)	MEAN DAYS PRECIP. ≥ 0.1" (DAYS)	MEAN NO. DAYS THUNDERSTORM (DAYS)
EL CENTRO NAVAL AUXILIARY FIELD, EL CENTRO, ELEV = -43'										
JAN	86	68	43	25	0.0	1.8	52	0.46	1.2	0.0
FEB	93	73	47	29	0.2	0.4	44	0.10	0.2	0.0
MAR	95	77	51	34	1.4	0.0	39	0.13	0.4	0.1
APR	104	86	58	44	10.9	0.0	36	0.08	0.3	0.2
MAY	115	93	64	49	20.8	0.0	31	0.01	0.1	0.2
JUN	119	101	71	52	28.3	0.0	28	0.04	0.1	0.2
JUL	119	107	79	62	30.8	0.0	37	0.09	0.4	0.7
AUG	119	106	78	61	30.5	0.0	38	0.37	0.6	1.6
SEP	120	103	74	57	29.4	0.0	32	0.01	0.0	0.4
OCT	108	91	63	44	19.9	0.0	35	0.34	0.7	0.6
NOV	94	78	50	32	1.4	0.1	39	0.11	0.3	0.0
DEC	88	70	44	29	0.0	0.6	45	0.08	0.3	0.0
ANNUAL:	120	88	60	25	173.6	2.9	38	1.82	4.6	4.0
IMPERIAL COUNTY AIRFIELD, EL CENTRO, ELEV = -56'										
JAN	86	69	38	16	0.0	5.0	52	0.41	1.5	0.0
FEB	90	73	42	23	1.0	3.0	44	0.33	1.3	0.0
MAR	102	80	47	29	2.0	0.3	39	0.20	0.5	0.1
APR	109	88	53	33	13.0	0.0	36	0.09	0.1	0.2
MAY	116	96	60	36	24.0	0.0	31	0.00	0.0	0.2
JUN	121	104	67	47	29.0	0.0	28	0.01	0.1	0.2
JUL	122	109	75	52	31.0	0.0	37	0.10	0.5	0.7
AUG	122	107	75	54	31.0	0.0	38	0.37	1.1	1.6
SEP	120	104	69	49	30.0	0.0	32	0.25	1.3	0.4
OCT	112	92	58	39	21.0	0.0	35	0.26	1.3	0.6
NOV	95	79	45	24	1.0	1.0	39	0.09	1.0	0.0
DEC	94	71	40	23	0.3	6.0	45	0.46	1.6	0.0
ANNUAL:	122	89	56	16	183.3	15.3	38	2.57	10.5	4.0

Source: U.S. Naval Weather Service

Source: California Department of Water Resources (1978)

El Centro 1945-1960 Wind Directional Frequency
Distribution (Wind Rose).

FIGURE
2-1

2.4 Vertical Stability and Inversions

Temperatures normally decrease with height. Since rising parcels of polluted air from the surface also cool as they expand, the temperature difference between the rising parcels and the ambient air will determine the buoyancy, if any, of the parcel. If the source on the ground is quite hot, then the mixing is extensive. If, however, temperatures decrease slowly with height or even increase (a temperature inversion), then polluted air sinks back down toward its source and remains trapped.

Only limited measurements of thermal structure have been routinely made in the area. They have shown that shallow surface inversions within 500 feet of the ground are common on desert nights, but that the inversions formed by subsiding air in the high pressure cell over the ocean rarely occur in Imperial County. When these inversions are present, they form at 6000 to 8000 ft (1830 to 2440 m) and do not adversely restrict local dispersion patterns.

One may infer the distribution of vertical stability from surface weather observations based on sunshine, clouds, wind and weather as indicators of mixing potential. El Centro's meteorological data has been analyzed and stratified according to a discrete set (6) of conditions known as Pasquill-Gifford stability classes. Results of this analysis performed by the STability ARray (STAR) computer program are seen in Table 2-2. Although this method often underestimates the frequency of extremes (extremely stable or unstable) in favor of more neutral conditions, Table 2-2 still shows that there is a high frequency of stable and unstable conditions. By day, the atmosphere is quite unstable. At night, it passes rapidly through a transitional phase and soon becomes stabilized. Maximum impact of any project-related low level sources would thus occur on winter nights; a corresponding minimum impact would occur on summer afternoons.

Table 2-2

ANNUAL OCCURRENCE--FREQUENCIES FOR SIX STABILITY
CLASSES, EL CENTRO, CALIFORNIA--1954-1958

<u>Stability Class</u>	<u>Atmospheric Condition</u>	<u>Frequency of Occurrence - %</u>
A	Extremely Unstable	3.73
B	Unstable	14.42
C	Slightly Unstable	13.72
D	Neutral	10.49
E	Slightly Stable	15.92
F	Stable	41.72
TOTAL:		100.00

Source: U.S. Department of Commerce (1975).

3.0 AIR QUALITY

3.1 Air Quality Standards and Rules

In order to assess the air quality impact of any proposed development, that impact, together with the existing baseline air quality levels, must be related to the applicable ambient air quality standard (AAQS). AAQS are an outgrowth of the Federal Clean Air Act Amendments of 1970. Standards were promulgated at levels that minimize the risk of exposure of that segment of the population most susceptible to respiratory distress (sensitive receptors). Federal standards were established to protect the public health (primary standards), and to protect the public welfare (secondary standards) from any known or potentially adverse effects of air pollution. National AAQS were developed for six pollution species, generally known as "criteria pollutants," with each state retaining the option of establishing their own standards as long as the most stringent set of standards was enforced. California had adopted a number of standards even before national AAQS were legislated, thus some diversity in pollutant species, concentration, and averaging times exists between Federal and State standards. AAQS at both the Federal and State levels are continuously under review for modification as new information is developed. The Clean Air Act Amendments of 1977 require consideration of a federal short-term standard for nitrogen dioxide similar to California's, and the Administrator of the U.S. Environmental Protection Agency (EPA) is considering changing the Federal oxidant standard equivalent to the California standard as well. The standards for the criteria pollutants — photochemical oxidants, carbon monoxide, nitrogen dioxide, sulfur dioxide, non-methane hydrocarbons, and total suspended particulates — and the additional California requirements are given in Table 3-1.

TABLE 3-1
**AMBIENT AIR QUALITY STANDARDS
 APPLICABLE IN CALIFORNIA**

Pollutant	Averaging Time	California Standards	Federal Standards	
		Concentration	Primary	Secondary
Photochemical Oxidants (Measured as Ozone)	1 Hour	0.10 ppm (200 $\mu\text{g}/\text{m}^3$)	160 $\mu\text{g}/\text{m}^3$ (0.08 ppm) *	Same as Primary Standard
Carbon Monoxide	12 Hours	10 ppm (11 mg/m^3)	---	Same as Primary Standard
	8 Hours	---	10 mg/m^3 (9 ppm)	
	1 Hour	40 ppm (46 mg/m^3)	40 mg/m^3 (35 ppm)	
Nitrogen Dioxide	Annual Average	---	100 $\mu\text{g}/\text{m}^3$ (0.05 ppm)	Same as Primary Standard
	1 Hour	0.25 ppm (470 $\mu\text{g}/\text{m}^3$)	---	---
Sulfur Dioxide	Annual Average	---	80 $\mu\text{g}/\text{m}^3$ (0.03 ppm)	---
	24 Hours	0.05 ppm in comb. w/ 0.10 ppm Ox or 100 $\mu\text{g}/\text{m}^3$ TSP	365 $\mu\text{g}/\text{m}^3$ (0.14 ppm)	---
	3 Hours	---	---	1300 $\mu\text{g}/\text{m}^3$ (0.5 ppm)
	1 Hour	0.5 ppm (1310 $\mu\text{g}/\text{m}^3$)	---	---
Suspended Particulate Matter	Annual Geo-metric Mean	60 $\mu\text{g}/\text{m}^3$	75 $\mu\text{g}/\text{m}^3$	60 $\mu\text{g}/\text{m}^3$
	24 Hours	100 $\mu\text{g}/\text{m}^3$	260 $\mu\text{g}/\text{m}^3$	150 $\mu\text{g}/\text{m}^3$
Lead (Particulate)	30-Day Average	1.5 $\mu\text{g}/\text{m}^3$	---	---
Hydrogen Sulfide	1 Hour	0.03 ppm (42 $\mu\text{g}/\text{m}^3$)	---	---
Hydrocarbons (Corrected for Methane)	3 Hours (6-9 a.m.)	---	160 $\mu\text{g}/\text{m}^3$ (0.24 ppm)	Same as Primary Standard
Ethylene	8 Hours	0.1 ppm	---	---
	1 Hour	0.5 ppm	---	---
Visibility-Reducing Particles	1 observation	In sufficient amount to reduce the prevailing visibility to 10 miles when the relative humidity is less than 70%	---	---
Sulfate (Particulate)	24 Hours	25 $\mu\text{g}/\text{m}^3$	---	---

ppm - parts per million

pptm - parts per ten million

pphm - parts per hundred million

$\mu\text{g}/\text{m}^3$ - micrograms per cubic meter

*Currently proposed by EPA to be increased by 50 percent to 0.12 ppm.

Of particular interest for geothermal development is the California state standard for H_2S . Considerable controversy surrounds this criteria because it is a one-hour standard, whereas adverse health effects are usually not anticipated until thirty times higher concentrations are reached at eight hours of exposure (California Administrative Code). Odor nuisance, on the other hand, can occur at instantaneous concentrations even below the 0.03 ppm standard, such that many agencies feel the present standard is too high and should be lowered to perhaps 0.02 ppm. A common experience in the Geysers area of northern California is that numerous odor complaints are received by the Air Pollution Control District (APCD), but the monitoring station nearby records no violation of the standard. The AAQS thus represents a definite target for judging the air quality with regard to H_2S , but the standard does not necessarily represent either a health hazard or a nuisance level.

3.2 Air Quality Effects

In order to judge the relationship of an additional pollutant burden on Imperial County air quality, the incremental impact needs to be weighed against the adverse effects it may cause. The general source and impact characteristics of EPA's six criteria pollutants are briefly summarized as follows:

- Photochemical Oxidants (Ozone): Oxidants are formed by a complex series of atmospheric chemical reactions which involve reactive hydrocarbons and oxides of nitrogen under the influence of sunlight. Oxidant standards are designed to prevent impairment of pulmonary function and to prevent vegetative damage to sensitive species.
- Carbon Monoxide: Carbon monoxide is a colorless, odorless, tasteless gas formed as a byproduct of incomplete combustion. Carbon monoxide standards are designed to prevent interference with the oxygen transport capacity of hemoglobin in the blood.

- Nitrogen Dioxide: Nitrogen dioxide is formed during combustion at very high temperatures. Emissions are mostly nitric oxide (NO), which oxidize to the dioxide (NO₂) in the atmosphere. Nitrogen dioxide standards are designed to prevent respiratory disease, vegetative damage, and atmospheric discoloration due to the rust-colored hue of the pollutant.
- Sulfur Dioxide: Sulfur dioxide is formed mainly by the combustion of fossil fuels containing sulfur. Sulfur dioxide causes pulmonary irritation, vegetative damage, and odor nuisance, and can oxidize to sulfate (SO₄) as sulfuric acid mist or sulfate salts, with their own additional ecological impacts.
- Non-methane Hydrocarbons Atmospheric hydrocarbons are produced through evaporation and incomplete combustion of organic materials, as well as from natural sources. Although hydrocarbon standards are designed for ozone control, hydrocarbons such as the photochemically produced peroxy-acetyl-nitrate-PAN (similar to tear gas) or vinyl chloride (a carcinogen) may have their own adverse impact.
- Total Suspended Particulates Ninety percent of all particulates are naturally produced, except in urban or industrial centers where that ratio may be reversed. Particulate standards are designed to minimize health effects due to prolonged exposure and to maintain suitable visibility.

3.3 Pollutant Emissions Inventory

A comprehensive and accurate compilation of present County emissions levels and future projections is an important element in gauging project impact. By comparing expected project emissions with existing levels, the incremental contribution to the County burden can be derived. Since it is generally assumed that ambient air quality is directly proportional to the emissions level, then by inference the general magnitude of project impact can be determined, at least in a regional sense.

Table 3-2 represents the pollutant emissions inventory prepared by the Imperial County APCD staff for 1975. By way of comparison, the California Air

Table 3-2

IMPERIAL COUNTY EMISSIONS INVENTORY (tons/day)

	TOG	ROG	PART	NO _x	SO ₂	CO
<u>Stationary Sources:</u>						
Petroleum Activities		0.3				
Organic Solvent Uses		0.1				
Chemical Processes						
Metallurgical Processes						
Mineral Processes			0.7			
Incineration		1.9	0.8	0.5		4.6
Combustion of Fuels		0.2	0.1	4.5	0.1	0.2
Agricultural Operations		<u>4.4</u>	<u>7.5</u>	<u>1.6</u>		<u>4.4</u>
TOTAL STATIONARY SOURCES:		6.9	9.1	6.6	0.1	9.2
<u>Mobile Sources:</u>						
Motor Vehicles		20.5	0.9	3.2	0.1	105.6
Aircraft		1.3		0.3		5.0
Ships and Railroads		<u>0.4</u>	<u>0.2</u>	<u>0.5</u>	<u>0.1</u>	<u>1.1</u>
TOTAL MOBILE SOURCES:		22.2	1.1	9.0	0.2	111.7
GRAND TOTAL:		29.1	10.2	15.6	0.3	120.9
ARB 1973 ESTIMATE:	24.2	19.3	50.1*	28.9	3.2	102.0
LOS ANGELES COUNTY:	517.1	491.1	91.1	728.2	53.8	4637.6

*Includes 30.0 tons due to Farming Operations (tilling, etc.)
not included in the Imperial County APCD estimates.

TOG - total organic gases	NO _x - oxides of nitrogen
ROG - reactive organic gases	SO ₂ - sulfur dioxide
PART - total suspended particulates	CO - carbon monoxide

Source: Imperial County
APCD (1978).

Resources Board 1973 Imperial County estimates and the 1975 Los Angeles County levels are also presented.

Several aspects of Imperial County emissions are readily apparent. Compared to a densely populated and highly industrialized area such as Los Angeles, Imperial County is relatively pristine. The only significant stationary pollution source is agricultural activity, which contributes about three-fourths of the particulate burden. If emissions from tilling, use of unpaved roads, and arid land wind erosion are included, particulates represent one of the major pollution sources in the County. Mobile sources, even in an area of light motor vehicle activity, are the dominant pollution source in the emissions inventory. Although they are only two to three percent of the Los Angeles levels, they nevertheless still dominate every pollution category. Since Imperial County may be very sensitive to additional oxides of nitrogen emissions as part of the ozone formation process, control of vehicular emissions as a strategy to minimize ozone production is an important element of the County air quality maintenance plan.

One interesting element of Table 3-2 is the lack of agreement between the County and ARB inventories. Although they are calculated for two separate years, the great disparity between them attests to the shortcomings in inventory methodology. Given the importance of accurate inventory data, these differences point out the difficulties in developing good pollution abatement strategies if the baseline is potentially uncertain by perhaps a factor or two. Since the APCD values are for a later year and the APCD staff may be assumed to be closer to the County pollution picture, their estimates are probably more correct, but they undoubtedly include substantial uncertainty and should be considered best estimates, rather than definitive values.

A final consideration of the relationship between the project-related emissions and the countywide pollutant burden is that the existing levels will change as a function

of time. These changes will come about for a number of reasons. Technological improvements, air quality management strategies, application of best available control technology, and new source review will contribute to future emissions reductions. Conversely, future Imperial County growth in agriculture, industry, recreation, or retirement will offset emissions reductions. Figure 3-1 demonstrates that the improvements in the next few years will be balanced by continued County growth, such that the total emissions level will become relatively stagnant by the mid-1980s. Figure 3-1 is only for total organic gases as a strategy for ozone control, but the other primary pollutant species have similar profiles. Particulates, in conjunction with further intensive agricultural operations, are even predicted to increase. Based on County emissions projections, the relative magnitude of the El Centro project will thus remain unchanged in the next several decades, as no dramatic changes in the total regional pollutant burden are forecast to occur.

3.4 Ambient Air Quality

Despite the potential for degraded air quality recognized in the meteorological baseline discussion, the air quality of Imperial County is quite good. With a sparse population and only nominal industrial development, the principal pollution source is agricultural operations. The dry, windy climate, combined with extensive tilling of the soil, creates a particulate problem throughout the entire year. Except for total suspended particulates, other air quality parameters are usually at or below applicable standards.

Table 3-3 summarizes 1976 El Centro air quality as an indicator of general Imperial Valley conditions. As noted, particulates exceed the 24-hour California standard by a factor of three or four, but the other pollutants are below state standards. Ozone and lead may approach their respective AAQS, but only particulates

SOURCE: IMPERIAL COUNTY APCD 1978

Imperial County Total Organic Gas Emission Projections Through 1997.

FIGURE
3-1

Table 3-3

EL CENTRO MONTHLY AIR QUALITY SUMMARY, 1976,
AND ANNUAL SUMMARY, 1977

(Maximum Monthly Values for Given Averaging Times)

<u>Pollutant</u>	<u>OZONE</u>	<u>SULFUR DIOXIDE</u>	<u>TOTAL SUSPENDED PARTICULATES</u>	<u>ATMOSPHERIC LEAD</u>
<u>State Standards</u>	<u>.10 ppm - 1 HR</u>	<u>.50 ppm - 1 HR</u>	<u>100 $\mu\text{g}/\text{m}^3$ - 24 HRS</u>	<u>1.5 $\mu\text{g}/\text{m}^3$ - 30 DAY AVG</u>
January	0.03	0.01	178	0.77
February	0.08	0.02	260	1.02
March	0.06	0.02	372	0.49
April	0.03	0.02	156	0.56
May	0.04	0.02	393	0.39
June	0.05	0.02	193	0.33
July	0.06	0.02	271	0.32
August	0.08	0.02	155	0.31
September	0.06	—	161	0.46
October	0.07	—	151	0.35
November	0.05	0.09	207	0.80
December	0.05	0.05	124	0.85
1976 ANNUAL MAXIMA:	0.08	0.09	393	1.02
1977 ANNUAL MAXIMA:	0.09	0.09	328	1.06

Source: California Air Resources Board (1976).

give any indication of serious exceedances. The recently released annual summary for 1977 shows very similar values to 1976; it may then be assumed that the monthly breakdowns in Table 3-3 are representative of most years.

The pervasiveness of the regional particulate problem is also evidenced in a comparison of El Centro with Brawley and Calexico particulate measurements performed by the Imperial County APCD, as seen in Table 3-4. By comparison, in 1977 El Centro was "cleaner" than either of the other two monitoring sites. Both in terms of total suspended particulate levels and frequencies of AAQS exceedances, the slightly more urbanized area of El Centro has better particulate air quality than more rural areas to the north or south. Except for high particulate levels, which are more or less an accepted aspect of desert living, El Centro air quality may be judged to be extremely healthy.

4.0 AIR QUALITY IMPACT OF THE PROPOSED PROJECT

4.1 Field Experiment Emissions Sources

Emissions from the proposed geothermal field experiment will be confined mainly to the exploration/construction/drilling phase of the project rather than from operational conditions. Since the completed system is a closed cycle, operational emissions will result only from maintenance or breakdown. An air quality assessment of the project thus must focus on the temporary construction emissions with their attendant short-term impacts.

Pre-operational phase pollutant sources consist of both gaseous and particulate material. While the small amounts of gaseous pollutants can be readily dispersed by the favorable local dispersion conditions, the sensitivity of the area to additional particulate sources requires careful attention. A second constraining factor is the proximity

Table 3-4

IMPERIAL COUNTY TOTAL SUSPENDED PARTICULATE SUMMARY--1977
 (Average Monthly 24-Hour Readings, $\mu\text{g}/\text{m}^3$)

<u>MONTH</u>	<u>BRAWLEY</u>	<u>CALEXICO</u>	<u>EL CENTRO</u>
January	306	310	112
February	225	215	87
March	201	266	99
April	167	184	114
May	108	172	82
June	204	227	139
July	223	212	195
August	141	149	135
September	168	188	185
October	144	188	133
November	152	186	148
December	185	187	160
Monthly Maxima	306	310	195

Source: Imperial County APCD (1978)

of the nearby houses to the drilling and well testing activities that may be adversely impacted.

4.1.1 Site Preparation and Well Drilling Emissions Sources

Before drilling the wells for brine production and reinjection, the well site will require initial preparation. This disturbance of the soil not only generates fugitive dust from earthmoving activities such as excavation of the drilling sump, but also leaves the earth susceptible to further erosion by lowering the wind threshold for soil movement until the soil becomes restabilized.

During drilling, emissions from the diesel drives on the drilling equipment will release combustion emissions (principally oxides of nitrogen and carbon monoxide) that may again create locally significant pollutant concentrations at adjoining residences. Additional minor vehicular emissions from drilling crew traffic will also be added to the local airstream. If there is a high level of H_2S encountered during drilling, small amounts may occasionally escape with the drilling mud or cuttings, but neither the nature of the resource nor normal drilling procedures present much potential for problems during actual drilling.

4.1.2 Well Testing Emissions Sources

By far the most probable adverse impact of the El Centro geothermal project will occur during well testing and periodic cleanouts. When the brine is flashed at atmospheric pressure, a portion of the liquid vaporizes and will be carried away by the wind. If the wind direction is toward local residences and plume buoyancy is relatively small (with minimum initial plume rise), then any noncondensables such as H_2S may be noted in significant concentration at nearby locations.

During operation of the heating/cooling system, the only release to the atmosphere will be from small amounts of drift in the cooling tower or during

temporary upset or scheduled maintenance conditions. Once the amount of H_2S in the El Centro steam has been determined during initial testing, the impact of future well venting may be better quantified. Since the timing of maintenance is somewhat discretionary, the work could be performed under conditions most likely to minimize the impact on nearby residences.

4.2 Project Emissions

4.2.1 Well Site Preparation Emissions

Although emission factors from earthmoving operations are very imprecise, such emissions can be roughly estimated from EPA's "standard" emission factor of 1.2 tons of dust/ac/mo of activity. Assuming that 2 ac (0.8 ha) of the 2.5 ac (1 ha) plot are disturbed, grading and sump excavation totals 2 weeks and that application of water spray reduces the dust level by 50 percent, then 1200 pounds of dust may be released during well site preparation. Much of this dust will be of sufficiently large particle sizes to settle out near the project site. Given the prevailing westerly breezes during much of the year, a portion of this dust will settle out on the Southern Paper and Supply property across First Street or on the seed crops along First Street between the Pacific Telephone and Dessert Seed Company yards. This dust may also cause a temporary nuisance at the two residences nearest the well site by settling on cars or laundry.

Operation of heavy-duty diesel equipment will also release combustion emissions into the local airstream. Assuming 40 hours each of a scraper and bulldozer are required to clear the site, dig the sump, and grade the property for drainage into the sump, the resulting emissions will be as follows:

Carbon monoxide:	1.0 lb/hr = 80 lbs total
Hydrocarbons:	0.4 lb/hr = 33 lbs total
Oxides of Nitrogen:	4.3 lb/hr = 345 lbs total

Oxides of Sulfur: 0.3 lb/hr = 26 lbs total

Particulates: 0.3 lb/hr = 23 lbs total

4.2.2 Well Drilling Emissions

Once the drill rig is in place and drilling operations commence, the major emissions will result from the diesel drives that run 24 hours/day. Based on an estimated fuel consumption of 550 gallons of diesel fuel per day and 30 days to drill the production well and 10 days to drill the reinjection well, the drilling emissions from the diesel drives can be calculated as shown below:

Carbon Monoxide: 56 lb/day = 2,240 lbs total

Hydrocarbons: 21 lb/day = 840 lbs total

Oxides of Nitrogen: 258 lb/day = 10,320 lbs total

Oxides of Sulfur: 17 lb/day = 680 lbs total

Particulates: 18 lb/day = 720 lbs total

Delivery trucks, drilling crew commuting and other traffic will also generate combustion emissions. Based on 1980 vehicular emission factors and an average daily trip generation of 600 vehicle miles, the corresponding emissions are estimated as follows:

Carbon Monoxide: 41.8 lb/day = 1671 lbs total

Hydrocarbons: 5.3 lb/day = 213 lbs total

Oxides of Nitrogen: 4.3 lb/day = 172 lbs total

Drift losses from the drilling mud cooling tower and additional disturbance of the unpaved soil during drilling will generate an additional particulate burden in the area. Evaporated salt particles from the cooling tower are negligible, but the fugitive dust from continued traffic (vehicular and foot) will continue to periodically raise dust sufficiently to constitute a minor nuisance on nearby objects such as parked vehicles or vegetation.

4.2.3 Well Testing Emissions

Hydrogen sulfide (H_2S) emissions, the primary concern during the flow testing phase once the production well is completed, are expected to be minimal because H_2S levels in the Heber KGRA are usually very low. Chevron's work in the Heber area has shown that H_2S averages 0.18 ppm by weight of the total brine fluids. At a maximum supply rate of 365,000 lbs of fluid per hour, the resulting maximum H_2S release is 0.066 lb/hour, or 1.6 lbs of H_2S per day. The proposed supply rate is only 49,920 lbs of fluid per hour, however, corresponding to 0.22 lb of H_2S per day. Although the H_2S emission rate is quite low, the very low odor threshold of H_2S might nevertheless adversely impact nearby receptor sites.

4.2.4 Operational Emissions

Except for potential losses of lithium bromide from the absorption chiller unit or H_2S releases through emergency brine vents during accident or upset conditions, the only operational emissions with an atmospheric pathway is from the cooling tower. Assuming 1000 gal (3780 l) of water is circulated in the tower each minute, the blowdown concentration is 4000 ppm and the drift loss rate is 0.02 percent, the resultant particulate emissions from the cooling tower is 0.384 lb per hour. This total is negligible compared to the evaporated salt crystals injected into the Imperial County atmosphere by spray irrigation. Thus, after the project construction and testing is completed, there should be no noticeable air quality impact from the proposed experiment.

4.3 Ambient Air Quality Impacts

Given the diverse distribution of project-related pollutants in space and time and their relatively nominal ratio to existing Countywide emission levels, it is very difficult to translate these emissions into an associated air quality impact. The very

rough estimates of several sets of emission factors further complicates any direct quantification of ambient air quality impact.

The one concern that lends itself to better source/receptor characterization is the diffusion of H_2S during well testing. Although neither the H_2S content of the noncondensable fraction of the flashed fluid nor the plume geometry are well defined, realistic assumptions of these parameters allow modeling of the downwind concentrations somewhat accurately. By applying the Gaussian diffusion equation, viz.,

$$X = \frac{Q}{\pi \sigma_y \sigma_z u} \exp -\frac{1}{2} \frac{H^2}{\sigma_z^2}$$

where X is the downwind concentration,

Q is the source strength,

$\sigma_y \sigma_z$ are the dispersion parameters describing the Gaussian concentration profile "half-width",

u is the mean wind speed,

and H is the height of plume rise,

to a family of windspeed, plume rise and atmospheric stability conditions, the spectrum of impacts can be determined. If one assumes that the sigma values as a function of downwind distance (X) can be expressed as follows:

$$\sigma_z = a x^b, \sigma_y = c x^d$$

then one may also compute at what distance from the source the maximum concentration will be found. The downwind distance of maximum concentration (X_{max}) is given by

$$X_{max} = \frac{b H^2}{a^2 (d + b)} \cdot \frac{1}{2} b$$

For wind conditions of 3, 1.5 and 1 m/sec corresponding to day, transitional and night conditions and plume rise estimates of 10, 20 and 30 m for the above winds, the distance of maximum concentration and the concentration at that location are shown in Table 4-1. Compared to a standard of 30 ppb, the maximum ground level concentration

Table 4-1

**H₂S CONCENTRATIONS AND DISTANCE OF MAXIMUM GROUND-LEVEL IMPACT
FROM FLOW TESTING FOR TYPICAL ATMOSPHERIC CONDITIONS**

STABILITY CLASS	DAYTIME $U^1 = 3 \text{ m/sec}$ $H^2 = 10 \text{ m}$		TRANSITIONAL $U^1 = 1.5 \text{ m/sec}$ $H^2 = 20 \text{ m}$		NIGHTTIME $U^1 = 1 \text{ m/sec}$ $H^2 = 30 \text{ m}$	
	DISTANCE (m)	MAXIMUM CONCENTRATION (ppb)	DISTANCE (m)	MAXIMUM CONCENTRATION (ppb)	DISTANCE (m)	MAXIMUM CONCENTRATION (ppb)
"A"	62.9	0.57 ●	108.0	0.35	148.3	0.27
"B"	64.2	0.95 ●	133.6	0.49	204.9	0.34
"C"	95.2	1.23 ●	203.9	0.62 ●	318.3	0.41
"D"	161.8	1.46	360.5	0.70 ●	544.9	0.45 ●
"E"	218.1	1.79	504.2	0.78 ●	954.0	0.43 ●
"F"	388.0	1.62	980.8	0.64	1912.3	0.34 ●

NOTES:

1. U = wind speed
2. H = plume rise
- most probable stability classes for day, transitional, and night conditions.

is less than 6 percent of that standard. Although it is possible that instantaneous concentrations of H_2S may be high enough to be detectable, the various combinations of conditions in Table 4-1 predict no probability of H_2S standard exceedance during testing or maintenance conditions. Concentrations at the closest residences (within 330 ft/100 m) are high during windy and unstable daytime conditions; the high degree of ambient turbulence during those conditions will not allow any H_2S pollutant stagnation. From an air quality perspective, the proposed project represents a benefit in terms of reduced energy consumption without introducing air contaminants usually associated with energy generation by other fuels.

5.0 MITIGATION

Although the cumulative project impact is small, especially during the operational phase of the program when emissions are essentially negligible, there are certain considerations to help minimize the project air quality impacts. Both for the benefit of nearby residents as well as the comfort of equipment operators, regular watering during construction, drilling and testing will reduce local dust levels. By restricting access to the site or preparing an oiled access and parking area, fugitive emissions from later vehicle access may also be minimized. If possible, testing and maintenance should be performed when winds carry the plume away from nearby homes.

Besides these specific steps, the fact that geothermal energy replaces energy from electrical generation by combustion of fossil fuels results in a net air quality improvement. Assuming that the average system energy savings is 100,000 BTU/hr, the annual energy replacement is about 200,000 KWH/yr. If that energy comes from burning oil in a power plant, the resulting pollutant savings is shown in Table 5-1. The

Table 5-1

EL CENTRO PROJECT POLLUTANT "SAVINGS"
(tons/year)

	ESTIMATED FIRST YEAR PROJECT EMISSIONS	SUBSEQUENT YEAR PROJECT EMISSIONS	ANNUAL POLLUTANT SAVINGS BY REPLACEMENT OF 200,000 KWH/year
TOTAL SUSPENDED PARTICULATES	0.97	neg.	0.07
SULFUR DIOXIDE	0.35	neg.	0.37
CARBON MONOXIDE	2.00	neg.	0.03
OXIDES OF NITROGEN	5.42	neg.	0.25
TOTAL HYDRO- CARBONS	0.54	neg.	neg.

project thus reduces total power plant emissions by a little less than one ton per year. Since the addition of other facilities for use of the geothermal resource is possible, and since future project-related emissions create a negligible air quality burden, the expansion and continuation of service by the project will continue to accrue future air quality benefits.

6.0 REFERENCES

California Administrative Code, Title 8, Section 5155, Table AC1, Occupational Health and Safety.

California Air Resources Board, 1976, The California Air Quality Data, Vol. VIII, Nos 1-4.

California Department of Water Resources, 1978, Wind in California, Bulletin No. 185, 267 pp.

Imperial County Air Pollution Control District, 1978, "Air Quality Summaries, Emissions Inventories and Projections," unpublished data.

U.S. Naval Weather Service, 1969, World-Wide Airfield Summaries, published by Environmental Technical Application Center, Asheville, North Carolina, 535 pp.

U.S. Department of Commerce, 1975, "Seasonal and Annual (Day/Night) Wind Distribution of Pasquill Stability Classes — Star Program Station #23199, El Centro, California, 1/54 — 12/58," published by National Climatic Center, Asheville, North Carolina.

APPENDIX B
EL CENTRO GEOTHERMAL UTILITY CORE FIELD EXPERIMENT
NOISE IMPACT ANALYSIS

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1.0	AMBIENT NOISE LEVEL AND STANDARDS	B-1
1.1	Present Setting	B-1
1.2	Equipment	B-3
1.3	Noise Regulation	B-5
2.0	NEW LEVELS OF NOISE	B-11
2.1	Noise Producing Operations	B-11
2.2	Noise Model	B-16
3.0	IMPACTS	B-17
3.1	Compliance with Adopted Standards	B-17
3.2	Residential Impact	B-22
4.0	MITIGATION MEASURES	B-23
5.0	REFERENCES CITED	B-25

LIST OF FIGURES

<u>Number</u>	<u>Title</u>	<u>Page</u>
1-1	Vicinity Map of El Centro Geothermal Field Experiment	B-2
1-2	County of Imperial Initial Geothermal Development Class I and Class II Noise Standards and City of El Centro Noise Ordinance Criteria	B-8
2-1	A-Weighted Sound Levels for Various Project Activities as Functions of Distance from Source	B-12
2-2	Community Noise Levels for Various Project Phases as Functions of Distance from Source	B-19
3-1	Parcel Boundary Noise Spectra for Each Phase of Project Operations	B-21

TABLE OF CONTENTS (Continued)

LIST OF TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
1-1	Existing Noise Levels in A-Weighted Decibels	B-4
1-2	Imperial County Noise Element Standards and Limits	B-6
1-3	Examples of Octave Conversion to ANSI Preferred Format	B-10
2-1	Octave Band Sound Pressure Levels (dB) at 100 ft (30 m) for Various Phases of the Project	B-14
2-2	Operation Assumptions	B-18
3-1	Estimated Community Noise Levels (CNEL/L _{dn}) at Nearest Sensitive Receptors (dB)	B-20

APPENDIX B

EL CENTRO GEOTHERMAL UTILITY CORE FIELD EXPERIMENT NOISE IMPACT ANALYSIS*

1.0 AMBIENT NOISE LEVEL AND STANDARDS

1.1 Present Setting

The proposed geothermal field experiment (Figure 1-1) is located within the city limits of El Centro. The well site is mid-block on First Street, south of Hamilton Avenue, with an underground pipeline extending to the El Centro Community Center at First Street and Olive Avenue. The energy utility core field experiment consists of drilling two wells, extracting geothermal fluid from one well, passing the fluid through a heat exchanger and reinjecting the fluid into the second well. The heat exchanger output will be to a closed cycle hot water system which in turn is connected to a lithium bromide chiller or hot water recirculating system which pumps water via the pipeline to the roof-top fan coil units located at the community center. The only added equipment at the community center will be fan coils which will be enclosed. Hence, any noise impact at the community center is negligible. On the other hand, the well site will contain all the remaining equipment and will generate added noise in the area. The well site shown in Figure 1-1 is located within 550 ft (167 m) of existing residential property on Hamilton Avenue. Two residences are located just south of the well site on land which is zoned for industrial use.

Ambient noise was measured on February 8, 1979 at the southeast corner of the well site and along the eastern (First Street) boundary of the second residence south

*Prepared by San Diego Acoustics, San Diego, California, 92101.

FIGURE
1-1

of the well site. Additional data were obtained in the vicinity for noise generated by surrounding industrial activity.

Noise measurement results are summarized in Table 1-1, which presents the ambient sound levels in terms of L_{90} , L_{50} , $L_{\max}$, $L_{\min}$, and L_{eq} . The descriptor of L_{90} is normally used as a measure of background noise since it depicts that level exceeded ninety percent of the time. The L_{eq} is the energy average over the measurement period and is useful in calculating the Day-Night Sound Level (L_{dn}) or the Community Noise Equivalent Level (CNEL).

The Day-Night Sound Level (L_{dn}) and Community Noise Equivalent Level (CNEL) are twenty-four hour averages calculated from hourly sound levels measured in A-weighted decibels. The L_{dn} and CNEL systems weight nighttime (2200-0700 hours) data by adding 10 decibels, and the CNEL system weights evening (1900-2000 hours) data by adding 5 decibels. In practice there is little difference between L_{dn} and CNEL, on the order of one decibel. Both are used interchangeably in this report.

U.S. Department of Housing and Urban Development (HUD) criteria levels are also shown in Table 1-1. The HUD descriptors, however, must be used with care since the full 24-hour measurement period was not employed.

The noise levels for each measurement period, as well as the calculated L_{dn} and CNEL, are given at the bottom of Table 1-1. Based on these measurements, the existing L_{dn} and CNEL levels are each 55 decibels.

1.2 Equipment

The equipment used in this survey included a General Radio 1945-7100 Community Noise Analyzer. This instrument meets Type 1 specifications of ANSI S1.4-1971. Field calibration of the equipment was performed using a GR Type 1562 sound level generator.

TABLE 1-1

EXISTING NOISE LEVELS IN A-WEIGHTED DECIBELS*

MEASURED AMBIENT SOUND LEVELS ON PROJECT SITE

Date	Time	L ₉₀	L ₅₀	L _{max} /L _{min}	L _{eq}
February 8, 1979	1010-1110	50	55	80/47	58
February 8, 1979	1215-1315	47	55	78/45	59

MEASURED AMBIENT SOUND LEVELS IN VICINITY

Date	Time	L _{max}	L _{eq}	Source	Measurement Distance From Source (ft/m)
February 8, 1979	1020	71	63	City Recycling Center	300/92
February 8, 1979	1030	80	75	City Recycling Center	75/23
February 8, 1979	1100	70	55	Ambient at Well Site	-----
February 8, 1979	1323	66	56	Southern Paper & Supply	300/92
February 8, 1979	1511	74	57	Halliburton Company	300/92
February 8, 1979	1511	65	63	Pacific Telephone	150/46

MEASURED HUD CRITERIA LEVELS

Date	Time	1/24	.5/8	8/24
February 8, 1979	1010-1110	62	62	56
February 8, 1979	1215-1315	66	64	57

CALCULATED AMBIENT COMMUNITY NOISE LEVELS

L _{dn}	55
CNEL	55

1.3 Noise Regulations

Noise regulations governing a geothermal development in the Imperial Valley present a rather confusing picture due to the use of a number of descriptors depicting community response. All of these descriptors stem from criteria promulgated by the U.S. Environmental Protection Agency (EPA). EPA (1974a) guidelines for the protection of public health and welfare set forth outdoor noise exposure criteria. According to these guidelines, outdoor ambient sound levels in L_{dn} below 55 dB(A) will not adversely affect public health and welfare.

Federal guidelines, when placed in the context of State and local limits, are often revised or applied using a different descriptor. Thus, when California State law was amended in 1972 to require a noise element for all City and County general plans, Imperial County adopted its own set of guidelines on October 1, 1974. The Imperial County Noise Element addresses such sources as airports, State highways and freeways, railroads, county roads, water vehicles, and other noise emitters. Standards and limits are given in terms of the Composite Noise Rating (CNR), Noise Exposure Forecast (NEF) and U.S. Department of Housing and Urban Development (HUD) criteria. A summary of the noise categories is given in Table 1-2.

Since CNR and NEF are descriptors used for aircraft noise, the HUD criteria is the most applicable of those given for the evaluation of geothermal community noise impact. Unfortunately, the HUD criteria are somewhat unwieldy for use in estimating noise levels using modeling techniques. Therefore, this report will address community noise impact primarily in terms of L_{dn} and CNEL. However, for completeness, project conformance with HUD criteria is addressed briefly.

Noise criteria specifically for geothermal development has been established in the "Terms, Conditions, Standards and Application Procedures for Initial Geothermal

Table 1-2

IMPERIAL COUNTY NOISE ELEMENT STANDARDS AND LIMITS

Critical

- HUD - Clearly Unacceptable; Exceeds 80 dB(A) for 60 minutes per 24-hour period, or exceeds 75 dB(A) for 8 hours per 24-hour period.
- NEF - Zone C, NEF greater than 40.
- CNR - Zone 3, CNR greater than 115.

Concern

- HUD - Normally Unacceptable; Exceeds 65 dB(A) for 8 hours per 24-hour period, or loud repetitive sounds on-site.
- NEF - Zone B, NEF greater than 30 and less than 40.
- CNR - Zone 2, CNR greater than 100 and less than 115.

Caution

- HUD - Normally Acceptable; Does not exceed 65 dB(A) for more than 8 hours per 24-hour period.
- NEF - Zone Upper A, NEF greater than 20 and less than 30.
- CNR - Zone Upper 1, CNR $100 + \frac{1}{2}$ the distance between CNR 100 and CNR 115.

Allowable

- HUD - Clearly Acceptable; does not exceed 45 dB(A) more than 30 minutes per 24 hours.
- NEF - Zone A, NEF less than 20.
- CNR - Zone 1, CNR less than 100..

Source: Imperial County Planning Department (1974).

Development in Imperial County" (Imperial County, 1971). These criteria establish two classes, Class I and Class II, of drilling and production noise standards (see Figure 1-2). As shown, the Class II standard is subdivided to take various land use categories (i.e. industrial, commercial, dense residential, normal residential, and open space) into account. The category which would apply to any particular geothermal development project is determined by the agency implementing the criteria.

To be in compliance with these criteria, continuous generation of wide-band noise must be limited to the levels shown in Figure 1-2. Noise levels are determined by measurements taken at the boundary of the development parcel, which is defined to be at least 100 feet from any well. The prescribed levels may be exceeded by 10 percent if the noise is intermittent and occurs during daylight hours.

The City of El Centro Municipal Code also contains an ordinance which regulates noise generated within the city. This ordinance establishes a limit on the maximum sound pressure level allowable on the property line of the source, and is equivalent to an A-weighted noise level of 55 decibels. Figure 1-2 demonstrates the relationship of the City standard to the County criteria.

The City of El Centro is currently required to review the proposed project based on its own municipal noise ordinance. However, at its discretion the City could elect to amend its current ordinance and review the project in terms of these County criteria rather than in terms of its own ordinance. This may be a logical direction, since geothermal development is an activity not considered in the City ordinance and the County's criteria differentiate between different zones or land use types, while the City's do not. If conformance with an industrial criteria is required, the City standard is much more restrictive than the County standard (A-level of 55 as opposed to 69 dB). However, where a residential criteria must be complied with, the City standard is less

County of Imperial Initial Geothermal Development Class I and Class II Noise Standards and El Centro Noise Regulation (based on preferred Octave Bands as defined by ANSI)

**FIGURE
1-2**

restrictive than the County standard (A-level of 55 as opposed to 50 dB). Because it is not yet known what set of standards the City will use as a basis for review, the discussion of impact will consider each of the potentially applicable criteria.

As seen in Figure 1-2, any of five categories of the Class II standard could be applied to the subject project. Because of the area's industrial zoning and industrial General Plan designation, application of the Class II-Industrial standard may be likely.

It should be noted that the frequency bands for the County geothermal development standards and City of El Centro noise regulations are given in terms of an older series, using a 75-Hertz (Hz) low-pass unit and the octave bands of 75 to 150, 150 to 300, 300 to 600, 600 to 1200, 1200 to 2400, 2400 to 4800, and 4800 to 9600 Hz. This series is, however, no longer preferred, according to American National Standards Institute (ANSI). The preferred series of octave bands has the center frequencies of 31.5, 64, 125, 500, 1000, 2000, 4000, 8000, and 16,000 Hz. The actual nominal frequency range of any one of these bands is 2 to 1; for example, the effective band for the 1000 Hz octave band extends from 707 to 1414 Hz.

The method of converting the older series to the preferred series is given in Appendix A of ANSI S1.11-1971, "Specification for Octave, Half Octave, and Third Octave Band Filter Sets," and is presented below:

$$L_N = L_O + 0.237 (L_{OH} - L_O)$$

where L_O = level in any old octave band, O

L_{OH} = level in next higher octave band, OH

L_N = level in corresponding new octave band N, contained
in O and OH, where N is 18 percent above O in frequency.

Examples of the conversion of the County's Class II (Industrial) and City ordinance frequency bands to the preferred form are shown in Table 1-3. It is of

Table 1-3

EXAMPLES OF OCTAVE CONVERSION TO ANSI PREFERRED FORMAT

CLASS II (Industrial)

<u>N</u>	<u>L_O</u>	<u>L_{OH}</u>	<u>(L_{OH}-L_O)</u>	<u>.237 (L_{OH}-L_O)</u>	<u>L_N</u>	<u>A-wgt</u>	<u>L_N(dba)</u>
63	86	77	-9	-2.1	83.9	-26.2	57.7
125	77	68	-9	-2.1	74.9	-16.1	58.8
250	68	63	-5	-1.2	66.8	- 8.6	58.2
500	63	61	-2	-0.5	62.5	- 3.2	59.3
1000	61	60	-1	-0.2	60.8	0	60.8
2000	60	60	0	0	60	+ 1.2	61.2
4000	60	60	0	0	60	+ 1.0	61.0
8000	60	60	0	0	60	- 1.1	<u>58.9</u>

Overall Maximum Noise Level (dBA) = 68.7 ~ 69

EL CENTRO NOISE REGULATIONS

63	72	67	-5	-1.2	70.8	-26.2	44.6
125	67	59	-8	-1.9	65.1	-16.1	49.0
250	59	52	-7	-1.6	57.4	- 8.6	48.8
500	52	46	-6	-1.4	50.6	- 3.2	47.4
1000	46	40	-6	-1.4	44.6	0	44.6
2000	40	34	-6	-1.4	38.6	+ 1.2	39.8
4000	34	32	-2	-0.5	33.5	+ 1.0	34.5
8000	32	(32)	0	0	32	- 1.1	<u>30.9</u>

Overall Maximum Noise Level (dBA) = 54.4 ~ 55

interest to note that the largest corrections occur in the lower frequencies, below 500 Hz. The overall A-weighted noise levels for the Class II standards were computed and found to be 75, 69, 63, 55, 50, and 46 dB(A) as shown on Figure 1-2. The El Centro noise regulation is equivalent to an A-weighted noise level of 55 dB(A).

2.0 NEW LEVELS OF NOISE

2.1 Noise Producing Operations

Noise levels resulting from development and operation of water-dominated geothermal projects are produced by the following activities: 1) drill site preparation, 2) well drilling, 3) well cleanout, 4) well flow testing, and 5) facility operation.

a. Drill Site Preparation

Drill site preparation is dominated by noise produced by a bulldozer and backhoe used to level the site and excavate a sump. The primary remaining noise source is from various heavy duty trucks going to and from the site. Preparation of the drill site will be occurring during daylight hours over a one- to two-week period.

Noise levels associated with this operation have been previously measured by San Diego Acoustics at the Union Oil Company Tow #1 drill site north of Brawley. Bulldozer and backhoe noise levels for site clearing were 53 dB(A) at a distance of 1600 ft. Using these data and the inverse square law, a curve of A-weighted sound level as a function of distance was constructed and is shown in Figure 2-1. The noise of heavy trucks will be a function of the speed, roadway grade and muffler system used. It is assumed that the worst case will be large semi-trailer/tractor rigs which will deliver equipment to the site. Truck noise reported by the EPA (1971) for a highway speed condition is used herein to depict the spectral level, since it represents nearly the average of the observed data. These levels at 50 ft have been extrapolated to 100 ft using the inverse square law, and corrected to a speed of 10 mph using a correction factor of:

WESTEC Services, Inc.

A-Weighted Sound Levels for Various Project Activities as Functions of Distance from Source

**FIGURE
2-1**

$$C - 40 \log_{10} \frac{V_1}{V_r} \quad (\text{from EPA, 1974b})$$

where V_1 is actual vehicle speed in miles per hour

V_r is reference vehicle speed in miles per hour

Representative spectral data for site preparation noise (including both excavation equipment and truck noise) are given in Table 2-1 for a distance of 100 ft, the approximate distance to drill site parcel boundary. The curve representing site preparation noise in Figure 2-1 also includes excavation equipment and truck noise.

b. Well Drilling

The well drilling operation will consist of mud drilling using a rotary rig. On-site equipment includes the rotary table driven by diesel engines, mud pumps, mud shaker, electric power generator, draw works engine, and small cooling tower. Well drilling is characterized by two distinct noise phases: the rotary table operation and the draw works operation. Noise from the draw works operation includes the impact of steel pipe banging together, primarily during stacking. In addition, running of casing will also result in pipe impact noise.

Drilling is a 24-hour a day operation and, in this instance, drilling of two wells is planned. Drilling operations are expected to require approximately nine weeks. Each well will be drilled from one well island.

Noise level data for geothermal drilling operations are scarce. VTN (1978) reported levels of 66 to 71 dB(A) at 200 ft. Data measured for this study include a series of composite measurements of drilling activity at several distances. These data, combined with those presented by VTN (1978) and U.S. Department of Energy (1978) have been used to establish a curve of A-weighted sound level as a function of distance. Both the inverse square law and atmospheric attenuation were used to correct the noise levels to the distances desired. The resulting curve is shown on Figure 2-1, and the spectral levels at 100 ft (30 m) are given in Table 2-1.

Table 2-1

OCTAVE BAND SOUND PRESSURE LEVELS AT 100 FT (30 M)
FOR VARIOUS PHASES OF THE PROJECT

<u>Octave Band</u>	<u>Drill Site Preparation</u> ¹	<u>Well Drilling</u>	<u>Well Cleanout and Testing</u>	<u>Flow and Testing</u>	<u>Facility Operation</u>
63	84/57	86		50	59
125	92/72	82		49	59
250	76/66	75		47	59
500	71/59	69		47	56
1000	74/57	68		47	53
2000	68/55	67		43	50
4000	62/46	55		38	47
8000	54/42	44		34	42
Overall A-weighted Sound Pressure Level	79/64	75		51	59

NOTE: 1. Excavation equipment/truck noise.

c. Well Cleanout and Flow Testing

After drilling, the wells will be flow tested for short periods of time to clean out drilling muds and other debris. The valve is opened and the fluid is pumped into an open pit or sump. Primary noise comes from pump noise and noise generated by fluid flows into the sump. The moderately low temperature fluid will not flash steam, hence this noise source is not present. The production pump will operate downhole; the reinjection pump, operating on the surface, will be electric, with about a 60 hp capacity.

Well cleanout noise is a function of the flow rate and the method of handling the effluent. Unpublished noise monitoring data on file at WESTEC Services and data reported in DOE (1978) were used to establish the well cleanout noise level curve given in Figure 2-1.

Composite spectra of well cleanout and flow testing and operation are given in Table 2-1.

d. Facility Construction and Operation

Production facilities at the well site will include the production and injection wells, separators, heat exchanger, cooling tower, absorption chiller, hot water system and recirculating pumps. Noise from the cooling tower and the pumps, plus any venting of noncondensable gases are expected to provide the primary impact.

Composite noise levels for operation of the facility are given in Figure 2-1, and octave band spectra at 100 ft are shown in Table 2-1. This composite spectra was derived by combining the individual noise levels of a ten horsepower cooling tower, the ambient, and the well pumps. Other noise sources are well below these levels and are considered negligible. Noise levels associated with each of the individual sources is discussed below.

Noise from the cooling tower was estimated using a procedure from the Industrial Acoustics Company (ICA Bulletin No. 1.0401.0). A dB(A) level of 62 at 50 ft was found assuming a total fan horsepower of 10.

Operation of the heat exchanger production facilities will result in noise predominantly from the pumps. Manufacturers' literature indicates that the heat exchanger has an 85 dB sound power level at a distance of three ft. Correcting this to octave band sound pressure level and calculating the A-weight sound level yields a value of 50 dB(A) at 100 ft. The noise from the pumps, cooling tower, and heat exchanger are combined to yield the noise level curve in Figure 2-1 and the spectra in Table 2-1.

Plant construction will take place concurrently with the installation of the production well equipment. Noise from this construction will be approximately the same as that produced during the drill site preparation (see Figure 2-1 and Table 2-1).

2.2 Noise Model

In order to accurately assess the effect of the above operations upon the present environment, it is necessary to construct a noise model showing the level and duration of the various noise sources. The approach taken was to calculate over a 24-hour basis the Community Noise Equivalent Level (CNEL) and Day-Night Sound Level (L_{dn}) for each operation. Thus, the noise level for any given hour is composed of the ambient level having a 60-minute duration plus the noise level of each specific operation having a 60-minute duration plus the noise level of each specific operation having an estimated duration.

Summation of the noise energy is performed according to the following equation:

$$L_{eq} = 10 \log \frac{1}{60} 10^{L_E/10} \times D_1 + (10^{L_2/10} \times D_2) + \dots (10^{L_N} \times D_N)$$

where L_{eq} = hourly equivalent noise level

- L_E = existing noise level
 L_N = noise level of each operation
 D_N = duration in minutes of noise level

The operation and duration assumptions in Table 2-2 were used to calculate the CNEL and L_{dn} values.

Calculating the hourly L_{eq} values and computing the CNEL and L_{dn} yields the set of curves shown in Figure 2-2. Note that the CNEL and L_{dn} are identical, and that the existing ambient is shown as a horizontal line on the graph.

3.0 IMPACTS

3.1 Compliance with Adopted Standards

As described in Section I, the proposed drilling program will commence at the production well site, and progress to the injection well location about 30 ft away, assuming favorable geothermal resource evaluation results during initial drilling. The distances from the proposed drill sites to the nearest boundary of the geothermal development parcel is 85 ft (26 m). By extrapolating the data shown in Table 2-1 (which shows octave band sound pressure levels for various project activities at 100 ft or 30 m) to 85 ft (26 m), the operation noise spectral data at the project boundaries can be derived. These data are illustrated on Table 3-1. For comparison, the City of El Centro performance standard and County of Imperial Class II-Industrial and Class II-Normal Residential standards are also shown on the figure.

As seen on Figure 3-1, noise from three of the five phases of project development and operation is in excess of the Class II-Normal Residential standard and City of El Centro standard across essentially the complete spectral band. Noise from well cleanout and flow testing exceeds these standards above 250 Hz. The Class II-Industrial standard is exceeded for frequencies less than 2000 Hz by well drilling and

Table 2-2

OPERATION ASSUMPTIONS

<u>Operation</u>	<u>Time of Day</u>	<u>Duration</u>
Drill Site Preparation	0600-1600 hours	30 min/hr
Well Drilling	0000-2400 hours	30 min without rotary/ 30 min with rotary
Well Cleanout	0600-1600 hours	30 min/hr
Flow Testing	0600-1600 hours	30 min/hr
Facility Operation	0000-2400 hours	60 min/hr

Community Noise Levels for Various Project Activities
as Functions of Distance from Source

**FIGURE
2-2**

Table 3-1

ESTIMATED COMMUNITY NOISE LEVELS (CNEL/L_{dn})
AT NEAREST SENSITIVE RECEPTORS (dB)

<u>Receptor</u>	<u>Location 1^a</u>	<u>Location 2^b</u>	<u>Location 3^c</u>	<u>Location 4^d</u>
Distance from Drill Site (ft/m)	135/42	235/72	550/168	700/214
<u>Activity</u>				
Site Preparation	70.5	66	58.5	56.5
Well Drilling	81	75.5	68	66
Well Cleanout	55(ambient)	55(ambient)	55(ambient)	55(ambient)
Flow Testing	55(ambient)	55(ambient)	55(ambient)	55(ambient)
Facility Operation	61.5	56.5	55(ambient)	55(ambient)

NOTES:

- a. Single-family residence immediately south of well site.
- b. Single-family residence immediately south of "Location 1."
- c. Single-family homes at southeast corner of First Street and Hamilton Avenue.
- d. Single-family homes north of Hamilton Avenue between First Street and Second Street.

- $\triangle$ Facility Operation
- $\circ$ Drill Site Preparation
- $\square$ Well Drilling
- $\triangle$ { Well Cleanout & Flow Testing

NOTE
1. Predicted sound pressure levels are based on measurements of equipment with no special purpose mufflers.

Parcel Boundary Noise Spectra for Each Phase of Project Development and Operation (assumes the use of no special noise attenuation devices on noise-generating equipment)

FIGURE 3-1

4000 Hz during drill site preparation. Noise from well cleanout, flow testing, and operation of the facility drops below the standard across the spectral band.

3.2 Residential Impact

The operation and duration assumptions in Table 2-2 were used to calculate the CNEL and L_{dn} values shown in Figure 2-2. These values were used to generate Table 3-1, which quantifies the impact of each phase of project development and operation on nearby residences. The two closest homes are located just south of the well site at distances of 135 and 235 ft (41 and 72 m). Other sensitive receptors include residences to the northeast and north at distances of 550 and 700 ft (168 and 214 m) from the well site (see Figure 2-11 in body of report).

Since the existing community noise level is a CNEL or L_{dn} of 55 dB, the proposed activities will be audible out-of-doors at receptors within 2000 ft (610 m) of the source. The maximum impact will be due to well drilling, which will raise the ambient exterior noise level by an estimated 26 decibels at the nearest home, 20.5 decibels at the next residence, and 14 decibels at the residential block beginning at the southeast corner of First Street and Hamilton Avenue. Operation of the facility, by contrast, would raise the ambient level in these locations by 6.5, 1.5, and 0 decibels, respectively.

Evaluating noise impact according to HUD criteria within the Imperial County Noise Element (Table 1-2) utilizes the A-weighted sound levels given in Figure 2-1. At the nearest receptor, the maximum noise from drilling is over 72 dB(A). This level, which would continue 24 hours per day for the duration of drilling, exceeds the Element's "Concern" limit of 65 dB(A) for 8 hours per 24-hour period and approaches the "Critical" criterion of 75 dB(A) for 8 hours per 24-hour period.

The attenuation in noise afforded by normal construction in buildings with windows open is sufficient to reduce this level by 15 dB. Thus, the nighttime impact, which is most critical in terms of the community response, would be reduced to an interior level of 57 dB at the nearest home, 52 dB at the adjacent residence, and 45 dB within the homes at the corner of First Street and Hamilton Avenue. An interior sound level of 45 dB is generally considered compatible with residential activity. Therefore, the sound reduction afforded by the buildings themselves is insufficient to mitigate the exterior noise impacting the two homes south of the drill site to an acceptable level.

4.0 MITIGATION MEASURES

As mentioned above, some activities associated with the proposed geothermal field experiment will result in significant noise impacts in terms of exceeding both ambient community noise levels (L_{dn} and CNEL) and applicable HUD noise criteria. Also, when compared to either the City of El Centro noise ordinance or the Class II-Industrial criteria in the "Terms, Conditions, Standards, and Application Procedures for Initial Geothermal Development in Imperial County," a significant impact is anticipated. This impact, unless mitigated, would be most noticeable to the residents in the two single-family homes immediately south of the well site, where the site preparation and well drilling phases of the project would have the greatest effect. Operational noise from the facility would also be discernable, but would cause a far less significant impact. The neighborhoods to the north and northeast of the project site (on Hamilton Avenue) would be significantly impacted only by noise from well drilling. Since the attenuation provided by the walls of the affected homes is not sufficient to reduce the interior sound levels to an acceptable level, additional efforts are required. Project compatibility with applicable noise standards will require the implementation of sophisticated mitigation measures.

The City of El Centro is requiring as a condition of approval compliance with strict performance standards. These measures are as follows:

1. Site preparation, well cleanout, flow testing and facility construction are restricted to daylight hours.
2. Well drilling operations must be adequately mitigated to achieve a 55 dB noise level (60 dB during daylight hours) or less at the City-owned property line. Pipe stacking and line section assembly will be restricted to daylight hours. Well drilling noise levels will be monitored by City staff and any residential complaints recorded. If the noise attenuation program is incapable of mitigating noise levels to 55 dB at the property line during evening hours then drilling will be prohibited between the hours of 10 p.m. to 7 a.m., unless a variance allowing 60 dB 24 hours per day is approved by the Planning Commission and City Council.
3. A 6 feet or higher block wall fence will be constructed along the eastern 120 feet of the southern property line.

Throughout this report, the data used to predict project-related noise were derived by measuring noise generated by equipment having no special-purpose mufflers or other sound-attenuating features. Thus, to achieve the necessary noise reduction, all equipment used in drill site preparation and well drilling, especially diesel engines and generators, will be fitted with hospital-type mufflers to reduce exhaust noise. The use of mufflers will be accompanied by construction of sound barriers around the facility. A temporary 20 foot high noise enclosure will be constructed around the perimeter of the drill site for the mitigation of noise impacts during 24-hour drilling operations. The noise enclosure will consist of 1½ inch fiberglass matting sandwiched into a quilted

blanket and wrapped around a structural framework. The structural framework will consist of vertical telephone poles, anchored in the ground, attached by 2 x 4 lateral crosspieces and will include access-doors for the movement of heavy equipment as well as man-doors for the movement of project personnel on and off the drill site.

Aside from the block wall which must be constructed along the southern property line, only temporary barriers present during site preparation and drilling would be needed on the north and east to shield the homes on Hamilton Avenue. The combination of mufflers and solid wall barriers will have to achieve a minimum of 25 decibels noise attenuation over the frequency range of 63 to 8000 Hz. No permanent walls around the northern or eastern sides of the facility would be required to protect the homes along Hamilton Avenue, since the attenuation afforded by the walls of those homes will reduce the interior noise during normal project operations to an acceptable level. Implementation of these measures will bring the noise level into compliance with adopted standards, and will reduce the residential annoyance factor to an acceptable level, even at night, because of the high nighttime ambient of 55 dBA (L_{10}).

Several alternative methods of mitigation were considered but rejected in favor of the adopted mitigation program. One approach to mitigation would be for the City of El Centro to condemn the two homes to the south under its redevelopment program and relocate the residents to other homes. The property could then be utilized for industrial purposes as designated by the General Plan. Under this alternative, temporary sound barriers would still be required during well drilling to protect the residents along Hamilton Avenue.

A second feasible alternative would involve providing the two most affected families with alternative housing in an El Centro motel or hotel during well drilling. This measure would effectively avoid the noise problem during its most significant

period, but sound attenuation of lesser stringency would be necessary to shield these homes during the life of the project.

A third and fourth means of reducing the significance of the impact would be to relocate the well site further west on the parcel toward the recycling center, or to restrict drilling to daylight hours. The effectiveness of these actions is discussed in Section 4.2, Alternate Operational Procedures.

5.0 REFERENCES

County of Imperial, 1971, "Terms, Conditions, Standards, and Applicable Procedures for Initial Geothermal Development in Imperial County," Planning Department, May.

County of Imperial, 1974, Noise Element of the Imperial County General Plan, Planning Department, adopted October 1.

U.S. Department of Energy, 1978, Environmental Assessment, Westmorland Development Project, Imperial County, California, June.

U.S. Environmental Protection Agency, 1971, Transportation Noise and Noise from Equipment Powered by Internal Combustion Engines, Report NTID 300.13, December 31.

U.S. Environmental Protection Agency, 1974a, Information on Levels of Environmental Noise Results Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, Report EPA-550/9-74-004, March.

U.S. Environmental Protection Agency, 1974b, Background Document for Proposed Medium and Heavy Truck Noise Regulations, Report EPA-550/9-74-018, October.

VTN Consolidated, Inc., 1978, Heber Geothermal Demonstration Project, Final Environmental Impact Report, prepared for the Imperial County Planning Department, March.

APPENDIX C
ARCHAEOLOGICAL CLEARANCES

ARCHAEOLOGICAL EXAMINATIONS OF
A PROPOSED GEOTHERMAL TEST
WELL IN EL CENTRO

Jay von Werlhof
and
Sherilee von Werlhof

2 January 1979

Imperial Valley College Museum
442 Main Street,
El Centro, California
92243

CONTENTS

Introduction	1
Summary of Results	1
Conclusions	2
Methods of Investigation	2
Natural History	3
Aboriginal Past	4
Archaeological Setting	5
Vitae of Investigators	6
References	6
Maps Showing Project Site	
California Landforms	8
California Counties	9
Site in El Centro	10
Project Plat	11

INTRODUCTION

The City of El Centro plans to conduct explorations for possible geothermal development within the city limits. If feasible, a small and limited geothermal energy unit would be installed for operating certain community facilities.

Since federal funds are involved in the project, the National Environmental Policy Act of 1969 (PL 91-190, 83 Stat 852) requires that the property be examined for archaeological resources the project might impact. The federal reviewing process for such concerns begins at the State Historic Preservation Office (Historic Preservation Act of 1974: PL 93-291, 88 Stat 174, amending the Reservoir Salvage Act of 1960: PL 86-523, 74 Stat 220).

The State of California also provides for a review process mandated by the California Environmental Quality Act of 1970, as amended in 1972, 1973, 1974, 1975, 1976, 1977, and 1978, Division 13, Public Resources Code, Section 21000 et seq. Ancillary to this is the State Environmental Impact Report Guidelines, California Administrative Code, Title 14, Natural Resources, Division 6, Resources Agency, Chapter 3, "Guidelines for Implementation of CEQA." Under these provisions the review process for City and County projects in Imperial County commences at the County of Imperial Planning Department.

As shown on Map 4, the project site encompasses the easterly 450' of Lot 47, between 1st and 2nd streets, on the east side of El Centro. The parcel is vacant land surrounded by commercial and industrial properties.

SUMMARY OF RESULTS

The field investigators did not discover any archaeological resources that the proposed project might impact, historic or prehistoric.

It is possible, though unlikely, that such resources exist in subterranean strata that construction activities might reveal. If during exca-

vations any unusual stone, ceramic, or bone items are unearthed, the foreman should halt operations at the site of discovery until the materials could be examined by a qualified archaeologist.

A search of records and literature failed to uncover any previously recorded historic or prehistoric sites at the project area.

CONCLUSIONS

On archaeological grounds there is no reason that the application the City of El Centro has made for this project should be delayed or denied.

METHODS OF INVESTIGATION

The purpose of the investigation was to determine whether any cultural resources of an historic or prehistoric nature existed at the project site, or close enough to it that the project activities might endanger them.

Should such resources be discovered, then the investigators were to identify them and to assess their integrity, sensitivity, and significance. And finally, the investigators would prepare a mitigation plan, in consultation with the California State Historic Preservation Officer, that would most likely protect and preserve the resources.

To realize the purpose of the investigation several methods had to be carried out. These included:

- 1) Records and literature search. The IVC Museum Library and Archives contain governmental survey records, historical publications, and archaeological records pertaining to Imperial County. These resources have to be consulted before engaging in any field work.
- 2) Map study. IVC Museum also maintains map books of historic and prehistoric sites; topographic, geologic, and soils maps, all of which are studied to predict site locations from other known data.
- 3) Examine the environs of the project site for contiguous or pinpointous cultural resources.

- 4) Walk the project site in ten meter transects to determine the presence or absence of cultural resources.
- 5) Prepare a report on findings and recommendations.

Researches and map studies did not reveal any historic or prehistoric sites of record, and the investigators predicted that no such of them would probably be encountered. The field examination did prove negative, so no mitigation plan was necessary.

NATURAL HISTORY

The project area is 35' below sea level in Imperial Valley and within the city limits of El Centro. The valley floor, from Calexico to Niland and between the East and West mesas, slopes gently down as it proceeds from south to north. The upper layers are lacustrine sediments from ancient Lake Cahuilla which the Colorado River created 2,000 years ago. Until the Late Fifteenth Century the entire drainage of the river emptied into the valley. When the Colorado re-discovered its former channel and flowed once more through the delta into the Gulf of California the lake rapidly dried up under the hot Imperial sun. By 1550 A.D. the Imperial Valley--or Salton Sink--was arid desert once again, and was to remain so until the Twentieth Century when agribusiness drastically modified the environment.

The biotic community in this lower portion of the Colorado Desert is officially classed as Desert Creosote Scrub Bush. With a high evaporation rate (5' per annum) and a low precipitation rate (3" per annum), native life was restricted to specialized plants and adaptive animals.

Hot summers are flanked by warm springs and falls, and with an occasional drop in winter temperature the thermal range for the valley can span 100° during a year. (Copies of official climatic records in IVCN archives).

The Salton Sink has no outlet, and waters percolate towards its low central point which, since the floods of 1905-07, has been the Salton Sea, thirty

miles north of El Centro.

Rainfall is inadequate to flush away natural salts in Imperial soils, further restricting the types of indigenous plants that could survive in arid zones. Today, despite ample irrigation water and the use of soil-builders, the valley would return to desert again had methods not been discovered to flush out the saline contents in the soil. This is the function of deep-tiling which carries wastes to the Salton Sea (Henderson, 1968).

ABORIGINAL PAST

Early Man in Southern California is still a controversial subject, with speculations for his entry ranging beyond 100,000 years (Heizer, 1978, sums the subject). Skeletal remains discovered thirty miles southwest of El Centro have been dated by C14 at 21,500 years (Childers, 1974), and IVC Museum archives contain several hundred field records of archaeological sites of the Late Pleistocene San Dieguito Culture (20,000 to 8,000 years ago). While these sites are distributed along both flanks of the valley, early foragers certainly exploited and crossed the valley between times of inundation. The direct evidence of this usage is absent because of lacustrine overburdens which Lake Cahuilla deposited.

Shortly before the lake arose the Yuman people began moving westward out of Arizona, perhaps to thin their numbers in desert areas which had a limited supporting capacity. The Lower Colorado River Basin absorbed most because of its abundant water and a large and varied biotic community. But many others continued beyond the river, across the East Mesa, valley, West Mesa, and into the Peninsular Range (Gifford, 1931).

The rise of Lake Cahuilla found peoples already settled into territorial tribes. The Mohave, Halchidoma, Kouana, Quechan, and Cocopa occupied the river basin. The Kumeyaay settled in the mountains, and ranged across the desert east of them for seasonal foods, trade, and social visits with riverine kin.

The lake blocked off the Kumeyaay from their eastern contacts, but it did provide a new economic base upon which their strategies now depended. Hundreds of camps

and clamming stations have been recorded along the western shoreline (von Werlhof, 1978). Kumeyaay trails tied together the whole of their territory, enabling the natives to reach any part of it with assurance and economy of time (IVCM has about 500 miles of such trails recorded).

Meanwhile, the Yuman agroups along the Colorado River gradually incorporated horticulture into their economy, no doubt learned from their Maricopa affiliate along the Gila River in Arizona. By 900 A.D. the river tribes were all planting squash, beans, and corn (Castetter and Bell, 1951; Hicks, 1974).

The demise of the lake wrought an economic crisis in Kumeyaay life by mid-Sixteenth Century, though it did enable them to once again establish contact with the river tribes. From them the Kumeyaay also learned the technology of planting.

Except during dry cycles, the melting snows of the Rock Mountains brought the Colorado River to floodstage in late May or early June. The natives of Parker Valley, Palo Verde Valley, Cibola Valley, and Yuma Valley poked holes in the wet muds after the floods subsided, and planted their seeds.

Following the desiccation of the lake, overflow waters were propelled westward along weak channels that later became the New and the Alamo rivers of southern Imperial County. It were along these fluctuating courses that the Kumeyaay found right conditions for practising their newly learned horticultural art. Though the lake remained a part of their folklore into current time, planting of crops eased the food crisis its evanescence had created (Cline, 1978 mss).

As late as 1856 A.D. some seventy-five families or bands were still tending their plots along the New River (US Surveys, 1856), having once been forced out during the long drought of the 1840s. As Americans settled into Kumeyaay country they relocated the natives onto reservations--or rancherias--as at Campo in the Peninsular Range (US GPO, 1975).

ARCHAEOLOGICAL SETTING

The only archaeological remains of prehistoric sites in Southern Imperial Valley are the scattered horticultural plots along the river banks. Many others had been destroyed during the massive floodtimes of 1905-07, and the expansion of agribusiness in this Century no doubt erased others. Rarely does one find an isolated tool or stone utensil in the valley, though it occasionally does occur. On both sides of the valley, however, there is an abundance of physical evidence with which to reconstruct the ancient past. Archaeological work is not completed by any means, but enough has already been recorded to enable investigators to identify artifacts and features, and to arrange them in cultural sequences from Pleistocene times to the coming of the historic age.

VITAE OF INVESTIGATORS

Jay von Werlhof is Senior Archaeologist at Imperial Valley College Museum, and is an instructor in anthropology/archaeology at the College and San Diego State University (Calexico campus). Before coming to Imperial County in 1973 von Werlhof had worked in all other counties of California at various archaeological tasks. He obtained his education at University of California, Berkeley, from which he received a B.A. and an M.A. degree (1950, 1952). von Werlhof has approximately 13,000 field hours in archaeology, and has published some thirteen tracts and articles on parts of his work. He belongs to the American Anthropological Association (Fellow, 1975 to date), Society of American Archaeology, Society for California Archaeology (charter member), Imperial Valley College Museum Society (charter member), and the Southwestern Anthropological Association.

Sherilee von Werlhof studied archaeology/anthropology at Cuesta College, Imperial Valley College, and San Diego State University. She has approximately 4,000 field hours in Central Coast and Southern California archaeology. She is a member of the Society for California Archaeology, and a charter member of the Imperial Valley College Museum Society. In addition to field duties as an IVCM Staff Archaeologist, she is also the Environmental Studies Coordinator to

the IVC Foundation. She has participated in preparing archaeological elements for approximately 150 environmental reports or statements.

REFERENCES

- Castetter, Edward F. and Willis H. Bell
1951 Yuman Indian Agriculture. University of New Mexico Press, Albuquerque.
- Childers, W. Morlin
1974 A Preliminary Report on the Yuha Burial, California. Anthropological Journal of Canada, Vol. 12, No. 1.
- Cline, Lora
1978 The Kwaaymii: Reflections on a Lost Culture. Mss in preparation for printing. IVC Museum.
- Gifford, E. W.
1931 The Kamia (Kumeyaay) of Imperial County. Smithsonian Institute, Washington, D. C.
- Heizer, Robert F.
1978 California, Vol. 8 of Handbook of North American Indians. Smithsonian Institute, Washington, D. C.
- Hicks, Frederic
1974 The Influence of Agriculture on Aboriginal Socio-Political Organization in the Lower Colorado River Valley. The Journal of California Anthropology, Vol. 1, No. 2.
- Henderson, Tracey
1968 Imperial Valley. Neyenesch Printers, Inc. San Diego, California.
- U. S. Department of Commerce
(1975) Federal and State Indian Reservations and Trust Areas. Government Printing Office, Washington, D. C.
- U. S. Geological Land Surveys
1856 Notes and Field Books. IVCM Microfilm.
- von Werlhof, Jay
1978 The Imperial County Footprint Site, 4-Imp-373. Pacific Coast Archaeological Society Quarterly, Vol. 17, No. 4.

The Indians of California

SCALE 1:24000

APPENDIX D
GEOTHERMAL WELL NEIGHBORHOOD SURVEY

City of El Centro
Geothermal Well Neighborhood Survey

Hello, I'm _____ with the City of El Centro Planning Department. We are doing a survey to see what people think about having a geothermal well drilled off First Street next door to the Recycling Center and the telephone company. If enough geothermal energy is found, it will be used to heat and cool the Community Center. (Show Map) The results of this survey will be presented to the El Centro Planning Commission and City Council.

1. How well do you understand geothermal development?
 1. very well - 10
 2. fair - 16
 3. not much - 25
 4. none - 27
2. Are you in favor or opposed to geothermal development outside the City in the Imperial Valley?
 1. strongly in favor - 12
 2. in favor - 27
 3. don't care - 15
 4. opposed - 3
 5. strongly opposed - 9

A study of the environmental impacts of the geothermal well has been prepared. In the long run, the well could help the City to save energy and possibly create some new jobs. The drilling of the well would take about 9 weeks and most of the costs would be paid for with money from a Federal energy grant.

3. Are you in favor or opposed to a geothermal well off First Street near the El Centro Recycling Center?

1. strongly in favor	-2
2. in favor	-32
3. don't care	-19
4. opposed	-11
5. strongly opposed	-24

Other _____

1. strongly in favor	- 8
2. in favor	- 31
3. don't care	- 9
4. opposed	- 12
5. strongly opposed	- 14

D-2