DOE/EA-0119

Environmental Assessmental, Geothermal Energy, Heber Geothermal Binary-Cycle Demonstration Project

Imperial County, California

October 1980

U.S. Department of Energy
Assistnt Secretary for Resource Applications
Geothermal Energy Division

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CONTENTS

FIGURES

TABLES

PREFACE

The San Diego Gas and Electric Company (SDG&E) proposes to enter into a cost-sharing agreement with the U.S. Department of Energy (DOE) to design, construct, and operate a commercial-scale (45 MWe net) binary-cycle geothermal demonstration power plant using the liquid-dominated geothermal resource at Heber, Imperial County, California. This report, which is intended to satisfy the required National Environmental Policy Act (NEPA) environmental review and documentation, is an assessment prepared by the Oak Ridge National Laboratory (ORNL) of the above-stated proposed Federal Action.

Information contained in several existing documents contributed substantially to the preparation of this report. These information sources are referenced at the end of this section and are called out in abbreviated form throughout this work. VTN Consolidated, Inc., prepared two environmental impact reports (EIRs) for the Imperial County Planning Department to comply with the State of California's Environmental Quality Act (CEQA). The report that was issued first (EIR 1978) assesses the impacts of the binary-cycle facility, whereas the later document (EIR 1979) reports the potential impacts of full development (500 MWe) at the Heber site. In addition, information obtained directly from the industrial partner, SDG&E, was used heavily in preparing this report; the technical and management proposal submitted by SDG&E to the Division of Geothermal Energy of the DOE (SDG&E 1979) describes the intended activities, and a series of letters from SDG&E to ORNL dating from March 28, 1980 through September 10, 1980 (SDG&E letter, date) contain information requested specifically for use in preparing the assessment. All information about the proposed Federal action, irrespective of the source, was verified before introduction into the impact analysis. This is documented in a series of verification memoranda (ORNL Verification Memo No. ___). Impacts associated with full-field development, which is not part of the proposed Federal action but which may be encouraged (although definitely not initiated) by the Federal action, are documented in this work as reported in the VTN Master EIR (EIR 1979). Although the full-field development is not part of the proposed Federal action assessed here, information extracted from the EIR (1979) was selectively verified as appropriate for fully addressing the environmental scope of the proposed action.

Development of the Heber resource is presently being actively pursued by private enterprise. Many of the permits necessary for full-field development have already been issued to the private sector. Thus the proposed Federal action is not initiating full-scale development of the Heber geothermal resource.

GENERAL REFERENCES

EIR 1978. Final Environmental Impact Report, 1978. Prepared for Imperial County Planning Department by VTN Consolidated, Inc. Report #170-77. Called out throughout the text as (EIR 1978).

EIR 1979. Final Master Environmental Impact Report, 1979. Prepared for Imperial County Planning Department by VTN Consolidated, Inc. Report #213-79. Called out throughout the text as (EIR 1979).

ORNL Verification Memo No.____. Documentation of investigations into the merit of information used for analysis of impacts. Called out as (ORNL Verification Memo No. ____).

SDG&E 1979. Heber Geothermal Project, Binary-Cycle Demonstration Plant - Vol. III, 1979. Proposal by San Diego Gas and Electric Company submitted to the Director, Division of Geothermal Energy, U.S. Department of Energy. Called out in the text as (SDG&E 1979).

SDG&E letter, date. Letters from Mr. Joseph Dietz, Supervisor of Environmental Programs, San Diego Gas and Electric Company to H. M. Braunstein, Project Manager, Heber Geothermal Project, Oak Ridge National Laboratory. Called out in the text as (SDG&E letter, date).

1. SUMMARY

In the FY 1980 Energy and Water Development Appropriation Bill conference report, the U.S. Department of Energy (DOE) was directed to select a site for a 50 MWe (nominal capacity) binary-cycle demonstration plant within three months and to proceed without delay in developing the plant. Using available U.S. Geological Survey (USGS) information, the DOE Division of Geothermal Energy (DGE) evaluated all known moderate-temperature resources and determined that only the Heber site had the potential to meet all project objectives. The San Diego Gas & Electric Company (SDG&E) submitted an unsolicited proposal to DGE to design, construct, and operate a binary-cycle demonstration plant at the Heber site. This proposal was submitted and evaluated in accordance with DOE Assistance Regulations (10CFR Part 600). DGE evaluated the proposal based on technical, financial, and managerial criteria and found it to be acceptable. Preliminary environmental information was available for the site because the site had been considered as an alternative site in the Baca Ranch Geothermal Demonstration Plant Environmental Impact Statement (DOE/EIS-0049, 1980) and two CEQA Environmental Impact Reports addressing this proposed project and full-field development had been prepared by Imperial County. This environmental assessment (EA) was prepared to fulfill DOE's NEPA requirements and, specifically, to determine the environmental acceptability of the proposed project and to determine the need for an environmental impact statement (EIS).

The Federal action addressed by this EA is the cost-sharing agreement for design, construction, and operation of a 65 MWe gross (45 MWe net) geothermal binary-cycle demonstration plant located near Heber, Imperial County, California. The agreement will contain provisions for other participants in addition to SDG&E who will share obligations and revenues in proportion to the financial investment. The participants will be the Southern California Edison Company, the Imperial Irrigation District, the California Department of Water Resources, and the Electric Power Research Institute.

The power plant will utilize a simple binary conversion process consisting of three fluid loops: a geothermal fluid loop, a hydrocarbon working fluid loop (an isobutane-isopentane mixture), and a cooling water loop. The geothermal well field will consist of a production island with 13 production wells (12 producing wells and one back-up well) and an injection island with 7 injection wells (6 injecting wells and one back-up well). A mechanical draft cooling tower using approximately 8.8 m^3/s (140,000 gpm) of cooling water will be utilized. Approximately 0.22 m^3/s (3,500 gpm) of make-up water is required by the project. Water for the first five years of operation will be Colorado River irrigation water obtained from the Imperial Irrigation District. After the initial five years of operation, water will be obtained from the New River, irrigation return flows, or both. Construction of 0.8 km (0.5 mile) of 35.6 kV transmission line and rebuilding of 14.0 km (8.7 miles) of existing IID line will be required to transmit electricity to the IID grid.

The proposed plant is located in the Imperial Valley of Southern California, about 193 km (120 miles) east of San Diego, 2.3 km (1.4 miles) south of the township of Heber, and approximately 4.8 km (3 miles) north of the U.S.-Mexico border. The plant will occupy approximately 9.3 ha (23 acres) of the 16.2 ha (40 acres) of land purchased by SDG&E and will be located in the center of the 2957-ha (7320-acre) geothermal overlay zone. The land is currently in agricultural use. The Imperial Valley is the middle portion of the Salton Trough. The basement rocks of the trough have been downthrown along a series of northwest-trending, nearly vertical faults and are now covered by up to 7010 m (23,000 ft) of clastic sediments. The closest known active fault, the Imperial Fault, is located approximately 10 to 15 km (6.2 to 9.3 miles) from the project site.

The geothermal resource to be developed is located at a depth of 610 m (2,000 ft) to 3048 m (10,000 ft). The available resource is estimated to be 17 km^3 (14 x 10^6 acre-ft) at temperatures ranging from 165°C (325°F) to 182°C (360°F). The exact nature and amount of geothermal recharge is not certain; however, recharge results from subsurface and surficial drainage along the mountains, leakage of unlined canals, Colorado River underflow, infiltration of irrigation water, and infiltration of precipitation.

The principal effluents are salt drift and blowdown released from the cooling tower. No other emissions will occur during normal operations.

Geological impacts resulting from the project are gradual reservoir depletion, and displacement of prime farmland soils. No induced seismicity or induced subsidence are expected for the project because 100% reinjection of geothermal fluid will mitigate these impacts. Also Chevron Resources Company will monitor for these effects as part of its production requirements or as required by the Geothermal Element of the Imperial County plan. A maximum of 9 ha (23 acres) of prime soil will be displaced by the project in the conversion of the site to energy production. Prime soil losses will be mitigated by using an island approach for locating wells. All structures will be designed to minimize the effects of earthquakes. The shallow groundwater system will be monitored in order to determine if accidental releases are contaminating this resource.

Hydrological impacts result from water depletion, effluent discharge, and thermal enrichment. These impacts will be mitigated by compliance with California Regional Water Quality Control Board CRWQCB permit requirements. The project is not located within the 100-yr. flood hazard boundary.

Air quality impacts are minor and consist of the release of small quantities of particulates, SO_x, CO, HC, NO_x, and H_2S during well drilling; particulates, CO, HC, and NO_x during plant construction; and salt drift during operation. Total suspended particulates (TSP) from cooling tower salt drift will be controlled to acceptable levels by drift elimination to losses of 0.008% or less.

No significant social or economic impacts will result from this project. Population and housing demand increases will be minor. A temporary minor increase in traffic will occur during construction. No cultural resources, archaeological or historic sites, or National Natural Landmarks will be affected by the project. Approximately 9.3 ha (23 acres) will change from its existing land use (agriculture) to energy production. The proposed project conforms with existing county and regional plans. Visual impacts will be minimal and partially mitigated by painting aboveground pipelines an earth tone. Noise levels will increase slightly over ambient levels.

Ecological impacts result from cooling tower blowdown and salt drift. Aquatic impacts will be minor as a result of compliance with the CRWQCB permits governing blowdown disposal. In addition, California Department of Fish and Game anticipates monitoring the effect of water withdrawals, on the New River Delta and Salton Sea, that would result from full-field development. Salinity of the Salton Sea is expected to reach 40,000 ppm two years earlier than without the full-field development. A rise in salinity to 40,000 ppm, regardless of time of occurrence, will result in elimination of game-fish reproduction with resultant, eventual elimination of game fish in the Sea. The effects of salt drift deposition on cropland and natural vegetation will be insignificant as long as the drift rate is maintained at no more than 0.008% loss. To ensure that salt deposition impacts remain insignificant, SDG&E will conduct field studies and monitoring programs at the project site during plant operations. If the studies indicate a potential for significant impact from salt drift, mitigation measures will be implemented.

Impacts associated with full-field development, which is not part of the proposed Federal action but which may be encouraged (although definitely not initiated) by the Federal action, are documented in this work as reported in the VTN Master EIR (EIR 1979). Although the full-field development is not part of the proposed Federal action assessed here, information extracted from the EIR (1979) was selectively verified as appropriate for fully addressing the environmental scope of the proposed action. Development of the Heber resource is presently being actively pursued by private enterprise. Many of the permits necessary for full-field development have already been issued to the private sector. The proposed Federal action is not initiating full-scale development of the Heber resource. No significant impacts are anticipated as a result of the full-field development that may be encouraged by the proposed Federal action.

Table 5.4, which is reproduced here from section 5.11, summarizes both the unavoidable adverse impacts of the proposed Federal action and their significance. No significant impacts are anticipated as long as mitigation and control measures are implemented. SDG&E will implement all necessary mitigation and control measures. DGE will review information obtained from the monitoring program and will inspect the site to verify that mitigation measures are implemented and effective.

Table 5.4. Unavoidable adverse impacts

Issue	Impacts	Significant — yes/no	Sections
Land use	9.3 ha (23 acres) will be consumed	No	5.2, 6.2
Noise	Minor increase in ambient level	No	5.6, 6.6
Population	Negligible increase	No	5.7.1, 6.7
Housing	Negligible increase in demand	No	5.7.3
Transportation	Very minor increases	No	5.7.5
Cultural resources	None	No	5.8
Aesthetics (construction)	Minor visual impact	No	5.9
Aesthetics (operation)	Minor visual impact	No	5.9
Air quality (well construction)	Increase in TSP, SO_x, CO, HC, NO_x, H_2S	No	5.5.1
Air quality (plant construction)	Increase in TSP, CO, HC, NO_x	No	5.5.2
Air quality (operation)	Emission of particulates and salt drift	No, as long as drift eliminators (0.008% loss or better) are used	5.5.2, 5.5.3
Resource depletion	Gradual fluid and thermal depletion of reservoir	No, mitigated as much as possible	5.1.1, 6.1.1
Induced subsidence	None projected, local alteration of drainage systems and agriculture possible	No,[a] will be monitored and if detected mitigated	5.1.2, 6.1.2
Induced seismicity	None projected	No,[a] will be monitored and if detected mitigated	5.1.3, 6.1.3
Impacts caused by soils and surficial conditions	None, corrosion or bearing failure possible if unmitigated	No,[a] mitigation will eliminate or minimize impacts	5.1.4, 6.1.4
Displacement of prime farmlands	Displacement of approximately 23 acres of prime farmland	No, design has minimized impact as much as possible	5.1.5, 6.1.5
Damage caused by earthquakes	Slight damage	No, facilities will be adequately designed	5.1.6, 6.1.6
Damage caused by floods	None	No	5.1.7, 6.1.7
Accidental contamination of soils and groundwater	None projected, slight deterioration possible	No, will be mitigated if detected	5.1.8, 6.1.8
Water depletion	Reduced water available for irrigation	No, as long as water allotment is controlled by IID	5.3
Effluent discharge	Potential water quality change in the New River	No, as long as CRWQCB mitigation and monitoring requirements are followed	5.3, 6.3
Thermal enrichment	Potential increase in New River aquatic weed growth	No[b]	5.4
Water withdrawal from agricultural drain	Drain flow drawdown, potential water quality degradation and altered instream flow	No[b]	5.3, 5.4, 6.3, 6.4
Salt drift on croplands	Salinization of soils and foliar damage to crops	No,[b] as long as drift eliminators (0.008% loss or better) are used	5.2.2
Salt drift on natural vegetation	Salinization of soils and elimination of salt-intolerant species	No,[b] as long as drift eliminators (0.008% loss or better) are used	5.4.1
Terrestrial ecology	50 ha of native desert vegetation removed for evaporation basin (one option for blowdown disposal after first five years of operation)	Qualified No,[b] survey of area for rare or important species will confirm	5.4.1

[a]Impact occurrence is unlikely or highly unlikely. Will be mitigated when and if detected.

[b]Monitoring during the first five years of operation will produce the data for establishing mitigation measures for the remainder of the plant life.

6

2. PURPOSE AND NEED FOR THE ACTION

2.1 INTRODUCTION

In the FY 1980 Energy and Water Development Appropriation Bill conference report, DOE was directed to select a site within three months for a 50-MWe (nominal capacity) geothermal binary demonstration power plant and to proceed without delay in developing the plant. Public Law (PL) 95-238 authorized the plant and funds were appropriated in PL 96-69. The DOE Division of Geothermal Energy evaluated all the known moderate-temperature resources (U.S. ERDA 1977; Muffler 1979; White and Williams 1975) and selected the Heber reservoir as the only geothermal demonstration site that has the potential of meeting all the objectives of a 50-MWe geothermal binary demonstration power plant. SDG&E submitted an unsolicited proposal to DOE for the design, construction, and operation of such a demonstration plant at Heber under a cooperative cost-sharing agreement with DOE. DOE participation in the project supports the goal of the Hydrothermal Subprogram of the DGE - to stimulate the development of hydrothermal resources as an economic, reliable, operationally safe, and environmentally acceptable energy source (U.S. ERDA 1977). SDG&E is the only utility in the country that has extensively evaluated the binary system and expressed a desire to build a 50-MWe binary demonstration plant.

Before any final decision can be made to proceed with the cooperative project, it is necessary that the NEPA process be completed. As indicated in the preface, two environmental impact reports, one for the proposed project and one for full-field development of the Heber resource, have been prepared for the Imperial County Planning Department. Although these documents contain helpful environmental information about the site and the proposed project, they are not acceptable for adoption as NEPA documents (Mezga and Brechbill 1980). Specifically, the EIRs failed to consider the following:

1. DOE's involvement in the project - resulting in a need for compliance with NEPA requirements and the Council on Environmental Quality (CEQ) regulations;

2. DOE's responsibility for the scope and content of the environmental review;
3. alternatives to the proposed action;
4. several important environmental issues.

Therefore, this environmental assessment was prepared to encompass and evaluate DOE's involvement in the project, to rectify the deficiencies, and to evaluate independently the data contained in the EIR.

2.2 OBJECTIVES OF THE ACTION

2.2.1 Hydrothermal subprogram goals

Rapid commercial development of the nation's hydrothermal resources as energy sources is a major objective of the Federal geothermal program. Hydrothermal resources over 90°C in the United States have a heat content of about 3 x 10^{21}J (7.4 x 10^{20} Cal.) and are located primarily in the Western states, Hawaii, and Alaska (U.S. ERDA 1979). Development involves both characterization of resources and economic application of their potential. Thus, the hydrothermal commercialization program seeks to cooperate with the private sector in

1. developing known hydrothermal areas;
2. overcoming technical, economic, and institutional restraints to hydrothermal resource development; and
3. demonstrating on a cost-shared basis the commercial feasibility of hydrothermal energy utilization.

The proposed Federal action fulfills the objectives of the hydrothermal program and furthers the aims of the Federal geothermal program.

2.2.2 Project objectives

DOE and SDG&E propose to enter into a cost-sharing agreement to design, construct, and operate a commercial-scale geothermal binary-cycle electric power plant utilizing a liquid-dominated hydrothermal reservoir. DOE hopes to demonstrate that the production of electric power from geothermal resources using binary conversion systems is technically, economically, environmentally, and socially acceptable. The project, which will also include associated reservoir development, will address the following objectives:

1. demonstrate a binary conversion system technology at commercial scale;
2. demonstrate reservoir performance characteristics for a specific liquid-dominated hydrothermal reservoir;
3. demonstrate the validity of reservoir engineering estimates of reservoir productivity (capability and longevity);
4. provide Federal assistance to initiate development at a resource of large potential;
5. act as a "pathfinder" for the regulatory process and for other legal and institutional aspects of geothermal development; and
6. provide a basis for the financial community to estimate the risks and benefits associated with geothermal investments.

The plan for commercialization is based on the premise that developers, utilities, and the financial community are reluctant to make commitments to unfamiliar technologies until confidence is gained from commercial demonstration of these technologies. Binary technology, which shows considerable long-term promise for significantly reducing the cost of electricity from moderate-temperature geothermal reservoirs, is perceived to have a higher risk than flash-steam technology. For example, the long-term operation of downhole pumps, the efficiency and reliability of a 65-MWe (gross) hydrocarbon turbine, and the handling and safety of the hydrocarbon fluid, are perceived as major risks by utilities and resource developers. Additionally, the uncertainty of binary plant economics can only be resolved by operating a demonstration plant of 50-MWe (nominal) generating capacity, the minimum size for an economical commercial facility. Thus, the proposed action is aimed at providing the private sector with assurance that the risks associated with an integrated binary geothermal system are low and that the technology is feasible, reliable, economical, and environmentally acceptable.

2.3 RELATIONSHIP TO OTHER DEMONSTRATION PROJECTS

In 1977, DOE issued a program opportunity notice (PON) for design, construction, and operation of a 50-MWe demonstration power plant using a liquid-dominated hydrothermal resource, for which the conversion technology was not specified (i.e., flash steam vs binary). The primary objective of the PON was demonstration of favorable economics, and the competition was won by a proposal for a flash-steam power plant located at Valles Caldera in New Mexico. Although the Heber site was found to have fewer environmental impacts than the Valles Caldera site, it was not selected because the original proposal was found to be unresponsive to the PON on technical, financial, and managerial issues. The proposal was later restructured and resubmitted (Section 2.4.2). In 1978, as a result of persistent activity by utilities and resource developers, DOE sponsored a study by the Geothermal Resources Council, which indicated a great need for hydrothermal demonstration projects – particularly technology demonstrations of binary systems. Because a privately owned 10-MWe binary pilot plant was under construction at East Mesa, California, and a 5-MWe binary pilot plant was to be constructed by DOE at Raft River, Idaho, DOE submitted to Congress (in response to PL 95-238, which authorized a second, binary, 50-MWe demonstration plant) a statement questioning the need for an additional binary demonstration plant. The committee on Science and Technology did not concur, and conference report 96-388 of the FY 1980 Energy and Water Development Appropriation Bill directed DOE to select a site within three months for a 50-MWe geothermal binary demonstration power plant and to proceed without delay in developing the plant. PL 95-238 authorized the plant and funds were appropriated in PL 96-69.

2.4 PROCUREMENT ACTIONS

2.4.1 Site selection

All the known moderate-temperature resources listed in USGS Circulars 726 and 790 (Muffler 1979; White and Williams 1975) were evaluated by DGE, and the only resource demonstration site found to have the potential of meeting all the objectives of the 50-MWe geothermal binary demonstration plant was Heber in the Imperial Valley of California. The reservoir criteria used in the selection, the reservoirs evaluated, and characteristics of the two possibly qualifying resources, Heber and East Mesa in the Imperial Valley of California, are given in Appendix A. Because the East Mesa site had several deficiencies, the Heber reservoir was selected as the better geothermal resource demonstration site. At the time of the evaluation, some difficulties were being experienced in obtaining sufficient fluid flow for the pending 50-MWe flash-steam plant at the East Mesa site. Although the fluid-flow difficulties have been remedied, the resource contains a lower temperature fluid than that at the Heber site, which results in a higher cost of produced electric power. The demand for this higher-cost power was questionable. East Mesa may also experience future difficulties in acquiring adequate supplies of cooling water or injection makeup water.

2.4.2 SDG&E proposal

SDG&E submitted an unsolicited proposal to DOE on December 4, 1979 for the design, construction, and operation of a 45-MWe net (65-MWe gross) geothermal binary demonstration plant to be located at the Heber site. SDG&E is the only utility in the country that has extensively evaluated the binary system and expressed a desire to build a 50-MWe nominal binary demonstration plant. The company has acquired the property for a plant at Heber and obtained many of the necessary permits from the county. The proposal by SDG&E satisfies the requirements of the FY 1980 Appropriations Bill conference report and also meets the needs of the geothermal industry in confirming binary technology as applied to moderate-temperature geothermal resources in the United States.

2.5 FEDERAL ROLE

2.5.1 Cost sharing

It is anticipated that the form of Federal participation for this project will be in the form of funding support under a cost-shared cooperative agreement. However, every effort will be made to assure that the Federal involvement does not perturb the project cost so that the project may provide a realistic basis for private sector assessment of commercial feasibility.

2.5.2 Management and schedule

The Federal role in project management will be significantly different from the role in Federal facility procurement. DOE, through DGE, will participate in major management decisions but will leave day-to-day management decisions to the industrial participants in order to provide as commercial a climate as possible for project operation. The schedule proposed by SDG&E calls for final plant design within 25 months after DOE agreement, 20 months of construction, several months of startup testing, and a minimum two-year operational demonstration period.

2.6 BENEFITS OF THE ACTION

Commercial adoption of binary plants could be advanced two to four years by a demonstration power plant. If the growth curve is roughly exponential, a capacity of 10,000 to 20,000 MWe could be added to the nation's supply by the year 2000.

Data from the flash-steam Valles Caldera 50-MWe demonstration plant, which will operate from a reservoir temperature of 273°C (523°F), will allow direct comparison with the proposed binary plant at Heber, which will operate from a geothermal resource at 175°C (347°F). Additionally, if Southern California Edison builds its planned two-stage, flash-steam plant at Heber, the comparison between flash and binary system plants at the same resource should provide the realistic assessment of commercial feasibility necessary to stimulate industrialization. Data from the DOE-constructed 5-MWe Raft River binary pilot plant will provide additional information for evaluating binary technology for future applications.

REFERENCES FOR SECTION 2

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Muffler, L. J. P., Ed. 1979. Assessment of the Geothermal Resources of the United States - 1978, USGS Circular 790, U.S. Geological Survey.

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White, D. E., and D. L. Williams, Eds. 1975. Assessment of the Geothermal Resources of the United States - 1975, USGS Circular 726, U.S. Geological Survey.

14

3. DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

3.1 INTRODUCTION

The proposed Federal action addressed in this report is to enter into a cost-sharing agreement to design, construct, and operate a commercial-scale geothermal binary electric power plant that utilizes a liquid-dominated hydrothermal reservoir. The goal of the Heber binary-cycle geothermal project is to demonstrate that the production of electric power from geothermal resources in the United States using a binary conversion system can be economical as well as environmentally and socially acceptable.

The plant will be an integrated, commercial-scale, geothermal electric power generating plant. It includes the geothermal field system, fluid production equipment, fluid transmission system, conversion system, electric generating plant, geothermal fluid treatment, spent fluid disposal facilities, and a tie-in to an electric utility transmission network.

The plant generating system will use geothermal energy as the heat source for power generation and binary conversion technology. The project will include provisions for collection and reduction of data generated by the demonstration project. Thus, considerably more instrumentation will be included in the operational design than for a strictly commercial power plant.

Because the project contributes to the furtherance of the Federal geothermal program goal (U.S. DOE 1979a) that is intended to stimulate non-Federal development in the United States of large moderate-temperature, liquid-dominated, hydrothermal resources for electric generation, full-field development of the Heber resource of up to 500 MWe of generating capacity is examined in Chapter 7. However, because full-field development is not dependent on this binary demonstration project, assessment of this subsequent action is not addressed in detail here (see Preface).

3.2 NO ACTION ALTERNATIVE

As discussed in Sect. 2.1, DOE was directed in the FY 1980 Energy and Water Development Appropriation Bill conference report to proceed without delay in developing a 50-MWe geothermal binary demonstration power plant. The proposed action fulfills the directive, whereas implementation of a "no action" alternative (i.e., denial or delay of Federal funding) contravenes the directive. Development of geothermal resources in the Heber anomaly would probably proceed without the proposed project but at a different rate and using a different technology mix. Therefore, commercial development of the binary cycle for utilizing the large liquid-dominated hydrothermal resources of the United States would suffer some delay. Because of the perceived financial and technological risks of the commercially unproven binary cycle (Sect. 2.2.2), industry adoption of binary plants would be delayed perhaps two to four years. The benefits of commercial adoption, namely, addition of geothermal electrical capacity to the nation's supply will not be realized as rapidly if the "no action" alternative is selected (Sect. 2.6).

3.3 PROGRAMMATIC ALTERNATIVES

The objective of the proposed action (Sect. 2.2) is the near-term development of the nation's moderate temperature hydrothermal resources by demonstrating the geothermal production of power at a price that is competitive with other conventional, nuclear, or fossil power sources. Adoption of an alternative power-producing program is inconsistent not only with the goal of the proposed action but also with that of the Federal Geothermal Program.

3.4 ALTERNATIVE SITES

In its selection of the Heber site, the Division of Geothermal Energy evaluated all the known moderate-temperature resources listed in USGS Circulars 726 and 790 (Muffler 1979; White and Williams 1975). As discussed in Sect. 2.4.1, the only resource demonstration site found to have the potential of meeting all the objectives of the proposed project was Heber (Appendix A).

3.5 ALTERNATIVE PROCESSES

The only currently reasonable alternative conversion technology for a moderate-temperature resource is the flash-steam cycle. A proposal to design, construct, and operate a 50-MWe flash-steam demonstration power plant at the Valles Caldera in New Mexico has recently been awarded by DOE (Sect. 2.3). Additionally, the Southern California Edison Company is planning to construct a 50-MWe flash-cycle power plant at the Heber site that is to be operational by January 1982 (SDG&E 1979). Since DOE is presently supporting a flash-cycle demonstration project at another geothermal location and a commercial operation using flash cycle will be on line shortly at Heber, the adoption of a flash-steam cycle in place of the proposed binary cycle would duplicate existing plans. Also, it would be inconsistent with the Congressional directive that specifically calls for demonstration of binary technology.

3.6 ALTERNATIVE USES OF GEOTHERMAL ENERGY

A nonelectrical application of the Heber resource is inconsistent with the objective of the proposed action to demonstrate the economic potential of electric power production from moderate-temperature geothermal resources. Therefore selection of an alternative use for the resource is counterproductive to achieving the goal of the action.

3.7 THE PROPOSED ACTION

3.7.1 Site location

The Heber Binary Cycle Geothermal Project will be located in southern California's Imperial Valley, about 193 km (120 miles) east of San Diego, 2.3 km (1.4 miles) south of the community of Heber, and approximately 4.8 km (3 miles) north of the U.S.-Mexico border (Figs. 3.1 and 3.2) on land presently utilized exclusively for agriculture. The site is in the southwest corner of Section 33 of R14E, T16S. Approximately 8.1 ha (20 acres), of the 16.2 ha (40 acres) purchased by SDG&E, will be required for the plant site. The site is about in the center of the 2965-ha

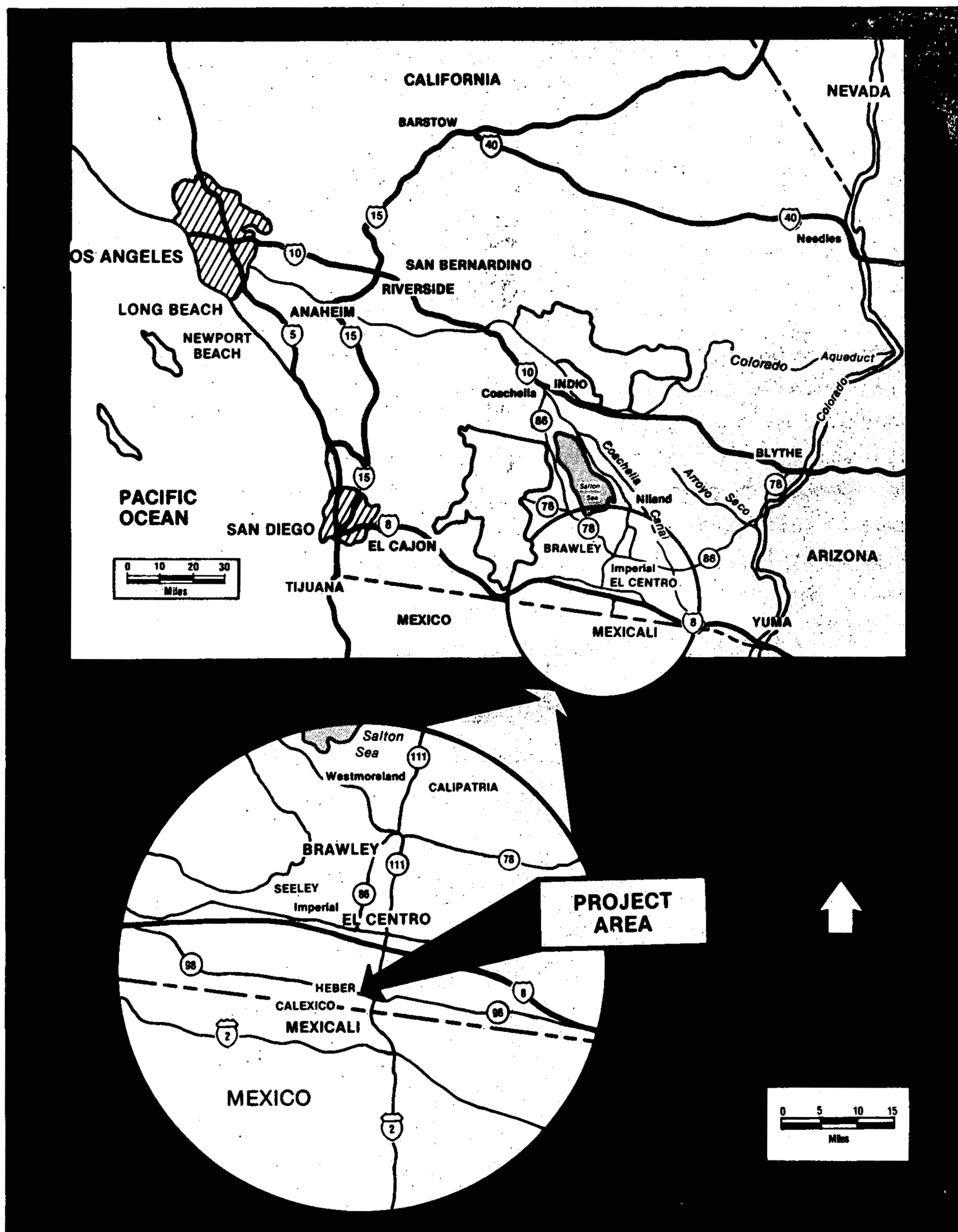

Fig. 3.1. Index map of Imperial Valley and the project area. Source: SDG&E 1979.

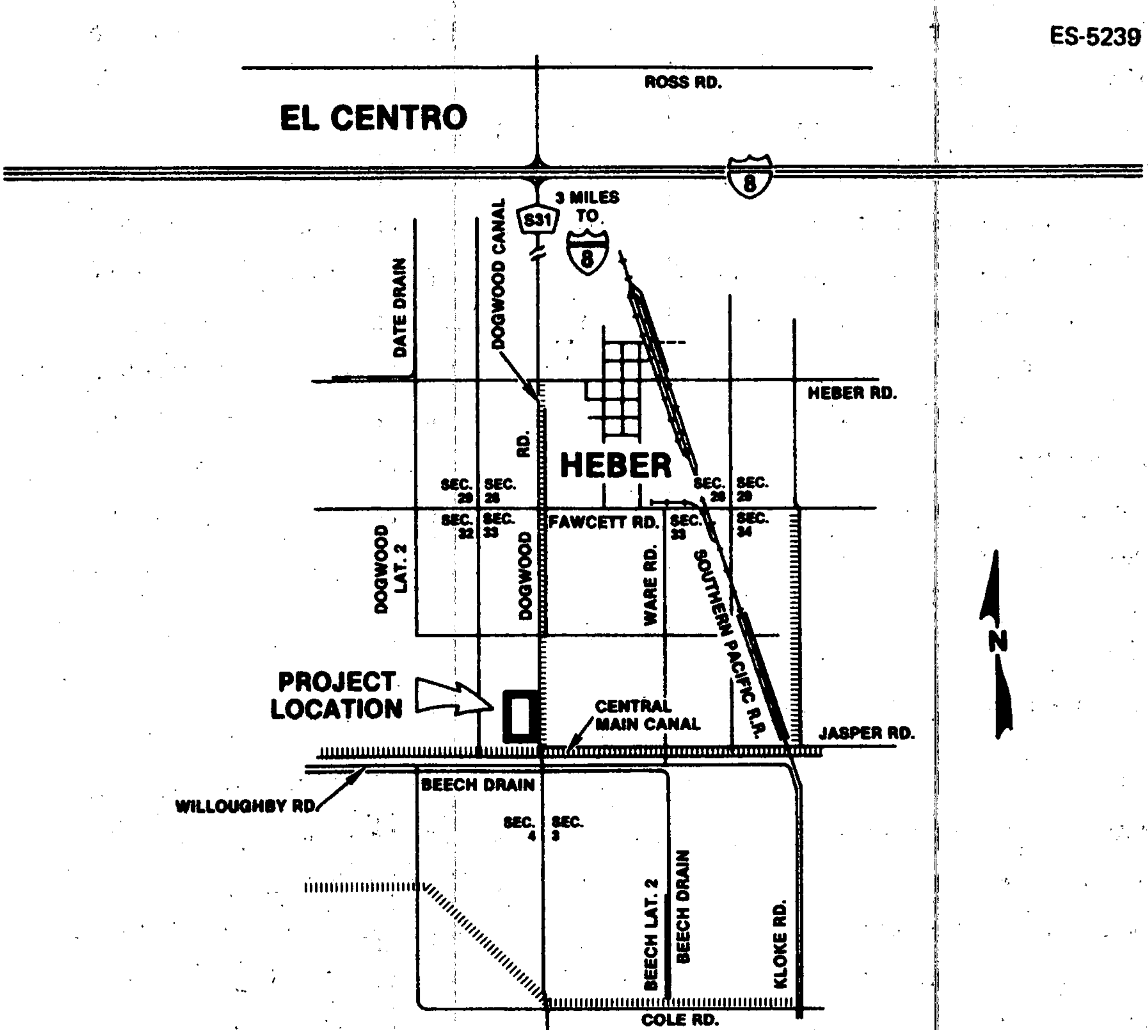

Fig. 3.2. Project location. Source: SDG&E 1979.

(7320-acre) geothermal overlay zone, which was established by a resolution of the Imperial County Board of Supervisors on May 19, 1978 (SDG&E 1979). It is bordered on the east by Dogwood Road and on the south by the Central Main Canal (and Willoughby Road). The Beech drain flows near the site on the south side of Willoughby Road.

A set of minimum conditions had to be met in order for the Heber location and reservoir to qualify as a demonstration site for the 50-MWe geothermal binary power plant. These conditions, which include reservoir temperature and salinity, depth and size of reservoir, electric demand, availability of cooling water, and the existence of adequate environmental, socioeconomic, and geothermal data, are listed in Appendix A. Of all the known hydrothermal reservoirs in the United States, only two resources have the potential of meeting the established reservoir criteria and of the two, only the Heber site is capable of meeting the nonreservoir criteria (ORNL Verification Memo No. 1).

3.7.2 Project description

The Heber Binary-Cycle Geothermal Project consists of design, construction, and operation of a demonstration binary power plant and development of the associated liquid-dominated hydrothermal reservoir. Because the commercial-scale electric generating plant will be an integrated plant, it will include the geothermal field system, fluid production equipment, fluid transmission system, conversion system, electric generating plant, geothermal fluid treatment and spent fluid disposal facilities, and a tie-in to an electric utility transmission network.

3.7.2.1 Site access roads

Major direct access routes (Interstate 8 and Highway 98) connect the Imperial Valley with San Diego, California and Yuma, Arizona (SDG&E 1979). Additionally, the project area, which is immediately accessible by two county roads (Highways 86 and 111) that border the project site, is also accessible from anywhere in the vicinity by a network of major and secondary roads that traverse the entire Imperial Valley area. Load limits on these roads are determined by the California Vehicle Code and loads in excess of these limits may require special permits.

3.7.2.2 Well drilling, testing, production, and abandonment

Because the Heber reservoir is located on prime farmland, it is essential that geothermal activities disturb as little agricultural land as possible. Therefore, an island drilling concept will be employed. All production wellheads will be centrally located on a production island and the wells will be directionally drilled to the required bottom-hole location. Similarly, injection wellheads will be located on a separate injection island and the wells will be directionally drilled to their desired bottom-hole locations (Fig. 3.3).

The proposed 50-MWe demonstration plant will require about 900 kg/s (7.14×10^6 lb/h) of geothermal fluid to be delivered from one production island comprising 13 production wells (12 operating wells and one well drilled as a spare). A single injection island containing seven wells (six operating wells and one well drilled as a spare) will handle the 100% reinjection of the fluid. All well-drilling procedures and equipment will be in accordance with rules and regulations of the the California Division of Oil and Gas (DOG) and are described in detail in EIR 1978. The regulations mandated by the DOG include criteria for drilling, casing, and monitoring to prevent well blowouts, the primary source of accidents in geothermal well drilling (Sect. 3.7.2.7).

Drilling and testing

Drilling of both the production and injection wells will be with conventional rotary mud-circulating drilling rigs utilizing oil-field procedures. Fifteen test wells ranging in depth from about 915 to 2750 m (3000 to 9000 ft) have been successfully drilled into the Heber anomaly using conventional oil field equipment and standard cementing hardware. Eight of the wells were cased, and subsequent tests indicated neither evidence of casing failure nor any corrosion greater than 0.13mm per year (5 mils per year), a tolerable corrosion rate. Because of the satisfactory results with this testing program, no drilling, casing, or cementing problems are anticipated in installing wells for the demonstration plant, and no additional test wells are planned (SDG&E 1979).

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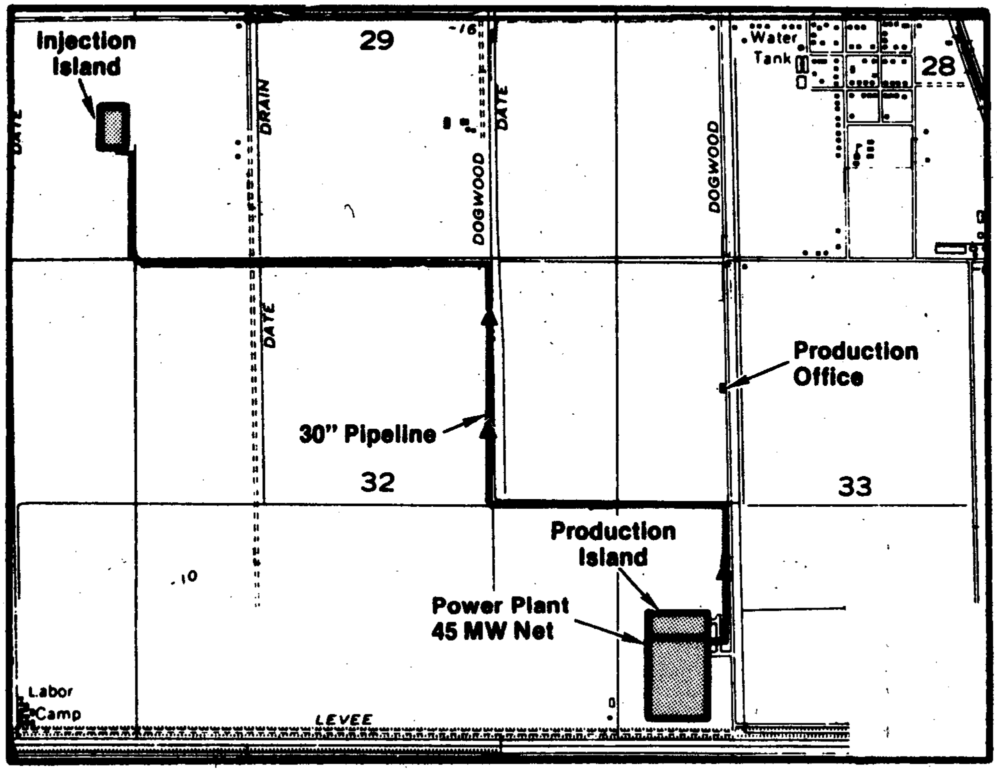

Fig. 3.3. Pipeline route from powerplant to injection island. Source: SDG&E 1979.

Present plans call for drilling primarily into the upper two of four designated production zones, numbered one through four, each with a thickness of 610 m (2000 ft) and beginning at a 610-m (2000-ft) depth. Production and injection wells will be drilled concurrently: six zone 1 producers, six zone 2 producers, three zone 1 injectors, and three zone 2 injectors. Additionally, one injector and one producer well will be drilled to 3000 m (10,000 ft), at the base of zone 4, to give further geologic and reservoir data. Each producer well will be fitted with an electrically driven downhole shaft-driven turbine pump. The pumps keep the fluid at sufficiently high pressure to prevent vaporization, assuring that the geothermal fluid is maintained in the liquid phase from the producing wells, through the heat exchanger, and to the injection wells. The producer wells will be drilled vertically to a depth below the expected setting depth of the pumps [180 to 240 m (600 to 800 ft)], then they will be directionally drilled to the desired bottom-hole locations. Injection wells, which will not contain pumps, will deviate from the vertical at shallower depths. Both production and injection wells will be cased as shown in Fig. 3.4 and the casings will be perforated by jet to provide the desired production rates. All casings will be fully cemented and an outside casing will also be employed and cemented through shallow sediments to protect against leakage of geothermal fluid into shallow groundwater. The wellheads will be located in concrete cellars *approximately* 1.6 m (6 ft.) below ground level to keep the wellhead manifolds below grade and to contain any small spills at the wellhead. The pump motors will extend above grade as shown in Fig. 3.5 (EIR 1978). The drilling mud system is a water-based slurry containing clay solids and other inert ingredients to maintain suitable density and viscosity characteristics, detergents for lubricating the cutting bit, and caustic soda (sodium hydroxide) as a cutting agent (Table 3.1). The pH of this fluid is about 9 or 10, and thus it will be handled as a potentially harmful substance and disposed of in an approved disposal area. Although the temperature of the mud is the major hazard, it can also be irritating, if not corrosive, to unprotected skin or eyes (Hahn 1979). As shown in Fig. 3.6, the mud slurry is pumped down the drill pipe through the drill bit where it removes rock cuttings and transports them to the surface.

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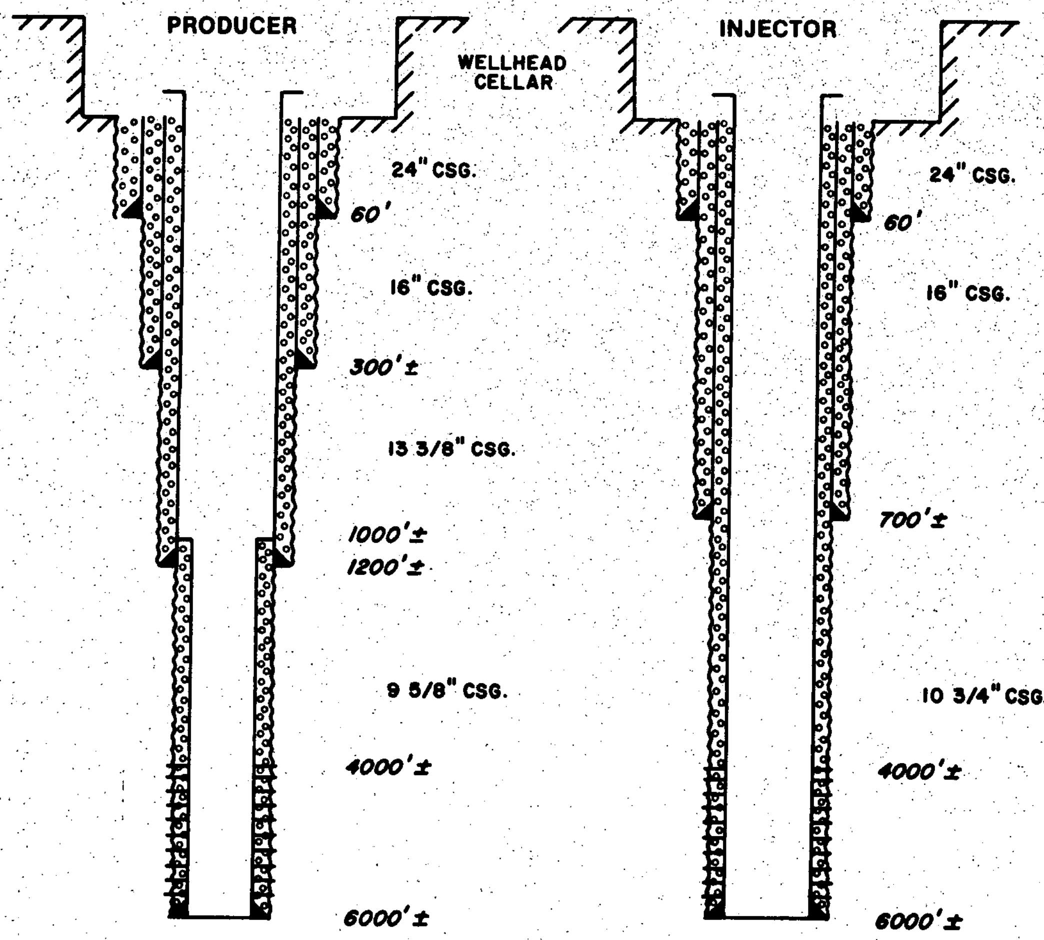

Fig. 3.4. Typical casing arrangement for geothermal wells.
Source: SDG&E 1979.

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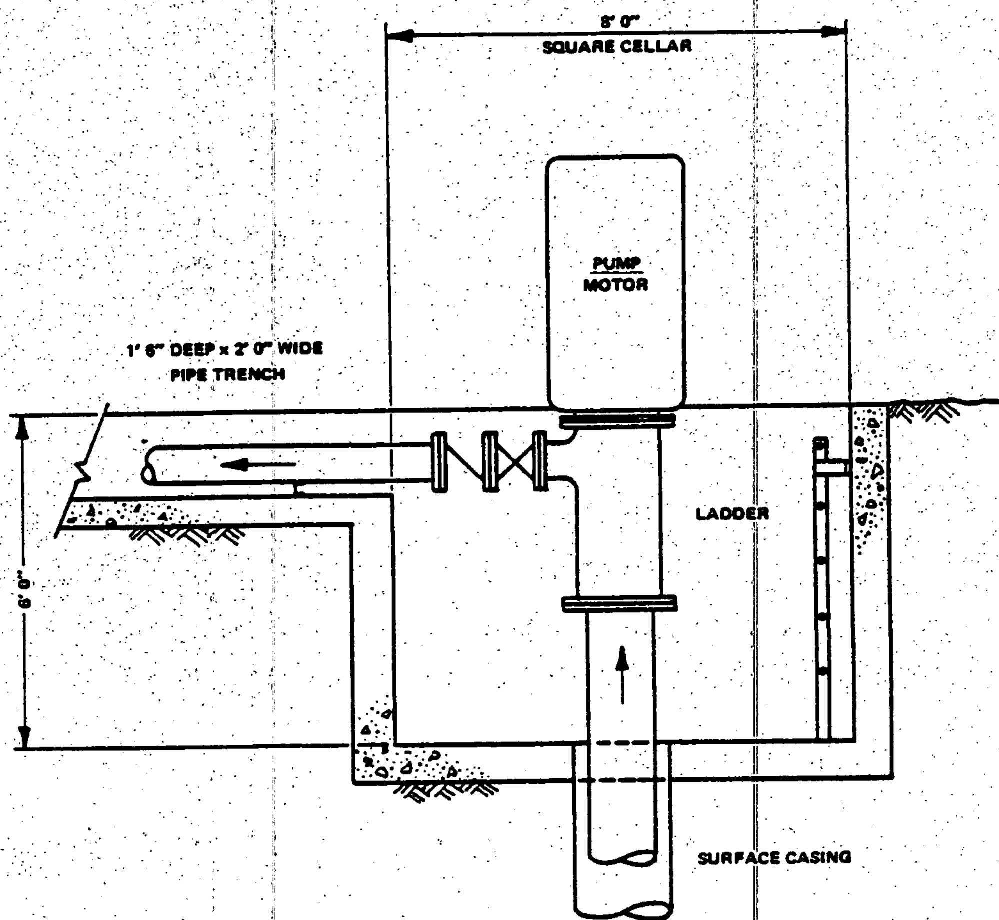

Fig. 3.5. Typical section of a well cellar. Source: Chevron 1977.

Table 3.1. Composition of typical drilling mud

Values are given in kg(lbs) unless otherwise indicated

Components	Amount for drilling to 1981 m (6000 ft)	
Magcogel (bentonite)	13,600	(30,000)
Tannathin (lignite)	2,540	(5,600)
Caustic soda	1,180	(3,700)
Barite (barium sulfate)	450	(1,000)
Bicarbonate of soda	225	(50)
Soda phosphate	725	(1,600)
Soda ash	680	(1,500)
Geo-gel (sepiolite)	31,400	(69,200)
WL-100 (sodium polyacrylate), L (gal)	662	(125)
Drilling detergent (soap), L (gal)	56.8	(15)
Water, ft^3; L (gal)	680,000	(180,000)
		(24,000)
Total volume of drilling mud is approximately, m^3 (ft^3)	708	(25,000)

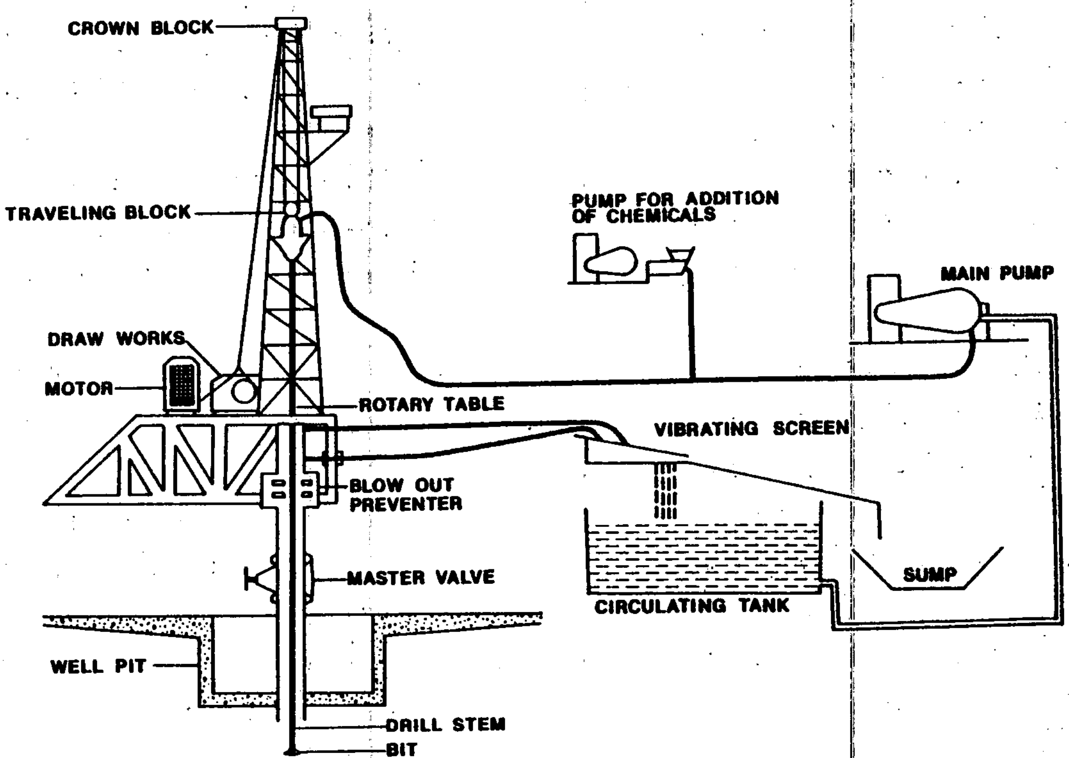

Fig. 3.6. Typical drilling mud cycle.

The cuttings and debris are separated by shaker screens from the drilling mud, which is reinjected down the drill pipe. The cuttings with adherent waste mud are discharged into an earthen pit from which they are collected and hauled to an approved disposal site (Sect. 3.7.2.7).

Production

The entire geothermal fluid [900 kg/s (7.14×10^6 lb/h)] will be produced at a wellhead pressure of about 1.38×10^6 Pa (200 psia) from wells located at one production island adjacent to the power plant (Fig. 3.7). The 13 producer wells are in two rows with sufficient space between them for drilling and maintenance. The producing island, which has a 0.46m (18 in.) high earth berm all around it to contain any unexpected geothermal fluid discharge, occupies 1.5 ha (3.73 acres) and has sufficient area for 32 wells.

Because the Heber resource is a moderate-temperature, fluid-dominated resource, the wells will not be at high pressure. Thus the likelihood of rapid fluid escape is lessened, decreasing the chances of serious flooding. However, in the unlikely event that large amounts of geothermal fluid escape, the volume of the bermed production island would contain 15 hours of flow at a rate of 80,000 barrels per day, the average free flowing volume for one well (Carroll 1980). In addition, spilled fluid will be reinjected as soon as possible by using the startup suction pump at the production island to move spilled fluid into the bypass line from which the fluid will enter the fluid return pipeline to the injection island (Carroll 1980).

A 1.8-m- (6-ft-) high chain link fence isolates the production area. The flow from each well can be adjusted manually by a valve in the discharge line at the wellhead. Discharge lines from individual wells connect to a common header from which the combined stream will flow through a desanding vessel and a metering station and then to the power plant. Each well will also have a bypass to the injection line or to the holding tank for use when bringing a well on line or during well cleanup. The production desander has four automatically controlled blowdown connections to remove accumulated sand from the desander and transport it into the fully lined sand pit from which the accumulated sand will be periodically trucked to an approved disposal site.

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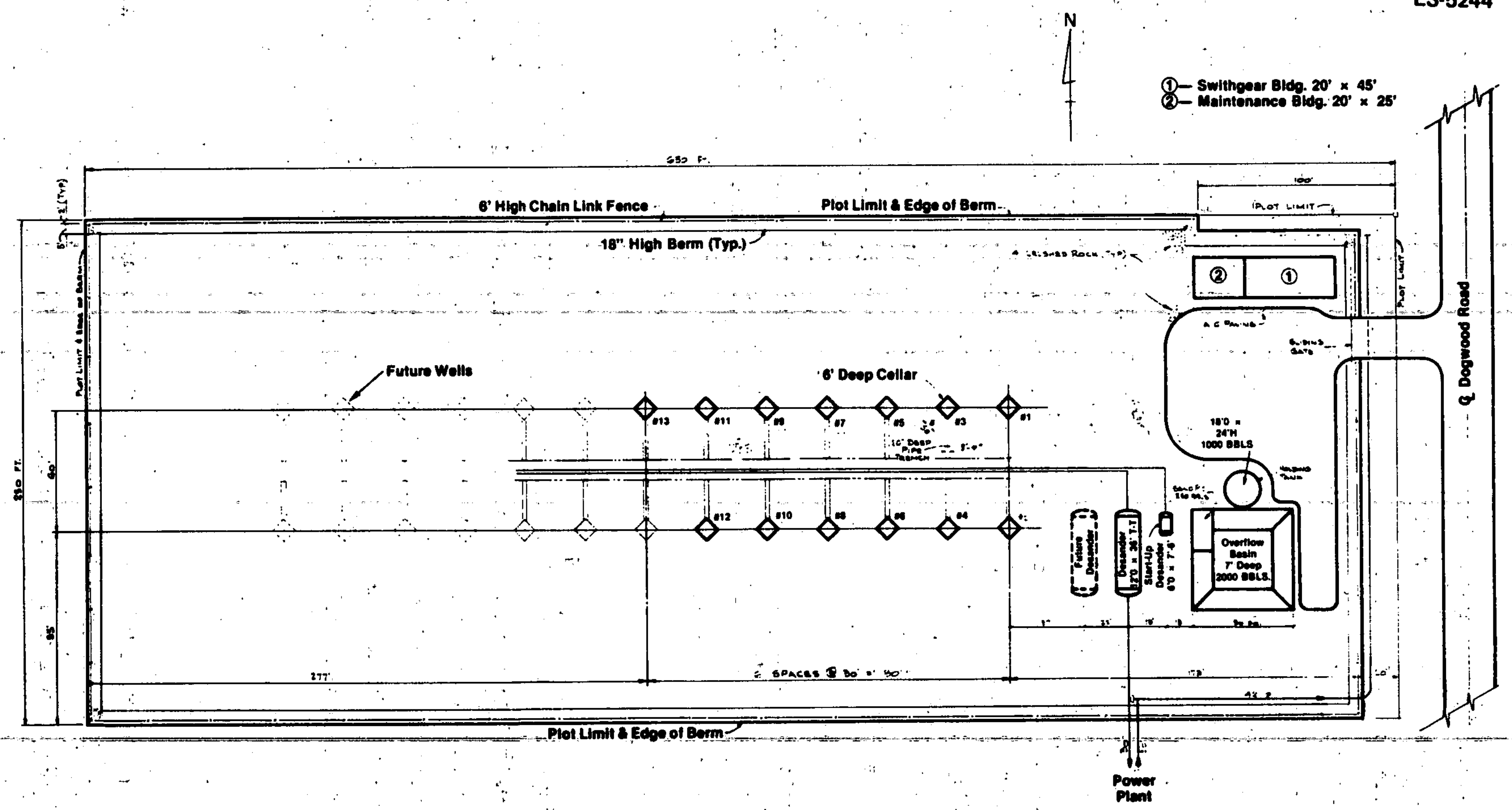

Fig. 3.7. Production island plot plan. Source: SDG&E 1979.

After passing through the heat exchanger in the power plant, the cooled geothermal fluid moves by pipeline to the injection island at a discharge pressure of 1.72×10^6 Pa (250 psia), provided by fluid return booster pumps. Because this pressure is insufficient for reinjection, additional pumping will be required at the injection island or equivalent location. The fluid temperature must be kept above 65°C (150°F) to prevent precipitation of solids before or during injection. Any cooler fluid will be diverted to a portable holding tank from which it will either be injected by mixing with hotter fluid or trucked to an approved disposal site. The holding tank will also accommodate fluid generated during backflow of an injection well although backflowing is expected to be needed infrequently. The layout of the injection island, which is located at the periphery of the resource, is similar to that of the production island. It also is surrounded by a 0.46m (18 in.) high earth berm and fence, contains seven wellheads with provisions for an additional seven wells, and occupies about 1.1 ha (2.8 acres) (Fig. 3.8). The fluid production facility construction will be completed approximately six months before the first turbine roll to allow time to evaluate the wells and the down-hole pumps.

Abandonment

Should well abandonment be necessary, it will be accomplished in accordance with State of California DOG regulations which require that proper steps be taken to protect underground or surface water from geothermal fluid infiltration and to prevent escape of all fluids to the surface. Written notice will be given of the intention to abandon a well and the proposed method of abandonment will be furnished the California DOG.

3.7.2.3 Power plant

The Heber power plant will be an outdoor station with a generating capacity of 45 MWe net and 65 MWe gross. On-site power consumption will be about 20 MWe. All major equipment, including the turbine generator,

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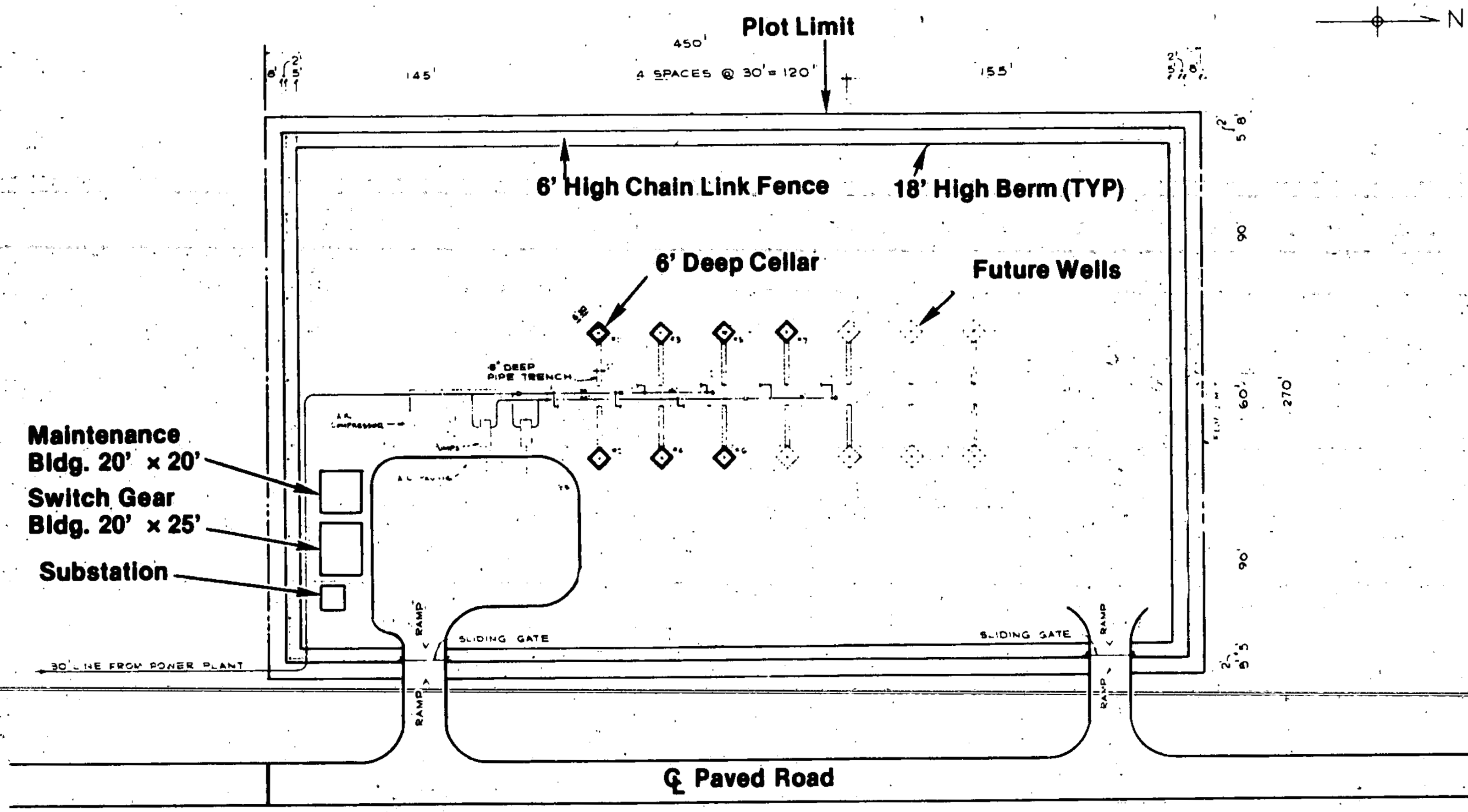

Fig. 3.8. Injection island plot plan. Source: SDG&E 1979.

will be installed outside. Outdoor installation will help avoid the safety hazards associated with handling and containment of hydrocarbons in an enclosed area (Sect. 3.7.2.8).

Process

The Heber power plant will use a simple binary-cycle conversion process which consists of three fluid loops: a geothermal fluid loop, a hydrocarbon working fluid loop, and a cooling water loop (Fig. 3.9). Only the cooling water loop produces emissions to the environment under normal operating conditions (Sects. 5.3 and 5.5.2).

The geothermal fluid is contained within a closed loop in which the single-phase liquid is withdrawn at a rate of 900 kg/s (7.14×10^6 lb/h) from the reservoir at 182°C (360°F), passes through the brine/hydrocarbon heat exchangers (where its sensible heat is transferred to the working fluid), and is returned in its entirety to the reservoir at about 72°C (160°F) without direct exposure either to the atmosphere or the working fluid.

The working fluid, which is a saturated hydrocarbon mixture of 90 mole percent isobutane and 10 mole percent isopentane, is also maintained within a closed loop and cycles through four stages:

1. vaporization in the brine/hydrocarbon heat exchangers to a supercritical fluid [153°C and 4×10^6 Pa (305°F and 575 psia)] by extracting heat from the geothermal liquid;
2. expansion through the turbine;
3. cooling and condensation in the hydrocarbon condensers to 43°C (110°F) by discharge of reject heat to cooling water; and
4. pressurization by pumping to 4×10^6 Pa (575 psia), the pressure required at the turbine inlet.

The cooling water, which is contained within a cooling loop, is cooled to 90°F by evaporation in a multicell mechanical-draft cooling tower (Sect. 3.7.2.4), is circulated through the power plant at a rate of 8.82 m^3/s (140,000 gpm), primarily through the hydrocarbon condensers

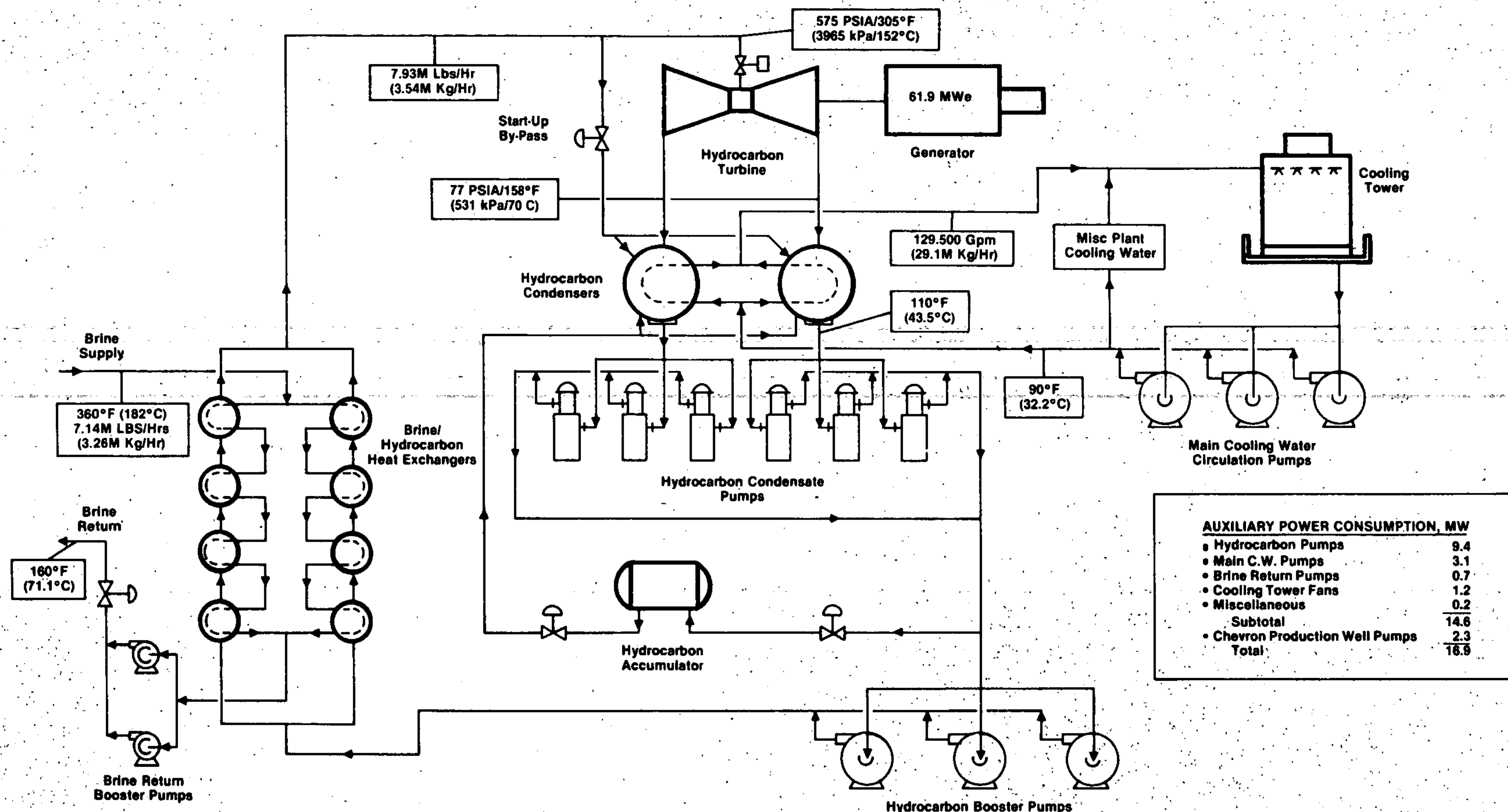

Fig. 3.9. Power cycle schematic. Source: EIR 1979.

[where it absorbs heat, raising the temperature to about 43°C (110°F)], and is returned to the cooling tower. Makeup water [0.20 to 0.22 m^3/s (3200 to 3500 gpm)] will replace both evaporative and drift losses and the approximately 0.044 to 0.050 m^3/s (700 to 800 gpm) blowdown that will control the total dissolved solids (TDS) content of the cooling water.

Equipment

Four major components comprise the power plant:

1. the heat exchangers — the brine/hydrocarbon heat exchangers and the hydrocarbon condensers,
2. the turbine generator,
3. the cooling tower (Sect. 3.7.2.4), and
4. the various pumping systems.

Because the proposed Federal action includes design as well as construction and operation, final decisions on the exact description of some of the components are not yet available. For example, information describing the geothermal fluid/hydrocarbon heat exchangers, which are central to operation of the power plant, remains to be developed. Environmental considerations identified in this assessment are being factored into the project design. The hydrocarbon condensers will be of the shell-and-tube type with carbon steel shells and admiralty metal tubes. Because the hydrocarbon pressure on the shell side will exceed the water pressure in the tubes, it will be essential that the tubes and the joints be designed to minimize the risk of hydrocarbon leakage to the cooling water. Hydrocarbons in the cooling water could be released to the atmosphere during cooling tower circulation. A hydrocarbon detector will be installed in the cooling water system to detect the presence of hydrocarbons in the cooling water.

The geothermal fluid/hydrocarbon heat exchangers will experience a buildup of scale that is brittle and can be mechanically scraped from the tube surface on the fluid side of the tubes. The scale contains silicon, iron, antimony, arsenic and sulfur (EPRI, ER-572 as cited in SDG&E letter, May 12, 1980). Scale cleanout is estimated to generate about 2.1 m^3/year (75 ft^3/year) of waste which will be disposed of at an approved solid waste disposal site (Sect. 3.7.2.7).

The hydrocarbon turbine is a key element in the binary conversion process. Many designs exist, but a unit that meets the exact specifications for the commercial size Heber facility has never been built (SDG&E 1979). However, at least three suppliers are willing to furnish the required turbine. The turbine generator will be designed to operate as a base-load unit and to accommodate occasional variations in the turbine-generator load because of variations in electrical demand and the presence of other generators connected to the grid. The turbine and generator will be directly-connected to operate as a unit at a synchronous speed of either 1800 or 3600 rpm. Demonstration of the technical feasibility of a geothermal binary power cycle on a commercial scale includes procurement, installation, and operation of the hydrocarbon turbine. This is an important element of the Heber demonstration project (Sect. 2.1).

Because the power cycle in a binary plant depends on circulating liquids, pumps and pumping become important, both in terms of power consumption (most of the plant's auxiliary power is consumed by pumps) and effective operation. Additionally, pumps within the hydrocarbon loop will need to be designed to contain the flammable hydrocarbon liquids. The technology for handling hydrocarbons is well established in the process industry, and it is expected that little modification will be required for adaptation of the technology to geothermal power generation (SDG&E 1979, Vol. I).

Plant layout

A layout of the power plant is shown in Fig. 3.10. The power plant and its adjacent production island (Fig. 3.3) together will occupy 8.1 ha (20 acres), and the injection island will occupy 1.1 ha (2.8 acres). Thus, the total area committed will be about 9.2 ha (22.8 acres) (Section 5.2). The energy conversion equipment is positioned around the turbine

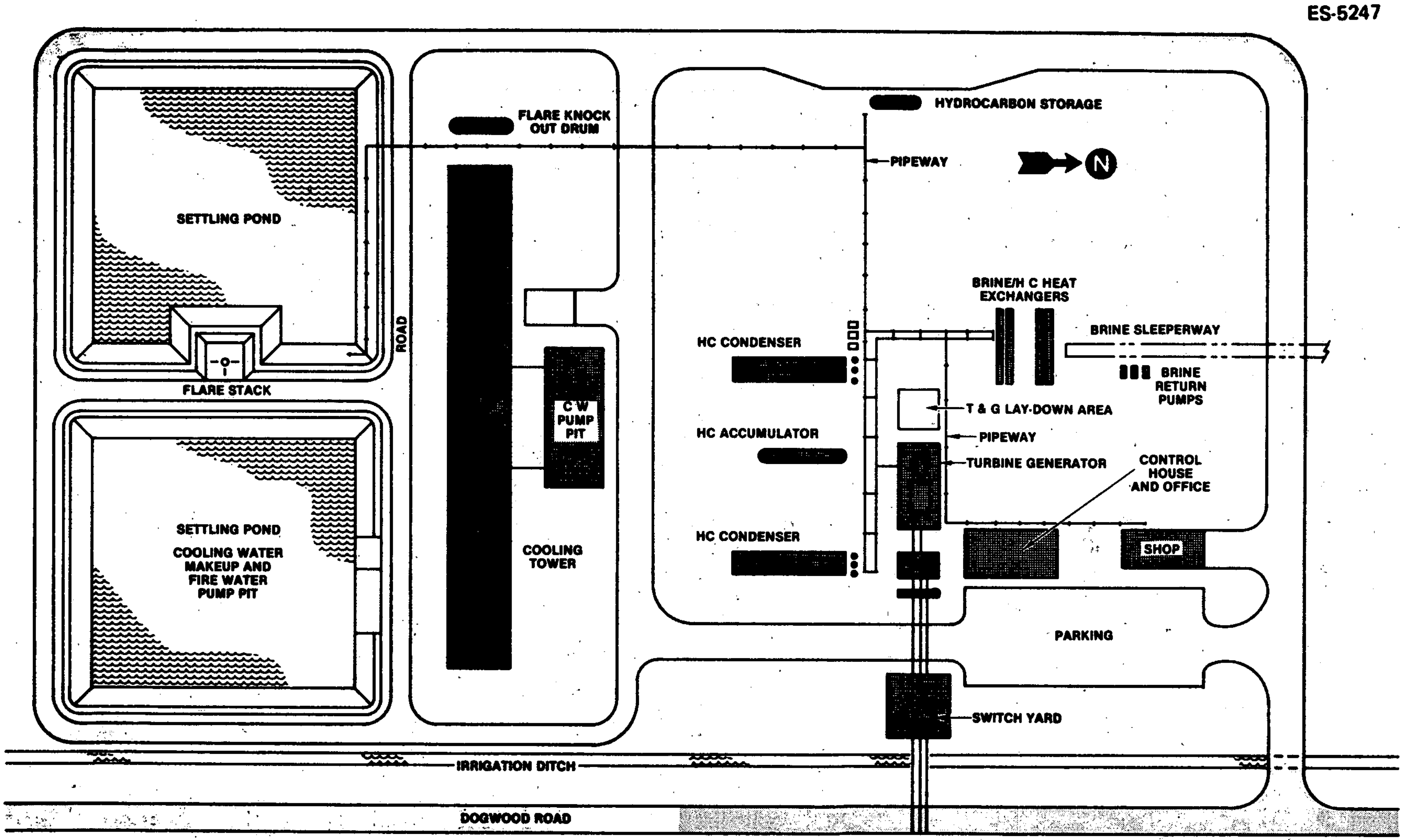

Fig. 3.10. Powerplant — layout. Source: SDG&E 1979.

generator along with the necessary buildings, the control house and shop. The cooling tower and settling ponds, which occupy almost half the plant site, are discussed in Sect. 3.7.2.4.

Maintenance accessibility will be a major consideration in the arrangement of the installation. For example, adequate clearance will be provided for a gantry-type crane to be used during installation and maintenance. Overhead pipes and electrical conduits will be avoided around the turbine to provide freedom of access. Additionally, the laydown area on the turbine end of the foundation will enable components to be lowered to grade for maintenance or transportation to a shop. Heat exchangers will be arranged for ease of tube cleaning and replacement.

Construction

All plant construction activities will be performed in accord with applicable ASME and electrical codes regulations. Construction will begin with plant site preparation (grading and excavation) performed with gasoline-powered, commercial-size grading and construction equipment. Foundations will be placed for each piece of major equipment. The major components of the plant will be assembled, mounted, and aligned; piping will be placed. The settling ponds will be constructed, and the cooling towers will be erected. After the control and maintenance buildings are constructed, instruments will be installed, electrical connections will be made, and the start-up program will be implemented (SDG&E 1979). Waste materials accumulated during construction will be collected and disposed of in an off-site approved disposal area (Sect. 3.7.2.7).

The energy conversion area will be covered with a hard surface capable of bearing maintenance equipment such as hydraulic cranes and their loads, portable air compressors, and loaded trucks. Paved walkways will be provided for direct access between areas. Any unpaved areas will be covered with a suitable ground cover to reduce fugitive dust within the power plant.

3.7.2.4 Cooling tower

Because the proposed Federal action includes design as well as construction and operation of the cooling tower, and also because the source of cooling water will change after the first five years of operation, a large number of design and operation options were available. In order not to eliminate any of the options arbitrarily, three possible drift rates were considered reasonable and each of these were evaluated for the first five years of operation and also for the remainder of the plant life. Additionally two sets of meteorological data were available, and each of the alternatives was evaluated using each set of meteorological data. Ultimately, standard drift elimination (0.008% drift rate) became the design option of choice and the one on which the environmental assessment was based. However, the analyses for the other alternatives were retained for informational purposes and are reported in appendices D-H as noted in Section 5.

Although a vendor for the cooling tower has not yet been selected, design data (Table 3.2) are based on the Marley 600 series cooling tower with a 8.5 m (28 ft) fan (SDG&E letters, April 3, April 29 and May 22, 1980). Specifications call for a 10-cell mechanical-draft tower 18.3 m (60 ft) high, and 121.9 m (400 ft) long with an inside cell radius of 4.8 m (15.7 ft). Approximately 8.8 m^3/s (140,000 gpm) of cooling water will circulate through the tower in a continuous loop. Water lost by evaporation, drift, and blowdown will be replaced by a makeup flow of about 0.20 to 0.22 m^3/s (3200 to 3500 gpm) from the adjacent storage and settling ponds (Fig. 3.10).

Water from one of three sources will be pumped to the silt-removal ponds. The ponds will be sized to contain enough water for one day of full-load operation, plus an adequate reserve for fire fighting (Sect. 3.7.2.7). A coagulant will be added to enhance clarification, and silt is expected to deposit at the rate of 680 kg/d (1500 lb/day). Silt will be removed from the pond on a regular basis and disposed of at an approved site.

Cooling water for the first five years of operation will be Colorado River irrigation water, and after the initial five-year period, cooling

Table 3.2. Cooling tower design data

Parameter	Specification
Type of cooling tower	Mechanical draft
No. of cooling cells	10
Length of tower bank, m (ft)	122 (400)
Latitude/longitude of tower, °	32.75/115.55
Tower base elevation above mean sea level	0
Tower height above ground, m (ft)	18.3 (60)
Inside radius of cell exit, m (ft)	4.80 (15.7)
Total heat rejected, MWt (Btu/hr)	405.7 (1.33 X 10^9)
Water/air mass ratio	1.27
Gas exit velocity, m/s (fps)	8.7 (28.43)
Temperature at cooling tower, °C (°F)	10.5 (19)
Concentration of total dissolved solids in drift, ppm	4000[a]
Drift rate, %	0.008
Drift size distribution:	

Diameter range (µm)	Weight fraction
0–50	0.25
50–100	0.20
100–150	0.12
150–200	0.12
200–250	0.08
250–300	0.06
300–400	0.08
400–500	0.04
500–600	0.025
600–700	0.0020
700–800	0.0021
800–1000	0.0024
1000–1200	0.0018
1200–1500	0.0036
>1500	0.0131

[a]Assumed to be equal to maximum allowable total dissolved solids (TDS) content for disposal of blowdown to agricultural drains; will increase to 20,000 ppm after 5 years of operation.

Source: Personal communication, J. Dietz and D. Kelly-Cochrane, San Diego Gas and Electric.

water will be obtained from either the New River, agricultural return flows, or both sources. These arrangements are discussed further in Sect. 4.3.1, Hydrology. Colorado River irrigation water has a total dissolved solids (TDS) content of about 1000 ppm, mostly as sodium chloride. The New River and agricultural return flow are wastewater sources containing high TDS, 4000 ppm for agricultural drain water and 5000 ppm for New River water. In addition to the high silt loads that all three sources contain, the New River water contains industrial and sanitary wastes that will require treatment prior to use. Treatment will be available as soon as the planned water treatment facility becomes operational (Sect. 7.3.4). Additionally, all cooling water (irrespective of the source) will be treated on site with sulfuric acid for pH control, chlorine for bacteria and algae control, and solid dispersants and corrosion inhibitors like heavy metal (zinc and/or chromium) salts. Although the amounts of additives have not yet been determined, the maximum blowdown concentration of additives (and therefore the maximum concentrations in the circulating water) will require controls like those shown in Table 5.1 (SDG&E letter, April 29, 1980) in order to comply with the California Regional Water Quality Control Board (CRWQCB) waste discharge requirement.

Because the allowable TDS content of water discharged into the New River is limited to 4000 ppm and because both irrigation return flow and New River water, which are the two most likely sources of cooling water after the initial five-year period, have a TDS content equal to or greater than 4000 ppm, it will be necessary to find an alternative means for disposing of cooling tower blowdown. The SDG&E plans call for utilizing one of two options — either injection into the geothermal reservoir or evaporation by open ponding in an evaporative basin. The amount of blowdown will depend upon both the drift rate and the number of allowable cycles of concentration of the cooling water to maintain the TDS content at an acceptable level, thereby meeting cooling tower operating needs and discharge requirements.

Table 3.3 describes the gross initial and final TDS concentrations of the three sources of cooling water and Table 3.4 outlines the blowdown rates to be expected from each source at various cooling tower drift

Table 3.3. Initial and final total dissolved solids (TDS) content of cooling water

	Irrigation water	Agricultural return flow	New River water
Makeup water — initial TDS, ppm	1000	4000	5000
Cycles of concentration through the cooling tower	4	5	4
Blowdown — final TDS, ppm	4000	20,000	20,000

rates. If the injection option for cooling water blowdown disposal is elected, two possibilities for disposal are available. In the first, blowdown, flowing at .054 m^3/s [1.9 cfs (maximum)] will be conveyed in a 0.09 m (3.5 in.) pressurized underground pipeline to the then existing (construction to start in 1980) Chevron New River water treatment plant (Sect. 7.3.4), where it will enter into the water treatment process at an appropriate point in the process stream. Because one of the purposes of the water treatment facility is to provide makeup water for injection into the geothermal reservoir to meet the requirement for no net fluid withdrawal from the reservoir, New River water will be treated specifically for that purpose. Addition of blowdown should not only reduce water consumption from the New River, it may help reduce processing costs because blowdown will come to the plant relatively "clean" in terms of biological wastes and suspended solids. In the unlikely event that pilot studies indicate that this scheme is not feasible, (e.g., if cooling tower blowdown is incompatible with New River water), blowdown could be treated in local facilities at the plant site and injected into the reservoir in separate wells. As indicated in Section 3.7.2.7, any solid wastes generated during treatment will be disposed of by transportation to an approved disposal site.

The alternative to injection is retention of the blowdown in an evaporative basin, located in the undeveloped desert, approximately 14.5 km (nine miles) west of the Heber site. A 0.09 m (3.5 in.) diameter underground pressurized pipeline approximately 14.5 km (9 miles) long would be required to convey the blowdown to the pond. Because the proposed project is in an arid area with a high evaporation rate, estimated as 2.2 m (88 in.) per year for a saturated salt solution (SDG&E letter, May 12, 1980), the total area for the pond for the lifetime of the plant (25 years) should not exceed 50.6 ha (125 acres) (Table 3.4). To ensure containment within the pond and prevent contamination of surface water or shallow groundwater, the pond will be lined with either an impermeable synthetic liner or a 10.2 cm (4 in.) thick asphaltic concrete liner. It will be important to obtain a liner capable of withstanding a high sodium chloride environment over a prolonged time period. Compacted

Table 3.4. Blowdown rate for 3 sources of cooling water

Drift rate (%)	Blowdown (gpm)		Evaporative basin area (acres)
	Maximum	Yearly average	
Irrigation water			
0.1	710	470	NA
0.008	835	555	NA
0.002	845	565	NA
Agricultural return flow			
0.1	495	330	75
0.008	625	415	90
0.002	635	425	95
New River water			
0.1	710	470	105
0.008	835	555	120
0.002	845	565	125

clay may not be suitable since chlorides are not retained by clays. Details of construction, operation, monitoring, and decommissioning are included in Appendix B (SDG&E letter, May 12, 1980).

3.7.2.5 Pipelines

Two geothermal fluid pipelines will be required: one to convey the hot geothermal fluid from the production wells to the power plant and the other to carry away the cooled fluid to the injection wells (Table 3.5). A single 0.61 m (24 in.) O.D. pipeline will transport the hot fluid 122 m (400 ft) to the powerplant heat exchanger and a 3658 m (12,000 ft) long, 0.76 m (30 in.) diameter return pipeline will be routed to the injection island as indicated in Table 3.5. All pipelines will be completely insulated, will run above grade, in a concrete-lined trench, and will be mounted on steel pipe supports anchored in the concrete.

3.7.2.6 Transmission lines

An existing Imperial Irrigation District (IID) 34.5 kV "VXW" transmission line, which passes near the Heber plant site, could be "looped into" the plant's 34.5-kV switchyard. This would require the construction of approximately one-half mile of double circuit, wood pole, 34.5 kV transmission lines and the rebuilding of 14.0 km (8.7 miles) of IID's "VXW" line to provide sufficient transmission capacity (SDG&E 1979). The output of the power plant is expected to eventually tie into the proposed major east-west transmission corridor crossing Imperial Valley (Sect. 7.3.6), which is discussed in EIR 1978 and 1979 and also in SDG&E 1979. Imperial County is currently preparing a separate assessment for this proposed project.

3.7.2.7 Solid waste disposal

Solid wastes will be generated during drilling (Sect. 3.7.2.2), plant construction (Sect. 3.7.2.3), power operation (Sects. 3.7.2.3 and

Table 3.5. Pipeline specifications

Pipeline parameters	Brine return pipeline	Production pipeline
Line size (OD), in.	30	24
Length, ft	12,000	400
Pipe material	*a*	*a*
Wall thickness, in.	0.750	0.500
Insulation	*b*	*b*
Design temperature, °F	360	360
Governing piping code	ANSI B31.1	ANSI B31.1

[a]ASTM A-155, KC70, Class 2.
[b]Fiberglass with aluminum weathercoat.

3.7.2.4), and decommissioning activities (Sect. 3.7.2.9). Two sites for solid waste disposal are presently being planned in Imperial County. A private disposal company, IT Corporation, is proceeding with plans for a class II-1 facility on a 259 ha (640 acre) land parcel they have purchased near Westmorland. The Imperial County Planning Commission approved a zoning change on April 23, 1980, as a step toward developing the disposal site. IT Corporation anticipates having all permits in hand by August 1980 and to be operating by the end of that year (SDG&E letter, May 12, 1980). Additionally, Imperial County is involved in developing a class II-1 disposal site on land it is attempting to acquire from the Bureau of Land Management through a land exchange. This site is 1.6 km (one mile) from the IT Corporation site on Andre Road a few miles west of Westmorland. Either of these facilities would be suitable for disposal of any solid wastes produced as a result of project activities. However, in the unlikely event that neither of these facilities materialize, solid wastes will be disposed of by transporting them to an approved solid waste disposal area such as existing sites in Riverside and San Diego counties (SDG&E letter, May 12, 1980).

3.7.2.8 Accidents and safety

Although the potential for accidents, especially fire or explosion, is great in any major industrial environment such as a power plant, the potential for accidents at the proposed Heber project is increased by the use of both the geothermal liquid and the supercritical hydrocarbon working fluid (LBL 1979; Stull 1977). However, building the station outdoors prevents the buildup of flammable or explosive gases and thus decreases much of the hazard. Because design of the power plant is part of the proposed action, sufficient detailed information is presently unavailable for adequately evaluating the safety of the facility.

However, assessment of accident impact at the Raft River Pilot Plant (U.S. DOE 1979b) indicated that if precautions are taken in the storage and handling of the hydrocarbon working fluid, including exclusion of ignition sources from the plant area, fire hazard should be greatly reduced. For example, a mercaptan odorant added to the working fluid allows leaks to be detected at concentrations that are 20% of the lower flammability limit. Additionally, if sufficient water storage and surge capacity is provided for fighting fires (Sect. 3.7.2.4) water can be effective in cooling the fire in order to limit damage and prevent its spread (U.S. DOE 1979b). A Preliminary Safety Analysis Report will be prepared by SDG&E for review by DOE subsequent to completion of the detailed design phase of the project, and the Final Safety Analysis Report prepared by SDG&E for review by DOE will be completed prior to initiation of plant operation.

Well blowout

Because of the moderate temperature and normal hydrostatic pressure of the Heber geothermal resource (sect. 4.1.4), containing the subsurface fluids during drilling should not be difficult. Therefore, the risk of a casing failure or blowout is very low because blowout prevention practices and casing programs will conform to the regulations and recommendations of the California Division of Oil and Gas (DOG).

In the unlikely event of a blowout, fluid would probably enter the environment in a mixed phase of vapor and liquid. Surface cratering around a well that has blown out can also occur. Depending on the magnitude of the blowout and weather conditions at the time, most of the vapor would be transported away from the site, while most of the liquid, in the form of drift and possibly surficial flow, would end up at and nearby the site. Temporarily increased deposition of salt in the vicinity of the blowout would result. Berms surrounding the production and injection areas will contain any surficial flow in most cases, preventing damage from the hot water to the general environment.

If a blowout did not quickly abate on its own, efforts to kill it by pouring water, mud, or grout into the borehole would be necessary. If this failed, drilling of a relief well, which could take several weeks, would be required. Once the blowout is contained, disposal of the accumulated brine would be necessary. Prevention of well blowout is a prime safety consideration. Blowouts occur as a result of casing failure, land slippage, or seismic damage to the well bore. Because numerous safety procedures have been developed and mandated by DOG, blowouts are considered unlikely (EIR 1979). Inspection of 15 test well bores at the Heber anomaly has indicated no casing failure and little evidence of corrosion damage (Sect. 3.7.2.2).

Another type of accident that could adversely affect the environment is a spill of geothermal fluids. The 0.46m (18 in.) high berm surrounding the plant site and each production and injection island should contain any leaks occurring on those sites (Sect. 3.7.2.2). Minor leaks from the pipeline outside the plant area would generally be contained in the lined trench running underneath the entire length of the pipeline. The trench is sloped to sumps for accumulation of fluid. The likelihood of a major pipeline rupture is thought to be negligible (SDG&E 1979).

Fire

Because fire protection will be an essential ingredient of the power plant design, fire protection facilities will be reviewed and approved by local fire authorities. Additionally, the fire-water system will be designed in accordance with applicable state and insurance standards (Stafco 1978). The cooling water storage ponds (Sect. 3.7.2.4) will function as a reserve for fire fighting. A sulphate-resistant concrete pump pit will provide sufficient water for all the fire-water pumps that will be monitored from the control room. Automatic starting controls will be initiated by decreasing fire-water pressure. Deluge systems, activated by high local temperatures, will be installed in hazardous areas.

Upset conditions

Two types of upset conditions will require safeguards to prevent serious accident, loss of electrical power load, and loss of geothermal fluid. Loss of load could cause a generator trip and the unit would be separated from the grid. In order to protect personnel and equipment, a quick-closing emergency trip valve (supplied by the turbine manufacturer) will provide quick shutoff of hydrocarbon flow to the turbine during emergencies. Relief valves and a flare system will be designed to ensure that hydrocarbon vapors will be diverted into the flare system should relief become necessary in order to prevent possible rupture of containment vessels. Vapors will be automatically ignited as they emerge from the flare tip. Isobutane burns with an intense but clean flame, and the flare will be designed to ensure that plant personnel and equipment are not endangered by the heat. Little environmental impact should occur as a result of flaring the hydrocarbon.

Loss of geothermal fluid is a much less serious upset condition. The operator would have sufficient time to take the plant off-line and shut it down. There probably would be no need to use the flare system.

Some health and safety considerations and possible mitigation measures, especially applicable to the construction and drilling crews, are discussed in EIR 1979. These consist of exposure of workers to heat and sun during the summer months, exposure to hydrogen sulfide (H_2S) during drilling and venting, and occurrence of accidents, fire, and noise. Mitigation of heat stress consists of arranging work schedules when ambient temperatures are milder, providing ample fluids and salt tablets, and advising workers about the causes and prevention of heat stress. Portable H_2S detection equipment at the drilling sites will allow appropriate steps to be taken to control H_2S emissions. However, the very low concentrations of H_2S in the resource (0.18 ppm) and the fact that it is a liquid-dominated source, suggest that the H_2S hazard is minimal. The prevention of accidents, fire and noise hazards will be accomplished by enforcing worker safety regulations. Noise standards will be met throughout construction and operation and protective ear coverings will be supplied to workers as required. Appropriate Occupational Safety and Health Administration (OSHA) regulations will be implemented to protect the health and safety of the workers.

3.7.2.9 Restoration and reclamation

At the end of productive life, all facilities will be dismantled and removed; wells will be plugged and capped; slabs, paved area, pond linings, and foundations (with the exception of the large turbine foundation) will be removed. Materials not salvageable will be disposed of in an approved waste disposal site. The compacted soil will be loosened and the land will be cleared and graded for restoration to its original use.

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4. DESCRIPTION OF THE AFFECTED ENVIRONMENT

4.1 GEOLOGY AND SOILS

4.1.1 Topography

The entire Heber Known Geothermal Resource Area (KGRA) is located in the nearly level and featureless Imperial Valley. The valley is bordered by mountains to the southwest and northeast, by the Salton Sea and Coachella Valley to the northwest, and by the Mexicali Valley to the southeast.

The elevation in the geothermal overlay zone varies between sea level at the extreme southeast corner and 5.7 m (19 ft) below sea level at the northwest corner. Elevation at the proposed power plant site is 1.8 m (6 ft) below sea level. Average slope of the valley is 1.04 m/km (5.5 ft/mile) or approximately 0.1 deg. to the northwest. The southwest boundary of the overlay zone includes a portion of the channel of the New River where the river trench is almost 401.2 m (0.25 mile) wide and approximately 7.6 m (25 ft) deep (EIR 1978).

4.1.2 Geologic features

The Imperial Valley is the middle portion of the Salton Trough, the landward extension of the Gulf of California. A structural as well as a topographic depression, the northwest-trending Salton Trough has formed as a result of a complex combination of crustal spreading and transform faulting. This activity has occurred from Miocene time to the present and is responsible for the current magnitude and frequency of seismic activity and unusually high subsurface temperatures.

To the north and south of the Salton Trough are mountain ranges composed primarily of Mesozoic and older igneous and metamorphic rocks referred to as the basement complex. In the Salton Trough, the basement complex has been downthrown along a series of northwest-trending, nearly vertical, faults so that it is now buried by clastic sediments reaching a maximum thickness of 7010 m (23,000 ft.) The downward throw is the minor component of fault movement; right lateral strike slip is the major component. Major faults in the Imperial Valley are indicated on the geologic map, Fig. 4.1.

Positive gravity values in the Imperial Valley, which are pronounced in the geothermal areas, imply that the crust beneath the sediment valley fill must be either thinner or denser than normal continental crust, or both (EPRI 1976). These data support the theory that the Salton Trough is a rift zone and a crustal spreading center between two tectonic plates. The depth at which the top of the basement complex occurs has been estimated by seismic refraction surveys to range between 4570 m (15,000 ft) at the East Mesa KGRA to 7010 m (23,000 ft) at the Heber KGRA (EIR 1979).

Although rock outcrops along the edges of Imperial Valley have been identified as belonging to specific stratigraphic units, it is impossible to correlate these with drilling results in the center of the valley (EIR 1978). Erosional remnants of early-to-middle Tertiary rocks (sedimentary and volcanic) outcrop on top of the basement complex in the mountains bounding the valley. Above these lies the marine, late Miocene or Pliocene Imperial Formation consisting of siltstone and sandstone with lenses of oyster shells. To date, the Imperial Formation has not been penetrated by drilling in the Imperial Valley. After the Imperial Formation was deposited, the Colorado River delta isolated the Imperial Valley from the Gulf of California, and predominantly terrestial sediments filled the valley throughout the Quaternary and Late Pliocene. In a typical facies sequence, coarse-grained sediments at the valley's edges grade into fine-grained sediments at the center. The primary source of sediments was the Colorado River, especially in the south central portion of the valley where the Heber project is located. Brackish lakes probably occupied most of the valley during much of the Quaternary, the most recent lake being Lake Cahuila, which existed in historic time. The valley floor consists of Lake Cahuila deposits. On either side of these deposits are low mesas of alluvium and pediments covered by alluvium. Windblown sand deposits occur in the southeastern part of the valley. Most recently, flooding of the Colorado River from 1905 to 1907 broadened and deepened the channels of the New and Alamo Rivers and formed the Salton Sea.

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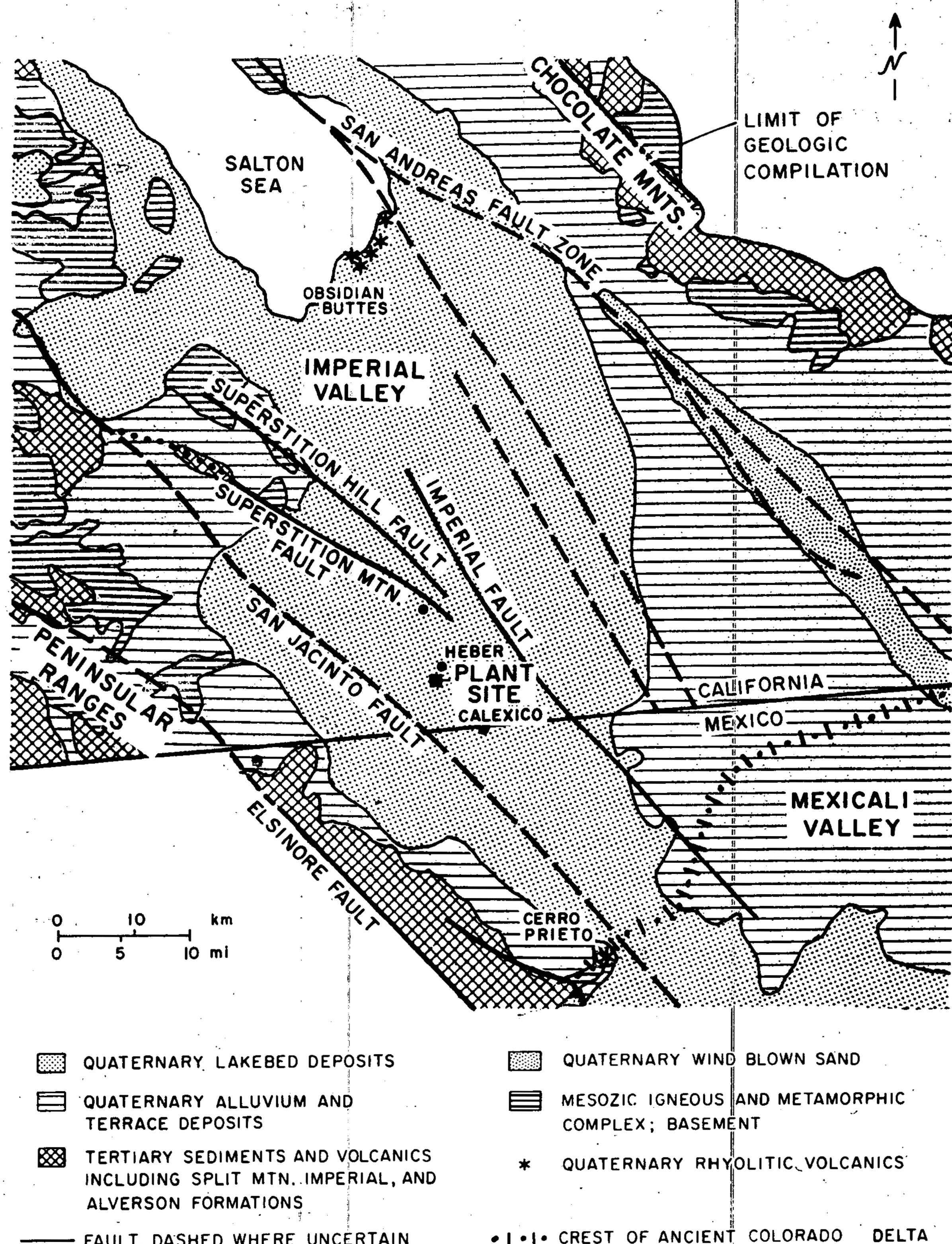

Fig. 4.1. Geologic map of Imperial Valley.

Four informal rock units have been distinguished in the Heber area as a result of drilling. From the surface to an average depth of 107 m (350 ft), unit D consists of poorly sorted, unconsolidated sand, and gravel with an equal thickness of clay. Unit C occurs between an average depth of 107 m (350 ft) to 457 m (1500 ft) and consists of massive beds of clay at the top, becoming shale at the base, interspersed with thinner beds of sand and silt. The base of unit C constitutes a zone approximately 137 m (450 ft) thick, which is continuous throughout the Heber anomaly. Unit C forms a caprock preventing geothermal fluids from reaching the surface and the shallow groundwater.

Unit B occurs at depths averaging between 457 m (1500 ft) and 1372 m (4500 ft). It consists of massive sandstone beds with thin beds of shale. Unit A occurs below unit B and is similar to it except that low-level thermal metamorphism is taking place in unit A. It has been estimated that 60% of units A and B is sand (EIR 1978). Permeability in units A and B generally decreases with depth probably because of increased compaction and hydrothermal alteration. Permeability results primarily from intergranular porosity with fracture porosity becoming increasingly important with depth. Permeability of sand intervals between 610 m (2000 ft) and 1829 m (6000 ft) ranges between 75 and 818 millidarcies (SDG&E 1979). Intrusive sills and volcanic flows have been penetrated during deep drilling (EIR 1978).

Geologic processes remain active in the Imperial Valley. Earthquakes, other seismic activity, subsidence, and uplift are considered in the section on geologic hazards (Sect. 4.1.3), and features of the geothermal resource are considered in the section on Geologic Resources (Sect. 4.1.4).

4.1.3 Geologic hazards

The major geologic hazards in Imperial Valley are earthquakes and subsidence, whereas other hazards such as flooding, erosion, and slope instability are much less important.

The Imperial Valley and the surrounding area is one of the most seismically active regions in the United States with a long history of major earthquakes. As many as ten earthquakes with magnitudes greater than 5.9 or epicentric intensities greater than VI on the Modified Mercalli (MM) scale have occurred since 1900 in the Imperial Valley or nearby (Porcella and Mathiesen 1979; Friedman 1976; Ulrick 1941). Three of these had epicenters within 20 km (32.9 miles) of the project sites, and they caused extensive damage in the Heber vicinity. The most significant of these was the May 1940 earthquake during which as much as 4.5 m (15 ft) of displacement occurred forming the trace of the previously unknown Imperial Fault (Ulrich 1941). Focal depths of earthquakes in the Imperial Valley occur throughout the crust and the base of the sedimentary deposits (EPRI 1976). During twelve months of testing only two seismic events, both with magnitudes less than 3, occurred in the Heber anomaly. There is no surficial evidence of faulting in the Heber G-overlay zone, and there is no evidence available to confirm the presence or absence of subsurface faults. Figure 4.2 shows the location of major earthquakes in Imperial Valley.

Although surficial rupture at the project site is improbable, ground acceleration (shaking) and ground failure are potential significant hazards that would result from a major earthquake which could affect the project at some time during its development or operation. Several approaches are used to estimate acceleration produced by earthquakes. Maximum credible rock acceleration at the project site has been estimated to be approximately 4.9 m/s^2 (0.5 g) by the California Division of Mines and Geology (Greensfelder 1974). The probability that an effective peak acceleration of 3.9 m/s^2 (0.4g) and an effective peak velocity of 0.3 m/s (12 in/s) will not be exceeded during any 50 year period, assuming firm ground, is estimated to be between 80 and 90 percent (ATC 1978).

Only minor instances of ground failure or liquefaction have occurred as a result of previous earthquakes in the Imperial Valley. However, potential for liquefaction exists at the project site due to the presence of saturated, unconsolidated underlying sediments. The hazard is significantly reduced by the abundant clay content of the sediments, which provides cohesion. The greatest potential for ground failure or liquefaction occurs along the channel of the New River where fine- and medium-grained sand has been deposited.

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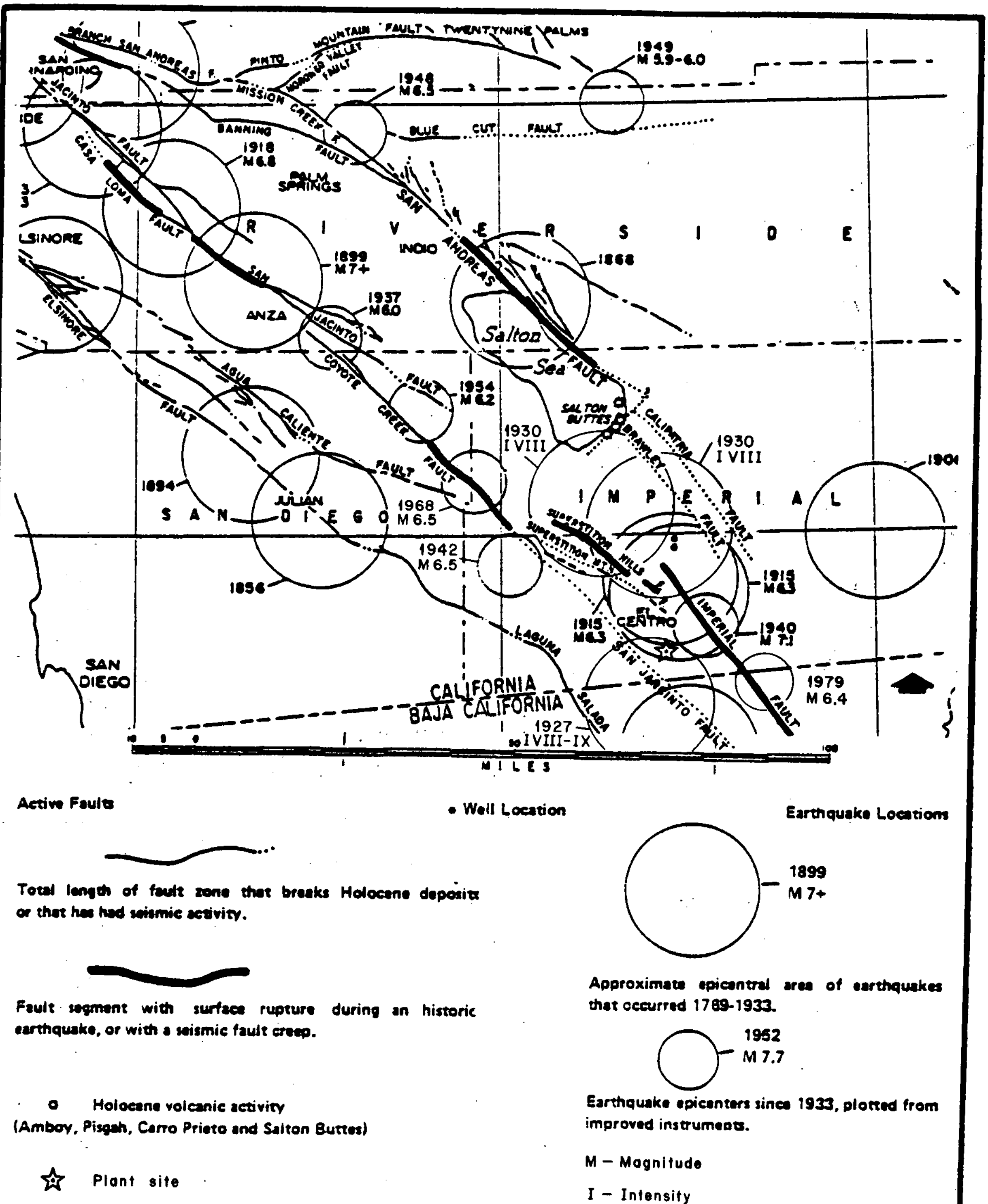


Fig. 4.2. Major earthquakes and recently active faults. Source: Association of Engineering Geologists 1973.

Triangulation and leveling networks indicate that the Imperial Valley is undergoing both vertical and horizontal movement. Although much of this movement is associated with seismic events, some is a result of aseismic creep, compaction, and other geologic processes. This movement may be hazardous to the valley's precisely leveled irrigation system.

A precise triangulation net for the entire Imperial Valley, consisting of 18 benchmarks, has been surveyed periodically since 1931 by the USGS. Over a 20-year period that included the May 1940 earthquake, cumulative right-lateral shear between the Peninsular Ranges and the Chocolate Mountains amounted to 1.5 m (62 in.) (EIR 1978). A local triangulation net to detect horizontal movement in the Heber area has been established, but no data from it are available yet.

Significant subsidence is occurring naturally in the Imperial Valley. A regional network of first-order and second-order leveling lines has been established, and three levelings have been completed since 1972. Referenced to a benchmark approximately 51 km (32 miles) west of Heber, cumulative subsidence ranged from less than 4 cm (1.6 in.) in the southwest corner of the Imperial Valley to more than 18 cm (7.1 in) in the vicinity of the Salton Sea. At the Heber G-overlay zone, the land surface subsided approximately 6 cm (2.4 in.). The leveling surveys indicate a downward regional tilt of the valley surface from the Mexican border, northward to the Salton Sea (Lofgren 1978). Results of a leveling survey completed by Chevron for the Heber area concurred with the regional trend (EIR 1978).

Geodetic control of the Imperial Valley is continually being improved. Tiltmeters and extensometers are placed throughout the valley and benchmarks are being added to the leveling and triangulation networks.

The potential hazards of erosion, slope instability, and flooding are slight in the Heber area compared to those of seismicity and subsidence. Because of the nearly level topography and the clay content of the soils in the Heber G-overlay zone, the potential for erosion or mass wasting is insignificant except for the steep banks of the New River channel. Along these banks, which consist of loose sand and silt, both wind and water erosion as well as sliding are possible. Flood hazards are limited to the area immediately on either side of the New River as shown in Appendix C.

4.1.4 Geologic resources

The geothermal resource is the outstanding geologic resource of both the Imperial Valley and the Heber KGRA. The USGS estimates that the potential for production of electricity from geothermal energy in Imperial Valley exceeds 6000 MWe over a period of 30 year of which 650 MWe could be produced from the Heber KGRA (Muffler 1979).

The pressure and temperature conditions of the geothermal resource in the Heber KGRA result in its being a convective, liquid-dominated hydrothermal system. Water circulates through the thick section of clastic sediments as a result of its being heated from a source in the mantle or deep in the crust. The impermeable strata in unit C, described in Sect. 4.1.2, limits heat transfer to the shallow subsurface. The relative significance of both designated and nondesignated faults in transferring heat and fluid is uncertain.

The value of a specific geothermal resource is dependent on its different properties. These include:

1. the amount of fluid available and the ease with which it can be withdrawn,
2. the amount of heat contained by the fluid and the rate at which it is supplied,
3. the chemical quality of the fluids.

Permeability of the sediments in the Imperial Valley generally decreases with distance from the mountains bounding the valley on the northeast and southwest and with distance from the Colorado River delta system at the southeast end of the valley. While the Heber KGRA is located in the center of the valley with respect to the surrounding mountains, it is relatively close to the Colorado River delta system. The permeability and thickness of units A and B, described in Sect. 4.1.2, make the resource in the Heber area attractive in this respect.

Although basic features of both the shallow and geothermal groundwater systems in the Imperial Valley have been established, detailed information about the flow regime in the Heber KGRA is scarce. Recharge mechanisms include the following: (1) subsurface and surficial drainage along the mountains, (2) leakage of unlined canals, (3) Colorado River underflow, (4) infiltration of irrigation water, and (5) infiltration of precipitation. From the time the Imperial Valley was isolated from the Gulf of California, the Colorado River has been the primary source of groundwater recharge in both the shallow and geothermal aquifers. Presently, the Colorado River recharges groundwater in the Imperial Valley by means of underflow, leakage of unlined canals and drains, and infiltration of irrigation waters. A significant, although not major, amount of recharge is supplied by subsurface and surficial drainage of the surrounding mountains, but only a negligible amount is supplied by direct infiltration of precipitation. It is estimated that 61% of the groundwater in the central part of the valley originated from the Colorado River; however, in the Heber KGRA the percentage is probably even greater because of the relative proximity to the Colorado River and its ancient delta.

Presently, annual recharge to both the shallow and geothermal aquifers in the entire Imperial Valley is estimated to be 0.49 km^3 (400,000 acre-ft) (EIR 1979). It is assumed that the amount of recharge is approximately equal to the amount of discharge; i.e. the entire amount of recharge is discharged either to the system of surface drains, to the Salton Sea, or by means of evaporation and evapotranspiration. There are no springs in the Heber area. The amount of water available in the Heber anomaly between 3657 m (12,000 ft) and 3048 m (10,000 ft) is approximately 17 km^3 (14×10^6 acre-ft). Because Chevron intends to inject 100% of withdrawn water back into the geothermal aquifer, the project will not deplete the availability of groundwater presently adequate for long-term geothermal development.

Groundwater in the Imperial Valley flows from the Colorado River northwest to the Salton Sea and from the surrounding mountain towards the center of the valley. This flow regime is probably altered in geothermal anomalies such as the Heber KGRA by the formation of convection cells in the geothermal aquifer as illustrated schematically in Fig. 4.3. Stratigraphic and structural complexity further complicate groundwater movement. Faults and clay, silt or shale strata may act as aquicludes or aquitards. The hydraulic gradient of the geothermal

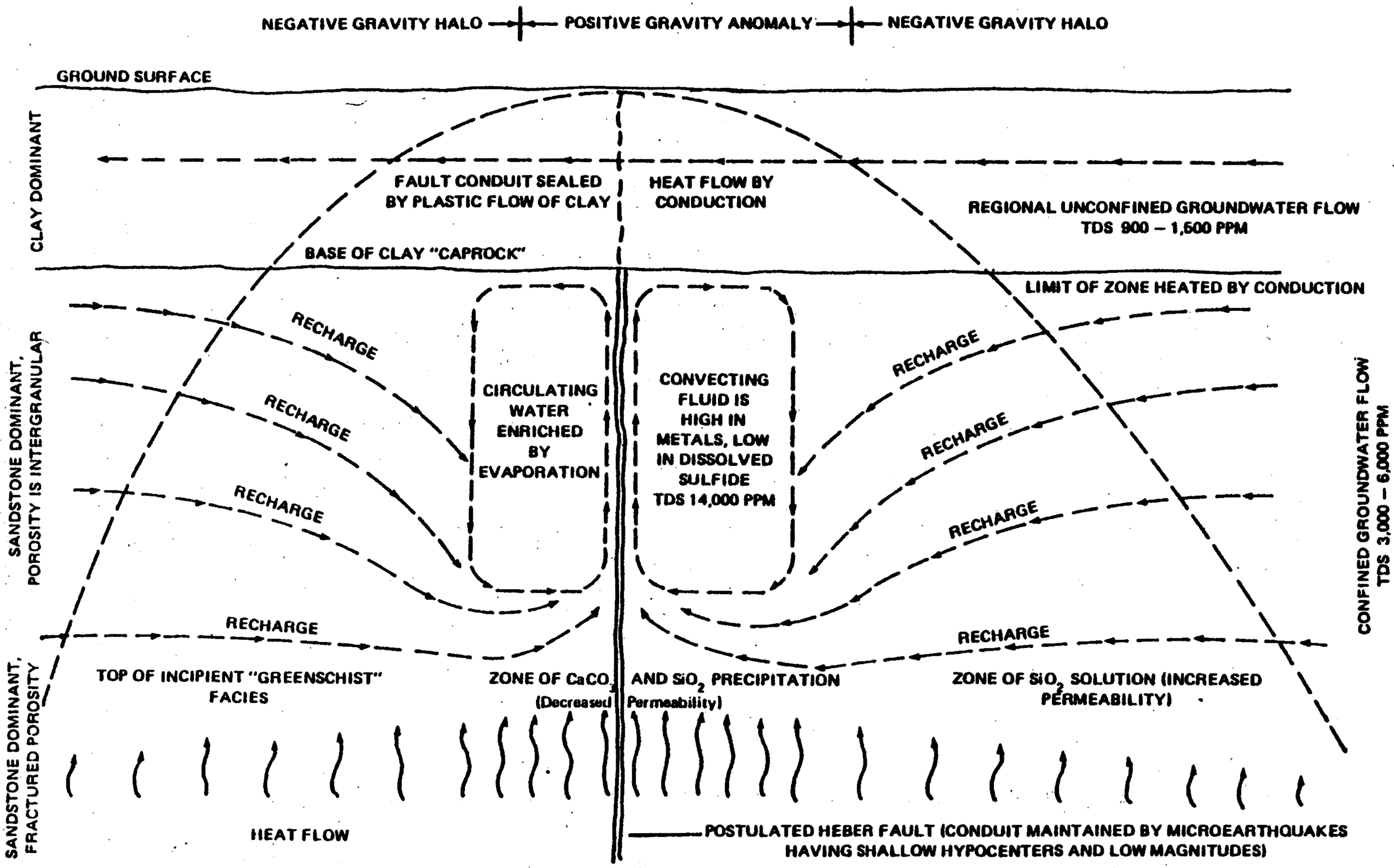


Fig. 4.3. Formation of convection cells in the geothermal aquifer.
Source: EIS 1979 (after Dutcher et al. 1972).

aquifer has not been determined, however in the Heber KGRA it probably slightly exceeds the hydrostatic gradient of 10 kPa/m (0.435 psi/ft).

Temperatures within the geothermal aquifer in the Heber KGRA range between 164°C (325°F) and 182°C (360°F) making it a moderate-temperature resource (Dutcher et al. 1972). The highest temperatures are found at the center of the anomaly where SDG&E has proposed locating the binary power plant. The temperature of the resource depends on the rate at which heat is being withdrawn, the rate of fluid recharge, and the rate at which heat is being supplied. Because the Salton Trough is an active crustal spreading center, heat is being supplied to the geothermal aquifer at a significant but uncertain rate as evidenced by high heat flow measurements. Based on Chevron's analysis the reservoir is capable of supplying the heat required by the demonstration project for its proposed life (SDG&E 1979).

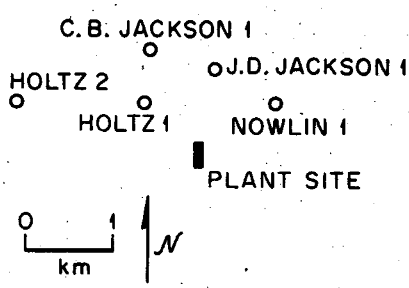
The quality of the deeper, geothermal groundwater in the Imperial Valley deteriorates from the southeast to the northwest and from the margins towards the center of the valley. Therefore, the quality of groundwater in the geothermal aquifer at the Heber KGRA is relatively good as shown in Table 4.1. Total dissolved solids below 610 m (2000 ft) range from 11,800 to 19,000 ppm and are mostly from 14,000 to 16,000 ppm. The water is predominantly a NaCl type with calcium as the third most important constituent. H_2S has been measured at levels of approximately 0.2 ppm by weight (EIR 1978). Variations in water quality in the Heber KGRA probably result from local and up-gradient differences in lithology of the aquifer. Water quality does not necessarily deteriorate with depth. The moderate quality of the geothermal water in the Heber KGRA makes it very suitable for geothermal development.

Although significant geologic resources, including construction materials and precious metals, are found in Imperial County they do not occur in the Heber KGRA. The minerals present in the geothermal water of the Heber anomaly are not present in great enough quantities to be economically valuable, under present market conditions or in the forseeable future.

Table 4.1. Chemical quality of water, Heber Geothermal Reservoir, Imperial Valley, California

Parameter[a]	Nowlin 1[b]	Holtz 1	Holtz 2	C. B. Jackson 1	J. D. Jackson 1
Total Dissolved Solids (TDS)	14,100	13,168	16,330	15,430	15,275
SiO_2	120	268	187	267	268
Li	6.6	4	4.1	2.8	3.4
Na	3,600	5,500	4,720	4,688	4,563
K	360	220	231	181	197
Ca	880	1,062	1,062	891	781
Mg	2.4	5.6	23	4.7	3.8
Cl	9,000	7,420	8,242	8,320	8,076
SO_4	100	100	148	152	150
CO_3	4				
HCO_3	20				
F	1.6	1.7	1.5	0.9	0.6
B	4.8	4.1	8	4.8	5.2
Fe	0.9	15	5	20	10
Mn		0.9	0.9	1.3	1.9
Pb	0.1	1.6	0.6	0.6	0.9
Zn	0.68	0.3	0.1	0.4	0.5
Cu	0.2	0.5	0.4	0.4	0.4
Ba		6	3	3	3
Sr		37	42	32	36
Al	0.04	15	12	0.5	18
Ag					
LI	4				
pH	7.1		7.4	5.8	6.5

[a] Except pH, all parameters are in parts per million.
[b] Location of wells:



Source: Geotechnical Environmental Aspects of Geothermal Power Generation at Heber, Imperial Valley, California, EPRI 299, Electric Power Research Institute, 1976.

4.1.5 Groundwater

Groundwater in the Imperial Valley is plentiful; however, its generally poor quality limits it use. Because Sect. 4.1.4 describes the features of the geothermal aquifer, this section concentrates on the shallow groundwater system. Unit C described in Sect. 4.1.2 probably acts as an aquiclude between shallow groundwater and deeper geothermal fluids. Shallow groundwater in the Heber area is recharged in much the same way as the deep, geothermal fluids are. Infiltration of irrigation water and canal leakage are the major sources of recharge. Shallow groundwater is discharged by two processes. An undetermined amount is discharged into the Salton Sea, either directly by underflow, or by its return to the extensive surficial hydrologic system of drains that includes the New and Alamo Rivers. The remainder is discharged to the atmosphere by means of evaporation and evapotranspiration. The ongoing program of placing drain tiles beneath irrigated fields increasingly enhances the discharge of groundwater to the surficial drainage system.

As of 1978, no wells were known to exist for domestic or agricultural use within 1.6 km (1 mile) of the Heber KGRA (Geonomics 1978). The well nearest the plant site for which hydraulic information exists is located approximately 11 km (7 miles) east-southeast of the proposed plant site. Testing of an interval from 34 m (110 ft) to 137 m (450 ft) below the land surface resulted in a yield 5.1 l/s (90 gpm), a specific capacity of 23 m^2/day (1.3 gpm/ft), and a transmissivity of 21 m^2/day (1700 gpd/ft) (Loeltz et al. 1975). These low values are probably representative of most of the central part of the valley, which consists of fine-grained lake bed deposits at shallow depths. The low values contrast with those one to two orders of magnitude greater on the sides of the valley.

Like the groundwater in the geothermal aquifer, shallow groundwater flows toward the center of the Imperial Valley and toward the northwest. In the vicinity of the plant site, shallow groundwater may flow west towards the New River. The groundwater table generally is parallel to the surface and at a shallow depth. At the proposed power plant site, the average water table level is 1.5 m (4.8 ft) below land surface, and the water table level varies 0.4 m (1.2 ft) because of irrigation practices.

Locally high or perched water tables frequently occur within 0.45 m (1.5 ft) of the surface during heavy irrigation (EIR 1978).

Four analyses of groundwater in the Heber area are shown in Table 4.2. The analyses indicate a NaCl water with lesser amounts of sulfate, calcium, magnesium, and bicarbonate. Most minor constituents were not analyzed. Total dissolved solids (TDS) range from 4920 to 9540 ppm, and salinity increases to the west and the northwest in the area (Geonomics 1975). Interpolating the analyses, groundwater at an approximate depth of 46 m (150 ft) beneath the surface at the power plant site is estimated to have a TDS of 7200 ppm. Salinity of shallow groundwater is increasing as a result of leaching of agricultural soils and extensively used fertilizers.

4.1.6 Soils

Soils present within and adjacent to the Heber geothermal overlay zone consist primarily of Imperial-Glenbar association (wet), Imperial (wet) and Holtville (wet) soils as shown in Appendix I. These soils occur on alluvial basin floors having slopes less than 2%. In this portion of the Central Valley, the soils are developed from lake bed sediments of mixed origin, combining deposits of Colorado River and mountain margin sources originally deposited in Lake Cahuila. The soils have been historically modified by the addition of silt from the early use of Colorado River water that had not been desilted prior to 1938. Soil modification has also resulted from the practice of soil leaching.

Generally, the surface layer of soil in the Heber G-overlay zone consists of pinkish gray to light brown silty clay and silty clay loam to a depth of 33 cm (13 in.). A deeper layer consists of more silty clay and silty clay loam stratified with sandy clay loam, clay loam, and occasionally silt loam and loamy fine sand to a depth of between 1.5 m (60 in.) and 1.8 m (72 in.). Available water capacity ranges between 20 cm (8 in.) and 25 cm (10 in.). The soil is generally alkaline, calcareous, and often gypsiferous (EIR 1978).

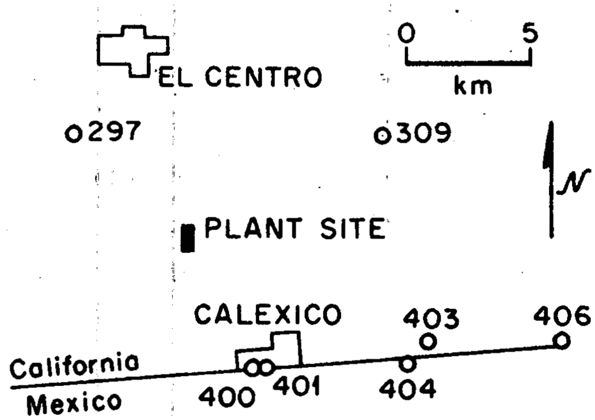
Slow permeability, slow runoff, high content of montmorillonite and other clays, high water tables, and high salinity of the soil cause low

Table 4.2. Chemical analyses of water from nongeothermal wells[a] in and within 1.6 km (1 mile) of Heber Known Geothermal Resource Area

Values given are in mg/L unless otherwise indicated

Parameter	Map No. and date						
	297 (7/62)	309 (7/62)	400 (1/62)	401 (3/62)	403 (4/58)	404 (1/62)	406 (1/62)
Temperature, °C	26.7	26.7					
pH	7.3	7.4	7.9	7.7	7.5		7.5
Specific conductance, μmho	16,600	16,100	11,000	8,350	8,500	8,890	4,800
Total dissolved solids (TDS) (sum)	9,540	9,410	6,980	4,920	5,610	5,410	3,020
Ca	362	376	448	175	253	244	103
Mg	211	214	261	122	143	161	48
Na	3,020[b]	2,920[b]	1,720[b]	1,480[b]	1,541	1,530[b]	953[b]
K	c	c	c	c	19	c	c
HCO_3	45	267	304	199	299	257	198
SO_4	175	400	1,350	800	1,450	850	538
Cl	5,750	5,350	3,040	2,240	2,040	2,490	1,280

[a] Location of wells:



[b] Na + K value.
[c] Not analyzed.

Source: *Geothermal Environmental Impact Assessment, Subsurface Environmental Assessment for Four Geothermal Systems,* EPA 600/7-78-207, Geonomics, Inc., 1978.

bearing strengths, high shrink-swell characteristics and corrosivity. Erosion hazard is slight. Much of the soil in the Heber G-overlay zone is classified as prime farmland, signifying that it is considered especially productive cropland by the U.S. Department of Agriculture, Soil Conservation Service (Fig. 4.4 and Appendix I).

4.2 LAND USE

The project area (Fig. 3.1) is about 2.3 km (1.4 miles) south of the unincorporated community of Heber, and 6.4 km (4 miles) south of El Centro, California. Land uses outside of these settled areas are chiefly agricultural, with only scattered residences and commercial/industrial facilities. The prevalent farming activities are served by the Imperial Irrigation District (IID) through an extensive system of canals supplied with water from the Colorado River. The U.S. Soil Conservation Service has designated the project area as prime farmland (Fig. 4.4 and Appendix I).

4.2.1 Zoning and community plans

Reflecting historic trends in land use, the project area is zoned for agriculture or related residences and industries. The privately owned project area is under the regulatory and administrative jurisdiction of Imperial County. A special zone allowing development of the geothermal field has been approved by the County in support of local plans for the area.

4.2.2 Regional and state plans

The General Plan of Imperial County includes policies promoting the proposed action at the Heber geothermal field. Areawide plans developed for this region by the Southern California Association of Governments are generally based upon local and county plans.

In addition, County regulations specify procedures for geothermal development. Floodplain regulations will not pertain, as the nearest floodplain is along the New River, south of the project area.

ES-5251

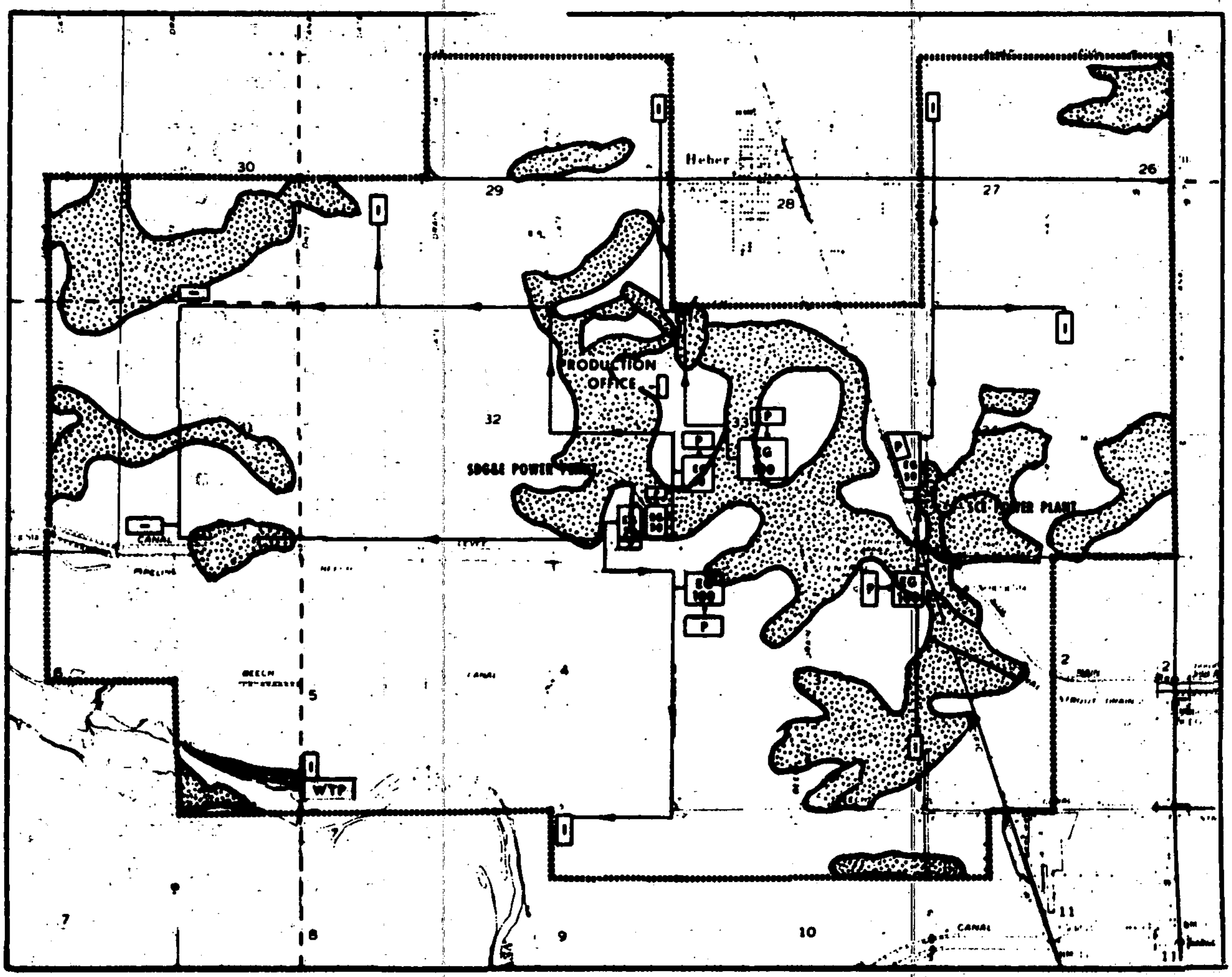


Fig. 4.4. Prime farmland soils at the Heber KGRA. <u>Source</u>: EIS 1979 for base map. SCS for overlay.

4.3 SURFACE WATER

4.3.1 Hydrology

The Heber project area lies within the 22,000-km^2 (8400-sq mile) Salton Sea watershed (Fig. 4.5). The watershed area includes the Imperial and Coachella Valleys in California, as well as the Mexicali Valley in Mexico. The Salton Sea, California's largest inland water body, measures 970 km^2 (375 sq miles) in area and is located in the northwestern corner of the Imperial Valley at an elevation of 70 m (230 ft) below sea level.

The Imperial Irrigation District maintains an elaborate canal system that distributes approximately 3.7×10^9 m^3 (3 million acre-ft) of Colorado River water via the All-American Canal to agricultural supply canals throughout the Imperial Valley (IID 1977). A detailed description of the irrigation and drainage systems can be found in EIR 1978 and EIR 1979. The drains maintain a favorable salt balance in the irrigated lands by carrying away the salt-laden drainage water. The mean elevational gradient, on which Imperial Valley irrigation is based, is 1.3 m/km (7 ft/mile). This extends from Heber, 1.5 to 6 m (5 to 20 ft) below sea level, to the Salton Sea, 70 m (230 ft) below sea level.

The New and Alamo Rivers, originating in Mexico, carry approximately 90% of the surface flow from the Imperial Valley northward into the Salton Sea. Flow of both rivers is comprised of agricultural runoff and seepage as well as industrial and municipal wastes, treated and untreated, from a number of communities in California and Mexico (Swajian 1977). As a result of agricultural drainage input, flow of the New River increases from 136 million m^3 (160,000 acre-ft) per year at the Mexican border to 550 million m^3 (450,000 acre-ft) per year at the Salton Sea (EPRI 1976).

Near the Heber area, the New River flows through a chasm 12 m (40 ft) deep by 457 m (1500 ft) wide created by the 1905 flood. Minimum discharge of the river was 2.7 m^3/s (95 cfs) in September 1956. Maximum discharge, not including the 1905 flood, was 34 m^3/s (1200 cfs) in September 1963. The flow capacity of the New River has been estimated to be 3170 m^3/s (112,000 cfs), which is over 1000 times the minimum flow values and far exceeds flood flows anticipated by local agencies (EPRI 1976).

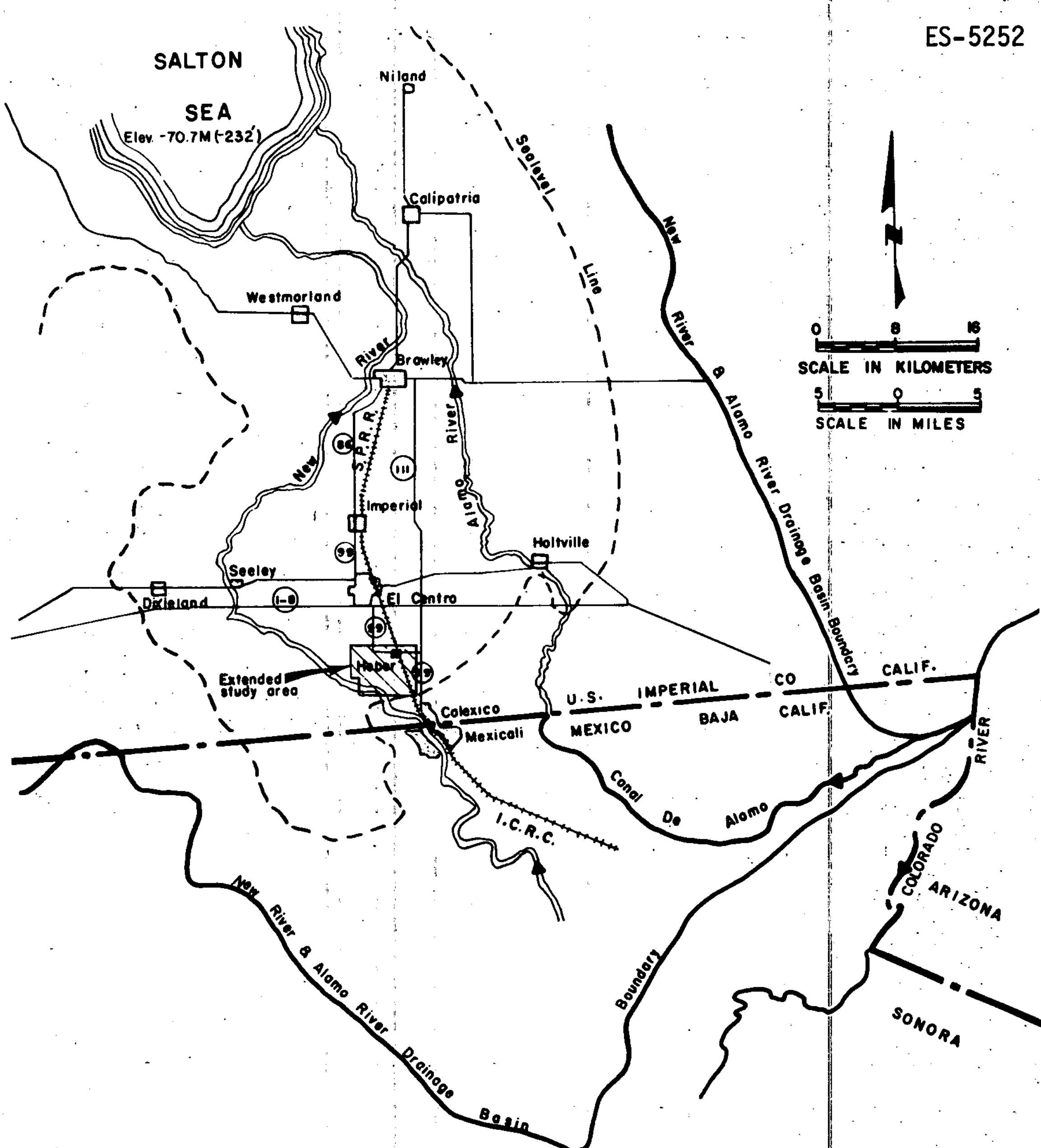


Fig. 4.5. Heber Project in relation to the Salton Sea watershed.
<u>Source</u>: EPRI 1977.

At its nearest point, the Alamo River is approximately 16 km (10 miles) east of the project site. Agricultural drainage in the Heber area is toward the Alamo River via the Central Drain despite the proximity of Heber to the New River [2.4 km (1.5 miles)] (Twogood 1977). The flow of the New River at the Mexican border is 100 times greater than that of the Alamo River, although the flow of the Alamo River at the inlet to the Salton Sea is 30% greater than that of the New River because of the more extensive agricultural drainage input.

4.3.2 Water quality

Surface water quality in the Imperial Valley can generally be described as poor but adequate for agriculture with continual, remedial control (leaching and water table control). Increasing salinity of imported Colorado River water is of particular concern for the Imperial Valley. Prior to 1955, Colorado River water diverted to the Imperial Valley had a total dissolved solids concentration of about 735 ppm (1.0 ton/acre-ft). By 1977, TDS levels were about 863 ppm (1.19 tons/acre-ft) (Twogood 1977), and are projected to be 1340 ppm (1.82 tons/acre-ft) by 2000 (IID no date). Typical agricultural drainage water shows a five-fold increase in TDS levels from 1052 ppm in the entering irrigation flow to 5136 ppm in the drainage discharge after it passes through the soil (Table 4.3) (Nyholm and Anspaugh 1977).

Water quality of the New and Alamo Rivers is poor (see Sect. 4.3.1). Water in the New River has TDS levels approaching 5000 ppm, has a high degree of mineralization, and is similar to agricultural drainage water, except for the higher concentration of magnesium. Irrigation water quality limits are exceeded by molybdenum (U.S. DOE 1979) Comparisons of New River water quality parameters with irrigation and drinking water standards are presented in Table 4.4.

The New River at the international border has extremely low dissolved oxygen levels and very high coliform counts. Temperatures of the river average about 22.8°C (73°F) with maximum temperatures exceeding 32°C (90°F) (EPRI 1976). Since the Heber project area is only 8 km (5 miles) from the border, physicochemical constituents and river flows near the site should be similar to those at the border (EIR 1978).

Table 4.3. Chemical composition of the water supply and drainage of Imperial Valley, California

Parameter	Concentration			
	Irrigation water		Agricultural drainage water[a]	
	mg/L (ppm)	% Total dissolved solids (TDS)	mg/L (ppm)	% Total dissolved solids (TDS)
Na	215.	20.4	1,070.	20.8
K	7.5	0.71	15.	0.29
Ca	102.	9.7	385.	7.5
Mg	22.	2.1	152.	2.96
Li	0.1	0.0095	0.3	0.0058
Cl	200.	19.0	1,245.	24.2
CO_3	16.4	1.56	2.3	0.05
HCO_3	140.	13.3	307.	6.0
SO_4	335.	31.8	1,833.	35.7
NO_3	0.2	0.02	8.3	0.16
NH_4	0.03	0.003	0.03	0.0006
B	0.32	0.03	0.97	0.019
F	0.35	0.033	0.15	0.003
As	0.002	0.0002	0.004	0.00008
Ba	0.10	0.0095	0.10	0.002
Cd	0.0005	0.00005	0.0005	0.00001
Co	0.005	0.0005	0.010	0.0002
Cu	0.002	0.0002	0.002	0.0023
Fe	0.03	0.003	0.09	0.018
Hg	0.0014	0.00013	0.0044	0.000086
Mn	0.01	0.00095	0.33	0.0064
Ni	0.005	0.0005	0.005	0.0001
Pb	0.004	0.0004	0.008	0.00016
Rb	0.02	0.0002	0.02	0.0004
Se	0.001	0.000095	0.0010	0.00002
Sr	—	—	—	—
Zn	0.010	0.00095	0.015	0.0003
TDS	1,052.		5,136.	
Specific μmho/cm conductance, at 25°C	1,650.		6,700.	
Temperature, °C	18.3		21.5	
pH	8.2		7.5	

[a]Vail 4 Drain, Gentry at Foss Road, (T11SR13E-3N), Sampled 2/25/76 (LLL).

Source: Nyholm 1977.

Table 4.4. Selected water quality parameters for the New River in the leasehold area (1966–67)

Drinking water standards and recommended irrigation water limits are given for comparison

Parameter	Measured concentration (mg/L)[a]	U.S. Environmental Protection Agency drinking water standard (mg/L)	U.S. Environmental Protection Agency irrigation water limit (mg/L)[b]
Al	0.7		5
Ba	0.44	1[c]	
B	0.28		0.75
Chloride	1144	250[d]	
Cr	<0.001	0.05[c]	0.10
Cu	0.004	1[d]	0.20
Fluoride	0.7	1.4[c,e]	1.0
Hardness (as $CaCO_3$)	1020		
Fe	0.02	0.3[d]	5.0
Pb	<0.001	0.05[c]	5.0
Mn	0.003	0.05[d]	0.20
Mo	0.022		0.010
Ni	0.002		0.020
Nitrate	14	10[c]	
Sulfate	798	250[d]	
Total dissolved solids (TDS)	3473–3990	500[d]	
V	0.005		0.10
Zn	0.025	5[d]	2.0

[a]California Department of Water Resources, *Geothermal Wastes and the Water Resources of the Salton Sea Area,* Bulletin No. 143-7, State of California, The Resources Agency, Sacramento, 1970.

[b]U.S. Environmental Protection Agency, *Water Quality Criteria 1972,* Ecological Research Series, EPA-R3-73-033, 1973.

[c]U.S. Environmental Protection Agency, *National Interim Primary Drinking Water Regulations, Fed. Regist.* 40(248) (1975).

[d]U.S. Environmental Protection Agency, *National Secondary Drinking Water Regulations, Proposed Regulations, Fed. Regist.* 42(62) (1977).

[e]Based on an estimated average daily maximum air temperature exceeding 27°C (80°F).

Source: *Westmorland Environmental Assessment,* 1979.

The Salton Sea serves as a drainage sink for agricultural, municipal and industrial waste discharges, and surface runoff. As a result of these inputs and the high TDS (greater than 35,000 ppm), Salton Sea water is unfit for domestic or agricultural use (EPRI 1976). The salinity of the Salton Sea is increasing at an annual rate of 500 ppm, primarily as the result of 4.1 million metric tons of salt from agricultural drainage entering the sea each year. The California Regional Water Quality Board (CRWQCB 1975) estimates that, if the current inflow of drainage water to the Salton Sea ceased, evaporation alone would result in an increase of 7600 ppm TDS within one year. Drainage to the Sea will be reduced by 3.7×10^8 m^3 (300,000 acre-ft) per year as a result of water conservation practices being initiated by IID (CWRCB 1979). In order to slow the rate of salinization, the evaporation loss must be offset by drainage water inflow.

Lawrence Livermore Laboratory studies, funded by DOE, were conducted to determine baseline levels of water quality and to evalutate and predict the impact of geothermal development on water quality in the valley (CWRCB 1979; Crow and Pimentel 1976). Only data for temperature, pH, and electrical conductivity are available to date (Crow and Pimentel 1976; Pimentel 1980).

4.3.3 Water use and rights

The Imperial Valley acquired appropriation rights to water from the Colorado River in 1901. The IID governs water use and allocation within the valley. Their system of canals, drains, outlets, and laterals provides irrigation and drainage for approximately 200,000 ha (500,000 acres) of farmland. An annual average of 3.7×10^9 m^3 (2.95×10^6 acre-ft) of Colorado River water was imported into the valley from 1974 to 1976 via the IID system (IID 1977). A summary of IID water use from 1954 to 1976 is contained in Table 4.5. This water is a share of California's 6.622×10^9 m^3/year (5.362×10^6 acre-ft/year) allotment of Colorado River water, as determined by the 1931 "Seven-Party Agreement" (see IID 1977 and EIR 1978 for complete water-right discussion). Of the IID allotment, municipal and industrial consumption accounts for approximately 1% [3.1×10^7 m^3 (25,000 acre-ft)] of the total volume.

Table 4.5. Water usage in the Imperial Irrigation District, 1954 – 1976

Calendar year	Total acreage irrigated for year	Total quantity of water diverted from Colorado River (acre-ft)	Total operational loss, canal loss, and unaccounted for (acre-ft)	Total quantity of water delivered to users (acre-ft)	Net acre-ft per acre delivered	Rainfall (ft)	Water delivered per acre plus rainfall during season (ft)
1954	451,567	3,095,783	1,131,972	1,963,811	4.34	0.07	4.41
1955	473,900	2,927,165	966,091	1,961,074	4.14	0.21	4.35
1956	481,661	2,906,746	894,686	2,012,060	4.18	0.01	4.19
1957	493,828	2,781,792	832,636	1,949,156	3.95	0.28	4.23
1958	496,722	2,730,876	789,994	1,940,882	3.92	0.23	4.15
1959	440,063	2,840,173	794,719	2,045,454	4.65	0.16	4.81
1960	434,179	2,983,860	805,747	2,178,113	5.02	0.15	5.17
1961	435,389	2,957,200	761,525	2,915,675	5.04	0.16	5.20
1962	429,318	2,951,266	727,275	2,223,991	5.18	0.15	5.33
1963	430,222	2,991,429	706,763	2,284,666	5.31	0.20	5.51
1964	431,451	2,770,474	371,781	2,398,693	5.56	0.08	5.64
1965	432,491	2,624,363	312,397	2,311,966	5.35	0.27	5.62
1966	433,775	2,817,912	347,644	2,470,268	5.69	0.13	5.82
1967	445,428	2,719,861	354,482	2,365,379	5.31	0.35	5.66
1968	441,155	2,806,124	330,299	2,475,825	5.61	0.17	5.78
1969	442,294	2,675,833	324,255	2,351,578	5.32	0.29	5.61
1970	437,336	2,754,898	336,459	2,418,439	5.53	0.14	5.67
1971	441,783	2,883,960	349,361	2,534,599	5.74	0.11	5.85
1972	444,393	2,846,613	315,270	2,531,343	5.70	0.18	5.88
1973	444,309	2,956,013	285,700	2,670,313	6.01	0.11	6.12
1974	450,038	3,072,327	295,106	2,777,221	6.17	0.17	6.34
1975	456,174	3,001,207	297,501	2,703,706	5.93	0.10	6.03
1976	458,131	2,783,630	268,365	2,515,265	5.49	0.42	5.91
Total	10,325,607	65,879,505	12,600,028	53,279,477	119.14	4.14	123.28
Average	448,939	2,864,326	547,827	2,316,499	5.18	0.18	5.36

Source: IID 1976.

With completion of the Central Arizona Project in 1980, the IID allotment will probably be reduced to 3.2×10^9 m^3/year (2.6×10^6 acre-ft/year), which results entirely from the third-priority water right (Swajian 1977). The irrigation loss resulting from decreased importation of Colorado River water may be offset to some extent by lining additional canals with concrete to reduce water loss through canal sides and bottom. However, with increasing salinity of the irrigation water, the amount of water needed for salt leaching increases proportionally.

In the Heber area the primary land use is agricultural. The water consumption rate for these lands was estimated to be 4900 to 7400 m^3 (4 to 6 acre-ft) of water per 0.4 ha (1 acre) of land per year (EIR 1978). For the 2957-ha (7320-acre) Heber overlay zone, water usage is approximately 4.3×10^7 m^3(35,000 acre-ft) annually (EIR 1978).

Agricultural drainage to the Salton Sea is engineered to an elevation of 70.8 m (233 ft) below sea level. Since 1960, water level of the sea has risen to the point that during rainfall periods elevations may reach 69.7 m (228.65 ft) below sea level, an increased elevation of 1.5 m (5 ft). The rise in water level inundates recreational developments and sea marsh habitat (Anspaugh et al. 1976). Prior to construction of dikes, agricultural lands to the north were also inundated (Layton 1978).

The following beneficial uses are listed in the River Basin plan (CRWQCB 1975) as reasons for protecting the New and Alamo Rivers and the IID water-supply canals.

1. noncontact water-related recreation like picnicking, sunbathing, hiking, beachcombing, camping, pleasure boating;
2. agricultural uses including crop, orchard, and pasture irrigation as well as stock watering and other farming and ranching support needs;
3. uses related to warm, freshwater habitats — sustaining aquatic resources associated with warm-water environments, providing wildlife habitats and habitat support;
4. freshwater replenishment of inland lakes and streams (Swajian 1977; Nyholm and Anspaugh 1977).

The IID drains are considered in need of protection only for warm-water habitat, wildlife and freshwater replenishment.

The Salton Sea was designated by the Regional Water Quality Control Board to receive agricultural wastes and seepage water from irrigated lands (Swajian 1977). The area was designated a recreational area by the State Department of Parks and Recreation in 1962 (McDaniel 1980), and portions of it were made a wildlife refuge by the U.S. Fish and Wildlife Service in 1960 (U.S. Bureau of Sport Fisheries and Wildlife 1971).

4.3.4 WRC Assessment

The U. S. Water Resources Council, in compliance with provisions of Section 13(b) of the Federal Nonnuclear Energy Research and Development Act of 1974, prepared the Water Assessment Report for the Heber binary demonstration plant (Fed. Register 1980). This report is an assessment of water requirements and water supply availability for the proposed binary project. Findings of the report were as follows:

1. The project would require approximately $7.4 \times 10^6 m^3$ (6,000 acre-ft) water per year for cooling system makeup and plant operations;

2. The project will utilize geothermal fluids at a rate of $2.2 \times 10^7 m^3/yr$ (18,000 acre-ft/yr) to provide heat energy with spent fluid being reinjected at peripheral wells; and

3. The project will induce modest population growth with accompanying increases in municipal water requirements of $3.7 \times 10^4 m^3/yr$ (30 acre-ft/yr).

These findings concur with those presented in this assessment.

4.4 ECOLOGY

The biological setting of the Imperial Valley is dominated by intensive agriculture. Most of the original natural biotic communities have been replaced or severely altered by agricultural and urban uses. The Salton Sea, located about 40 km (25 miles) north of the overlay zone, is the most important biological habitat in the region. The Sea supports a sport fishery, and its associated wildlife refuges are important wintering habitats for large concentrations of waterfowl and shorebirds. In the central Imperial Valley, wildlife habitat is restricted to narrow bands of natural vegetation along the New and Alamo rivers and along the major irrigation canals. The irrigation system also supports a variety of aquatic life, including a warm-water sport fishery (Layton and Ermak 1976; Shinn 1976; SDG&E 1977; U.S. DOE 1977; U.S. DOE 1979a; U.S. DOE 1979b).

4.4.1 Terrestrial ecology

4.4.1.1 Vegetation

Most of the Imperial Valley originally supported the native creosote bush plant community, described by Munz and Keck (1973), which consists of widely scattered perennial shrubs dominated by creosote bushes (*Larrea tridentata*). Although the creosote bush community remains on the uncultivated margins of the valley floor, agricultural activities have removed most of this native desert vegetation from the central Imperial Valley. Remaining natural vegetation in the central Valley is restricted to the floodplains of the New and Alamo rivers and consists of desert riparian species and an alkalai sink community of salt-tolerant plants (Munz and Keck 1973). Vegetative cover is densest near the streams and is characterized by perennial shrubs, grasses, sedges, forbs, and rooted aquatic plants. Near the Salton Sea, the deltas of the New and Alamo rivers support large fresh water marshes with dense stands of rooted aquatic plants. The alkalai sink community occurs in poorly drained, saline areas around the perimeter of the sea. Within the cultivated portion of the Valley, grasses, forbs, and annuals grow in disturbed areas along roads and irrigation canals.

Almost all of the 2963-ha (7320-acre) overlay zone is presently under cultivation. All of the sites for the proposed power plants and well pads, including those for the binary demonstration plant, are on agricultural land. Natural vegetation within the overlay zone is restricted to the extreme southwest section, along the New River (Fig. 4.6). Some of this riparian habitat has been disturbed by off-road

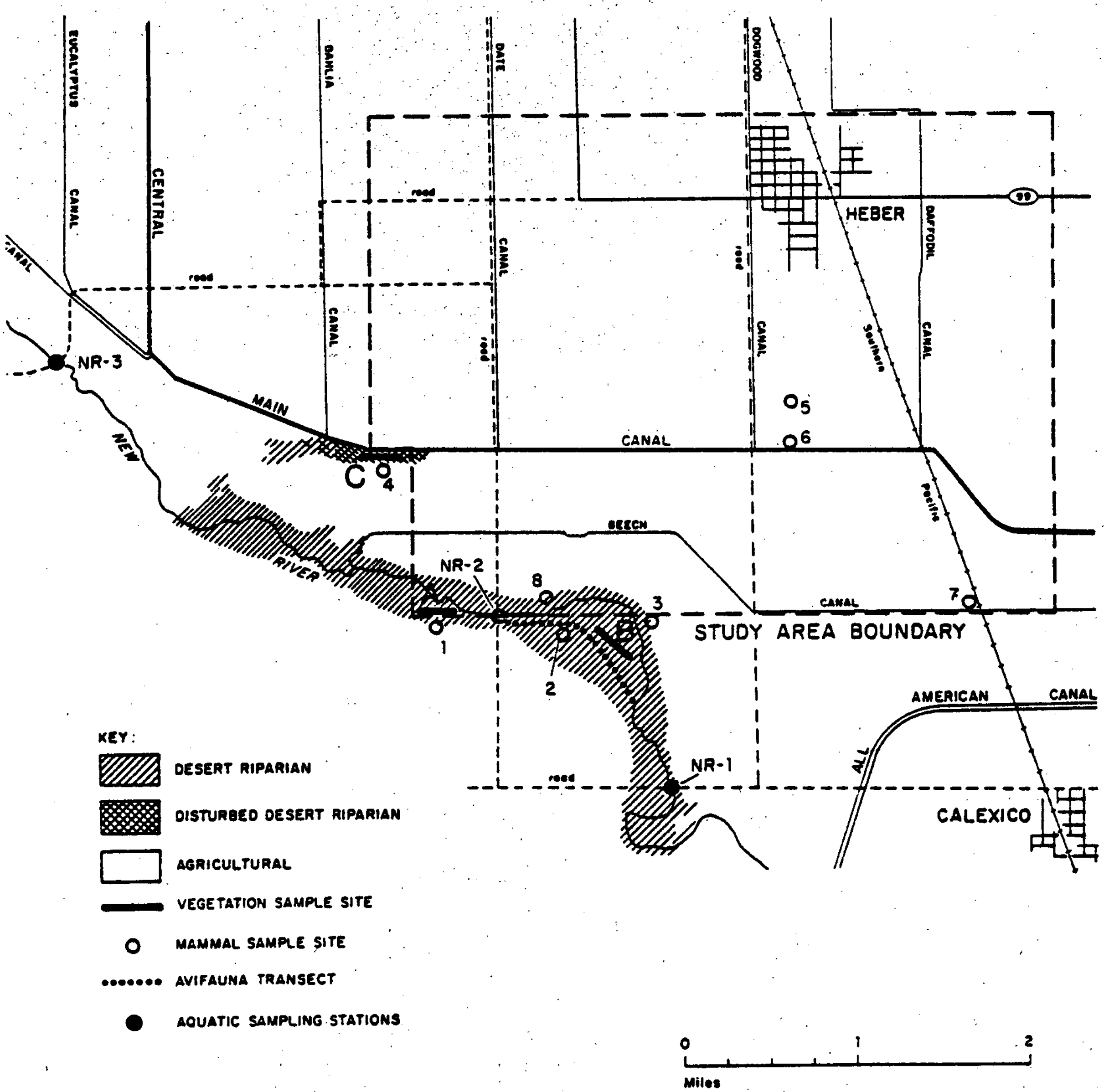


Fig. 4.6. Vegetation, wildlife, and aquatic sample sites. Source: EIR 1979.

vehicles and a recent fire which occurred after completion of the biological survey. Species lists of plants that were encountered in sample plots within this section of the overlay zone are presented in EIR 1978, EIR 1979, and in SDG&E (1977). The site for the proposed water withdrawal and treatment facility that will be required for full development to 500 MWe is within this riparian habitat (Sect. 7.3.4).

4.4.1.2 Fauna

Regional fauna compositions are determined by the habitat types in the Imperial Valley: creosote bush desert, wetlands, desert riparian, and extensive tracts of agricultural land. Remaining native creosote bush desert on the margins of the Valley floor supports populations of desert fauna characteristic of the hot Colorado desert (Miller and Stebbins 1973). The Salton Sea and its associated wetlands in the river deltas are important waterfowl and shorebird habitats. The Sea is the wintering area for a large percentage of the birds of the Pacific flyway; a total of 105 species of water birds has been recorded at the refuges in the southern part of the Sea (U.S. FWS 1970).

Desert riparian vegetation along the river floodplains in the central Valley provides abundant cover for a wide variety of songbirds, shorebirds and small mammals. The importance of this vegetation type to wildlife is enhanced by the dearth of adequate habitat in the surrounding agricultural fields. The riparian community along the New River provides the only wildlife habitat in the overlay zone. A much greater abundance and diversity of wildlife were observed in the riparian habitat than in the surrounding agricultural fields of the overlay zone. A complete discussion of species observed occurs in several references (EIR 1978, EIR 1979; SDG&E 1977).

The agricultural areas support a low diversity of small mammals and birds that are tolerant of man's activities. These species feed in the fields and depend upon the natural growth of weeds and occasional trees along the margins of the fields for roosting and cover. Information concerning animal species observed and collected from agricultural fields within the overlay zone is contained in several references (EIR 1978, EIR 1979; SDG&E 1977).

4.4.2 Aquatic ecology

The New River and Salton Sea are the major surface waters in the project area (Fig. 4.5). The Alamo River, although in close proximity to the project area, will not be directly affected by this project (EIR 1978). The New River in the project vicinity is highly polluted and is untenable for most aerobic aquatic organisms (CRWQCB 1975); however, as it proceeds toward the Salton Sea, its quality improves. There is an active population of flathead catfish (Pylodictis olivaris) fishery from Seeley to the Salton Sea, with channel catfish (Ictalurus punctatus) also found and fished for in the river (EIR 1979). The Imperial County Department of Public Health, however, discourages fishing in the New River for health reasons (EIR 1979). The State Water Resources Control Board in 1977 found that forage fish in the New River contained levels of chlorinated hydrocarbon pesticides (DDD, DDT, DDE) approaching 5 ppm (fresh weight). Levels of heavy metals were also found to be high (Ponder 1977).

The irrigation system serves as a freshwater habitat and supports a limited recreational fishery (CRWQCB 1977). A listing and discussion of species present can be found in US ERDA (1977), Milanovich et al. (1976) and in the EIR (1978). Mosquito fish (Gambusia affinis) have been introduced by the Imperial County Health Department for mosquito control. In addition, species of Tilapia were introduced following discovery of Hydrilla verticillata (an aquatic weed) in the All-American Canal in 1977 (Milanovich et al. 1976).

Irrigation return lines provide habitats for crayfish, numerous insect species, amphibians, and fish. Mosquito fishes are abundant and Tilapia winter in the drain lines. The Beech drain fronting the site to the south side is typical of the irrigation return lines in the system Parker 1977.

The Salton Sea supports a saltwater sport fishery of orangemouth corvina (Cynoscion hanthulus), sargo (Anisotremus davidsoni), and bairdiella or gulf croaker (Bairdiella icistius). The desert pupfish (Cyprinodon macularius) is native to the area. Threadfin shad (Dorosoma petenense), mudsucker (Gillichthys mirabilis), and several exotic species have also become established (SDG&E 1977). By 1929, fish species introduced in

1905 with failure of the Colorado River diversion system were practically extirpated from the sea by increased salinity (Layton and Ermak 1976).

Planktonic algae are abundant in the Salton Sea where they utilize salts, dissolved nitrogen, and phosphorus. Algal blooms occur causing eutrophic symptoms of water discoloration and oxygen deficiencies; localized fish kills result. Pile worms (Neanthus succinea), amphipods (Carinogammarus mucronatum), and barnacles (Balanus amphitrite), all introduced between 1930 and 1957, are the only abundant invertebrates. A total of 29 invertebrate species has been introduced into the food chain, but only those listed above were successful (Layton and Ermak 1976).

Increasing salinity of imported Colorado River water and the Salton Sea is a growing threat to the present fishery in the sea. Elimination of some game fish by the mid-1980's and essentially all by 1990 is expected because of the egg and larval mortality resulting when salinity exceeds 40,000 ppm (Goldsmith 1976).

4.4.3 Rare and endangered species

4.4.3.1 Plants

Of the 14 California plants officially listed by the U.S. Fish and Wildlife Service as threatened or endangered (U.S. FWS 1979), none occurs in Imperial County. Pursuant to the California Native Plant Protection Act of]979, the state maintains a list of officially designated endangered or rare plants (Cal. Resources Agency 1980a). Four plants that occur in Imperial County are: slenderpod squaw-cabbage (Caulanthus sternocarpus), Peirson's milkvetch (Astragalus madgdalenae var. Peirsonii), Wiggin's croton (Croton wigginsii), and the Algodones sunflower (Helianthus niveus spp. tephrodes); none occurs in the region of the Heber geothermal overlay zone. The squaw-cabbage occurs on dry chapparal slopes in the hills bordering San Diego County, west of Imperial Valley (Munz & Keck 1973). The other three species are associated with undisturbed sand dunes in native creosote scrub desert in the Algodones dunes and Yuma sand hills areas, on the eastern margin of the Imperial Valley (Munz and Keck 1973; Cal. Resources Agency 1980b).

4.4.3.2 Animals

Five species designated as endangered by the U.S. Fish and Wildlife Service are known to occur in the Salton Sea region: the yuma clapper rail (Rallus longirostris yumanensis), the southern bald eagle (Haliaeetus leucocephalus leucocephalus), the California least tern (Sterna albifrons brownii), American peregrine falcon (Falco peregrinus anatum), and the California brown pelican (Pelecanus occidentalis californicus) (U.S. FWS 1979). All five species are also on the California list of rare and endangered animals maintained pursuant to the California Endangered Species Act of 1970 (Cal. Resources Agency 1978a). Additionally, one other state-designated rare species, that is not on the Federal list, the California black rail (Laterallus jamaicensis coturniculus), also occurs in the region. All species are associated with the Sea and its peripheral wetlands. Only the rails breed in the Salton Sea region. The other four species occur as migrants or occasional visitors to the refuges adjacent to the Sea (U.S. FWS 1970); none of the four is likely to range far upriver from the New River delta and would not be expected to occur near the overlay zone.

Both the yuma clapper rail and the black rail are known to breed in the southern part of the Salton Sea at the deltas of the New and Alamo rivers, where freshwater marshes provide adequate breeding habitat (Cal. Resources Agency 1978b). Bennett and Ohmart (1978) have described breeding habitat requirements for the yuma clapper rail. The most important criteria include extensive areas of emergent cattails and bullrushes, stable standing water levels, and abundant populations of the preferred food, crayfish. The rising level of the Salton Sea has already innundated many acres and continues to threaten remaining habitat at the river mouths.

It is possible that breeding habitat for both rails exists upstream of the delta in sections of marshes at major agricultural drain outfalls along the rivers. From an aerial survey by VTN in 1979, fourteen large cattail marshes were indentified along the New River from an area just downstream of the Heber overlay to north of Brawley (Cook 1980). Subsequent ground surveys of seven of these marshes indicated that the marshes were fed from irrigation runoff entering the New River floodplain from adjacent agricultural fields (Cook 1980). In some cases the marshes were several feet above the channel of the river. Even upstream from Seeley, where the New River is badly polluted and devoid of aquatic life, the marshes surveyed supported abundant aquatic life. Most of the marshes were greater than 0.4 ha (1 acre) and one was as large as 4 to 8 ha (10 to 20 acres); there is a good possibility that these marshes along the New River could provide breeding habitat for both the yuma clapper rail and the black rail. There has never been a survey during the breeding season of any marsh habitats along the New River upstream of the delta (Powell 1980). During a field study of seven of the marshes in September 1979, VTN biologists did not find clapper rails, but they did record other species of rails. Among them was the state-designated rare California black rail (Cook 1980).

Although habitat for the clapper and black rails may exist along the New River floodplain downstream of the Heber overlay zone, large cattail marshes do not occur within the overlay zone (EIR 1978, EIR 1979; SDG&E 1977). The extremely poor water quality in the New River and the disturbed nature of the aquatic and riparian habitats in this area precludes the possibility that adequate habitat for either rail exists within the overlay zone. Surveys of the riparian habitat within the overlay zone by VTN biologists (EIR 1978) and earlier sampling by San Diego Gas and Electric Company's environmental staff (SDG&E 1977) did not produce any evidence that either the yuma clapper rail or the California black rail occurs in the overlay zone.

No other species on either the Federal list or the California list of rare and endangered animal species was observed in the overlay zone during these surveys, and none is expected to occur within the overlay zone. The overlay zone is within the geographical range of the flat-tailed horned lizard (Phyrnosoma m'calli), a candidate species whose status is currently under review by the U.S. Fish and Wildlife Service to determine whether it should be proposed as an endangered or threatened species (USFWS 1977, Sweeney 1980). However, based on results of recent studies of the species by Turner and others (1978, 1980), it is absent from the developed agricultural area of the Imperial Valley. It is possible, but unlikely that the lizard could still occur in areas of natural desert vegetation adjacent to the New River within the overlay zone. The lizard generally occupies areas at elevations below 250 m, with flat or modest slopes and with sparse vegetation cover consisting of creosote bush, bursage and saltbush (Turner et al 1978, 1980). The best habitats for the lizard exhibit surface soils of fine packed sand or desert pavement with scattered deposits of loose sand (Turner et al 1978, 1980). There is a possibility that the flat-tailed horned lizard could inhabit the vicinity proposed for the location of the blow-down evaporation ponds in the event that that disposal alternative is selected.

Aquatic

A designated California endangered species, the desert pupfish (*Cyprinodon macularius* Baird and Girard), that is found in the Salton Sea and its tributaries is proposed for inclusion on the federal list of endangered species. The desert pupfish is found primarily in the San Felipe Creek tributary to the Sea (Moyle 1976). The pupfish feeds on octracoda, copepods, and occassionally insects and pileworms in the Salton Sea (Cox, 1972). The pupfish is confined primarily to the tributaries of the Sea probably as the result of establishment of competing mesquito fish (*Gambusia* sp.) and sailfin mollies (*Poecilia latapinna*) (Fisk 1972).

There are no additional rare and endangered fish and invertebrates on either the Federal list or the State of California's list whose range would include the Heber and Salton Sea regions of the Imperial Valley.

4.5 AIR RESOURCES

4.5.1 Meteorology and climatology

The Heber Geothermal Project lies in the southeastern portion of the California desert basin. The region has a desert climate with hot, dry summers and mild winters. In July the average temperature is about 90°F (32°C) with daytime temperatures usually well above 100°F (38°C). Considerable radiational cooling is experienced at night. Relative humidities are very low throughout the summer months. In January the average temperature is about 55°F (13°C), with sub-freezing temperatures being experienced on about 12 nights in a typical year. The average diurnal temperature variations are 20°F to 30°F (11 to 17°C) throughout the year. The average annual rainfall is 2.7 inches (6.8 cm), most of which occurs during frontal passage periods. The occurrence of fog or thunderstorms is infrequent.

The dispersion of air pollutants is dependent upon the wind patterns and the atmospheric stability. Stability is recorded according to Pasquill's classification with Classes A, B, and C corresponding to unstable conditions, Class D to neutral conditions, and Classes E and F to stable conditions. The frequency of occurrence for each stability class by season is shown in Fig. 4.7 for El Centro, the closest station to the site for which this information is available (4 miles or 6.4 km from the project site). Class F conditions are the most prevalent, particularly during the fall and winter months because of the occurrence of these conditions at night when surface radiational cooling occurs.

The seasonal wind speed distribution is shown in Fig. 4.8. It indicates that winds are slightly stronger during the spring months, when the average wind speed is nine knots, compared to the rest of the year. The lowest winds occur during winter months. Calm conditions occur most frequently during the winter months when 9 percent of all observations are recorded as calms, whereas the spring calms are present for 4 percent of the time. A wind rose for El Centro is shown in Fig. 4.9 and indicates that prevailing winds are from the westerly quadrant, with a secondary maximum from the southeast. This suggests that air quality in the area could be affected significantly by transport of air pollutants from the metropolitan areas of southern California and from the agricultural areas of Imperial Valley and Mexicali Valley in Mexico.

4.5.2 Air quality

4.5.2.1 Overview

The major industry in the Imperial Valley is agriculture. Fugitive dust emissions from various soil cultivation practices and agricultural burning represent the most significant air pollution sources in this region. Because of the soil aridity, dust storms are generated in the dry months of late fall, winter, and early spring. Because of these conditions, the total suspended particulate levels are currently in

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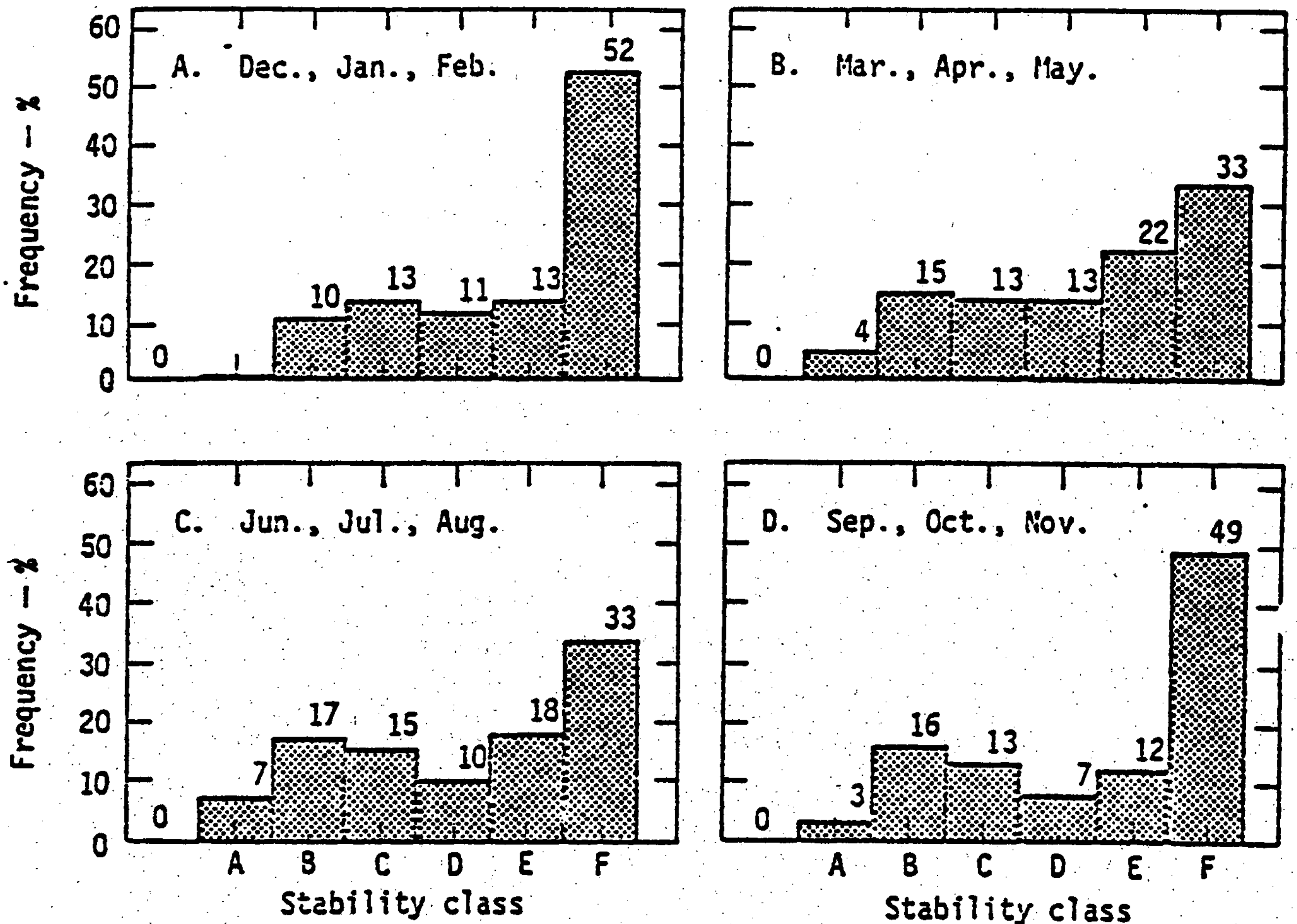

Fig. 4.7. Frequency distribution of atmospheric stability for El Centro, California. Source: EIR 1979.

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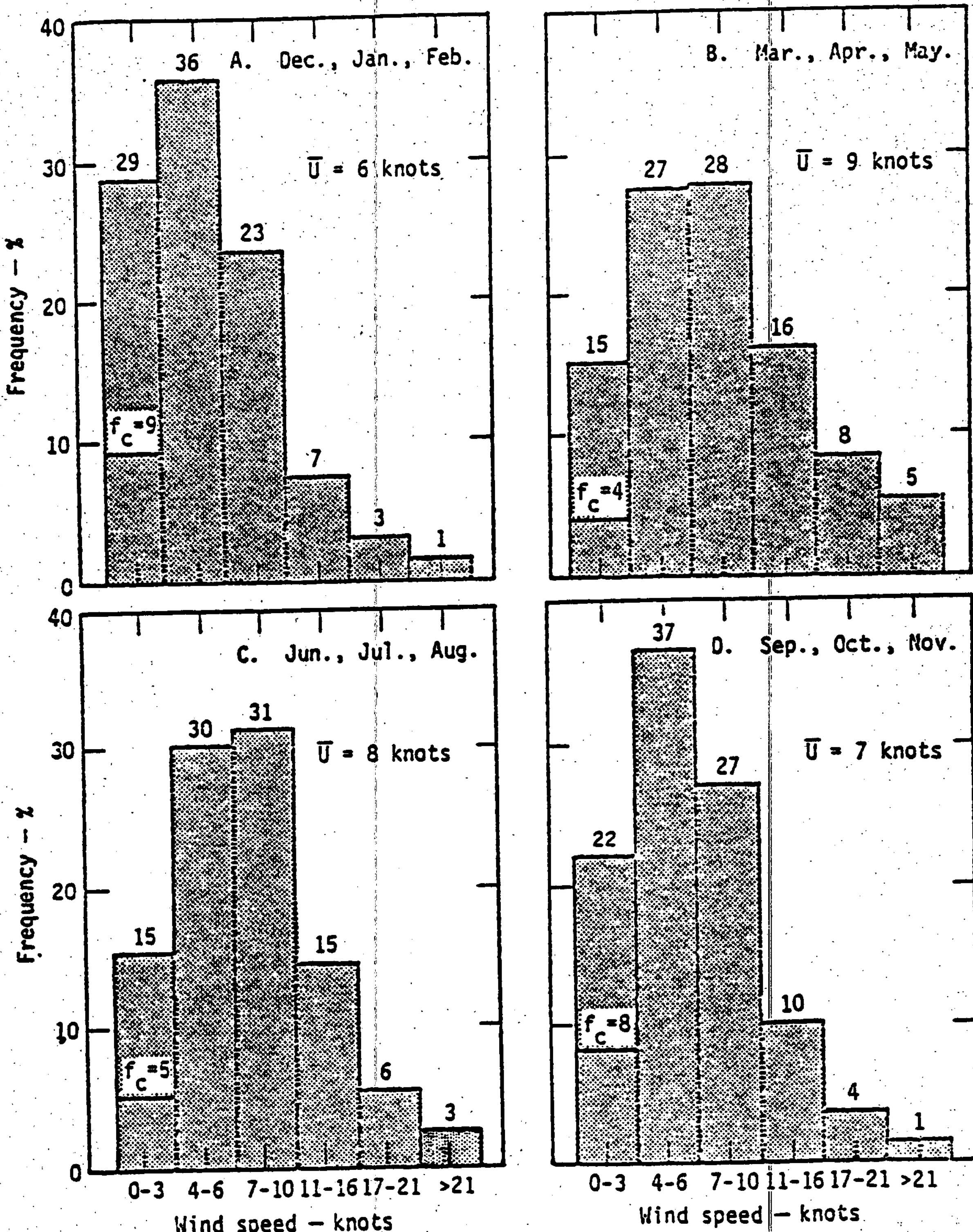

Fig. 4.8. Wind speed distribution at El Centro, California.

Source: EIS 1979.

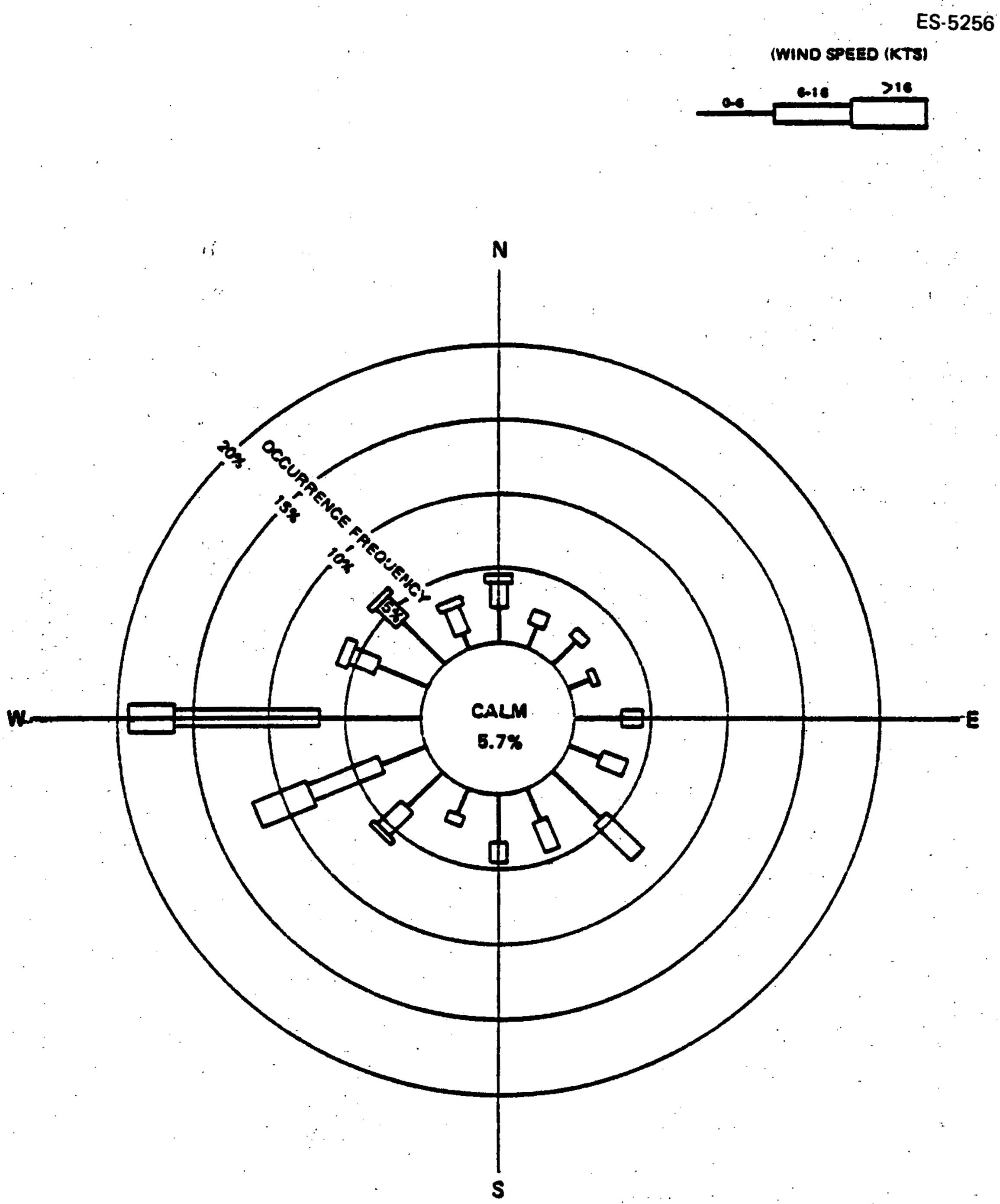

Fig. 4.9. Wind rose for El Centro, California. Source: National Climatic Center.

violation of the state and National Ambient Air Quality Standards. However, the region is not classified as a non-attainment area for TSP because of EPA's Fugitive Dust Policy which allows rural areas experiencing TSP violations as a result of fugitive dust to claim attainment of the NAAQS.

4.5.2.2 Pollutant emissions inventory

A pollutant emissions inventory was issued by the Imperial County APCD in November 1978. Of the total particulate emissions of 1245 metric tons/year (1373 tons/year), the major portion [40 percent or 508 metric tons/year (560 tons/year)] is contributed by agricultural processing. However, these values do not allow for fugitive dusts generated by agricultural tilling operations and arid land dust storms. It is likely that airborne dusts produced by these latter sources would greatly exceed the total particulate emissions of 1245 metric tons/year (1373 tons/year). Analysis of particulate samples collected in the Imperial Valley by Lawrence Livermore Laboratory, show that the most prevalent element is silicon. This would indicate that most of the particulate is soli-derived fugitive dust (EIR, 1979). In terrain and climates similar to that of Imperial Valley, the total fugitive dust emissions for an equivalent area are estimated to be about 1,814,400 metric tons/year (2,000,000 tons/year). Emissions of NO_x are 3,725 metric tons/year (4,106 tons/year) and 2,926 metric tons/year (3,225 tons/year) respectively, primarily as a result of fuel combustion in the utility sector. Mobile source emissions were not compiled in this inventory, but based on 1975 levels are extremely low and consist primarily of HC and CO emissions.

4.5.2.3 Ambient air quality

The most recently available ambient air quality monitoring results for TSP, SO_2, and O_3 have been reported in the California Air Quality Summary for the period April through December 1978, and are presented in Table 4.6. The maximum 24-hour averaged concentrations of suspended particulates from June through December are well in excess of the California ambient air standard of 200 $\mu g/m^3$. These violations are almost entirely a result of fugitive dust emissions. Lower TSP levels occurred during the spring as a result of the decreased aridity of the soil during this period.

The maximum 1-hour averaged SO_2 concentrations are well below the state standard of 0.50 ppm for all months. However, in July and August

Table 4.6. Pollutant concentrations in ambient air for El Centro, California, April–December 1978

Pollutant	Sampling period	Location	Maximum concentration									California standard	National standard
			Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.		
Total suspended particulates (TSP), $\mu g/m^3$	24 h	Brawley	102	166	316	216	198	602	260	315	443	100	260
		Calexio	96	155	248	219	200	456	303	410	550		
		El Centro	76	93	120	.76	149	303	191	154	186		
Ozone, ppm	1 h	El Centro	0.10	0.05	0.10	0.11	0.12	0.07	0.08	0.07	0.03	0.10	0.12
SO_2, ppm	1 h	El Centro	0.01	0.02	0.04	0.05	0.04	0.01	0.08	0.03	0.09	0.50	

the maximum 1-hour ozone levels exceeded the state standard of 0.10 ppm, and in April and June the standard was equalled. In the 1977 annual summary, CARB reported the maximum 2-hour concentrations of ozone for the year at Heber and El Centro at 0.11 and 0.09 ppm respectively. At Heber the O_3 standard was exceeded on 22 days of the year. The emissions of NO_x and hydrocarbons, the major precursors to O_3, are relatively small in the valley. This suggests that the major cause of the O_3 problem is long range transport of the pollutant from urbanized areas to the west, northwest, and perhaps even south. Sulfur dioxide levels for 1977 were well below the state standard, the maximum 1-hour concentration at Heber and El Centro measured as 0.17 ppm and 0.09 ppm, respectively.

4.6 NOISE CHARACTERIZATION

Average day-night sound levels from a 1977 survey of the project area ranged between 58 and 73 dB(A), with higher levels associated with aircraft flights and railroad noise (EIR 1979). The relatively low noise levels in the area are considered typical of a predominantly agricultural area (Wilson 1980). The Imperial County general plan includes noise standards for geothermal developments.

For the proposed project, Imperial County class I standards will apply; class II standards would apply to development near or adjacent to an existing development (Fig. 4.10).

4.7 SOCIOECONOMICS

4.7.1 Population

Imperial County's population increased from 74,492 in 1970 to an estimated 93,600 in 1979. This growth represented an average annual increase of 2.3% compared to a 1.4% annual growth rate experienced by the State. Adjacent to the project area is the unincorporated town of Heber with a 1975 population of 2206 (EIR 1979). Estimates for the 1979 population in the nearby incorporated cities include: Brawley – 14,150, El Centro – 24,350, and Calexico – 13,550. A large share of the County's growth has been absorbed by El Centro and Calexico. In addition, a substantial number of workers from the neighboring Mexican city of

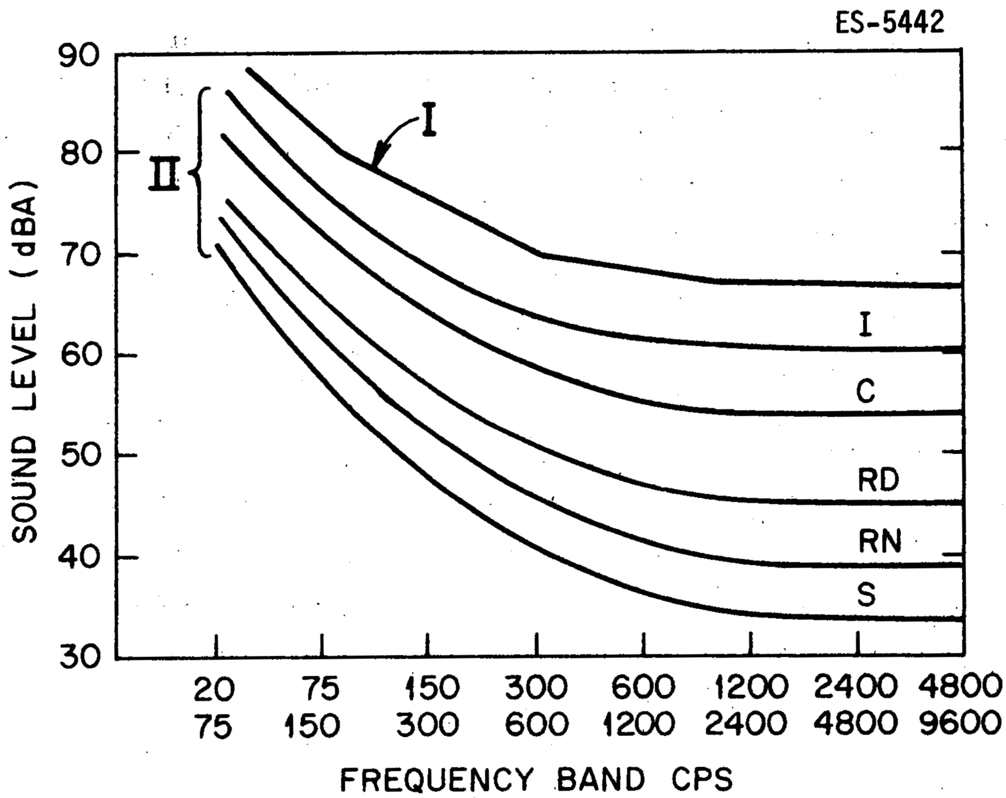

Fig. 4.10 Imperial County Class I and II Noise Standards.

Mexicali, Mexico, are employed in the county. Mexicali is the dominant population center in the region, having an estimated 515,000 inhabitants in 1980 (EIR 1978).

Seasonal fluctuations in population are common, with significant increases from migrant farm labor during the peak harvest season – November through April. The County's agricultural labor requirements, coupled with the proximity to Mexicali, encourage migration. There are 6000 legal Mexican nationals residing in the County and between 6000 and 12,000 seasonally employed legal Mexican commuters (Stahrl and Rose 1979). There is no estimate of the undocumented Mexican national population. The 1970 census indicates 46% of the population is composed of Hispanics.

Half of the County's population growth has been caused by natural increase, reflecting a high birth rate, with the remaining half due to in-migration (U.S. Bureau of the Census 1977). The median age of Imperial County residents is 24.0 years, well below the State median, of 28.1 years (EIR 1979). Residents of Imperial County completed 10.8 median school years compared to 12.4 for the state (U.S. Bureau of the Census 1972).

Imperial County has nearly twice the number of families below the poverty level compared to State averages. Of those families below the poverty level in the County, 62% were Hispanic households.

Projections for population growth in the County predict a growth rate of 2.4% per year, yielding 124,000 by the year 2000. During the 2000 to 2020 period, the population is predicted to grow by 1.7% per year and will total 175,000 by 2020 (Stahrl and Rose 1979). Population trends and characteristics are further described in EIR (1978) and EIR (1979).

4.7.2 Economic characteristics

Agriculture is the mainstay of the Imperial County economy. Agriculture comprised 38% of all wage and salary employment, or 14,800 people out of the total 40,300 employed. Agricultural production is divided evenly among vegetables, livestock, and field crops. The southern section of the County near the project area is planted with vegetable crops. Nonagricultural employment is relatively concentrated in the government sector (22%) and the retail-services sectors (23%) (EIR 1979). Agricultural land at the Heber Geothermal field is mostly under cultivation for alfalfa although rotation to cotton or vegetable crops occurs periodically with alfalfa dominating for several years at a time. The displaced 23 acres of alfalfa corresponds to an annual value of $13,800 if cubed for dehydrators and $7,000 if baled for hay (Borton 1980).

Imperial County has a high unemployment rate. In 1979, 24% of the County labor force was unemployed. The unemployment rate is highest from July to October when demand for agricultural labor is minimal (Hurst 1980). The unemployment problem is exacerbated by the proximity of the large labor force in Mexicali. Over 6000 legal Mexican nationals commute daily to Imperial County jobs, with an unknown percentage of low-paying jobs being held by undocumented Mexican nationals (EIR 1979).

Taxes are levied by the County, municipalities, schools and special districts. The taxing districts in the project area have the following rates per $100 of assessed valuation: Calexico - $5.0711, Heber - $5.6780, and McCabe - $4.1520 (Wilson and Smith 1980).

4.7.3 <u>Housing</u>

Housing is presently limited in Imperial County. Shortages are especially evident in El Centro, which had a vacancy rate of only 1.59% in 1977. New housing construction is currently sluggish due to high interest rates (Jones 1980).

The available housing has a higher number of persons per household than housing in surrounding counties. Imperial County averages 3.5 persons per unit and El Centro's average was 3.3 in 1970, compared to the State average of 3.0 persons per unit. Conditions in Heber are even more crowded with 5.2 persons per household as reported in the 1975 special census (EIR 1979).

The percentage of households having more than one person per room is an additional indicator of crowding; 19.4 percent of Imperial County households have more than one person per room compared to the state average of 7.7%.

Much of the area housing is in need of repair. Eighteen percent requires some rehabilitation, and by 1990 an estimated 42% will require repair to maintain resale value and rental potential (EIR 1979). Overcrowding also seems to contribute to the deterioration of both renter and owner-occupied units.

4.7.4 Community services and facilities

Imperial County and the Imperial Irrigation District (IID) are the primary providers of utilities in the project area. The IID provides electricity to more than 52,000 customers and maintains a generating capacity of 417,806 kW (Hartshorn 1980). Additional capacity of 27,000 kW is scheduled to come on line in the summer of 1980. Natural gas is supplied by the Southern California Gas Company. There have been substantial increases in utility customers in the last three years.

The Heber Utility District purchases water from IID, and maintains the town's sewer system. Private haulers provide garbage collection and disposal. Sewage treatment capacity (primary) is being expanded locally to provide secondary treatment (Lopez 1980).

Other public services, including fire and police, are provided by the County to unincorporated areas, and by municipalities in the incorporated communities. Current demands for these resources are being adequately met, though expenditures are increasing (by 12% for FY 1979) (Paine 1980). Increases are due more to inflation than to addition of personnel.

School facilities are provided by the Heber Elementary School District and the El Centro School District. Elementary enrollment is 4187 (Ruiz 1980), and high school enrollment is 1923. No significant increase in enrollment has occurred in recent years, and no expansion is planned (Duggan 1980).

4.7.5 Transportation systems

The project area is well-served by interstate highway number eight, U.S. highways, and State highways. Local roads in the immediate vicinity of the project are limited in number and in carrying capacity because they were designed primarily for access to agricultural activities (Figs. 3.1 and 3.2 and Section 3.7.2.1).

Freight rail service is provided by the Southern Pacific Railroad, and passenger service is available between Holtville and El Centro. Commuter airlines operating from Los Angeles, San Diego, and other area cities serve El Centro.

4.8 CULTURAL RESOURCES

Studies of cultural resources in the project area conducted by Imperial Valley College's museum concluded that no archeological resources of significance were present in the project area. Moreover, none of the sites studied has been nominated to either the National Register of Historic Places or the California Inventory of Historic Sites (EIR 1979). A spokesman for the Imperial County Planning Department confirmed the lack of significant cultural resources in the area, stating that the area had been extensively cultivated for decades without revealing the presence of any archeological resources (Mitchell 1980).

4.9 AESTHETICS

The project area is flat valley land bordered by the Orocopia and Chocolate Mountains, the Sand Hills, and East Mesa to the east and northeast. The area is currently being cultivated and is surrounded by agricultural activities and a low-density network of roads (several of which are unpaved) and irrigation canals. Natural vegetation is sparse in the desert climate, and there is little topographic relief. Extensive agricultural activity in the valley prevents the region from being a natural or undisturbed area. Views from the valley and across the valley are often obscured by naturally occurring haze, dust, and smoke from agricultural operations.

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5. POTENTIAL ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION

5.1 GEOLOGY, GROUNDWATER, AND SOILS

Possible or probable impacts to the geologic environment, including groundwater and soils, resulting from geothermal development of the G-overlay zone are as follows:

1. alteration and depletion of the geothermal resource,
2. induced subsidence,
3. induced seismicity,
4. soil impacts: erosion, corrosion, and bearing failure,
5. displacement of prime farmland soils,
6. damage caused by earthquakes,
7. accidental contamination of groundwater and soils.

These impacts may occur as development of the Heber anomaly progresses even if the proposed Federal action is not implemented. None of the project facilities are located in a floodplain, flood hazard area, or wetland, and therefore it is very unlikely that there will be any impacts associated with these features resulting from the project.

5.1.1 Resource depletion

Reduced pressure and thermal gradients are expected to result eventually from depletion of the geothermal resource. The rate at which these reductions occur will not be thoroughly understood until production experience is gained. More detrimental impacts such as subsidence and seismicity may also accompany geothermal resource depletion. Chevron plans to minimize subsidence and seismicity by injecting 100% of the amount of fluid extracted. Reservoir model optimization studies conducted by Chevron indicate that its preferred site for the injection island most effectively limits depletion of the geothermal resource (EIR 1978). As production progresses, Chevron may vary injection and production depths to determine what combination is optimal. The binary power plant is predicted to be more efficient (i.e., achieves higher productivity with less resource depletion) than the flash process for certain temperatures. This efficiency would be a beneficial impact not only at the Heber Known Geothermal Resource Area (KGRA), but for any other areas with similar resources.

5.1.2 Induced subsidence and uplift

Because a large amount of the revenue in the Heber area vitally depends on the precisely leveled, gravity-flow irrigation system, potential alteration of the topography by subsidence or uplift is a crucial issue.

Chevron's preferred alternative of injecting 100% of the amount of fluid withdrawn greatly limits, but does not exclude, the possibility of harmful subsidence. Two preliminary analyses based on Geertsma's equation (Geertsma 1973) have been made to estimate subsidence from elastic response. The initial analysis estimated that an average of 21 cm (8.4 in.) of subsidence could result from development for production of 200 MWe. This gross estimate is an average value for the entire geothermal anomaly, considered to cover 130 km2 (50 sq miles) in the analysis, and it does not account for local variations (EIR 1978). For this reason it is unsatisfactory. The second analysis was for a cumulative production of 500 MWe and was based on more specific data. It is estimated that 7.6 cm (3 in.) of subsidence in the immediate vicinity of production and 10.2 cm (4 in.) of uplift in the immediate vicinity of injection could be induced by such development (EIR 1979). Such changes in the topography could be tolerated by the irrigation system and existing structures without impact, but the analysis can only be considered an approximation. Although low estimates of subsidence and uplift normally do not require further attention, they must continue to be validated in the Heber area by more sophisticated models as additional information becomes available due to the significance of the issue.

To establish a baseline for distinguishing between natural and induced subsidence, Chevron has conducted annual first-order leveling surveys of the Heber area since 1975. In accordance with the Imperial County Geothermal Element (1977), additional monitoring for subsidence and uplift will include a network of stations consisting of 53 km (33 miles) of survey lines and about 50 benchmarks. This network will cover the Heber geothermal anomaly and its vicinity, and monitoring will be conducted every three or six months during initial production. After initial production, the anomaly will be monitored annually. Chevron's monitoring will be supplemented by additional monitoring by other organizations. Experience may indicate that monitoring is necessary on a more or less frequent basis.

Once production commences, results from leveling surveys must be interpreted carefully to determine how much movement is natural and how much is induced. If monitoring reveals that significant subsidence or uplift is being caused by geothermal development, several options are available to minimize the impact. Because field development and plant operation are permitted on a conditional basis, agencies of Imperial County have the authority to implement effective mitigation measures with assistance from the California Division of Oil and Gas. Detection of significant induced subsidence or uplift will result in intensified monitoring with more frequent and more detailed leveling.

Lower production and injection rates may reduce pressure losses or gains adequately to prevent continued subsidence or uplift. As a result, more wells might have to be drilled to maintain desired power production. Locating injection wells and production wells nearer to each other might have the same effect, but this would also probably deplete the resource faster and be more costly. Mitigation might also be achieved by producing or injecting into deeper intervals. Deeper sediments are likely to be better consolidated and cemented, and there is more opportunity for compaction to be diffused and compensated for by a broader, thicker section of overlying sediments. If necessary, these programmatic alternatives will be evaluated on technical, economical, and environmental bases, and DOE will determine if a supplement to the environmental assessment is required. To mitigate surficial impacts, filling or grading might be necessary to maintain irrigation canal and drain gradients. (Note: Agricultural lands in the project area are normally regraded every two to three years.) If serious enough, induced land surface changes could result in operations being halted either temporarily or permanently.

5.1.3 Induced seismicity

The effect of altering the geothermal regime in a seismically active area such as the Imperial Valley is uncertain. Production of liquid-dominated geothermal resources in seismically active areas of Mexico (Cerro Prieto), New Zealand (Wairakei), and El Salvador (Ahuachapan), has not caused significant, if any, seismicity. It has been documented that injection of fluids into the subsurface at pressures exceeding those required to fracture the rock has caused seismicity, although these cases occurred in geologic environments different from those of the Salton Trough (regions that were not seismically active) (EIR 1978). Theoretically, it has been calculated that geothermal production increases the frequency and may slightly increase or decrease the magnitude of earthquakes in production areas. However, theory must be validated by careful analysis of data from actual seismic monitoring.

Injection wells are regulated by the California Division of Oil and Gas, which determines the maximum safe injection pressure for them. The California Division of Oil and Gas grants permits to operators of injection wells, and the permits establish maximum pressures at which fluid can be injected into the subsurface. This pressure is established by the Division once rate pressure tests have been analyzed to determine fracture gradients.

Although significant seismicity induced by geothermal development is unlikely based on past experience elsewhere, monitoring is necessary to detect any seismicity that may occur. Results of monitoring must be analyzed carefully to differentiate between natural and induced seismicity. Induced seismic events would probably occur at more shallow depths than would natural ones. The U.S. Geological Survey has placed permanent seismic monitoring stations in the vicinity of Heber. Chevron will place a seismic net in this area prior to the onset of production. The net is required by the geothermal element of the Imperial County plan; it will obtain necessary data on baseline seismic activity and deviations that occur during periods of power production.

If the California Division of Oil and Gas or Imperial County establishes that seismicity during geothermal production varies significantly from the baseline activity, appropriate mitigation will be implemented. As discussed in Sect. 6.1.3, and in accord with the recommendations in EIR (1978), and EIR (1979), a program consisting of alternate periods of shutdown and full operation to demonstrate a statistical relationship between seismicity and production/injection or computer modeling using accumulated engineering data could be undertaken to determine what measures are necessary (EIR 1978; EIR 1979). Injection rates may have to be reduced, injection wells may have to be backwashed to eliminate clogging, additional injection wells may have to be drilled, or operations may have to be halted.

5.1.4 Soil impacts: erosion, corrosion, and bearing failure

Without proper mitigation, detrimental impacts can be caused by soils at the project sites because of their low bearing strength and corrosion potential, as described in Sect. 4.1.6. A detailed coring program has been conducted at the San Diego Gas and Electric site to provide sufficient detail of the shallow subsurface environment. This information enables foundation and structural engineers to determine the scope of mitigation necessary for competent design. Gathering lines will be protected from soil contact and sulphate-resistant concrete will be used to prevent corrosion. Unsatisfactory soils may be removed and replaced with more desirable soils, or soils may be consolidated with various surface loads prior to building. Pile foundations can utilize the cohesive properties of the soils, and thicker structural members can compensate for weak soils. More intensive investigation of shallow subsurface characteristics will be made for the design of particular facilities, such as the turbine foundation.

Generally, erosion should be insignificant because proper care will be taken to leave soils uncovered for as little time as possible. The only place in the Heber G-overlay zone where slope instability and erosion are potential hazards is along the banks of the New River because the land surface is nearly level everywhere else. Careful design and grading techniques will be applied to minimize the possibility of serious erosion or slope failure.

5.1.5 Displacement of prime farmland soils

A maximum of 9.3 ha (23 acres) of soils classified as prime farmland by the U.S. Department of Agriculture will be negatively impacted as part of the proposed demonstration project. This includes soil that will be covered by structures, paving, concrete pads, or impermeable linings for settling ponds, trenches, or sumps. Because of the soil's low bearing strength, it is very likely that most of the soil will be compacted or removed, severely reducing or possibly destroying its agricultural capacity. However, agricultural production in the Imperial Valley is not limited by the availability of prime farmland, but rather by the availability of water.

Because nearly all of the Heber G-overlay zone has prime farmland soils, (Fig. 4.4, Sect. 4.1.6) geothermal development of the Heber anomaly will inevitably result in the loss of some prime farmland, regardless of the specific technology used. Chevron has already incorporated several features into its development plan to minimize the amount of prime soil it impacts. All production wellheads will be located on one island and all injection wellheads will be on another to minimize space required for these activities and for access to them. Fluid transmission lines will be built along the rights-of-way of existing roads so that additional roads will be unnecessary, and existing transmission corridors will be utilized.

As indicated in sections 5.2.1 and 5.7.2, agricultural land at the Heber Geothermal field is mostly under cultivation for alfalfa, for which the annual crop value (calculated for 1979) varies between $7,000 and $13,800 for the 23 acres replaced.

5.1.6 Damage caused by earthquakes

Because the proposed project is located in an intensely active seismic area, damage could occur as a result of a major earthquake. As noted in the section on geologic hazards (Sect. 4.1.3), ground acceleration and ground failure (liquefaction) are the primary earthquake hazards. Ground acceleration could damage well casings, and, if it occurred during drilling, could damage drilling equipment. Ground acceleration could also damage surface facilities. Facilities will be designed to withstand appropriate effective peak acceleration and effective peak velocity (Sect. 6.1.6) by incorporating recommendations in "Tentative Provisions for the Development of Seismic Regulations for Buildings" or other comparable state guidelines (Applied Technology Council 1978).

Ground failure could result in the buckling or shearing of well casings or damage to foundations of structures from differential settlement. Fine sand occurring below 16 m (50 ft) and thin intervals of sand and silt occurring at more shallow depths (EPRI 1977) have the potential of causing ground failure. Therefore, specific analysis of the capability of structures to withstand ground failure will be included in the engineering design.

Impacts that might occur as a result of ground acceleration or ground failure would generally be limited to the project's facilities. However, these impacts could result in the release of geothermal fluids to the surface or the shallow subsurface causing contamination of air, water, and soil.

5.1.7 Accidental contamination of soils and groundwater

During normal construction and operation, contamination of soils and groundwater will be insignificant. Occasional small spills or leaks of oil, lubricants, drilling muds, or geothermal fluids are likely to occur during normal project activities. However, because they will be confined to paved, lined, or concrete areas enclosed by earth berms, they will not affect the local environment. Fires, blowouts, and major spills (described in Sect. 3.7.2.8, "Accidents") are unlikely to contaminate soils or groundwater because of planned mitigation. The spill-control system consisting of trenches, sumps, and berms (SDG&E 1979) will isolate contaminated fluids and prevent them from infiltrating soils and groundwater. In the case of a very severe accident, the isolation system is expected to be adequate to contain the fluids until a more extensive system of collecting them can be implemented. If it is not, hot water and condensed vapor could contaminate nearby soils and infiltrate the groundwater. These fluids are not hazardous, and their impacts on the environment would not be major.

Because Chevron must obtain a permit from the California Division of Oil and Gas for all injection and production wells assuring it has complied with regulations and standards designed to ensure that casing failure does not occur, a casing failure is unlikely.

Once California implements an underground injection control program, as required by regulations of the U.S. Environmental Protection Agency, Chevron will comply with all of its provisions.

5.2 LAND USE

5.2.1 Displacement of agricultural land

Preservation of productive agricultural lands is the most significant land-use issue. Proposed geothermal development is not perceived as making adjacent lands unsuitable for agricultural use. This is confirmed in the Geothermal Element (1977) of the Imperial County general plan, which, in considering the total geothermal resource in Imperial County, states:

> Suitable geothermal development will not seriously diminish the agricultural capabilities of Imperial County. Research indicates less than 2 percent of the present agricultural land will be removed from production which can be made up by utilizing undeveloped land or opening up new agricultural land. Electric and non-electric geothermal applications are compatible with most agricultural activities and development can benefit agriculture by generating by-products such as potable water, chemicals or fertilizers produced from the minerals in the brine (EIR 1978).

The project will only remove about 9.3 ha (23 acres) of agricultural land from active production for the 30-year-lifetime of the plant. A mitigating measure that will be used is grouping wells into production and injection islands, to minimize land consumption. Farming can continue around the islands. Agricultural land at the site is mostly under use for alfalfa farming. Alfalfa value in 1979 for 23 acres in Imperial County was $13,800 annually when cubed for dehyrators and $7,000 when baled for hay (Borton 1980).

Utilization of an evaporation basin for disposal of the cooling tower blowdown will not have significant land-use impacts. The construction (at a point five years into the project) of an 8.9-cm- (3.5-in.-) diameter underground pipeline for transporting blowdown water to a 50.6 ha (125-acre) evaporation basin 14.5 km (9 miles) west of the Heber project site would have insignificant land-use impacts. Areas of scattered residences southwest of Heber would be passed by the pipeline, but its construction procedure would be so rapid that the duration of the trenching and pipe laying would render any land-use conflicts negligible.

Housing areas would be avoided to the extent possible by both the pipeline and the basin. Moreover, the proposed basin location is in the desert, beyond any land needed for agricultural use. Temporary disturbance of agricultural uses during pipeline construction would be insignificant.

5.2.2 Effects of salt drift on croplands

Deposition of salt drift from the cooling towers associated with the binary plant has potential to adversely affect valuable agricultural land by causing reduced germination success and lower crop yields as a result of accumulation of salts in the soil (Bernstein 1964, Richards 1969). Airborne salt deposited on the foliage can also cause injury to crops from salt uptake by the leaves (Moser 1975, Hindawi et al. 1976). Appendix D presents an analysis of predicted levels of salt deposition resulting from cooling tower operation at the binary plant. Appendix E presents a detailed analysis of the effects of these predicted deposition levels on croplands surrounding the plant. The towers are assumed to be operating with circulating water containing 4,000 ppm total dissolved solids (TDS) for the first five years and 20,000 ppm thereafter. Depositions were estimated using two sets of meterological data (see Appendix D). The effects of three drift loss rates were analyzed corresponding to three alternative tower designs: no drift eliminators (0.1% drift loss rate); standard drift eliminators (0.008% loss); and "state-of-the-art" drift eliminators (0.002% loss). Because the proposed tower design is for 0.008% drift loss rate, the impacts associated with this drift rate (using Heber site meteorological data) will be summarized here. The reader is referred to Appendix E for the discussion of impacts associated with the two alternative drift loss rates.

Tables D.7 and D.8 in Appendix D present the predicted salt depositions at 0.008% drift loss rate and the approximate areas which will be affected by the predicted depositions. The areas in the Table refer to those within the isopleths of salt concentration depicted in Figures D.14 through D.17. Maximum salt depositions at 0.008% drift loss rate are predicted to be 100 g/m^2 (900 lbs/acre) for the first five years of operation and 700 g/m^2 (6400 lbs/acre) thereafter. These maximum depositions will affect a relatively small area of less than 3 ha in the immediate vicinity of the towers.

Accumulation of salt in soils is a continual hazard in the Imperial Valley where irrigation is a prerequisite for agriculture and irrigation water is relatively saline. Salt accumulation is controlled by leaching soluble salts from the rooting zone with a fraction of the irrigation water. The fraction of the irrigation water which must pass through the root zone is referred to as the leaching requirement. It is a function of the salinity of the irrigation water and the desired salinity of the soil in the root zone, which is dependent upon the salt tolerance of the crop species being grown on that soil. Appendix F contains a discussion of the method of calculation of the leaching requirement. As the salinity of the irrigation water increases so does the leaching requirement necessary to flush the additional salts from the soil.

Operation of the cooling towers will deposit an increment of salt as drift on the surrounding croplands, which will effectively raise the salinity of the irrigation water being applied to these lands, thereby necessitating an increased leaching requirement in order to maintain the desired soil salinity. The soils in the vicinity of the Heber plant site which would be affected by a major portion of the salt deposition at 0.008% drift are holtville silty clay and Imperial-Glenbar silty clay loam (see Fig. I.1 in Appendix I). These soils are presently at or very near their maximum achievable leaching capacity. Addition of a sufficient increment of salt from the cooling towers will result in accumulation of salts in the soil to the point where yields of all but the most salt tolerant crops could be reduced. From Appendix E, between 12 and 24 ha are expected to receive sufficient salt deposition at 0.008% drift and 20,000 ppm circulation water to cause some reduction in yield for moderately salt tolerant crops, including alfalfa, the crop presently grown (Bernstein 1964, Richard 1969). For the first five years of operation with circulation water containing 4000 ppm TDS, there should be no adverse effects on croplands from salt accumulation (see Appendix E).

In addition to salinization of soils, deposition of salt drift on croplands has the potential to cause foliar injury to crops. Limited data are available which relate salt deposition to leaf damage. Furthermore, because foliar damage is related to salt uptake by the leaves, which is itself related to leaf structure and morphology, it is difficult to extrapolate data from one crop species to another. However, all crop species thus far tested have exhibited damage to short term exposures of less than 100 g/m^2/year (Mulchi and Armbruster 1974, Maas 1980). Although it cannot be stated with certainty, it may be comfortably speculated that areas receiving long-term exposures to over 100 g/m^2/year are likely to exhibit some crop damage from airborne salt drift from the towers. From Table E.2 in Appendix E, between 20 and 24 ha could receive over 100 g/m^2/year at 0.008% drift and 20,000 ppm circulation water. With 4000 ppm circulation water, from none to less than three ha will be exposed to deposition levels of over 100 g/m^2/year.

In summary, salt drift from 0.008% drift loss rate when 4000 ppm circulation water is used (for the first five years of project operation) will not cause adverse effects to surrounding croplands. However, at such time that 20,000 ppm circulation water is used, a maximum of 24 ha could potentially be adversely affected by both accumulation of salts in the soils and damage to crops from airborne salt deposition of the foliage. These adverse effects could be mitigated by reducing the salt loss from the towers or possibly by planting extremely salt tolerant crop species on the affected area. Mitigation of salt drift is discussed in more detail in Section 6.2.2.

5.2.3 Other considerations

There are no residences or commercial buildings on the project site, the closest buildings are a few residences 0.4 km (0.25 mi) or more from the site. There are no recreational resources nearby, and no impact on recreation.

According to the ultimate land-use plan, the Heber geothermal field is located in an area designated for urban and general agricultural use (EIR 1978). Although the project does not conform with this use, the establishment of the G-overlay zone and the granting of pending conditional-use permits for the project will make it consistent with all other applicable community plans and Imperial County planning goals (EIR 1978). Geothermal development appears consistent with the Conservation Element because the Heber geothermal field is not contained in any water or biological resource areas. There is also consistency with the Open Space Element because the project site is not contained in any open space designated for the preservation of natural resources or for outdoor recreation (EIR 1978). Geothermal development and resource production are particularly consistent with the Geothermal Element's designation for managed production for geothermal resources.

Mitigation of land consumption is being achieved by locating the power plant and the injection well near existing roads. Appropriate landscaping will help alleviate adverse visual impacts.

5.3 SURFACE WATER

5.3.1 Hydrology and water quality

Preparation and operation of the 50-MWe Heber demonstration project should have no significant impact on surface waters in the area. Sumps will be used to store waste products produced during development for later disposal. Berms [45.7 cm (18 in.)] around the site will be used to contain any leakage or spills associated with the project (EIR 1978). As a result of these containment measures and efforts to minimize erosion and runoff, surface water impacts associated with these activities should be minimal. SDG&E will prepare a Spill Control and Countermeasures Plan defining actions to be taken in the event of an accidental spill.

The plant will require a cooling water flow of 8830 l/s (140,000 gpm). Replacement (makeup) of evaporation, drift, and blowdown losses from cooling towers will require about 202 to 220 l/s or 3200 to 3500 gpm (6.7×10^6 m^3/year). For the first five years of operation or until another environmentally and economically feasible source of cooling water becomes available, makeup flow will be comprised of Imperial Irrigation District (IID) irrigation water [approximately 1000 ppm total dissolved solids (TDS)] from the Central Main canal (EIR 1978). This makeup water will be delivered to settling ponds at a maximum rate of 220 l/s (3500 gpm) (SDG&E letter April 29, 1980) prior to use within the plant. Makeup water requirements are not expected to exceed $7.4 \times 10^6 m^3$ (6000 acre-feet) annually for the life of the plant (EIR 1978). In order to meet the CRWQCB discharge requirements, as applied to Southern California Edison's 10-MWe demonstration plant (Swajian 1979) (Table 5.1), blowdown discharge will be a maximum of 52.6 l/s (835 gpm or 1.9 cfs) at 4000 ppm TDS. This discharge will have an elevated water temperature of 43.3°C (110°F) during the summer and 23°C (73°F) during the winter. This figure is based on makeup and evaporative flows of 202 and 160 l/s (3200 and 2540 gpm) respectively, and an irrigation water salinity of 1000 ppm.

Blowdown discharge will be to the Beech drain, an agricultural drain adjacent to the site, and ultimately to the New River (Fig. 7.1). Assuming compliance with CRWQCB requirements, blowdown (4000 ppm) will have a lower salinity than the agricultural drainage water (5000 ppm) flow into the New River. Additional impacts of blowdown discharge on surface water quality will result from addition to the cooling water of the following:

(1) sulfuric acid for pH control,
(2) chlorine for antifouling,
(3) inhibitor for corrosion control, and
(4) coagulant for desilting

The impact of these other discharge-associated heavy metals or chemicals on New River waters will be minimized by required adherence to discharge limits set by the CRWQCB (Table 5.1). Meeting these discharge requirements should ensure that no adverse water quality impacts on the New River or the Salton Sea result from chemical input blowdown characteristics (Swajian 1979) and their potential environmental effects. The CRWQCB limits temperature increases to a maximum of 3°C (5°F) 9 m (30 ft.) downstream from the discharge outfall. As indicated in the EIR 1979,

Table 5.1. Regional Water Quality Control Board (RWQCB) discharge requirements for cooling tower blowdown to the New River as applied to Southern California Edison Company's 10 MWe demonstration facility north of Brawley

Parameter	30-Day mean	Maximum
Total dissolved solids (TDS), ppm	4000	4500
Suspended solids, ppm	20	40
Setteable matter, ppm	0.3	1.0
Zinc, ppm		0.30
Chromium (total), ppm		0.08
Chlorine, ppm	0.2	0.50
pH	Effluent pH to remain within limits of 6.0 to 9.0	
Temperatures	Temperature of waters in the New River shall not increase by more than 5°F at a point not greater than 30 ft from the agricultural-drainage outfall	
Heavy metals	Wastewater discharge to the Beech drain shall not cause presence of heavy metals or chemicals at concentrations toxic to fish or other aquatic life	

Source: Swajian, 1979.

and verified by the ORNL staff (Lee 1980), the proposed discharge design will exceed this temperature limit in the Beech Drain. Because flow in the Beech Drain is intermittent, the CRWQCB temperature increase limitation will probably be applied to the New River instead of the drain (Table 5.1) (Swajian 1979). Discharge to the Beech Drain will flow into the New River 2.4 km (1.5 miles) to the west of the Heber site at a rate of 0.052 m^2/s (1.9 cfs) and a maximum summer temperature of 43.3°C (110°F) and winter temperature of 23°C (73°F). The average summer and winter temperatures and flow rates for the New River and Beech Drain are shown in Table 5.2. Under these conditions (Table 5.2) the change in temperature 9 m (30 ft.) downstream from the Beech Drain discharge into the New River would be 2.74°C (4.94°F) during the summer and 1.6°C (2.8°F) during the winter. Provided these limits are met, discharge to the New River will be within limits set by the CRWQCB.

Discharge of cooling water blowdown or geothermal fluids into the irrigation supply system could have an adverse effect on the water resource uses of the area. The probability of this occurring is very limited since blowdown will flow by gravity from the plant through a steel pipe attached to the Dogwood Road bridge (over the Central Main canal) into the Beech Drain. In the remotely possible event of a rupture in the pipeline, the maximum flow of the blowdown [0.06 m^3/s (1.9 cfs)] is so small compared to the flow in the Central Main canal [28.3 m^3/s (1000 cfs)] that its impacts would be minimal. Routine inspection will insure rapid maintenance and restoration of integrity of the above-ground pipeline (EIR 1978).

Following five years of operation using irrigation water as a cooling water source, the Heber plant will change to agricultural return flow or New River water as the cooling water source (SDG&E letter May 12, 1980). Effluent discharge following this change in cooling water source will be to evaporation basins (Sects. 7.3.2.4 and 5.3.2) or injection into the geothermal reservoir. With cessation of discharge to the New River, water quality parameters and water temperature in the river should, barring other interim developments and discharges to the river, approach predischarge levels. In other words, after five years of operation when SDG&E can no longer use irrigation water for cooling

Table 5.2. Temperature and flow characteristics for the New River and Beech drain[a]

	Summer		Winter	
	Temperature [°C(°F)]	Flow [m^3/s(cfs)]	Temperature [°C(°F)]	Flow [m^3/s(cfs)]
New River	28 (83)	3.8 (135)	15 (59)	3.3 (115)
Beech drain	29 (110)	0.044 (1.6)	14 (54)	0.044 (1.6)

[a]Sources: SDG&E letter, May 12, 1980 and EIR 1978, Fig. 3-19. (Verification Memo August 21, 1980).

and no longer discharges to the New River, water quality and temperature will no longer be influenced by input from the binary facility and should return toward predischarge conditions.

5.3.2 Water use

For the first five years of operation the 50 MWe plant will utilize IID irrigation water for (1) the power plant, (2) the cooling water system, (3) the fire system, and (4) the sanitary system. Potable water at the plant will be supplied by bottled drinking water. Irrigation water will be pumped from the Central Main Canal into a large holding or "settling" pond (Sect. 7.3.2.4 and Fig. 3.10) to ensure sufficient water on hand for operation.

The IID irrigation water allocation for the 50 MWe plant will not reduce the amount of water available for priority agricultural uses (Twogood 1977; SDG&E letter May 5, 1980). The annual 7.4×10^6 m^3 (6000 acre-ft) allocation for the demonstration plant accounts for only 0.2% of the water use for the Imperial Valley and 0.7% of the flow diverted through the project region via the Central Main Canal. The average flow of the New River at the overlay zone is about 4.3 m^3/s (150 cfs) for an average annual flow of about 134×10^6 m^3 (111,500 acre-ft); low flows are about 2.8 m^3/s (100 cfs). Thus, cooling water makeup requirement represents about 5% of the average flow of the New River and 7% of the low flow. SDG&E and Chevron are evaluating the feasibility of applying conservation measures at the project site (EIR 1978). Eighty percent (5×10^6 m^3 or 4100 acre-ft) of the water used will be evaporated with the remaining 20% (approximately 1×10^6 m^3 or 1000 acre-ft) emitted as blowdown (EIR 1978).

After five years of operation, as per the agreement between SDG&E and IID, the 50-MWe Heber plant will convert to use of either New River water or agricultural drain water as a cooling water source (Sect. 3.7.2.4). Both sources have higher total dissolved solids (TDS) contents (4000-5000 ppm) than irrigation supply water (1000 ppm). If New River water is used as the replacement cooling water source, the water will probably be supplied by the treatment plant at the Clark Road Crossing and will be part of the 6.2 x 10^7 m^3 (50,000 acre-ft) annual permit allocation for the full-field development (Sect. 7.3.4).

If agricultural drainage water is used for cooling water makeup, this water will probably be withdrawn from Central Drain Number 3, probably at the inflow from the Date Drain (Kelly-Cochrane 1980). Flow in the drain at this point was estimated by SDG&E to be 1.9 m^3/s (68 cfs). Flow in the drain in the vicinity of makeup withdrawal averages 1.3 m^3/s (46 cfs) and ranges from 0.4 to 2.9 m^3/s (13 to 101 cfs). SDG&E anticipates a makeup withdrawal of 0.3 m^3/s (9 cfs), which includes a 20% contingency. At low flow this withdrawal would virtually eliminate flow in the drain while removing approximately 10% during average flow periods. Given the above information, the upstream location of the drains, and a TDS of approximately 5000 ppm, the withdrawal should have no appreciable effect on water quality or hydrology. Likewise, the final blowdown should have no effect on surface water quality because discharge will be piped to an evaporation basin for ultimate disposal in Class I approved sites or injected at the periphery of the production reservoir (Sect. 3.7.2.4), with no liquid release to surface waters.

The maximum rate of blowdown discharge to the evaporation basin will be the same after 5 years as it was to the New River [52.6 l/s (835 gpm)], to maintain a cooling tower drift loss rate of not greater than 0.008%. If the cooling tower design is for 0.008% drift, an evaporation basin covering 48 ha (120 acres) will be required to contain and provide sufficient evaporative surface for the plant cooling water discharge (Sect. 3.7.2.4, Table 3.4). For a drift rate of 0.1% and 0.002%, the areas needed for evaporation ponds would be 42 ha (105 acres) and 50 ha (125 acres) respectively. The cooling basin will be located in the undeveloped desert approximately 14 km (9 miles) west of Heber.

Blowdown will be transported to the evaporation basin via a 9 cm (3.5 in.) pressurized, underground pipeline. The basin will be lined with either an impermeable synthetic liner or an asphalt concrete liner (Sect. 3.7.2.4) which should insure containment within the pond and prevent contamination of surface water. The basin will be sized to contain all TDS produced during the life of the plant.

The second option for disposal of blowdown after 5 years is treatment of the blowdown (e.g. at the Clark Road water treatment facility) for reinjection into the periphery of the Heber geothermal reservoir. With use of berms around the reinjection islands, there should be no adverse impact on surface waters or water use.

5.3.3 Other considerations

Other impacts associated with the 50 MWe demonstration project include minor depletion of available irrigation water due to cooling water evaporation and thermal enrichment of the Beech drain, which may trigger accelerated growth of aquatic weeds. Unless these weeds are controlled by Tilapia spp., they could spread into the New River. It is unknown if or how much a 1.6°C or 2.7°C (2.8°F or 4.9°F) winter or summer temperature increase would accelerate aquatic weed growth in the New River.

The increased water use from additional leaching of agricultural soils necessitated by salt drift (Sect. 5.2.2) will be insignificant.

5.4 IMPACTS ON ECOLOGICAL SYSTEMS

5.4.1 Terrestrial ecology

Construction of the Heber binary demonstration plant within the Heber Overlay will have minimal effects on native terrestrial biota. Placement of well pads and construction of the power plant and related facilities will disturb about 9.3 ha (23 acres) of land, all of which is presently under cultivation. Existing access roads will be used and all pipelines will be placed within the present rights-of-way for roads and irrigation facilities. The power plant will tie into an existing transmission line. While IID irrigation water is being used for cooling makeup, blowdown will be of a salinity low enough that it may be disposed of in an adjacent agricultural drain. For at least the first five years, while IID water is available for cooling, project activities will not disturb any natural vegetation.

Animals that are associated with the croplands surrounding the project site are accustomed to human presence; noise and increased activity related to project construction and operation should not adversely affect them. The nearest wildlife habitat is along the New River, about

2.5 km southwest of the plant site. Project activities associated with the binary demonstration plant should not disturb wildlife utilizing this habitat.

After the first five years of operation, or when IID water is no longer available, higher salinity agricultural return flow or New River water will probably be used for cooling makeup. In this case, blowdown will be disposed of by either injection into the geothermal reservoir or retention in an evaporative basin which will be located in the undeveloped desert, approximately 14 km (9 miles) west of the project area. The exact location for the pond has not been determined and there has been no specific biological survey of the vicinity in which the pond may be located. Construction of the pond will disturb about 50 ha (125 acres) of native Colorado desert vegetation.

The blowdown, as accumulated in the lined evaporation pond, will become extremely saline, with an estimated saturation of about 250,000 ppm total dissolved salts. The ponds will be fenced and vegetation will be removed from the sides of the pond in an effort to discourage wildlife use of the ponds. The pond would probably not adversely affect waterfowl that might occasionally use it. Large saline bodies of water are not uncommon in the desert southwest. Important waterfowl habitat exists on the periphery of the Salton Sea which is about 35,000 ppm salinity. Furthermore, large commercial salt evaporation ponds already exist around the perimeter of the Salton Sea. Available data from the literature concerning adverse effects of salinity on waterfowl relate to the toxicity of saline drinking water (EPA, 1977). In the project vicinity, there are sources of relatively fresh drinking water in the freshwater marshes around the Salton Sea, in the agricultural drains and along the New and Alamo Rivers. Considering that there are sources of drinking water available to birds, it is unlikely that the evaporation pond for blowdown disposal would adversely affect them.

After the first five years, either agricultural return flow or treated New River water will be the most likely sources of water makeup. In either case, flow in the New River would be reduced by the amount of makeup water required, about 7.4×10^6 m^3/yr (6000 acre-feet/yr). The average annual flow of the New River at the Overlay Zone is about

137.5×10^6 m^3 (111,500 acre-feet); low flows are about 170 m^3/minute (100 cfs), or two-thirds of mean flows. The cooling water makeup requirement will represent about a 7% reduction in the low flow of the New River and a 5% reduction in the average flow. These minor flow reductions should not significantly affect the riparian habitat downstream of the Overlay Zone.

Atmospheric emissions from construction, well drilling and well testing will be inconsequential (Sect. 5.5). During project operation, the only atmospheric emission of environmental concern is salt drift from the mechanical draft cooling towers. Appendix D includes a discussion of estimated salt deposition from operation of the cooling towers for two sets of meteorological data and six combinations of alternative drift loss rates and salinities. The major portion of salt drift will be deposited on agricultural lands surrounding the project site. Potential effects of this salt on the croplands are discussed in sect. 5.2.2 and Appendix E. The closest natural vegetation to the proposed Heber site is along the New River between 1.6 and 2.4 km (1 and 1.5 miles) southwest. Salt deposition on the riparian habitats from 0.008% drift loss from the cooling towers is estimated to be about 0.2 g/m^2 (2 lbs/acre) annually for the first five years of operation with 4000 ppm circulation water. Thereafter, annual deposition is estimated to be about 2 g/m^2 (20 lbs/acre) when the towers are operated with 20,000 ppm circulation water.

Even at the comparatively low deposition rates to which the natural vegetation communities will be exposed, salt accumulation in the soils over the operating life of the Heber plant is of concern because these communities do not receive the benefit of regular leaching practiced on the croplands. Appendix G contains an analysis of potential increases in soil salinity and the effects in the natural communities for three alternative drift loss rates. Over the thirty year operating life of the Heber plant, a drift loss rate of 0.008% could cause an estimated increase in soil salinity of about 1.5 mmhos/cm (see Appendix G).

The soils in the riparian communities are naturally saline to varying degrees (see Appendix G). Table G.1 in Appendix G presents salinity tolerance ranges for many of the commonly occurring vegetation species in the riparian habitats. The most saline soils support a highly salt tolerant vegetation community of iodinebush, salt grasses and sea blight (see Section 4.4). Other less saline soils support a moderately salt tolerant cover of salt cedar, saltbushes, and arrowweed. Scattered individuals of creosote bush, which has a very low salt tolerance (Marks 1955, Basek and Barbour 1977), probably occur in isolated pockets of lower soil salinity. The predicted increase in soil salinity of 1.5 mmhos/cm from 0.008% drift should not cause the soil salinity to exceed the tolerance range for most of the highly to moderately tolerant vegetation species. However, creosote bush is probably existing at the upper end of its salinity tolerance range and it could be eliminated from the habitats closest to the towers. This would be expected to affect less than 50 ha of riparian habitat (see Appendix G). Considering that creosote bush is not presently a major component of the riparian communities and that it would be eliminated from probably less than 50 ha, this shoud not constitute a significant adverse affect.

Damage to natural vegetation from deposition of airborne salt on the foliage should not occur. Foliar injury from ambient salt is related to uptake of salt deposited on the leaves. The leaf morphology and structure of many desert plants which have evolved to reduce water loss from the foliage should also reduce salt uptake. Desert species would be expected to be less sensitive to airborne salt than most crop species. At the natural vegetation communities, predicted annual average ambient salt concentrations from 0.008% drift loss are approximately 0.5 ug/m^3 when the towers are operating with 4000 ppm circulation water and about 2.5 ug/m^3 when they are operating with 20,000 ppm circulation water (see Appendix D). Maximum short-term concentrations (up to a few days duration) might be an order of magnitude greater than the annual average, resulting in maximum short-term concentrations of 5 ug/m^3 with 4000 ppm circulating water and about 25 ug/m^3 with 20,000 ppm circulating water.

Data relating ambient salt concentrations to foliar injury and plant damage are very limited for agricultural species and nonexistent for native desert vegetation. Bush beans, a crop species which is known to be extremely sensitive to airborne salt, exhibited foliar injury after short-term exposures (up to five days duration) between 75 and 165 ug/m^3 of ambient salt (Moser 1975, Hindawi et al 1976). The predicted maximum ambient salt concentration at the natural communities of 25 ug/m^3 is at least one-third of the concentration known to affect the salt sensitive bush beans. Considering this, and also that the natural vegetation is in all likelihood less salt sensitive than the bush beans, foliar damage to natural vegetation should not occur at 0.008% drift. Even at the high drift loss rate of 0.1%, resulting in predicted maximum ambient short-term concentrations of about 125 ug/m^3, damage to natural vegetation would probably not occur.

5.4.2 Aquatic ecology

Blowdown from the 50-MWe demonstration plant for the first five years will contain 4000 ppm dissolved solids, as required by the California Regional Water Quality Control Board (CRWQCB), and will be about 43°C (110°F) during the summer and 23°C (73°F) during the winter (Sect. 5.3.1). The discharge will be chemically similar to agricultural drain water with the exception of increased levels of anticorrosion additives. The chemical quality and increased temperature of the discharge will provide conditions suitable for rapid growth of algae and aquatic weeds (McKee and Wolf, 1963). With a constant water source provided by the blowdown discharge, Tilapia spp., introduced into waters of the Imperial Valley for aquatic weed control, may survive and reproduce in the Beech Drain. Feeding by these species could reduce the impact of the increased vegetation growth in the drain. Elevated temperature from the drain discharge will increase the temperature of the New River near the discharge site 2.7°C (4.94°F) in the summer and 1.6°C (2.8°F) during the winter. This may encourage algal and aquatic weeds growth in the discharge vicinity. However, if tolerant of water quality in the river, Tilapia may live in or at least feed in the river in the discharge vicinity and provide some control of aquatic weeds.

Blowdown from the plant should have no significant impact on aquatic fauna in the discharge area because of temperature increase compliance, similarity of chemical composition with agricultural drainage, and the sparse pollution-tolerant fauna in the New River (Setmire 1979). Intermittent flow, blowdown discharge temperature (33° to 43°C), and algal blooms possibly resulting from these conditions will restrict faunal colonization of the Beech Drain. Compliance with effluent quality limitations established by the CRWQCB will minimize water-quality effects on downstream biota. Assuming compliance with RWQCB effluent limitations (see Sect. 5.2), the 50-MWe project should have no significant impact on the biota of the Salton Sea.

After five years of operation, cooling water makeup will come from either the New River as part of the 6.2×10^7 m^3 annual withdrawal or from agricultural return flow in the Central Drain (see Sect. 5.3.1). Given the upstream location of the drain and the range of flow within the drain, it is assumed that there would be a limited aquatic community in the Central Drain. If, however, fish do exist in the drain at that time, the withdrawal of 0.3 m^3/s (9 cfs) could affect the fish population during low flow periods (0.4 m^3/s).

5.4.3 Rare and endangered species

Construction of the major facilities for the binary demonstration plant will affect only agricultural land within the Heber G-Overlay Zone, and thus has no potential for effects on rare or endangered species. There are no habitats for the Federally designated endangered yuma clapper rail nor for the state designated rare California black rail which are sufficiently close to the project site to be affected by salt deposition from operation of the cooling towers (see Section 5.4.1). There will be no impacts to the desert pupfish from construction or operation of the binary power plant because chemical composition of the blowdown to agricultural drainage and temperature increases to the New River will comply with CRWQCB regulations (sect. 4.4.3.2).

If the alternative of an evaporation pond is chosen for disposal of cooling-tower blowdown, about 50 ha (125 acres) of native desert habitat will be displaced. The exact location for the proposed basin has not been determined at present; it will probably be located in an area about 14.5 km (9 miles) west of the Overlay Zone. The vicinity proposed for the pond will probably not include habitats for the rare and endangered plants discussed in Section 4.3. Also, it will not include any habitat for the yuma clapper rail, nor the California black rail. However as discussed in Section 4.4.3, there is a very good possibility that the proposed vicinity for the evaporation pond could contain habitat for the candidate species the flat-tailed horned lizard. In the event that the evaporation pond is the chosen disposal method, any proposed location for the pond will be surveyed by a biologist who is familiar with the species. The survey will be coordinated with the U.S. Fish and Wildlife Service area office. The pond will be located only in an area which does not contain habitat for the lizard, ensuring that construction of the pond would not adversely affect the species.

5.5 AIR RESOURCES

The potential air pollution impacts associated with the proposed project are generated at the wells and the power plant itself. Additionally, some relatively minor temporary impacts could occur during facility construction and the well testing phase of the project. The pollutants of importance from geothermal plant operations are hydrogen sulfide (H_2S) and total suspended particulates (TSP).

5.5.1 Geothermal well emissions

Emissions from the geothermal wells occur as a result of site preparation, well drilling, resource testing, and venting during well production (EIR 1978). For a 50-MWe binary power plant the total emissions associated with site preparation and well drilling would be 3.2 kg (7 lb) of TSP, 6.8 kg (15 lb) of SO_x, 275 kg (607 lb) of CO, 11.3 kg (25 lb) of hydrocarbons and 52.2 kg (115 lb) of NO_x. Testing and drilling of the resource would yield less than 0.5 kg (1 lb) of H_2S. All of these emissions would have negligible impact on air quality.

5.5.2 Power plant emissions

For the binary-cycle power plant, the geothermal fluid will be completely contained during normal operation, and there will be essentially no H_2S emissions to the atmosphere. Particulate emissions from geothermal power plants consist of solids contained in the cooling tower drift (water droplets discharged from the tower). The solids emission rate is a function of the tower drift rate and the salt content of the cooling flow. An additional consideration is the concentration factor of total dissolved solids (TDS) in the cooling tower water. As water evaporates from the tower, the remaining cooling tower water increases in TDS content. The value of the concentration factor depends on the makeup and blowdown rates and can range from 2 to about 18.

For the first five years of operation, it is assumed that the TDS content of the drift will be equal to the blowdown solids content of 4000 ppm which is the state limit for disposal into agricultural drains. Assuming a drift rate of 0.008% and a circulating water rate of 8.8×10^3 l/s (140,000 gal/min), the salt emission in the drift will be approximately 90.7 metric tons/year (100 tons/year). After five years of operation, agricultural return water will be used for cooling and then ponded or injected with the geothermal brine. Assuming a maximum TDS content of 20,000 ppm in the drift, the annual salt emission will be approximately 453.6 metric tons/year (500 tons/year).

5.5.3 Ambient air quality impacts

The impacts of the cooling tower operation were determined by using a computerized model, ORFAD, which produces estimates of fog and drift deposition that results from operating wet cooling towers. The results indicate that the use of drift eliminators (0.008% drift loss or less) during the first five years of plant operation when the TDS levels in the cooling water will not exceed 4000 ppm, will produce no significant air quality impact. After the first five years of operation, when the TDS levels will increase to 20,000 ppm, implementation of mitigation measures may be in order to meet the PSD (prevention of significant deterioration) Class II increment requirements in effect at that time.

5.5.3.1 Approach

The hot, dry conditions prevalent in a desert environment would seem to be ideal from the standpoint of minimizing the impacts of drift emissions from evaporative cooling towers. During the frequent occasions of extremely low relative humidity (sometimes less than 10%) and high temperatures of the daytime a substantial amount of evaporation will occur from the drift droplets. As evaporation occurs, they decrease in size and in fall velocity and can be carried and dispersed to large distances from the cooling tower. However, the larger droplets emitted from the tower will not evaporate sufficiently fast to be carried away and will fall close to the tower. Thus a tower emitting a significant portion of large droplets can have a large amount of drift deposition occurring in close proximity to it. Furthermore, the frequent occurrence of unstable conditions in the daytime desert atmosphere can act to bring an elevated cooling tower plume rapidly to the surface and enhance deposition. The nighttime desert atmosphere is more stable than the daytime, but also has much lower temperatures and higher relative humidities with correspondingly less evaporation.

It appears that despite the generally high rate of evaporation in the desert, an evaporative cooling tower may still produce sizable amounts of drift deposition, especially if many large droplets are emitted. This could be potentially hazardous to local salt-sensitive plants and crops depending on the amount of dissolved salts in the drift water.

ORFAD - Atmospheric dispersion models are a necessary tool used to predict the impacts of emissions at a given location by estimating the transport and dispersion of that emission in the local meteorological conditions. In general, in the absence of experimental site data, cooling tower models can be considered to be best estimates of what will actually happen in the physical world.

To assess the impacts of the cooling tower operation, a cooling tower model named ORFAD (Oak Ridge Fog and Drift) was utilized. ORFAD produces estimates of fog and drift deposition resulting from the operation of wet cooling towers using hourly surface weather data. The distribution of water vapor is assumed to be Gaussian, whereas water droplets or particles are assumed to fall in distinct trajectories determined by size and ambient conditions (LaVerne, 1977). A specified distribution of fractional mass with respect to particle diameter is used to assign droplets to classes. Each class has a nominal diameter and represents a certain fraction of the total drift discharged from the tower. Separate calculations are made for each class, and the results are summed to yield the total drift. The atmospheric salt concentration at ground level is determined by dividing the terminal fall velocity into the drift salt deposition. The plume rise calculation is derived from Brigg's formulation (USAEC 1969). Additional buoyancy and the resulting larger plume rise occurring from the close proximity of several towers or tower cells is also estimated from a relationship given by Briggs (ATDL 1974).

ORFAD treats every individual cooling tower as a point source of drift and vapor emissions. This indicates that it will produce conservative (high-side) estimates of maximum drift deposition from a mechanical draft cooling tower which is, in fact, a bank of several cooling cells rather than a point source. ORFAD will account for the additional plume rise caused by multiple cells, but will treat the emission as if it is occurring from one point at the center of the tower. The primary effect of this is to underestimate horizontal dispersion and overestimate drift deposition in the near-field. Farther away from the source the mechanical draft tower has much the same impact as a point source of emission and the effect of the point source assumption is diminished. An alternative way of calculating near-field impacts would be to model each cell in the cooling bank separately as a point source located at that cell's midpoint and calculate the cumulative impact of all cells. This, however, will overestimate dispersion of the plume as it will not account for the fact that the individual cell plumes are entraining drift-containing air from each other and not being diluted by ambient air. The point source representation of the cooling tower results in a conservative estimate of impacts.

The cooling tower design data for the Heber geothermal plant are given in Sect. 3.7.2.4. Although these parameters do not represent the actual cooling tower specifications because an actual cooling tower and drift elimination type have not been selected, they were provided by San Diego Gas and Electric as a typical representation (SDG&E letter, April 3, 1980). The drift droplet size spectrum is appropriate for a Marley Corporation mechanical draft cooling tower with standard (0.008%) drift eliminators. The ORFAD model was run utilizing two sets of meteorological data: two years of surface meteorological data from Blythe, California, on a NOAA weather tape and 12 months of the 22 months of meteorological data collected at the Heber site by SDG&E.* The results using Heber data should be more appropriate, since these data should reflect most closely the local wind, temperature, and humidity conditions. However, the Heber site data was less complete than the Blythe data, with only 79% data recoverability compared to 99% at Blythe. Blythe is located approximately 80 miles northeast of Heber in a similar desert environment. This data was used initially because it was the only immediately available source of hourly meteorological data.

The estimation of drift deposition and ambient concentration of salt particles was performed for six cases. It was assumed that for the first five years of operation that the TDS content of the drift is equal to the blowdown solids content of 4000 ppm. After five years, the TDS content of the drift was assumed to increase to 20,000 ppm. For each of these two cases three different drift rates were assumed: 0.002%, 0.008%, and 0.1% of the cirulating water rate. These three rates can be considered to represent a state-of-the-art drift eliminator, a standard drift eliminator, and no drift eliminator, respectively. Results of these model runs are discussed below.

Each case was run twice to yield both a near-field view and an expanded view of the impacts. The purpose of the near-field [to 2.4 km (1.5 mi.)] study was to detail the region where impacts are maximum. ORFAD allows specification of up to 19 deposition distances which lie equidistant between deposition boundaries. The deposition value given by the model at each of the 19 distances is an average value of the deposition for the entire interval between boundaries. Therefore, to better analyze regions where deposition values were changing rapidly, the intervals between deposition boundaries were kept small. Beyond 2.4 km. where the deposition decreased less rapidly, larger intervals were considered adequate.

5.5.3.2 Salt particulates

As stated earlier, the ORFAD model computes the concentration in the atmosphere of particulate salt by dividing the terminal fall velocity

*The full 22 months were not used because the results would have been biased by the months that were duplicated in calculating annual averages.

at any location into the drift salt deposition. In the computation, the droplets containing salt may have fallen out of the plume without evaporation, evaporated to a saturated solution, or evaporated completely to leave a dry salt particle. In any case, it is only the salt portion of the final drift that will be accounted for in the salt particulate concentration estimated by ORFAD. In the dry desert environment a large number of droplets evaporate to dry particles.

The salt particulate concentrations calculated using the Blythe weather data are presented in Appendix D (Fig. D.1, Fig. D.2, and Table D.1 for the near-field view and Fig. D.3, Fig. D.4, and Table D.2) for the expanded view. The same results using the Heber site data are also contained in Appendix D (Fig. D.5, Fig. D.6, and Table D.3 for the near field view and Fig. D.7, Fig. D.8, and Table D.4 for the expanded view). These results indicate that the maximum salt concentration occurs to the east and east-southeast of the tower within about 0.5 miles (0.3 km). The maximum salt concentrations are summarized in Table 5.3 and compared to the applicable standards and increments. The 0.008%, 4000 ppm case should not jeopardize standards or increments as the maximum concentration is 9 μg/m. However, the 20,000 ppm case is predicted to result in a maximum annual TSP concentration of 40 $\mu g/m^3$ which is well above the Class II PSD increment of 19 $\mu g/m^3$.

It is unlikely that the use of almost 50% of the PSD increment in the first 5 years will constrain any other new sources wishing to locate in the area. Increment consumption by the cooling tower will be extremely localized. The potential exceedance of the TSP increment after five years may have to be mitigated through the use of cooling water pre-treatment or a more efficient drift elimination system. It is possible, however, that a regulatory problem may not exist after five years. EPA is presently working towards eventual proposal of an inhalable particulate standard which would regulate only those particles smaller than 15 μm. This would eliminate many of the drift salt particles from consideration.

Table 5.3. Maximum predicted salt particulate concentrations from the Heber geothermal cooling tower

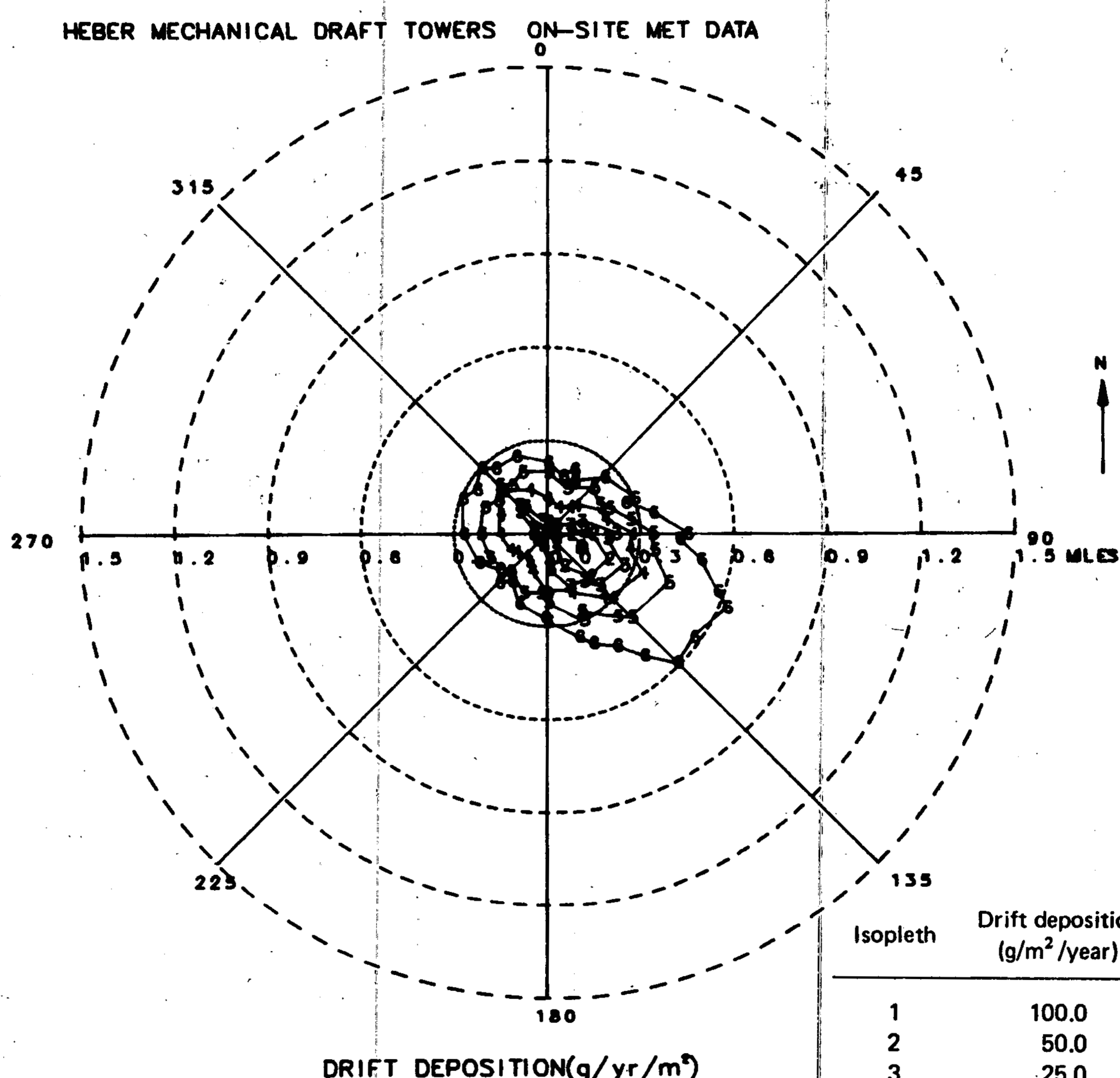
Period of operations (year)	Cooling water TDS content (ppm)	Drift rate (%)	Annual salt particulate concentration (μg/m³)	Ambient particulate standard (μg/m³)		Class II PSD increment (μg/m³)
				California	Federal	
First 5	4,000	0.002	2.2	100	260	19
		0.008	9.0			
		0.100	112.0			
After 5	20,000	0.002	10.0	100	260	19
		0.008	40.0			
		0.100	500.0			

5.5.3.3 Drift deposition

The deposition of salt from cooling tower drift water occurs when the emitted droplets break away from the bouyant and mechanically turbulent forces keeping them aloft in the plume. The droplets fall to earth at distances that are determined by droplet size, relative humidity, and other ambient conditions. The results of the ORFAD salt drift deposition calculations for both the Blythe and Heber site weather data are contained in Appendix. D. The near-field drift deposition patterns for the 0.008% drift rate case using the Heber site data are shown in Figure 5.1 for the first five years of operation (4000 ppm of TDS) and in Figure 5.2 for the period after five years (20,000 ppm of TDS). The major direction of the impacts is to the east and east-southeast. It is also apparent that the major portion of the drift salt deposition occurs extremely close to the cooling tower. The maximum deposition is approximately 100 g/m^2/year for the first five years of operation and 700 g/m^2/year thereafter.

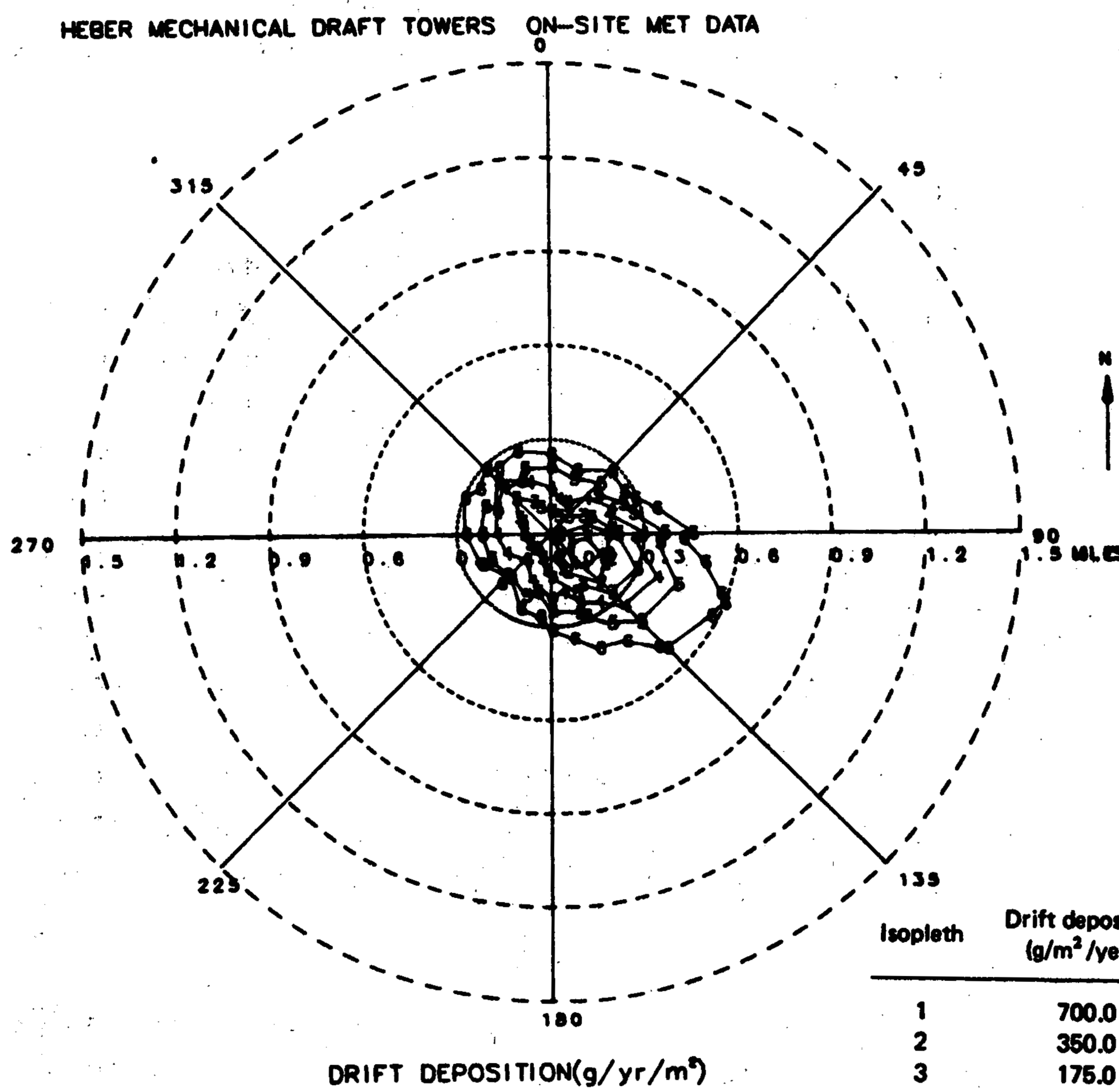
Not only is the heaviest deposition within a few hundred meters of the tower, it is more likely to be in the form of droplets which haven't evaporated or droplets evaporated to a saturated solution rather than dry particles. This is because the deposition this close to the tower will be predominantly from the larger droplets which have not had sufficient time to evaporate to dryness. Beyond a few hundred meters of the tower both dry particles and droplets which have evaporated to a saturated solution are deposited.

A notable result of the drift calculations is the percent of salt emitted from the tower that is carried far away from the tower before depositing. With cooling water containing 4000 ppm of TDS, 21.7% of the total salt emitted is deposited within 2.5 km (1.5 miles) of the tower while 36.7% deposits within 8 km (5 miles). For cooling water containing 20,000 ppm of TDS these results change to 30.7% and 47.5% respectively. Thus, for both cases more than 50% of the emitted salts are still suspended in the atmosphere beyond 8 km (5 miles) of the tower. This result is a combination of the large weight percent of the assumed droplet spectrum in the smallest weight classes and the extremely low relative humidity



Isopleth	Drift deposition (g/m^2/year)
1	100.0
2	50.0
3	25.0
4	12.5
5	6.2
6	3.1

Fig. 5.1. Near-field drift deposition for the 4000 ppm case (Heber site weather data).



Isopleth	Drift deposition (g/m^2/year)
1	700.0
2	350.0
3	175.0
4	87.5
5	43.8
6	21.9

Fig. 5.2. Near-field drift deposition for the 20,000 ppm case (Heber site weather data).

of the area causing droplets to evaporate and reduce in terminal velocity. More deposition close-in, on a percent basis, occurs for the 20,000 ppm case due to the increased density of droplets and the larger sizes of droplets evaporated to dry particles.

5.5.3.4 Significance of results

Drift salt deposition and salt particulate concentrations resulting from cooling tower operation would be extremely high if the drift emissions are not controlled through the use of drift eliminators. Use of standard drift eliminators (0.008% of better) during the first five years of plant operation when the TDS levels in the cooling water will not exceed 4000 ppm, will produce no significant air quality impact as determined from calculations using the ORFAD model. However, after five years of operation when the cooling water contains 20,000 ppm of TDS the annual PDS Class II increment may be exceeded due to atmospheric salt concentrations close in to the tower. Use of a state-of-the-art drift elimination system (0.002% or better) after the first 5 years of operation would mitigate this impact. The ORFAD model tends to produce conservative estimates of drift impact and can thus be assumed to yield estimates that are on the safe side for the purposes of avoiding adverse environmental impact.

The analysis leads to several conclusions:

1. Drift deposition will be at a maximum within a few hundred meters of the cooling tower and drop off rapidly beyond that maximum.
2. A fairly large portion of salt emitted will be transported beyond 8 km (5 mile) from the tower due to the effect of the rapid evaporation of droplets in the dry desert atmosphere.
3. Drift deposition will be somewhat greater on a per unit mass emission basis for the 20,000 ppm TDS case than for the 4000 ppm case.
4. The PDS Class II increment for TSP could be exceeded after five years if 20,000 ppm TDS cooling water is used with standard drift eliminators.
5. There will be no measurable impact as long as the drift loss is controlled to 0.008% or better.

5.5.4 Other impacts

The major impact of water vapor discharge from the cooling tower would be aesthetic due to formation of water vapor plumes. Formation of a visible plume depends on the temperature and humidity of the cooling tower exhaust, and of the ambient air. The plume will be most visible during cool, humid periods such as occur during winter mornings. Local fogging induced by the cooling tower will be extremely rare. (ORFAD predicts less than 1 hour of additional fog per year at any point in the vicinity of the tower). Ground icing because of plume impingement on freezing surfaces is not anticipated to occur.

5.6 NOISE IMPACTS

Construction of the demonstration plant facility, well drilling, pipeline construction, plant operation, and injection island operations will produce noise levels ranging from around 70 dB(A) to 95 dB(A) at a distance of 15.2 m (50 ft.) from the source. Construction equipment used at the site will be the chief source of noise from the project, and some additional noise will occur along access routes used in transporting equipment and workers to the site.

A backhoe machine that digs trenches with one end and lays pipe with the other is proposed by the applicant. This procedure makes it possible to lay up to several km of pipe per day, provided no complications occur. Noise audible at houses within 152 km (500 ft.) could occur as a result of the pipeline installation, but its temporary nature reduces its impact to insignificance.

Heavy equipment used to excavate the evaporation basin would only be in use for a short time. Noise impacts, therefore, would not be significant.

Operational noise levels at the facility will be less than those associated with construction, and will be especially audible only at close ranges. Employees of the plant would be the primary receptors.

Other potential noise receptors in the vicinity of the site are very limited because of the predominance of cultivated agricultural land uses and the considerable distances to residences. Even where residents are close enough to hear drilling or construction activities, the expected noise emission would only be enough to cause a minor disturbance during outdoor activities. Noise control will be in compliance with restrictions specified in the Geothermal Element of Imperial County, namely, that noise levels be limited to 65 db(A) at the property lines of geothermal facilities.

5.7 SOCIOECONOMIC EFFECTS

5.7.1 Population

The estimated work force required for the project is 190 during construction and 30 for daily 24-hour power plant operations. There will be a temporary population increase during the well-drilling and construction phases. Consultation with the project developers and the local community authorities and experience on similar projects led to generation of the following assumptions (EIR 1978):

1. All well-drilling crews will be nonlocal,
2. Twenty-five percent of total labor on pipeline construction and 40% of total labor on power plant construction will be drawn from the local labor pool.

The large number of unemployed persons in Imperial County provides a ready source of labor to fill these positions.

From past experience, it is anticipated that the construction workers who are brought in from outside the area will not bring their families with them. Furthermore, the workers will probably live in temporary or rental housing and will normally return to their homes on weekends (EIR 1978).

The mix of local and nonlocal personnel for power plant operation is undetermined but because the total number of 30 persons is so small, there will be an insignificant population increase generated in any case. Mitigation measures are unnecessary because there are no sizeable population impacts.

5.7.2 Area economics

The wage and salary income from employment at jobs created by the project will be available for potential spending in the local economy. For those workers who are nonlocal, their expenditure patterns will vary because workers are expected to maintain residences outside of the local economic area.

Purchases of certain materials and services in the locality would be subject to retail sales taxes. Taxes would also be levied on the geothermal resource power plant, the land, the production and injection wells, and the pipeline system. A detailed description of taxing policies can be found in EIR 1979. There are costs incurred by various local government agencies in providing services to the residents of the area; however, the costs will not be great because of the small increase in permanent population.

The economic effects that are projected would be beneficial in that they would pump money into the local economy. Thus, no mitigation measures would be necessary. As discussed in sections 5.1.5 and 5.2.1, 9.3 ha (23 acres) of agricultural land will be displaced for the 30-year lifetime of the project. The annual value of the crop cultivated on this land, in 1979, was between $7,000 and $13,800. Alfalfa grown to be cubed for dehydrators at 6 tons per acre yields $100 per ton whereas that grown for baled hay at 4 tons per acre yields $76 per ton (Borton 1980.

5.7.3 Housing

The most significant housing impact of the proposed project will be the requirements for temporary housing in the local area for nonlocal construction and development personnel. The types of housing likely to be required in project area communities include rental units (in conventional structures, motels, and mobile home parks), and facilities for accommodating the workers' own mobile homes or recreational vehicles. Some temporary residents will prefer to share accommodations. Because of the housing shortage in Imperial County and the particularly low number of vacant rental units in El Centro (only 0.6% of all housing units in 1977), it will be difficult to obtain temporary housing in the area. This situation is highly dependent upon interest rates and the building industry, as there is much planned residential construction on hold in El Centro because of the current economic conditions. The small number of new permanent residents to the community would probably not have a problem finding housing in the area, especially if they seek other than rental quarters.

The potentially adverse impact of demand for temporary local housing beyond the means of the existing market may be mitigated by coordinating advance planning for housing needs and corresponding housing resource requirements with the project proponents, County, and local city planning officials.

5.7.4 Community services and facilities

The proposed demonstration project would benefit the local area by providing additional generating capacity. The purchase of this additional power by the IID would amount to approximately a 14% increase in the District's generating capacity. The small population increase is not expected to place a burden on water and sewer facilities. Water and sewage facilities for the project will be provided on site, with water supplied from the Dogwood irrigation canal and septic tanks to be used for disposal of onsite sewage. Bottled water will be supplied to the site for use as drinking water and will have no effect on the existing water systems.

Existing local health, fire, and police services are expected to be adequate for the proposed demonstration project, and additional staff or facilities should not be necessary. Likewise, educational facilities in the project area should not experience any adverse impacts. Only a few new families might move into the area, increasing school enrollment slightly. This increase will not be sufficient to justify new facilities.

Construction of pipeline to an evaporation basin may have an impact on services. Some buried cables, other pipelines, and similar community-purpose activities could be temporarily disturbed by the laying of the proposed pipeline across them. Such impacts on a very few services/ facilities would be insignificant because of the limited area involved and timing requirements for the installation of the pipe. It is expected that Imperial County would be compensated by the applicant for minor repairs that might be necessitated by trenching and pipelaying across such facilities.

5.7.5 Transportation systems

The most significant impacts to transportation posed by the demonstration project will be increased commuter traffic and heavy equipment, particularly during the construction phase. To mitigate the traffic impacts, carpooling of drilling and construction crews might be undertaken in order to decrease the number of commuting vehicles coming into the project area on workdays. Also, staggering drilling and construction crew work shifts could mitigate traffic problems during the early morning and late afternoon hours. Rail and air transportation into the project area will not be adversely affected.

If the evaporation basin and pipeline alternative are selected, 10 of 12 limited use public roads southwest of Heber could be disturbed by pavement cuts in trenching, depending on the exact route ultimately chosen for the pipeline. Boring a small tunnel under each of these roads would eliminate the need for pavement cuts, but such an alternative action might be prohibitively expensive compared to simply compensating Imperial County for the minor costs of repairing the cuts.

5.8 CULTURAL RESOURCES

The absence of documented archaeological resources or historic sites in the project area essentially precludes any impacts (sect. 4.8). However, the exact locations of the possible evaporation basin and pipeline are not known at this time, and their impact on cultural resources cannot be determined. A more specific determination of potential effects will be made if and when the exact locations are selected.

5.9 AESTHETICS

Due to the flat terrain of the project area and the physical nature of the proposed project, the impact on visual resources in the immediate project area will be considerable. The greatest impact will be perceived from the local perspective, with regional impacts derived largely from the effect on vistas across the section of the valley containing the project area. The development would not constitute a consumption or disruption of unique or irreplaceable visual resources.

Many visual impacts will be temporary, such as the intrusion of the vertical drilling rigs into an otherwise uninterrupted horizontal landscape. There are already some vertical intrusions in the environment, such as telephone and utility poles and occasional trees.

Well and production island design can be engineered to minimize the visual impacts by keeping as close to grade level as possible.

Cooling towers and evaporative steam plumes at the power plant would cause the most significant visual impact. When visible, these steam plumes may range from 15.2 to 30.5 m (500 to 100 ft.) in height from the tops of the 15.2 (50-ft) tall cooling towers. Other necessary facilities at the site would have comparatively low profiles.

Electrical power to be transmitted along the existing Imperial Irrigation District transmission corridor along Dogwood Road would generate no new impact.

All impacts are somewhat mitigated by the project's distance from major population centers. Besides mitigation measures already discussed, the visual impact of the above ground pipes will be lessened by painting them earth-tone colors so that they will blend in with the existing environment.

5.10 ACCIDENTS

The proposed project has the combined accident potential of a geothermal energy source and an electric power plant, increased by the presence of a highly flammable hydrocarbon mixture. Because an important objective of the proposed action is demonstration of the safety of the integrated system (Section 3.7.2.8), the design will incorporate both common and unique safety features as well as instrumentation for monitoring and recording the operational parameters necessary for maintaining industrial safety. In the event an occupational accident does occur, damage should be confined almost exclusively to the isolated occupational environment, with little danger to property or persons external to the project site.

5.10.1 Well blowout

Impacts of a well blowout will depend on the magnitude of the event. Because the Heber resource is of moderate temperature and located at a relatively shallow depth, severe blowouts are not likely. For all but the most severe blowout, impacts would be slight or negligible because most of the geothermal fluid will be contained at the production or injection islands by 0.45 m (18 in.) berm. The fluid can be disposed of after the accident is brought under control (sect. 3.7.2.2). Air and water quality could deteriorate temporarily as a result of accidental release of geothermal fluids. The dispersal of salt-laden drift from the spray associated with a well blowout could impact nearby farmlands as well as aquatic and terrestrial ecosystems, but the effect should be negligible for all but the most severe blowout. A severe blowout would involve uncontrolled flow of significant amounts of hot water into nearby areas with resultant thermal pollution, erosion, and possibly surface cratering. Surface cratering is highly unlikely because of the moderate pressures and temperatures of the Heber resource. The largest probable area that could be directly affected has been estimated to be 5 ha (12 acres) (U.S. DOE 1979).

5.10.2 Power plant accidents

The most likely power plant accidents involve upset conditions (Sect. 3.7.2.8) and the consequent vulnerability to an ensuing fire or explosion. Use of the highly flammable binary fluid increases the fire or explosion hazard. However, demonstration of safe operation and development of techniques for safe handling of the fluid is one of the primary aims of the project. Because the plant is located outdoors, the likelihood of a severe mishap is decreased. As with well blowout, the impact of an accident should be confined to the plant area with little serious effect in the external environment.

Close attention to plant personnel safety training will be important if accidents are to be averted. Procedures for proper handling of construction material such as the chemicals used in drilling (i.e., caustic soda) can avert the potential for occupational injury. Because the geothermal fluid will circulate in a closed loop without contacting the atmosphere, the major occupational hazard associated with more conventional geothermal energy production, H_2S emission and abatement, will be eliminated.

5.11 UNAVOIDABLE ADVERSE IMPACTS

Table 5.4 contains a summary of unavoidable adverse impacts and their significance. The assessed Federal action will result in no significant environmental impacts as long as mitigation and control measures (outlined in Table 5.8 and discussed in Sect. 6) are implemented. SDG&E will implement all necessary mitigation and control measures.

Table 5.4. Unavoidable adverse impacts

Issue	Impacts	Significant — yes/no	Sections
Land use	9.3 ha (23 acres) will be consumed	No	5.2, 6.2
Noise	Minor increase in ambient level	No	5.6, 6.6
Population	Negligible increase	No	5.7.1, 6.7
Housing	Negligible increase in demand	No	5.7.3
Transportation	Very minor increases	No	5.7.5
Cultural resources	None	No	5.8
Aesthetics (construction)	Minor visual impact	No	5.9
Aesthetics (operation)	Minor visual impact	No	5.9
Air quality (well construction)	Increase in TSP, SO_x, CO, HC, NO_x, H_2S	No	5.5.1
Air quality (plant construction)	Increase in TSP, CO, HC, NO_x	No	5.5.2
Air quality (operation)	Emission of particulates and salt drift	No, as long as drift eliminators (0.008% loss or better) are used	5.5.2, 5.5.3
Resource depletion	Gradual fluid and thermal depletion of reservoir	No, mitigated as much as possible	5.1.1, 6.1.1
Induced subsidence	None projected, local alteration of drainage systems and agriculture possible	No,[a] will be monitored and if detected mitigated	5.1.2, 6.1.2
Induced seismicity	None projected	No,[a] will be monitored and if detected mitigated	5.1.3, 6.1.3
Impacts caused by soils and surficial conditions	None, corrosion or bearing failure possible if unmitigated	No,[a] mitigation will eliminate or minimize impacts	5.1.4, 6.1.4
Displacement of prime farmlands	Displacement of approximately 23 acres of prime farmland	No, design has minimized impact as much as possible	5.1.5, 6.1.5
Damage caused by earthquakes	Slight damage	No, facilities will be adequately designed	5.1.6, 6.1.6
Damage caused by floods	None	No	5.1.7, 6.1.7
Accidental contamination of soils and groundwater	None projected, slight deterioration possible	No, will be mitigated if detected	5.1.8, 6.1.8
Water depletion	Reduced water available for irrigation	No, as long as water allotment is controlled by IID	5.3
Effluent discharge	Potential water quality change in the New River	No, as long as CRWQCB mitigation and monitoring requirements are followed	5.3, 6.3
Thermal enrichment	Potential increase in New River aquatic weed growth	No[b]	5.4
Water withdrawal from agricultural drain	Drain flow drawdown, potential water quality degradation and altered instream flow	No[b]	5.3, 5.4, 6.3, 6.4
Salt drift on croplands	Salinization of soils and foliar damage to crops	No,[b] as long as drift eliminators (0.008% loss or better) are used	5.2.2
Salt drift on natural vegetation	Salinization of soils and elimination of salt-intolerant species	No,[b] as long as drift eliminators (0.008% loss or better) are used	5.4.1
Terrestrial ecology	50 ha of native desert vegetation removed for evaporation basin (one option for blowdown disposal after first five years of operation)	Qualified No,[b] survey of area for rare or important species will confirm	5.4.1

[a]Impact occurrence is unlikely or highly unlikely. Will be mitigated when and if detected.

[b]Monitoring during the first five years of operation will produce the data for establishing mitigation measures for the remainder of the plant life.

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6. MITIGATION MEASURES AND MONITORING PLANS

DOE will require the industrial partner to be responsible for implementing several specific measures to mitigate the impacts of the proposed action. In addition, DOE will monitor the project to verify that impacts are within the predicted range of significance and that the mitigation measures are reducing the impact of the project. If monitoring activities indicate that the mitigation measures are not sufficient or that additional unforeseen impacts are resulting from the project, DOE will develop new mitigation measures. If the impacts cannot be mitigated, DOE will reevaluate the project in light of the new information.

6.1 GEOLOGY, GROUNDWATER, AND SOILS

6.1.1 Resource depletion

Rates of both temperature and pressure depletion of the Heber geothermal resource are not known precisely. Injection of 100% of the fluid extracted, which is the alternative that Chevron prefers and the one that Imperial County requires, ameliorates depletion. In addition, reservoir model optimization studies conducted by Chevron indicate that the preferred site for the injection island would most effectively limit depletion of the resource (EIR 1978). As production experience is obtained and the resource becomes better understood, Chevron may be able to develop methods that will utilize the resource even more efficiently.

6.1.2 Induced subsidence and uplift

Although Chevron's preferred alternative of injecting 100% of the fluid withdrawn greatly limits the risk of harmful induced subsidence or uplift, it is possible that such subsidence or uplift may still occur locally. No mitigation other than 100% injection is necessary unless monitoring reveals that induced subsidence or uplift is occurring. In accordance with the Imperial County Geothermal Element, monitoring for subsidence and uplift will include a network of stations consisting of

53 km (33 miles) of survey lines and about 50 benchmarks. This network will cover the Heber geothermal anomaly and its vicinity, and monitoring will be conducted every three or six months during initial production. After initial production, (approximately two years) monitoring will be done annually. Imperial County, in conjunction with the California Division of Oil and Gas, will determine the significance of any induced subsidence or uplift and will also determine the mitigation necessary. In all cases, detection of significant induced subsidence or uplift, which will be determined by Imperial County, will result in intensified monitoring including more frequent and more detailed leveling. Lower production and injection rates or other alterations in field practice (described in Sect. 5.1.2) may be required. To mitigate surficial impacts, filling or grading might be necessary to maintain irrigation canal and drain gradients. This is normally done on a regular basis in Imperial Valley to mitigate natural subsidence effects.

6.1.3 Induced seismicity

Although significant induced seismicity is not anticipated since injection pressures will comply with permitting requirements of the California Division of Oil and Gas, monitoring is necessary to detect any that might occur. Chevron plans to place a seismic net in this area before production begins. The net is required by the geothermal element of the Imperial County plan; it will provide necessary data on baseline seismic activity and any deviations that occur during periods of power production.

If the California Division of Oil and Gas or Imperial County establishes that seismicity during geothermal production varies significantly from the baseline activity, it will determine what mitigation must be implemented. A program consisting of alternate periods of shutdown and full operation to demonstrate a statistical relationship between seismicity and field development or computer modeling, using accumulated engineering data, could be undertaken to determine what measures are necessary as recommended in EIR (1978) and EIR (1979). Injection rates may have to be reduced, injection wells may have to be backwashed to eliminate clogging, additional injection wells may have to be drilled, or operations may have to be halted.

6.1.4 Soil impacts, erosion, corrosion, and bearing failure

To avoid impact caused by the limiting characteristics of soils in the Heber area, mitigation will be incorporated in the design of project facilities, as discussed in Sect. 5.1.4. Gathering lines will be protected from soil contact, and sulphate-resistant concrete will be used to prevent corrosion. Undesirable soils will be removed and replaced with more desirable soils or will be consolidated by means of surface loading prior to building. Pile foundations can utilize the cohesive properties of the soils, and thicker structural members can compensate for weak soils. Shallow subsurface soil bearing characteristics will be intensively investigated before facilities are designed, particularly the turbine foundation. Careful design and grading, as well as avoidance of cut-and-fill technique when possible, will minimize the possibility of serious erosion or slope failure.

6.1.5 Displacement of prime farmland soils

Some soil classified as prime farmland is inevitably displaced if the Heber geothermal resource is developed. Mitigation to minimize the amount removed from agricultural use for project activities has been a major consideration throughout site planning. Chevron is locating all production wells on one island and all injection wells on another to minimize the space required for these activities and to provide access to them. Fluid transmission lines will be built along the right-of-way of existing roads so that additional roads will be unnecessary, and existing transmission corridors will be utilized.

6.1.6 Damage caused by earthquakes

Mitigation will be incorporated in the design of all the facilities to minimize the risk of damage from a significant earthquake. One design will require facilities to withstand an effective peak acceleration of 3.9 m/s^2 (0.4g) and an effective peak velocity of 0.3 m/s (12 in./s) (Sect. 4.1.3). A current, technically reliable source of design data is available in the report, "Tentative Provisions for the Development of Seismic Regulations for Buildings" (Applied Technology Council 1978).

An objective study of the capability of structures to withstand earthquake-induced ground failure will be completed during the design phase, and recommendations of the study will be incorporated into the structural design of project facilities.

6.1.7 Accidental contamination of soils and groundwater

Contamination is unlikely because of mitigation measures incorporated in the site planning by Chevron and San Diego Gas and Electric. The system of trenches, sumps, and berms that Chevron and SDG&E propose will isolate contaminated fluids and prevent them from infiltrating soils and groundwater (Section 3.7.2.8).

Regulations from the U.S. Environmental Protection Agency will require states to implement an underground injection control (UIC) program. Under the UIC program, geothermal injection wells are to be regulated as Class III wells which will make them subject to construction, operating, monitoring, and reporting requirements (Fed. Register 1980). These requirements are similar to or the same as those presently implemented by the California Division of Oil and Gas with the additional requirement that wells adjacent to the injection site be monitored quarterly. Chevron will comply with the requirements of the UIC program when it becomes effective.

If monitoring indicates that contamination of shallow groundwater is occurring, mitigation will depend on the level of contamination. Because of its poor quality, shallow groundwater is not used for any purpose; therefore, contamination may not be significant enough to require mitigation. In all cases, should contamination be detected, monitoring activity will be intensified and, if it is not already known, the source of contamination will be identified. The California Division of Oil and Gas, in cooperation with Imperial County, will determine whether the problem well needs to be reworked or plugged, or if other actions are necessary.

6.2 LAND USE

6.2.1 Displacement of agricultural land

The removal of about 9.3 ha (23 acres) of prime farmland from production (as discussed in Sect. 5) could be partially mitigated by placing 9.3 ha (23 acres) that are not under cultivation into production. The applicant cannot order placement of substitute acreage into agricultural production, but, presumably, the release of water now committed to agriculture at the plant site for use elsewhere would precipitate such a substitution. The EIR (1978) discusses this possibility.

Other adverse impacts on land use (and noise and aesthetics) will be substantially mitigated by locating power plants and pipelines away from sensitive areas, as is currently planned (EIR 1978).

6.2.2 Effects of salt drift on croplands

There are three approaches to mitigating potential adverse effects on croplands which may result from salt deposition from the cooling towers. One approach would be to reduce the amount of saline drift from the cooling towers. This may be accomplished by either reducing the salinity of the circulating water (and thus reducing the salinity of the drift) or by decreasing the rate of drift loss, or both. At the Heber plant maximum salt deposition results from using agricultural return flow or New River water of about 5000 ppm salinity for makeup water. If IID irrigation water at 1000 ppm salinity were available for the entire operating life of the plant, the salinity of the drift would be reduced by a factor of five. Drift salinity may also be reduced by using fewer cycles of concentration. Presently, four cycles of concentration are proposed at the binary demonstration plant; by using two cycles of concentration, the salinity of the drift could be reduced by half. Finally, salt deposition could be decreased by reducing the drift loss rate. Cooling towers are also available which disperse drift over a larger area, resulting in lower salt deposition on any one given area. One such alternative, which would be appropriate in the Imperial Valley, would be circular mechanical draft towers which have a drift loss that approximates that of a natural draft cooling tower.

Mitigation of effects of salt deposition may also be accomplished to some extent by appropriate management of the cropland. In the Imperial Valley, croplands are presently managed to reduce effects from salinization as a result of using IID irrigation water of about 1000 ppm. The major control method is to leach the salts from the rooting zone by applying irrigation water in excess of crop needs and draining the excess via an efficient underground tile drain system. However, the majority of the soils in the project vicinity are presently at or very near their maximum leaching capacity. Other control measures available include planting extremely salt tolerant crops, and using special tilling, furrowing and planting methods to ensure lowered salinity during the critical germination period (IID no date; Richards 1969).

A third possible mitigation scheme would consist of retiring the affected cropland from agriculture and converting an equal acreage of unused land around the periphery of the irrigated zone into cultivation by allocating the released irrigation water to the new site (as discussed in Section 6.2.1). This mitigation scheme involves preparation of the new land including installation of drainage tiles, land leveling, and installation of a water distribution system. Additionally the legal and institutional mechanisms to achieve this mitigation may not be available.

The three possible mitigation measures are not environmentally equal. The control of salt drift at the source is definitely preferable in terms of environmental considerations (e.g. it would create the least disruption of the existing environment). SDG&E will control the salt drift at the source for at least the first five years of operation by employing drift eliminators designed to control drift loss to 0.008% or less and using relatively low-salinity IID water (Sect. 5.2.2). During this period, SDG&E will conduct an impact assessment program, including field studies and monitoring activities, to characterize the cooling tower drift patterns at the project site. Data acquired will be used to determine design or operating measures needed to maintain salt deposition impacts at an insignificant level when agricultural return flow will be used for cooling water make-up, e.g. for the remaining plant life.

6.3 SURFACE WATER

6.3.1 Hydrology and water quality

Compliance with the California Regional Water Quality Control Board's (RWQCB) waste discharge requirements will substantially mitigate impacts on surface water. Before issuing a waste discharge permit, which also serves as a National Pollutant Discharge Elimination System (NPDES) permit, the RWQCB will establish discharge limitations for composition of the blowdown effluent from the 50-MWe demonstration project (Swajian 1979). These limitations will be reviewed by State agencies and interested persons to determine if these limitations will protect water quality and other associated parameters, i.e., water use, aquatic biota, and recreation. Therefore, the limitations contained in the waste discharge permit should preclude the need for further mitigation requirements (Table 5.1, Section 5.3).

To ensure successful mitigation of impacts to the Salton Sea, the California Department of Fish and Game (DFG) has requested that a comprehensive energy development plan for the Imperial Valley be formulated to allow maximum energy development while minimizing adverse effects. The DFG proposes that these objectives be to (1) preserve the sport fishery of the Salton Sea by keeping salinity below 40,000 ppm; (2) protect lands adjacent to the Salton Sea, both resort and agricultural, from flooding; and (3) develop uses for excess Salton Sea water (DFG 1979). The proposed means of meeting these objectives are given in DFG (1979).

The RWQCB permit, as applied to the Southern California Edison Company plant (SCE) (Table 5.1), contains a section stating that if more stringent water-quality requirements are established or shown to be necessary for protection of water quality and associated factors, these requirements will replace those in the permit (Swajian 1979).

Monitoring, as outlined in Table 6.1 for the SCE 10-MWe demonstration project, will be similarly applied to the 50-MWe facility. This will eliminate the need for additional water-quality monitoring requirements. However, monitoring of the water temperature 9 m (30 ft) downstream from the discharge to the New River will be instituted. A transect across the river at 0.3 m (1 ft) intervals would be most effective

Table 6.1. Potential Regional Water Quality Control Board requirements for blowdown monitoring from the 45 MWe Heber facility as applied to Southern California Edison's 10 MWe demonstration plant

Values will be reported in mg/L unless otherwise indicated

Constituent	Type of sample	Sampling frequency
	Effluent monitoring[a]	
Total dissolved solids	Grab	Weekly
Flow, gpd	Averaged daily	Reported monthly
pH, units	Grab	Weekly
Coper	Grab	Weekly
Zinc	Grab	Weekly
Lead	Grab	Weekly
Suspended matter	Grab	Weekly
Settleable matter	Grab	Weekly
Total chromium	Grab	Weekly
Total chlorine	Grab	Weekly
	Receiving water monitoring[b]	
Temperature, °C (°F)[c]	Grab	Weekly

[a] *Effluent monitoring:* Wastewater discharged into drains will be monitored for the constituents listed. All samples will be taken between 6 AM and 6 PM. A sampling station will be established at the point of discharge and will be located where representative samples of the effluent can be obtained.

[b] *Receiving water monitoring:* Water in the New River will be monitored for the listed constituents. All samples will be taken between 6 AM and 6 PM. A sampling station will be established where representative samples of water can be obtained.

[c] Temperature of the receiving water shall be taken within 9 m (30 ft) upstream and downstream of the point of discharge.

Source: Swajian, 1979.

in verifying the location of the thermal plume and to ensure continued compliance with the 3°C (5°F) temperature increase limitation.

In-stream flow requirements to be established before issuance of a RWQCB water withdrawal permit for full-field development and the permit requirements promulgated after review by various state agencies will ensure that all measures necessary to minimize surface water impacts to the New River will be taken by the applicant (Turner 1980a). These permit requirements will apply to water to be withdrawn from the New River for cooling after five years of operation of the 50-MWe demonstration project as well as the 500-MWe full-field development (Sects. 5.3 and 7.3). The permit also covers monitoring necessary to ensure compliance with the permit's requirements.

6.3.2 Water use

The New River is protected for the beneficial uses of noncontact recreation, irrigation, stock watering, and for warm, freshwater habitat (Sect. 4.3.3). These uses will be protected by the RWQCB effluent discharge limitations, which should prevent significant changes in water quality and temperature downstream. Considering the limited fishery above Seeley, the poor water quality in the Clark Road vicinity, and limited beneficial uses of New River water, the 50-MWe project should have little impact on water use in the Heber area.

6.4 ECOLOGICAL SYSTEMS

6.4.1 Terrestrial ecology

Native vegetation, and thus wildlife habitat, will be disturbed only if the method chosen for disposal of saline cooling tower blowdown is an evaporation basin. A maximum of about 50.5 ha (125 acres) of native desert vegetation will be eliminated by construction of such a basin. The lined evaporation basin will be fenced and kept clear of vegetation to discourage its use by wildlife and waterfowl. The basin is not expected to have adverse effects on waterfowl or other wildlife. If the basin disposal alternative is chosen, a survey of the proposed location will be conducted to minimize effects on important wildlife habitat.

Potential effects of salt drift on natural vegetation along the New River should be negligible from 0.008% drift. Methods to reduce salt drift are discussed in Sect. 6.2.2.

Because the predicted effects on terrestrial biota are minimal, the commercial partners do not anticipate the need for a monitoring program in this area.

6.4.2 Aquatic ecology

Impacts to the New River associated with the 50-MWe demonstration project will be substantially mitigated by the requirements of the CRWQCB waste discharge permit (see Table 5.1) for protection of surface waters (Turner 1980b). Because of the restrictions on discharge composition and the sparse pollution-tolerant fauna in the New River, further mitigation needs should be minimal. However, if growth of aquatic weeds proves to be unacceptable, control measures may be required. There should be no impacts on the biota of the Salton Sea that require mitigation.

Monitoring required by the CRWQCB waste discharge permit and the adherence of San Diego Gas and Electric to the effluent limitation for blowdown composition should eliminate the need for additional monitoring of the biota in the New River. Fish in the Salton Sea are monitored as time and funds permit by the California Department of Fish and Game (Turner 1980c). Monitoring instituted by the applicant would best be coordinated with the appropriate State and Federal agencies.

6.4.3 Rare and endangered species

Construction and operation of the Heber Binary Demonstration Plant should not affect any State or Federally designated rare or endangered species. If the evaporation basin disposal alternative is chosen, the proposed location will be surveyed for any rare or endangered species listed at that time and the basin will be located outside of those areas found to be habitats for rare and/or endangered species.

6.5 AIR RESOURCES

6.5.1 Geothermal well emissions

During production, emissions at geothermal wells are essentially zero. Occasional venting of gas from a well to the atmosphere during maintenance periods releases minute amounts of H_2S. These emissions will have no significant impact on air quality.

6.5.2 Power plant emissions

The major pollutant of concern associated with the power plant is mineral particulates contained in the cooling tower drift droplets. Drift emissions and the resulting salt deposition can be mitigated in several ways. One way is to limit drift emissions through performance specifications. Drift emissions can range from 0.1 to 0.001% of the total circulating cooling water; current cooling towers are capable of limiting drift emissions to 0.002% or less.

For the first five years of operation, drift losses will be controlled to 0.008% or less of cooling water circulation. This will maintain TSP concentrations within acceptable limits (Sect. 5.5.3). Probably an equally effective means of limiting salt drift is to limit the total dissolved solids content of the makeup water, as well as the number of times the cooling water is circulated through the tower before it is discharged. However, limiting the number of cooling cycles will increase the volume of cooling water required by the project.

The commercial partners are presently developing an air-quality monitoring program. Plans will also be developed to include monitoring of salt deposition on croplands near the towers during the early years of operation with IID makeup water. The results will be used to determine levels of salt drift and to predict whether salt deposition will be high enough to cause adverse effects when higher salinity makeup water must be used. Appropriate mitigation will then be instituted as appropriate.

6.6 NOISE

The relatively insignificant noise impacts of the project noted in Sect. 5.5 could be mitigated by limiting work to daylight hours; using diesel electric drilling rigs, sound barriers, selected routing of construction-related traffic; and ensuring, by land use control, that no noise-sensitive receptors are allowed to encroach within an unacceptable distance of the geothermal facility.

6.7 SOCIOECONOMICS

Scheduling construction activities to avoid duplication of crews would mitigate population impacts and reduce demands for scarce housing. Advance planning and a building program or local accommodations of temporary housing would also lessen housing demand. Methods such as training programs to facilitate use of local labor would further reduce the demand for housing.

Carpooling and staggered work shifts for drilling and construction crews would mitigate the commuter-traffic impact. The socioeconomic impacts of the project are discussed in Sect. 5.7.

6.8 CULTURAL RESOURCES

As stated in Sect. 5.8, the absence of documented archaeological or historical resources in the project area essentially precludes adverse impacts. If previously unknown archaeological resources are uncovered during the drilling and construction phases of the project, project activities will stop until the State Historical Preservation Office has been contacted and the appropriate action taken (resource excavation and recovery, etc.).

6.9 AESTHETICS

Visibility of cooling towers and steam plumes at the power plant cannot be decreased because of the terrain on which they are located. Other visual impacts will be lessened by strategic landscaping and use of earth-tone colors for aboveground pipelines. The aesthetic impacts of the project are discussed in Sect. 5.9.

6.10 ACCIDENTS

Accident prevention will be encouraged throughout the project's lifetime by incorporating safety features into the project design and by implementing safety measures in the construction and operating procedures.

In the unlikely event of a blowout, all reasonable efforts will be made to regain control of the well. Mitigation would consist of pouring mud, grout, or water into the borehole to kill the uncontrolled flow, or, if this failed, drilling of a relief well, which could take several weeks. If necessary, surficial flow would be diverted to existing drains to limit impacts to adjacent agricultural areas. After the blowout is killed, accumulated water at the site will be disposed of by a method acceptable to responsible California and Imperial County agencies.

Mitigation of casing failure would consist of halting drilling, injection, or production of the malfunctioning well and undertaking workover procedures. If the workover is unsuccessful, the well will be plugged and abandoned in accordance with regulations of the California Division of Oil and Gas.

REFERENCES FOR SECTION 6

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Turner, J. 1980a. Personal Communication to V. R. Tolbert, Oak Ridge National Laboratory, May 15, 1980.

Turner, J. 1980b. Personal Communication to K. M. Oakes, Oak Ridge National Laboratory, April 18, 1980.

Turner, J. 1980c. Personal Communication to V. R. Tolbert, Oak Ridge National Laboratory, May 14, 1980.

7. POSSIBLE FUTURE DEVELOPMENTAL ACTIVITIES AT THE HEBER ANOMALY

Imperial County overlies a major geothermal heat source of more than 10,000 MWe of power, of which 4500 MWe of electricity are projected as feasible for development over the next 40 years (Geothermal Element 1977). The Heber Known Geothermal Resource Area (KGRA), which occupies about 23,000 ha (58,000 acres), has a projected capacity of 5000 MWe (Geothermal Element 1977), although the USGS estimates a 30-year generating capability of about 1000 MWe (USGS 1978). A conditional use permit (CUP) has been issued by Imperial County for planned geothermal development within an area of 2960 ha (7320 acres) specified by the county as the Heber geothermal (G) overlay zone. Results of exploration and well drilling have demonstrated proven reserves (proven reserves are that portion of a reservoir that can be economically utilized with present technology) at Heber of at least 500 MWe of capacity (SDG&E 1979).

Full-field development of the Heber resource is not part of the proposed Federal action. It is being actively pursued in the commercial sector, irrespective of the Federal action. SDG&E has indicated that it would pursue the development of geothermal resources in the Heber anomaly even if DOE did not fund the Heber Geothermal Binary-Cycle Demonstration Project. SDG&E has indicated that they would use flash and binary technology to utilize the resource and that developmental activities would begin sometime in the early-1980s. Chevron has a CUP for field development for the above plant and for the water treatment facility. At the present time Southern California Edison (SCE) is in the process of obtaining the remaining required permits for its planned 50-MWe plant at Heber, and construction is scheduled to begin in 1980.

7.1 INTRODUCTION

Plans for full-field development of the Heber geothermal field for electric generation, although not yet finalized, call for construction and operation of seven power plants along with all of the associated auxiliary equipment such as wells, pipelines, power transmission lines, access roads, and water treatment facilities. Two of the plants of approximately 50-MWe capacity each are projected as utilizing the binary cycle whereas the remaining plants, of either 50- or 100-MWe capacity, are expected to employ the dual-flash cycle. As presently envisioned, seven facilities are phased to come on-line at intervals between 1982 and 1989. SCE is currently obtaining all the permits required for construction and operation of a flash plant at Heber and plans to begin construction in 1980.

7.2 SITE LOCATION AND DESCRIPTION

The full-field development is expected to be located completely within the same G-overlay zone as the Binary Cycle Demonstration Project (Fig. 7.1). Existing plans call for the seven power plants to be clustered in the central portion of the project area, each plant being supplied by its own production island. The plants are connected by about 19.3 km (12 miles) of pipeline to eight peripherally located injection islands. A water treatment facility will be located on a site within the floodplain of the New River. The associated injection island will be located outside the floodplain, immediately north of the facility (EIR 1979). It is anticipated that facilities (plant plus production and injection islands) for each 50 MWe of electric generation will require about 10.1 ha (25 acre). The 500 MWe of capacity should thus require about 101 ha (250 acre). Additionally, the water treatment facility will require 8.1 ha (20 acre) for the initial module, 1.1 ha (2.75 acre) for the injection island, and about 6.1 ha (15 acre) for each additional module. Because plans call for about one module for each 50 MWe of generating capacity, the expected land area required for treating river water for the full-field development will be about 64 ha (158 acre). The total land for both electric generation and water treatment comes to approximately 162 ha (400 acres) or 5% of the land area defined by the G-overlay zone.

7.3 FULL-FIELD DEVELOPMENT

As currently envisioned (EIR 1979) the full-field development consists of seven power plants, seven production islands, eight injection

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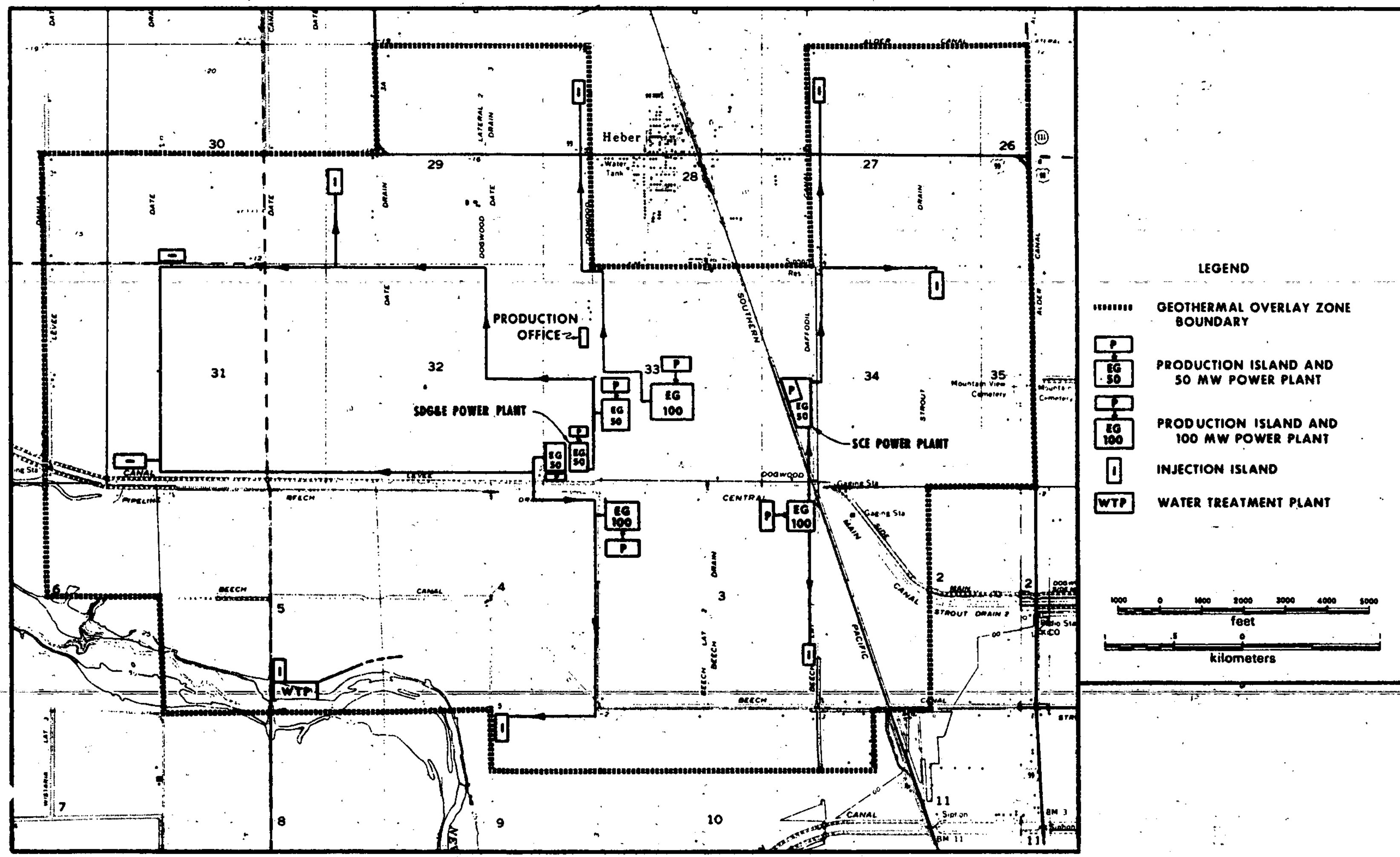

Fig. 7.1 Preliminary development plan within the Heber G-Overlay Zone. Source: EIS 1979.

islands, geothermal fluid transmission pipelines, power transmission lines, and water treatment facilities.

7.3.1 Access roads

Because existing roads provide access to the proposed geothermal site, there should be little need for new roads (Figure 7.2). Some of the existing roads may need to be modified to improve their bearing capacity.

7.3.2 Wells and well sites

The surface area requirement for one geothermal well is 0.4 ha (one acre) per well of which half the area can be returned to other uses after services are established (Geothermal Element 1977). Because all wells will be directionally drilled, the total area occupied by wells will be reduced. For example, for a 1829m (6000 ft) deep reservoir, a single well-head location having wells with a 30° slant can cover about 121 ha (300 acre); a 45° slant can cover almost 405 ha (1000 acre). The production island for a 50-MWe facility will accomodate 9 to 15 wells and will occupy about 2.0 ha (5 acres), whereas the injection island for the same facility will accommodate 6 to 9 wells and will require about 1.4 ha (3.5 acres). Production islands will be located as close as possible to the power plant, whereas injection islands will be located around the periphery of the resource. The water treatment facilities will require 1 to 2 injection wells for each 50 MWe of capacity (EIR 1979). Thus, development of the full 500-MWe field would require about 90 to 150 production wells and 80 to 110 injection wells.

The well drilling, production, and abandonment will be the same as described in Sect. 3.7.2.2. All procedures and equipment will comply with California DOG requirements.

Fifteen testing wells have already been drilled into the Heber geothermal field. This has provided sufficient information to characterize the resource and to make decisions for siting both production and injection wells. Thus, additional test well drilling is not anticipated (EIR 1979).

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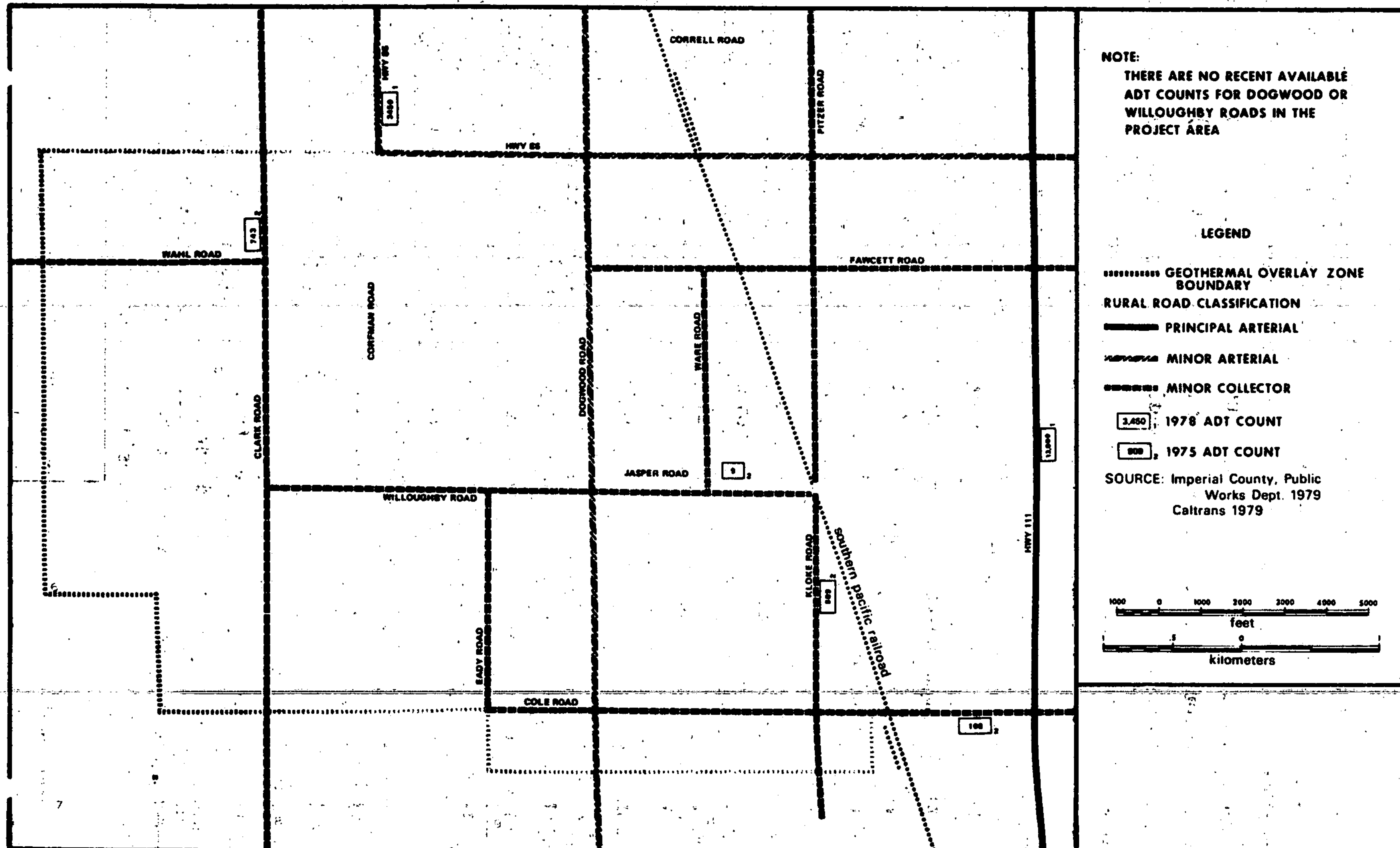

Fig. 7.2 Roads and highways within the Heber G-Overlay Zone.
Source: EIR 1979.

7.3.3 Power plants

Full-field development of the proven 500 MWe of capacity at Heber is anticipated to involve seven power plants: two 50-MWe binary cycle, two 50-MWe dual-flash cycle, and three 100-MWe dual-flash plants (Fig. 7.1) (EIR 1979). Components, construction, and operation of the 50-MWe binary-cycle plants are described in Sect. 3.3.3.4. Thus, only a 50 MWe dual-flash cycle power plant will be described here. The general process for a 100-MWe dual-flash cycle plant will be the same, except that some factors such as flow rates will be doubled. All plant construction activities will be performed in accordance with applicable American Society of Mechanical Engineers (ASME) and electrical codes and regulations.

The construction period for a 50-MWe plant, dual-flash or binary, will be about 20 to 24 months and will proceed for both as described in Sect. 3.7.2.3 for the binary demonstration plant.

A schematic of a 50-MWe dual-flash cycle power plant is shown in Fig. 7.3. The major components are the first- and second-stage flash separators, the dual-admission turbine generator, the condenser and non-condensible gases removal system, and the cooling tower. The temperatures and flow rates are indicated in Fig. 7.3. Geothermal fluid, which enters the system at 182°C (360°F) and is reinjected into the reservoir at 102°C (216°F), will flow at a rate of 3.7 million kg/h (8.1 million lb/h). After passing through two cascaded flash separators, the remaining liquid will be reinjected. Exhaust steam leaving the turbine will be condensed and used as replacement water for the cooling tower. Condensate will be produced at the rate of 554,000 kg/h (1,220,000 lb/h) and used for makeup at the rate of 425,000 kg/h (935,000 lb/h). The excess condensate will be combined with the spent fluid for reinjection. The 425,000 kg/h (935,000 lb/h) of water lost as a result of cooling tower operation amounts to an 11.5% deficit in the geothermal fluid return and will need to be provided from another source to attain 100% return flow. The establishment of a water treatment facility on the New River is to provide either this return flow or cooling tower makeup water.

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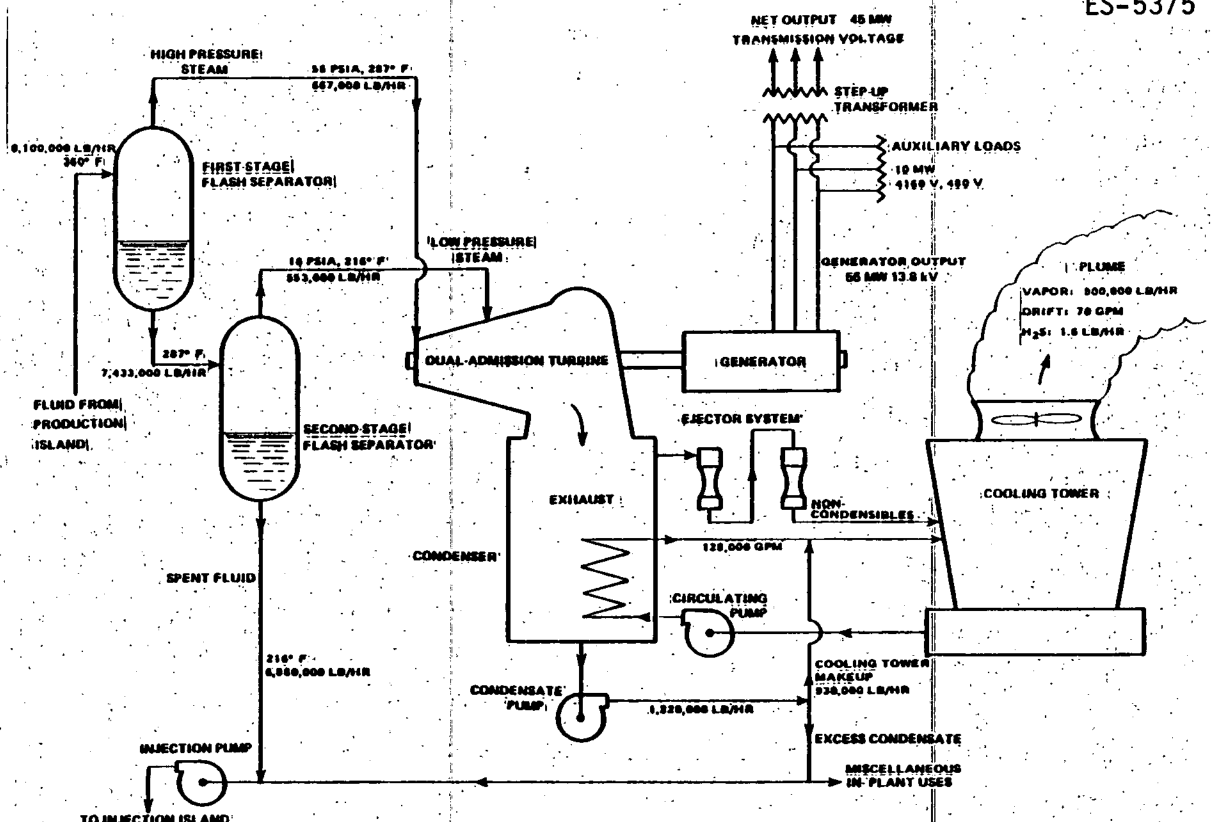

Fig. 7.3 Schematic flow diagram of a 50MWe dual-flash cycle powerplant. <u>Source</u>: EIS 1979.

All of the noncondensible gases in the geothermal fluid will pass through the system along with the flashed steam ultimately to be released to the atmosphere with the cooling tower plume. The noncondensible gases, shown in Table 7.1, constitute 48.55 ppm of the fluid by weight including 0.18 ppm H_2S. The H_2S emission rate from the cooling tower is estimated at 0.65 kg/h (1.44 lb/h) for a 50-MWe dual-flash cycle plant (EIR 1979).

7.3.4 Water treatment facility

Plans, as described in EIR 1979, call for the water treatment plant to be located on the floodplain of the New River (Fig. 7.1) with construction to begin in 1980. It will be of modular design, with each module of sufficient size to supply the makeup water for one 50-MWe dual-flash cycle power plant [425,000 kg/h (935,000 lb/h) or approximately 0.1 m^3/s (4 cfs)]. The need for treating the New River water arises from the raw sewage discharged into the river in Mexicali. Thus, the treatment will be similar to that of a conventional sewage water treatment plant. Water diverted from the river (via diversion works with a screen to prevent entrainment of fish) will be routed to a primary settler before treating with flocculating agents to settle the remaining solids. All ponds will be lined or treated to prevent seepage. The water will be filtered, treated with chlorine (or other biocide) then deaerated before injection into the reservoir. The settled solids will be anaerobically digested, dewatered, and dried. Disposal will be in an approved landfill. The treatment process will be tested in a pilot facility at the plant site before construction.

Construction of the water treatment facility will take about six months and will require clearing and grading of the site and pouring of foundations and concrete slabs for the above grade tanks and equipment.

7.3.5 Pipelines

Tentative pipeline routing for the full-field development is given in Fig. 7.1. As discussed in Sect. 3.7.2.5, fluid return pipelines for all the plants will be about 76 cm (30 in.) in diameter, will be constructed

Table 7.1. Analysis of noncondensible gases (Heber geothermal fluid)

Component	Mole percent
Air[a]	2.45
Hydrogen (H_2)	1.57
Nitrogen (N_2)	28.30
Carbon dioxide[b] (CO_2)	58.96
Methane (CH_4)	8.19
Ethane (C_2H_6)	0.11
Propane (C_3H_8)	0.01
Butane, pentane, hexane	tr.
Heptane (C_7H_{16})	0.01
Hydrogen sulfide (H_2S)	0.40
Total	100.00

Calculated molecular weight: 36.1043
Weight fraction of total flow[c]
1. Noncondensibles: 48.37 ppm
2. Hydrogen sulfide: 0.18 ppm

[a]Contamination from process vessel leak.
[b]Percentage depends on operating pressure of flash vessel.
[c]Determined from average gas flow readings of 3 ft^3/hr at average water flow of 6250 lb/hr.
Source: Chevron 1977.

above grade on steel pipe supports, will be routed parallel to existing roads, drains, canals, and field boundaries, and will be entirely underlain by a concrete-lined trench, which will be sloped to sumps located at intervals along the pipeline.

7.3.6 Transmission lines

A major east-west transmission corridor crossing Imperial County has been proposed to connect the SDG&E transmission system with that of the Arizona Public Service Company and other utilities to the east (EIR 1979). The potential impacts of these transmission facilities are addressed in EIR #228-79 being prepared by the County of Imperial. The output of each power plant at Heber will be via overhead lines to a central collection station within the G-overlay zone. From the collection station, power will be transmitted through an overhead line to the east-west line.

7.4 EXISTING ENVIRONMENT

Section 4 contains a description of the existing environment that includes the Heber geothermal overlay zone and all other areas that may be affected by possible future activities described above. The description will not be repeated here.

7.5 POTENTIAL ENVIRONMENTAL CONSEQUENCES

The environmental impacts of the planned full-field development are reported here as described in EIR 1979. As stated previously, this information was selectively verified as appropriate for addressing the environmental scope of the proposed action. Inasmuch as development is planned to occur over an 8-to 10-year period, impacts, especially those caused by construction, will probably be less severe because of the reduction in intensity that occurs when an activity is distributed over a long period of time.

7.5.1 Geology and Soils

Impacts resulting from full-field development are likely to be similar to those from the proposed project, but magnified considerably. It is likely that as many as 65.6 ha (162 acres) of soils classified as prime farmland will be irretrievably displaced. The occurrence, extent, and significance of resource depletion, induced seismicity, and induced subsidence or uplift will remain uncertain until field development commences. However, it is projected that the likelihood of significant induced seismicity, subsidence, or uplift is small, whereas a considerable amount of the resource will be depleted. Impacts that could be caused by soil and shallow subsurface conditions as well as earthquakes can be prevented by appropriate engineering and design practices. Although the risk of accidents increases with the scale of development, measures similar to those described in Sections 5.1.8 and 6.1.8 can satisfactorily minimize the risk.

7.5.2 Land use

The proposed geothermal field development would impact prime farmland but, except for lands in the immediate vicinity of the cooling towers for the second binary plant, would not make adjacent lands unsuitable for agriculture, as is affirmed by the geothermal element of the Imperial County General Plan. While some 64.8 ha (160 acres) of prime farmland would be removed from production, farming could continue all around the geothermal production islands and related facilities. Moreover, land presently unused for agriculture because of limited water availability could be cultivated in place of that removed for geothermal use. Power plants and pipelines could be located in such a way as to minimize adverse impacts on agriculture and other land uses. If development to 500 MWe involved two binary plants, the impacts on croplands from salt drift which are detailed in Sect. 5.2.2 would involve twice the acreage for the binary demonstration plant.

The very few residences that do exist in the vicinity, are near the edges of the project area at distances from actual proposed operations that should be sufficient to minimize adverse impacts.

7.5.3 Surface water

Most of the 500-MWe full-field Heber development will utilize the flash process rather than the binary process and as a result will not require a supplemental cooling water supply. The major surface water impacts associated with the 500-MWe project at full development are: (1) withdrawal of up to 6.2×10^7 m^3 (50,000 acre-ft) of water annually from the New River, (2) reduction of flow in the New River and into the Salton Sea, and (3) increased salinity of the Salton Sea (EIR 1979). Withdrawal is necessary to meet the Imperial County 100% geothermal reinjection requirements to prevent subsidence (Sect. 5.1.2). Table 7.2 shows the effects of water withdrawal on streamflow downstream of the Clark Road Crossing and at the outlet to the Salton Sea. Using Leopold and Miller's formula for stream channel hydraulics, a flow of 4.3 m^3/s flow, a water depth of 1.5 m, and withdrawal of 6.2×10^7 m^3 (50,000 acre-ft) annually, VTN calculated that at full-field development (500 MWe) Heber water use will lower the average water level of the New River approximately 0.3 m (1 ft). Calculations were independently verified by the ORNL staff (Lee 1980). SDG&E, in response to comments from the California Regional Water Quality Control Board (CRWQCB) concerning the change in water level with withdrawal under minimum-flow conditions, stated that the maximum change in depth at the Clark Road Crossing would be 42.9 cm (16.9 in.) and 8.6 cm (3.4 in.) at the Salton Sea outlet (SDG&E 1979b).

Diversion of 6.2×10^7 m^3 (50,000 acre-ft) of New River water annually will have both positive and negative impacts on the Salton Sea. This water diversion will lower the stage of the Sea an additional 0.8 m (2.5 ft), thereby reducing inundation of areas around the sea. However, the Heber 500-MWe project will increase salinity of the sea (38,000 ppm) by 3000 ppm. As a result, salinity of the Salton Sea would reach 40,000 ppm two years sooner based on current calculations, i.e., 1988 rather than 1990. In comparison, if IID succeeds in conserving 3.7×10^8 m^3 (300,000 acre-ft) of water by 1985, salinity of the Salton Sea will reach 40,000 ppm eight years earlier than without conservation.

Full-field development will not utilize irrigation water as a cooling source and will, therefore, have no effect on priority agricultural uses. Withdrawal of the New River water for reinjection will

Table 7.2. Summary of changes to mean New River hydraulic characteristics as a result of 500 MWe reinjection withdrawal[a]

Location		Width		Depth		Flow		Velocity	
		m	ft	m	ft	m^3/s	cfs	m/s	ft/s
Clark Road crossing	w/o[b]	3.1	10	1.5	5	4.2	150	1.4	4.5
	w[c]	2.6	8.5	1.2	3.9	2.3	80	1.1	3.6
% of original		85%		78%		53%		80%	
Salton Sea	w/o[b]	25	82	1.1	3.6	16.1	568	.58	1.9
	w[c]	24.9	81.7	1.0	3.4	14.1	498	.55	1.8
% of original		96%		95%		88%		95%	

[a]6.2×10^7 m^3 (50,000 acre-feet) withdrawal/year.
[b]w/o – without withdrawal.
[c]w – with withdrawal.

increase the salinity of both the New River and the Salton Sea and may therefore interfere with future potential users of these waters.

Unavoidable adverse impacts to surface water associated with the proposed 500-MWe project can occur from alteration of floodplain hydraulics as a result of water treatment facility construction on the floodplain (EIR 1979). Other adverse surface water impacts associated with the 500-MWe development are potential erosion, runoff, or sewage contamination of surface waters in the vicinity during construction and operation of the geothermal plants and water treatment facilities. These impacts are expected to be minimal as the result of implementation of mitigative measures discussed in the following paragraphs.

As discussed for the 50-MWe demonstration facility (Sect. 6.3.1), compliance with the CRWQCBs waste discharge requirements will substantially mitigate impacts on surface water. As a result of the Department of Fish and Game's protest against issuance of water rights for 6.2×10^7 m^3 (50,000 acre-ft) annually for the 500-MWe full-field development, SDG&E and Chevron must participate in instream flow studies on the New River prior to permit issuance. The May 15, 1980 decision on this permit retained water rights jurisdiction for the New River but not the Salton Sea. The sea will be protected to some extent by jurisdiction over the New River. The decision states that no water shall be diverted under this permit until the Department of Fish and Game has determined that measures necessary to protect fishlife in the vicinity of the diversion works has been incorporated into the plans and construction of such diversion. The permittee must submit for CRWQCB approval a study showing the minimum flow quantity required to protect aquatic habitat in the New River. The study is required to show how the diversions will be managed to avoid reducing flow in the river to the point where it would adversely affect aquatic habitat. The CRWQCB also reserves jurisdiction to include specific mitigation measures in the permit (CRWQCB, 1980).

The 500 MWe full-field development will not require monitoring of surface water discharge since there will be no surface water discharge from these plants. Monitoring will be associated with the water withdrawal facility according to a CRWQCB permit projected to be similar to the SCE permit (Table 6.1).

7.5.4 Ecology

7.5.4.1 Terrestrial ecology

All sites for well pads and power plants related to eventual development to 500 MWe within the Heber overlay zone are on agricultural land. Full development will require diversion of about 6.2×10^7 m^3 (50,000 acre-ft) of water from the New River to accomplish 100% reinjection. Related to this diversion, a water treatment facility will be constructed adjacent to the river in the southwest portion of the overlay zone. Construction of the facility will destroy a total of about 61 ha (150 acres) of natural riparian vegetation. Although the riparian habitat has been somewhat disturbed in this part of the New River, it still represents valuable wildlife habitat, which is an extremely limited resource in the intensively cultivated Imperial Valley. While no threatened or endangered species are likely to be present in this habitat (see Sect. 4.4.3), a variety of songbirds, gamebirds, and small mammals will be displaced. Locating the treatment facilities away from the natural vegetative communities would avoid the adverse effects on wildlife habitat, but would probably entail a trade-off of removing an additional 61 ha (150 acres) of agricultural land from production. If the treatment facilities are located within the natural habitat, some mitigation of adverse effects could possibly be achieved by enhancement of wildlife habitat elsewhere along the New River. Such mitigation will be coordinated with the California Fish and Game Department.

Diversion of 6.2×10^7 m^3 (50,000 acre-ft) at the Clark Road diversion point within the overlay zone will reduce the flow of the New River by about 47% at this point. Reducing the present river flow by almost half will in all likelihood result in the loss of some aquatic vegetation and riparian habitat downstream from the diversion point. To determine whether this might constitute a significant loss of riparian habitat would require a detailed study of present water levels (and their variations) relative to existing downstream riparian habitats. It is very possible that in the future, flows in the New River will be reduced by other factors not connected with the Heber project, including decreased inflow from Mexico and reduced irrigation return flows, in which case, the additional flow reduction from the Chevron withdrawal could severely decrease downstream riparian habitat. One important wildlife habitat, the freshwater marshes downstream of the overlay zone that were described in Sect. 4.4.3 as potential habitats for the yuma clapper rail and the California black rail, are apparently independent of New River water and should not be affected by any reduction in flow of the river.

At the Salton Sea, it is estimated that the flow reduction in the New River as a result of the diversion will be less than 12% of the average flow at the mouth. VTN has predicted that the reduced flow into the Salton Sea will reduce the present rate of increasing water level in the Sea (see Sect. 7.5.3). Such a reduction could also slow the present rate of saltwater intrusion into the freshwater marshes around the periphery of the Sea. If this is the case, it would constitute an overall benefit to the wildlife (including the yuma clapper rail and the California black rail) that depend upon this freshwater marsh habitat. However, at the New River delta, it is possible that any reduction of the rise in the Salton Sea's level could be offset to some degree by the reduced flows in the New River resulting from the diversion. Therefore, the rate of saltwater intrusion into the marshes at the New River delta might be unaffected or even accelerated by reduced river flows. It is not possible to predict with accuracy the effect of the water diversion on the New River delta. The monitoring and mitigative measures outlined in the CRWQCB permit provisions (Section 7.5.3) should help ensure protection of the marsh habitat.

The diversion will hasten the increase in salinity of the Salton Sea as indicated in Sect. 7.5.3. When the salinity of the Sea reaches the point of elimination of much of its aquatic biota, a major food resource for some of the birds that use the Sea will be lost. Mitigation of any adverse effects of the diversion on the Salton Sea, on the riparian habitats along the New River, and on the marshes at the New River delta would be possible by reducing the amount of reinjection, thereby necessitating the withdrawal of less water from the river. Reduction in the amount of reinjection entails a possibility of subsidence that is discussed in Sect. 7.5.1.

Most power plants planned for the 500 MWe of development will be of the flashed-steam type. These plants will use relatively pure condensed steam for cooling water makeup, and salt drift from the towers will be inconsequential. Salt drift from cooling towers associated with binary plants is much greater than that from flashed-steam plants because the binary plants must use irrigation return flow for cooling tower makeup, which is much more saline than condensate. Presently, one other binary plant in addition to the binary demonstration plant is planned for 500 MWe of development. The location of this second binary plant is not presently known. Effects of salt drift related to the proposed binary demonstration plant are discussed in detail in Sects. 5.2.2 and 5.4 and Appendices E-H. Whether salt drift from a second binary plant could significantly affect the natural vegetation communities along the New River would depend upon the location of this second plant relative to these communities. If the plant were located close enough to this area that a significant amount of salt drift impacted the natural communities, then the possibility of adverse effects on this community from accumulation of salts in the rooting zone is likely. This is because the natural vegetation communities do not receive the benefit of flushing of salts from the soil that is practiced on the adjacent agricultural lands.

One alternative for disposing of the saline blowdown from the cooling towers associated with the binary plant is to construct evaporation ponds, which would be located in native desert habitat to the west of the irrigated lands near the Heber overlay (see Sect. 5.4.1). If this disposal alternative is employed for the second binary plant, an additional 50.5 ha (125 acres) of desert habitat would be eliminated as a result of development to 500 MWe.

Atmospheric emissions other than salt drift from development to 500 MWe should not adversely affect terrestrial biota. Because the binary plants are closed loops, there are no emissions of H_2S associated with their operation. Emissions of H_2S from the flashed plants will be minimal because of the low H_2S content of the Heber reservoir (EIR 1979). Ambient concentrations of less than 10 $\mu g/m^3$ are predicted in the vicinity of each flash plant. This is many orders of magnitude below the levels at which vegetation and animals are affected by H_2S (Thompson 1976; Miner 1969).

Development of 500 MWe of power in the Heber region will necessitate construction of additional transmission facilities to carry the power to large population markets in southern California and Arizona. A major east-west transmission corridor crossing Imperial County has been proposed (EIR 1979). Details of the location of the corridor are not available at this stage of development. Because of the low-growth form of desert vegetation, construction of the line would require minimal clearing of vegetation. The major ecological concern related to placement of the corridor in the Imperial Valley is the potential for effects on the large numbers of waterfowl that use the Salton Sea wetlands. Transmission lines could cause increased bird mortality through collisions with lines and towers. Waterfowl are particularly subject to collisions with power lines when the lines are adjacent to feeding and resting areas where the birds are flying low. In addition to direct mortality, transmission lines could cause changes in patterns of waterfowl use of adjacent land, thereby possibly affecting hunter success. A study conducted as part of the Imperial Valley Environmental Project identified some major flight patterns of birds using the Salton Sea area (Leitner and Grant 1978). The patterns generally parallel the south shore of the Sea and follow the New and Alamo Rivers inland to feeding areas. Such major flight pathways should be avoided by transmission corridors.

7.5.4.2 Aquatic ecology

The aquatic habitats of the New River and the Salton Sea fishery are the two areas of major concern associated with the Heber 500-MWe full-field development. The proposed diversion of 6.2×10^7 m^3 (50,000 acre-ft) per year of water from the New River would remove 3.4% of the freshwater inflow into the Salton Sea. This would have two major effects: (1) the sea would reach a salinity level inimical to reproduction of resident sport fishes (Bairdiella, Sargo, and Orangemouth Corvina) at least two years sooner (1988) than without the project (1990) (May 1976; Cal. Fish and Game 1979) and (2) the rate of land inundation around the sea would be reduced.

The Department of Fish and Game's protest against withdrawal of water from the New River has been considered. The decision reached by the State Water Resources Control Board (SWRCB) on May 15, 1980 reserved jurisdiction over water withdrawal from the New River but did not reserve jurisdiction over water or resultant effects on the Salton Sea. The sea, however, will be protected to some extent by instream flow studies to be conducted prior to issuance of the water withdrawal permit and by instream flow requirements and water quality limitations to be placed on water withdrawal from the river. If the withdrawal is determined at a later date to have an adverse effect on aquatic habitats, the permit will be modified (Section 7.5.3). Monitoring will be carried out by the applicant for compliance with the SWRCB permit.

The water treatment facility for the 500-MWe development will be located in the floodplain of the New River at the Clark Road crossing. Impacts on aquatic biota, as a result of intake pipe location, will be reviewed by the Department of Fish and Game before granting a permit for streambed alteration. Considering the limited aquatic community in the New River upstream of Seeley, there should be little impact on aquatic biota in the project vicinity. Downstream of Seeley, water withdrawal could have an adverse effect on the flathead catfish, <u>Pylodictic olivaris</u>, a popular sport fish. Reduction of the water level, ranging at maximum from 30 cm (12 in.) at Seeley to 8 cm (3 in.) at the New River delta, would reduce the cross-sectional area and amount of channelside habitat (deep holes, cavities, and bank cuts) available for catfish resting and spawning. The EIR (1979) states that improved water quality as a result of water withdrawal could extend the catfish range upstream; however, until dissolved oxygen levels between the Clark Road withdrawal site and Seeley, 22.5 km (14 miles) downstream, approach the 5 ppm adequacy limit set by EPA (EPA 1976), use of the New River areas upstream of Seeley will be severely restricted (Setmier 1979). The rock weir at Seeley may also impede fish movement upstream and further restrict upstream habitat use. Impacts of decreased water level on seven other lesser utilized sport fish species not restricted by habitat are not known. The major effect of water withdrawal on fishes of the Salton Sea will be through increased sea salinity and resultant decreased fish reproduction as the result of removal of 6.2×10^7 m^3 (50,000 acre-ft) per year of dilutional flow.

Monitoring of surface water quality and instream flow at the Clark Road site will occur as part of the SWRCB permit requirements for water withdrawal. This monitoring will insure compliance with instream flow limits and any water withdrawal restrictions placed on the applicant as the result of these studies. The instream flow studies will be conducted prior to issuance of the water withdrawal permit. The SWRCB in the May 15, 1980 decision retained jurisdiction over the New River water (sect. 7.5.4). This decision insures monitoring and any necessary mitigation measures determined necessary by the SWRCB or the Department of Fish and Game if flow from Mexico or agricultural drainage decreases and is determined to be inadequate to maintain sufficient aquatic habitats in the New River. If, during permitting, a use-need is determined for the New River, the California Department of Fish and Game (DF&G) may be asked to provide consultation or mitigation measures (Turner 1980).

The biota in the Salton Sea will be protected to some extent by the instream flow requirements to be established for the New River. As time and funds permit, the DF&G presently conducts a population survey and toxic materials survey every one to two years in the Salton Sea. Depending upon monitoring and potential mitigation measures in the New River, if salinity increases to or flow decreases to unacceptable water quality and biotic habitat levels, the impacts on biota of the Salton Sea may be in part mitigated by measures in the New River. At this time it is not known what efforts will be made to protect the biota of the Salton Sea as salinity of the sea increases (sects. 4.3 and 4.4).

7.5.4.3 Rare and endangered species

The only potential effects on rare or endangered species from development to 500 MWe are related to the diversion of 6.2×10^7 m^3 (50,000 acre-ft) of New River water and possible ramifications on fresh-water marshes at the New River delta that are breeding habitats for the yuma clapper rail and the California black rail. The populations of these species are presently monitored by the DF&G and by the U.S. FW clapper rail recovery team. The diversion would be occurring in phases as power plants are brought on-line, and monitoring and mitigation will be built into the SWRCB permit (Sect.7.5.3) to insure that possible adverse effects that may be linked to the diversions will be avoided by ceasing further withdrawals.

No direct impacts to the endangered desert pupfish are anticipated as the result of full-field development. Although salinity of the Salton Sea will increase as additional plants are brought on line, the pupfish should not be directly effected, since the species has been shown to live in waters with salinities that vary from that of fresh water to two times that of sea water (68 ppt) (Barblow, 1968). However, additional information on survival of food sources and competing species at increased salinities must be known before it is possible to determine that there will be no impacts to the pupfish population in the Salton Sea and its tributaries.

7.5.5 Air resources and quality

The Heber geothermal field is projected to eventually produce 500 MWe of generating capacity of which 50 MWe to 100 MWe will be binary plants and the remainder dual-flash plants. The individual power plants should be either 50-MWe or 100-MWe plants and will generally be located at least 0.8 km (0.5 mi) from each other. Because the greatest air quality impacts occur within 0.8 km (0.5 mi) of the cooling tower, there should be no significant cumulative impacts of more than one plant compared to the impact of a single plant. The H_2S impact of a dual-flash power plant has been established as minimal and occurs extremely close to the tower (EIR 1979). The drift deposition from a dual-flash plant is one to two orders of magnitude less than from a binary plant because of the quality of the makeup water used. The drift deposition from two 50-MWe binary plants will not produce a maximum deposition significantly different than a single plant, but the impacts that do occur will be more widespread. In other words, an annual deposition of 35.0 g/m^2 of salt occurring over 8.2×10^4 $m^2$of land for one plant would become 35.0 g/m^2 of deposition over 1.6×10^5 m^2 for two plants. Other impacts such as fogging, icing, and particulate concentrations should be minimal for full-field development, as they are for a single facility.

7.5.6 Noise

Predicted noise impacts of full-field development are given in EIR (1979). Though there would be a slight increase in the area's ambient noise, the minimal levels anticipated would fall within acceptable ranges of U.S. Department of Housing and Urban Development guidelines and the noise standards of Imperial County.

7.5.7 Socioeconomics

7.5.7.1 Population

The estimated work force required for full-field development includes a peak construction force of 613 workers and 187 workers for both power plant and support operations. The temporary construction force will peak during 1985 through 1987 with 60% of these workers being nonlocals, which equates to 367 employees. It is anticipated that these nonlocal construction workers will not bring their families with them. These workers will reside in rental housing, trailers, or recreational vehicles and normally return to their homes in Yuma or San Diego during weekends.

A majority of the operational work force can be supplied by the local labor force. The nonlocal contribution to the operation work force will be 88 people, which is insignificant in light of the overall population growth expected for the region.

The most significant population impact will be the temporary addition of workers associated with the construction periods of the project. These impacts will occur over the eight-year development period . Timing of construction projects should be phased evenly so duplication of construction crews is unnecessary. Training programs to increase qualifications of the local labor force would reduce the need for nonlocal labor.

7.5.7.2 Economic effects

Income generated by employment from the project will be potentially available for spending in the local economy. Nonlocals who retain their permanent residency outside the region will probably spend a major portion of their construction wages outside of the county.

The purchases of material and services made in the local area will be subject to retail sales tax. Taxes will be levied by the county on the power plants, the land owned by geothermal developers, the production wells, and the pipeline system (EIR 1979). The costs incurred by local governments in providing services will be most severe at the height of the construction period. Extra taxes generated by the geothermal development should help considerably to defray these costs of providing public services and facilities because they are expected to be minimal.

The positive economic effects from the project will outweigh the costs incurred. Thus, no mitigation measure would be necessary.

7.5.7.3 Housing

The impact of the proposed project will have a pronounced effect on the demand for temporary housing. The types of housing that will be required in the vicinity of the project area include: motels, mobile home parks, recreational vehicle campgrounds, and conventional rental units. Because of the housing shortage and crowded conditions in the existing housing stock, it will be difficult to obtain housing in the area. This situation may improve somewhat because builders are currently planning new construction in the El Centro area when interest rates decline. This planned construction would ease the demand placed upon the housing market by the relatively small number of new permanent residents associated with the project.

The potentially adverse impact upon the housing market, especially during peak construction periods, may be mitigated by a coordinated planning effort involving both the project developers and county and local officials. Local governments may also seek energy development impact grants to construct the types of housing and facilities suitable for a fluctuating work force. Even without the geothermal development, the addition of temporary housing would ease the existing shortage in temporary housing created by the demands of the seasonal farm laborers, border crossing traffic, and tourists.

7.5.7.4 Community services and facilities

Both project construction and additional generating capacity could facilitate growth and industrialization in the area and increase the demands on public services. Expansion of some local infrastructure is already planned, and capacities of most are expected to be adequate to absorb the impacts caused by the full-field development. Schools are the public facilities most likely to be inadequate to accommodate expected growth. Otherwise, impacts of the project should be beneficial to provision of community services through infusion of tax dollars received from expanded economic activity. Other mitigation measures entail Federal and/or State assistance to make up shortages in community services. Temporary solutions (e.g., use of modular, temporary classrooms) could be used due to the impermanency of the project action. Also, a planned dispersion of workers' families throughout a reasonable commuting area would spread and diminish the impacts upon any single school district or unit of local government. Phasing of construction would have a similar effect.

7.5.7.5 Transportation systems

Commuter traffic and moving of heavy equipment in the project area would increase, especially during construction. Roadways would deteriorate more quickly, requiring more maintenance than presently.

Mitigation measures could include car-pooling of drilling and construction crews and staggered shifts for workers. Heavy equipment could be left at the construction site as much as possible, further minimizing the impact on area roads and resulting maintenance expense.

7.5.8 Cultural resources

The absence of documented archaeological resources or historic sites in the project area precludes any expected impacts.

7.5.9 Aesthetics

Because of the flat terrain of the project area and the physical nature of the proposed project, the impact on visual resources in the immediate project area will be considerable. The greatest impact will be perceived from the local perspective, with regional impacts derived largely from the effect on vistas across the section of the valley containing the project area. However,the development would not constitute a consumption or disruption of unique or irreplaceable visual resources.

Many visual impacts will be temporary, such as the intrusion of the vertical drilling rigs into an otherwise uninterrupted horizontal landscape. There are already some vertical intrusions in the environment, such as telephone and utility poles and occasional trees.

Well and production island design can be engineered to minimize the visual impacts by keeping as close to grade level as possible.

Cooling towers and evaporative steam plumes at the power plant would cause the most significant visual impact. When visible, these steam plumes may range from 15.2 to 30.5 m (50 to 100 ft) in height from the tops of the 15.2m (50 ft) tall cooling towers. Other necessary facilities at the site would be comparatively low profile.

Electrical power to be transmitted along the existing Imperial Irrigation District transmission corridor along Dogwood Road would generate no new impact.

All impacts are somewhat mitigated by the project's distance from major population centers.

REFERENCES FOR SECTION 7

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8. REGULATIONS AND PERMIT REQUIREMENTS

8.1 INTRODUCTION

Applicable environmental laws, regulations, executive orders, and other types of guidance were identified (1) by using procedures identified in the Draft Environmental, Safety, and Health Requirements Document (GEVR)(U.S. DOE 1980), (2) by reviewing the EIRs (EIR 1978 and EIR 1979), and (3) by consulting with SDG&E and federal, state, and local agencies.

8.2 FEDERAL REQUIREMENTS

Federal requirements that apply specifically to this project are listed below. Summaries of these requirements are contained in the GEVR (U.S. DOE 1980).

8.2.1 Federal laws

1. Archaeological and Historic Preservation Act of 1974 (P.L. 93-291)
2. Safe Drinking Water Act of 1974 (P.L. 93-523 and amendments)
3. Federal Water Pollution Control Act of 1972 as amended by the Clean Water Act of 1977 (P.L. 92-500 and amendments)
4. Rivers and Harbors Act of 1899 (33 U.S.C. 401 et seq.)
5. Soil and Water Resources Conservation Act of 1977 (P.L. 95-192)
6. Endangered Species Act of 1973 as amended (P.L. 93-205 and amendments)
7. Fish and Wildlife Coordination Act of 1934 (P.L. 121 and amendments)
8. Clean Air Act of 1963 as amended (42 U.S.C. 7401 et seq. and amendments)
9. Noise Control Act of 1972 (P.L. 92-574 and amendments)
10. Non-Nuclear Research and Development Act of 1974 (P.L. 93-577)
11. Resource Conservation and Recovery Act of 1976 (P.L. 94-580)

8.2.2 Federal regulations

1. Prevention of Significant Deterioration Regulations – EPA
2. Underground Injection Control Regulations – EPA
3. Hazardous Waste Disposal Regulations – EPA
4. Interagency Cooperation Regulations (Fed. Reg. 1978)

8.2.3 Executive orders

1. E.O. 11514, "Protection and Enhancement of Environmental Quality"
2. E.O. 12088, "Federal Agency Compliance with Pollution Abatement Regulations"

8.2.4 Other Federal guidance

1. Council on Environmental Quality, Analysis of Impacts on Prime and Unique Farmland in Environmental Impact Statements (Aug. 30, 1976)
2. The United States Water Resources Council (WRC) prepared a Water Assessment Report under the provisions of Section 13 (b) of the Federal Nonnuclear Energy Research and Development Act of 1974 (PL 93-577). The WRC report was published in the Federal Register on July 25, 1980, and states that no significant water impacts will result from the project. The Division of Geothermal Energy has reviewed the WRC report and concurs in its findings.

8.3 STATE AND LOCAL REQUIREMENTS

Applicable State of California and local requirements are listed below.

8.3.1 State of California requirements

1. California Endangered Species Act of 1970
2. California Native Plant Protection Act of 1979

3. California Environmental Quality Act of 1970
4. California Division of Oil and Gas, Requirements for Drilling and Operating Geothermal Wells in California
5. California Laws for the Conservation of Geothermal Resources
6. California Regional Water Quality Control Board, Effluent Discharge Permit

8.3.2 Imperial County requirements

1. Land use change for geothermal overlay zone (completed)
2. Building permit
3. Road Department permit
4. Fire safety permit
5. Environmental Health Division permit
6. Geothermal production permit

8.3.3 Imperial County Air Pollution Control District requirements

1. Rule 207 _ New Source Review; Permit to Construct
2. Rule 208 _ New Source Review; Permit to Operate
3. Rule 401 _ Emissions Opacity
4. Rule 403 _ Emissions Quantification
5. Rule 407 _ Nuisance

REFERENCES FOR SECTION 8

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U. S. DOE 1980. Draft Environmental, Safety, and Health Requirements Document, Vols. 1 and 2.

9. LIST OF PREPARERS AND THEIR QUALIFICATIONS

This Environmental Assessment was prepared by ORNL with the assistance of Radian Corporation and Henningson, Durham and Richardson for the Division of Geothermal Energy of the U.S. Department of Energy. ORNL staff and consultants contributing to this report are listed below.

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10. AGENCIES CONTACTED DURING PREPARATION OF THE ENVIRONMENTAL ASSESSMENT

The Federal, State, and local agencies listed below were contacted during preparation of this Environmental Assessment to

1. aid in the verification of information presented in EIR No. 213-79, the Final Master Environmental Impact Report for the 500-MWe Geothermal Development at Heber, Imperial County, California and EIR No. 170-77, the Final Environmental Impact Report for the Heber Geothermal Demonstration Project;
2. obtain more current information than that presented in the referenced EIRs; and/or
3. obtain additional new information on topics not addressed in the referenced EIRs.

Federal

U.S. Department of the Interior – USGS, Water Resources Division and Office of Earthquake Studies
– Fish and Wildlife Service

U.S. Department of Agriculture – Soil Conservation Service
U.S. Salinity Laboratories at Brawley and Riverside, CA.

U.S. Department of Commerce – Bureau of Economic Analysis

U.S. Environmental Protection Agency

U.S. Department of Housing and Urban Development – Federal Insurance Administration

State of California

Division of Fish and Game

Division of Oil and Gas

Regional Water Quality Control Board – Colorado River Basin Region

Department of Parks and Recreation

California Energy Commission

Division of Mines and Geology

State Department of Finance

<u>County of Imperial</u>

Planning Department

Department of Public Works

Tax Assessor and Collection Office

Air Pollution Control District

Office of the Agriculture Commission

Audit Department

<u>Other Agencies and Organizations</u>

Imperial Irrigation District

Lawrence Livermore Laboratory

City of El Centro - Community Development Office

El Centro Chamber of Commerce

Heber Utility District

Central Union High School District

Heber Elementary School District

APPENDIX A

MINIMUM RESERVOIR CRITERIA

APPENDIX A – MINIMUM RESERVOIR CRITERIA

Minimum Reservoir Criteria

The objective of this section is to establish a set of minimum conditions that must be met in order for a hydrothermal (hot water) reservoir to qualify as a demonstration site for a 50 MWe geothermal binary power plant.

a. Mean reservoir temperature should be greater than 150°C (300°F) and less than 200°C (392°F).

A minimum reservoir temperature is chosen because current state of conversion technology does not permit economic power production with geothermal fluids cooler than 150°C. In actual practice the temperature must be higher than 150°C for near-term competitive power. A maximum temperature is selected because high temperature reservoirs are not representative of the large moderate temperature hydrothermal resource of the U.S. About 80 percent of the identified geothermal resources for electrical production are in the 150°C to 200°C temperature range.

A maximum reservoir temperature is also chosen because current state of geothermal downhole pump technology does not allow placement at depths greater than 1000 feet. At well head depths of 1000 feet, the static hydraulic head is at a maximum of 433 psi. A NPSH requirement of approximately 100 psi must be met to ensure that there will be no cavitation in the intake of a pump operating in this environment. This means that the maximum geothermal fluid saturation pressure must be less than 333 psi which requires a fluid temperature of less than 220°C (saturation temperature at 333 psi) to prevent vapor from causing pump cavitation. In actual practice, depending upon the amount of noncondensible gases in the fluid and limitations of pump bearings and seals, temperatures less than 200°C will be limiting.

b. Salinity of the geothermal fluid should be less than 50,000 ppm.

High salinity will cause excessive scaling and corrosion (fouling) of the binary system heat exchangers and extensive spent fluid processing prior to injection.

c. Depth of the reservoir should be less than 10,000 ft (3.1 km) and wells should have a minimum flow rate of 700 gpm when pumped.

A very sharp rise in well drilling cost occurs at depths greater than 10,000 ft and the drilling cost per MWe capacity increases substantially with well flow rates of less than 700 gpm.

d. The reservoir should be large enough to support significant development potential (J150 MWe) for 30 years or more.

Significant development potential and minimum reservoir life is required for capital amortization purposes.

e. Demand for power and identified utility interest should exist in the region.

Major transmission lines are uneconomical below 500 kva capacity and new lines present significant environmental and permitting problems. Without utility interest the resource cannot be developed.

f. Adequate supplies of cooling water should be available, at least for the near term.

Dry cooling towers and combination wet-dry cooling towers are not viable alternatives in the near term for binary plants because the cost of a power plant increases at least 50 percent over the cost of a plant employing wet cooling towers.

g. There should appear to be no overriding environmental or socio-economic constraints.

Significant environmental or socio-economical constraints could delay or prevent proceeding with the demonstration.

h. There should exist adequate data upon which to base reliable estimates of reservoir size, production, and injection characteristics.

Without adequate development and sufficient wells drilled and tested, the above minimum conditions cannot adequately be addressed and a successful demonstration would be questionable. If the demonstration failed due to an inadequate reservoir, it would substantially retard development of geothermal energy.

Existing Reservoir Evaluation

This section evaluates all the known hydrothermal (hot water) reservoirs against the minimum reservoir criteria. In USGS Circular 790, "Assessment of Geothermal Resources of the United States - 1978," all the known resources that have estimated temperatures greater than 150°C are listed with their known characteristics (Circ. 790, Table 5).

a. Resources too high in temperature (J200°C) and/or salinity (J50,000 ppm TDS) to qualify for the binary demonstration site.

No.	Resource Name		Mean Reservoir Temperature, °C	Fluid Salinity ppm TDS
018	Geyser Bight	(A,B)	208 ± 20	No data
041	Morgan Springs	(A,B)	217 ± 15	No data
056	Long Valley Caldera	(B)	227 ± 10	No data
057	Coso area	(B)	220 ± 11	J5,000
064	Salton Sea area		323 ± 8	J200,000
064A	Westmorland	(B)	217 ± 7	J50,000
065	Brawley		253 ± 10	J100,000
084	Kamailli Homesteads	(B)	273 ± 12	No data
085	Kapoho Reservoir	(A,B)	275 ± 11	No data
148	Desert Peak area	(B)	221 ± 5	No data
151	Humboldt House	(A,B)	217 ± 16	No data
162	Beowawe Hot Springs	(A)	229 ± 8	No data
171	Valles Caldera		273 ± 8	F10,000
184	Newberry Caldera	(B)	230 ± 20	No data
196	Hickey Hot Springs	(B)	205 ± 10	No data
209	Roosevelt Hot Springs		265 ± 8	F10,000
215	Yellowstone Caldera	(C)	267 ± 14	No data

Notes:
A Less than 150 MWe for 30 years
B Lack of adequate well data
C Area withdrawn from commercial exploration

Resources with electrical energy potential of less than 150 MWe for 30 years and/or lacking adequate wells or well data (applicable resources from the previous table are not repeated).

No.	Resource Name		Electrical Energy MWe for 30 Years	Well Data No. of wells/depth
017	Hot Springs Cove	(D)	27	No wells
027	Bailey Bay Hot Sprgs	(D)	26	No wells
029	Power Ranches Inc.	(D,E)	23	2 - 3 km
035	Surprise Valley	(D,E)	1490	8 - 2 km
046	Sulphur Bank Mine	(E)	75	4 - 1.2 km
047	Clear Lake Volcanic Field	(E)	900	3 - 3 km
058	Rondsburg area		84	1 - 0.2 km
070	Border	(D)	31	No wells
078	Paradise Hot Sprgs	(D)	24	No wells
083	Steaming Flats	(D)	No estimate	No wells
093	Crane Creek-Core Creek	(E)	340	2 - 0.6 km
105	Big Creek Hot Sprgs	(D)	26	No wells
130	Baltazar Hot Sprgs	(D)	46	No wells
132	Pinto Hot Springs		90	1 - F1 km
137	Great Boiling Sprgs		32	1 - 0.2 km
138	San Emedio Desert		28	No wells
141	Steamboat Springs	(E)	350	6 - F0.6 km
143	Lee Hot Springs		28	No wells
144	Soda Lake	(D,E)	146	2 - 1.3 km
145	Stillwater area	(D,E)	450	1 - 1.3 km
146	Fernley	(E)	33	3 - F0.3 km
147	Brady Hot Springs	(D,E)	157	13 - F2.3 km
152	Kyle Hot Springs	(D)	97	No wells
154	Leach Hot Springs	(D)	77	No wells
164	Hot Sulphur Springs	(D)	27	No wells
190	Crump's Hot Springs		61	1 - 0.2 km
197	Alvord Hot Springs		49	No wells
198	Hot (Borax) Lake area		91	No wells
199	Trout Creek area	(D)	24	No wells
203	Neal Hot Springs		36	No wells
204	Vale Hot Springs	(D)	870	No wells
208	Cove Fort-Sulphurdale	(E)	330	3 - F2.3 km
213	Gamma Hot Springs		27	No wells

Notes: D Marginal mean reservoir temperature
E Lack of significant well production or injection data

c. Resources potentially qualifying for the binary demonstration power plant site.

There are only two known resources that have the potential of meeting the established reservoir criteria for the binary demonstration plant. These are Heber and East Mesa, both of which are located in the Imperial Valley of California.

East Mesa

East Mesa has a mean temperature of 182 $\pm$ 7°C, a water salinity of 2,000-28,000 ppm TDS and an electrical energy potential of 360 MWe for 30 years, and over 25 wells between 0.9 and 2.8 km deep have been drilled and tested.

East Mesa field development is presently being carried out by Republic Geothermal, Inc., under a Federal loan guaranty from the Bank of America and by Magma Power Company under private financing. Magma is constructing an 11.2 MWe (net) hybrid binary power plant, scheduled for operation in 1979. San Diego Gas and Electric (SDG&E) has agreed to buy all the elctricity produced by the plant. New Albion Resource Company (NARCO), a subsidiary of SDG&E, has completed a trade with Magma Power that gives SDG&E first call on all power developed on the Magma/NARCO leases at East Mesa (165 Mwe).

Republic Geothermal under the loan guaranty has initiated design of a flash-steam power plant. The plant will consist of a 10 MWe generator installed in 1980 and 50 MWe generator installed in 1981. SDG&E will operate the plant for Republic. Electricity from the plant will be purchased by the Imperial Irrigation District (IID).

Union Oil Company of California also owns leases at East Mesa but presently has not initiated any field development.

Heber

Heber has a mean reservoir temperature of 175 ± 5°C, a water salinity of 12,000-20,000 ppm TDS and an electrical energy potential of 650 MWe for 30 years, and over 15 wells between 0.6 and 3.1 km deep have been drilled and tested.

Heber field development is presently being undertaken by the three lease holders, Chevron, Union, and NARCO, with Chevron as Unit Operator. They plan to jointly produce this resource in commercial quantities to its maximum capacity. In May 1978, SDG&E was granted by the County of Imperial as lead agency under the California Environmental Quality Act, a Conditional Use Permit (CUP) to build a 45 MWe net binary demonstration plant. At the same time, Chevron was granted a CUP to construct and operate the geothermal production and injection facilities for the power plant. Concurrently, a special 7,320-acre (2,957 ha) G-Overlay Zone was created to allow geothermal development at the Heber field. The environmental effects of these actions are addressed in Imperial County EIR #170-77. SDG&E has exercised its option to purchase the 50-acre site for the binary plant and a follow-on unit. Southern California Edison (SCE) is also applying for a permit to build a 45 MWe net flash-steam power plant at Heber. They plan to have the plant in operation at the same time as the binary demonstration plant. SCE, based on informal conversation, is not interested in building the first commercial binary plant because of the perceived risks, but has contributed to the proposed plant and would like to compare results for future resource expansion. The County of Imperial has issued and approved a Master EIR (#213-79) for up to 500 MWe of flash and binary power plant development at the Heber reservoir.

The development as envisioned in the Master EIR would consist of a series of geothermal power plants (seven are planned at this time for a total of 500 MWe), with a sufficient number of production and injection wells to produce geothermal fluid for the power plants and to return the spent fluid to the geothermal reservoir from the Geothermal (G) Overlay Zone near Heber. Since the power generation process will consume a portion of the geothermal fluid produced, the project also includes proposed facilities to withdraw, treat, and inject water from the New River into the geothermal reservoir. Thus, as required by The Imperial County Geothermal Element of the General Plan, the same amount of fluid produced from the geothermal reservoir will be injected back into it.

In conjunction with this development envisioned in the Master EIR, the County of Imperial, as lead agency under the California Environmental Quality Act, has acted on the following: (1) a CUP application by SCE to construct and operate a 45 MW dual flash cycle geothermal power plant; (2) an amended CUP application by SDG&E to construct and operate either a 45 MW binary cycle or a 49 MW dual flash cycle geothermal plant; (3) a CUP application by Chevron to construct and operate the supporting production and injection facilities, and water treatment/injection facilities.

The water treatment/injection facilities will resemble a waste water treatment plant. To support 50 MW of capacity, 50,000 (62 hm) acre-feet of water would be diverted annually from the New River at the Clark Road facilities site. The diverted water would be treated and used as cooling tower or injection makeup. As part of a separate contingency plan, up to 20,000 acre-feet/year (24.7 hm) of water could be diverted from the New River at the Drew Road Crossing to supply the requirements of SDG&E facilities. Under any conditions, the maximum annual diversion of water would be 50,000 acre-feet (62 hm).

The wells to be drilled for the proposed geothermal development would be similar to a number of other geothermal wells already drilled at Heber and other areas of the Imperial Valley. To minimize the use of land, the wells will be clustered on "islands" at the surface and will be "directionally drilled" outward from these islands. Production wells will be located adjacent to the power plant they supply; injection wells will be 1 to 2 miles (1.6 to 3.2 km) distant, connected to the power plants by fluid transmission pipelines.

Power from the initial plants would be fed into existing power transmission lines, which might require some upgrading. Eventually, as more plants are developed, an additional large transmission line across the Imperial Valley would be required. The environmental effects of the new transmission line are addressed in another EIR (#223-79) being prepared by Imperial County.

APPENDIX B

ALTERNATIVE METHODS OF BLOWDOWN DISCHARGE*

*Source: SDG&E letter dated May 12, 1980.

APPENDIX B – ALTERNATIVE METHODS OF BLOWDOWN DISCHARGE

After the first five years of plant operation an alternative source of make-up water may be required. As detailed in Response No. 4 the most likely alternative sources of water are New River water and agricultural drain water. Since blowdown concentrations using these sources will be around 20,000 ppm, discharge to surface waters will be prohibited.

Several alternative methods of blowdown discharge exist. Although a specific method has not been determined the following methods are possible.

1. Discharge to Saline Bodies of Water

Return of blowdown to other bodies of water, such as the Gulf of California or Salton Sea, is considered technically and economically unfeasible due to the lengths of pipeline required.

2. Retention in Evaporation Basin

Discharge of the blowdown to an evaporation basin of 84 acres is an alternative for the Heber Binary Plant. This practice is employed in similar applications for discharge of cooling tower blowdown and other liquid waste in arid areas where high evaporation rates offer an economical means of liquid disposal.

Location

The site would be located in a geologically stable area which would be suitable for construction of an evaporation basin. The evaporation basin will be located so as to minimize impacts on current land uses. The probable location would be in the undeveloped desert area approximately nine miles west of the Heber site. A 3.5-inch diameter underground pressurized pipeline would be required to convey the blowdown to this area.

The evaporation basin area is sized to allow for continuous evaporation of blowdown while the volume of the basin is sufficient to retain all of the solids accumulated during the life of the plant. An 88 inch per year evaporation rate for the blowdown was calculated by derating the average evaporation rate typical of the Heber site (113 inches per year) to account for salinity (approximately 25% at saturation) and rainfall (3 inches per year). With a yearly average blowdown flow rate of approximately 470 gallons per minute (gpm) from the unit, the total evaporation basin area will be 85 acres. The accumulation of salts during each year of plant operation will be approximately 660,000 cubic feet. This assumes a dry salt density of 50 pounds per cubic foot which is a conservative estimate of the salt density. The depth of the basin required to retain all the solids over a 25 year plant operating life is eight feet including a three foot freeboard allowance.

Liners

A liner of sufficient impermeability would be installed along the bottom of the basin and inside the perimeter dikes to isolate the brine solution and, thereby, prevent contamination of surface water or groundwater.

Synthetic membranes, asphaltic concrete, and compacted clay are among the materials which would be considered as liners for the evaporation basin. Laboratory permeability test data for polyvinyl chloride (PVC), chlorinated polyethylene (CPE), Hypalon, asphaltic concrete, and compacted clay have been obtained from laboratory studies by others (2), (3), (4), and are listed in Table 3 in order of increased permeability. These values range from a low of 10^{-12} centimeters per second (cm/sec) for typical synthetic liners (Hypalon, PVC, CPE) to 10^{-8} cm/sec for a high quality compacted clay liner.

A. Synthetic Membranes

Synthetic membranes (PVC, CPE, Hypalon) are installed in sheets, typically 20 to 30 mils thick. These are available in both reinforced and unreinforced types.

A PVC membrane could be used to line the basin, provided the membrane is covered by at least a foot of soil. The soil cover prevents embrittlement of the liner by protecting it from sunlight, heat and wind. The soil cover must be placed carefully to prevent damage to the liner.

CPE and Hypalon are much more resistant than PVC to weathering and are usually left exposed unless there is danger of mechanical damage to the liner. CPE and Hypalon could be left exposed on the bottom of the basin which would soon be covered by salts and water. The liner on the slopes would be protected by a gravel cover. Slopes would be graded to 3:1 to prevent sliding of the gravel placed over the liner.

A recent example of a large scale application of synthetic liners is that of a paper mill in Florida, where 30 mil Hypalon was used to line a secondary treatment aeration lagoon having an area of 120 acres.

B. Asphaltic Concrete Liner

A 4-inch thick asphaltic concrete liner could be used to line the slopes and base of the basin. The interior slopes of the dikes would probably be 5:1 to allow placement and compaction of the mix in the direction parallel to the dike crest. Compaction in this direction provides a tighter seal at the joint between adjacent lanes of asphalt. This design was used successfully at a 50-acre evaporation basin recently constructed by an electric utility in Nevada.[(3)]

Table 3. Permeability Coefficients of Typical Liner Material

Material	Approximate Permeability Coefficient (cm/sec)
Synthetic liner materials (Ref. 2)	
PVC	10-12
CPE	10-12
Hypalon	10-12*
Asphaltic concrete, 8.5 percent asphalt by weight, compacted to 97% Marshall density (Ref. 3)	10^{-9}
Moderately plastic clays, compacted to void ratios of 0.2 to 0.50 (Ref. 4)	10^{-8}

Note:
*Data available for CPE, which is practically the same formulation as Hypalon.

C. Compacted Clay

Compacted clay would be an effective liner provided:

1. Permeability of the compacted clay is low;

2. Ion exchange properties are favorable (i.e., the clay will not become more open and permeable in a saline environment);

3. The moisture content of the compacted clay liner can be controlled to prevent drying and cracking of the liner prior to the start of blowdown.

A program of field investigations and laboratory tests would be required to document the availability of a suitable clay source. The dikes of a clay-liner basin would probably have 5:1 interior slopes to allow placement and compaction equipment to operate parallel to the crest of the dikes and to help dissipate wave energy. The slopes would be covered with gravel to prevent erosion of the liner. At an electric generating station near Barstow, California, compacted clay was used to line five evaporating basins with a total area of 130 acres. The clay liner is covered by 8 to 10 inches of gravel ranging from 1 to 6 inches diameter.[6] Cracking of the liner was prevented by saturating a one-foot thick sand layer placed over the clay. Field observations showed the treatment would prevent cracking for a period of about four months. The operating instructions for those basins require that no basin is to be left dry for more than two months.

Construction

Construction of the evaporation basin will consist of two main activities: excavation and fill placement required to prepare the bottom of the basins and the dikes forming the basin perimeters and installation of the basin liners.

The natural soils in the basin area could be used to construct the base and dikes of the basin. Water would be added to these soils during placement to ensure adequate compaction.

The interior slope of the dikes would be approximately 3:1 if a synthetic liner were selected, and 5:1 if an asphaltic concrete or compacted clay liner were selected. The flatter slopes for the asphaltic concrete or clay liner would permit better and faster compaction by allowing the compaction equipment to travel parallel to the dike crest. The exterior slopes would probably be 3:1 in all cases.

The dikes surrounding the evaporation basin will be designed to withstand the effects of earthquakes. For final design of the basin slopes, field investigations will be performed to determine the subsurface conditions beneath the proposed dikes, and laboratory soil tests will be performed to determine the static and dynamic properties of the soils to be used in dike construction. Static and dynamic analyses will then be performed to assure that the dikes will have an adequate factor of safety.

The permeability of the evaporation basin liner with respect to the blowdown will be carefully investigated prior to and during construction. For an asphaltic concrete liner, samples containing various asphalt percentages would be compacted to a range of densities and tested for permeability. A similar program would be employed to test compacted clay samples with the additional requirement that the tests be conducted over a sufficiently long time to allow any change in permeability caused by ion exchange. For a synthetic membrane, permeability tests would be performed on samples of representative materials supplied by liner fabricators.

A field quality control program will be employed during installation of the liner to ensure proper procedures are adhered to in placing and compacting the liner material.

Field quality control for a synthetic liner would include inspection of each sheet and thorough checking of every foot of seam to assure proper overlap and bond. All seams would be field tested using a high pressure air jet, and peel tests to check solvent bond would be made on seam strips taken at random. Permeability tests would be performed on representative samples of the installed membrane.

Field quality control during construction of an asphaltic concrete or clay liner would include one or more test sections to determine optimum procedures for placing and compacting the liner material. The asphalt mixing plant would be monitored to assure compliance with the job specification, and field tests would be made to assure the specified density had been achieved. A number of asphaltic concrete cores would be tested for permeability. For a clay liner, the borrow and placement operations would be monitored to assure the material supplied and the as-placed density meet job specifications. A number of undisturbed samples obtained from the liner would be tested for permeability. In addition, a small clay-liner basin would be constructed to observe the length of time that a blanket of initially saturated sand would prevent cracking of the clay.

Operation

A system to monitor groundwater levels and groundwater quality will be installed in the evaporation basin area. The monitoring system will consist of a series of observation wells installed along the basin perimeter and at several locations along interior dikes. Groundwater samples will be obtained from the observation wells prior to discharing blowdown into the basins. The samples will be tested for chemical composition, and the results will be compared to the quality of groundwater samples obtained periodically from the observation wells during operation of the basin. Groundwater levels will also be measured periodically.

The influent flow of blowdown to the basin will be monitored. Test evaporation pans will be installed to measure a water balance of evaporation loss and influence flow.

The pond perimeter will be fenced to exclude entry by animals and unauthorized personnel. The area on the sides and top of the dikes will be kept free of emergent vegetation so as not to attract waterfowl.

Decommissioning

Upon completion of the generating station operational life, the evaporation basin will not receive any additional liquid release. The basins will then be decommissioned in an environmentally acceptable manner utilizing the most practical and economical means available at that time while complying with all existing state and federal regulatory requirements.

The groundwater monitoring system used during the basin operation period will continue to be used for a sufficient period of time to demonstrate the effectiveness of the decommissioning procedure.

3. Injection into Geothermal Reservoir

Injection of conditioned blowdown into the geothermal reservoir is an alternative for the Heber Binary Plant. This practice is employed in similar applications of geothermal power plants at The Geysers and quite extensively in the enhanced oil and gas recovery industry.

Blowdown treatment facilities would prepare the blowdown for injection into the reservoir. The design criteria would be similar to those of the New River Water Treatment Plant, as proposed by Chevron to support the nominal 50 MWe geothermal flash power plant of Southern California Edison (Master EIR, pages II-13 and II-38).

The Chevron water treatment plant will be designed to produce a stable, sanitized and deaerated supply of water which is free of suspended solids (less than two parts per million). The unit operations which may be employed are shown in Figure 2 (Fig. B.1). As indicated in the diagram, water to be treated flows through a trash rack and comminutor to a lift station. Large debris is removed by the trash rack and loaded on trucks for disposal. Large pieces of organic material are chopped up as they pass through the comminutor.

Water is pumped from the lift station to a primary sedimentation tank. Part of the suspended solids settle out in the primary sedimentation tank. A packaged alum feed unit is provided to facilitate

ES-5376

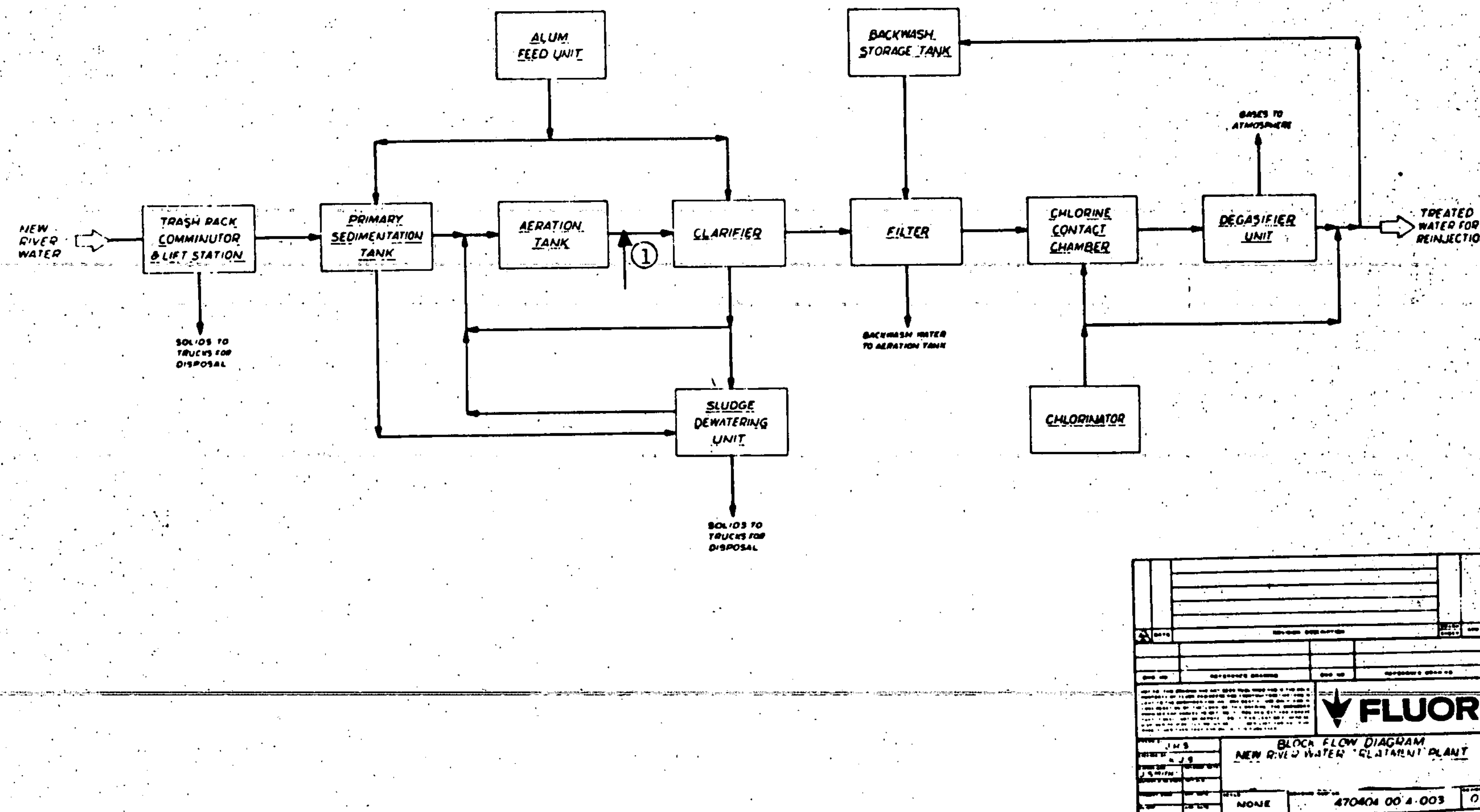

Fig. B.1. Unit operations in the Chevron water treatment plant.

settling out of solids. Effluent water from the primary sedimentation tank flows to an aeration tank, which is sized for a minimum BOD_5 removal of 85 percent.

Aeration tank effluent water flows to a clarifier, where the sludge solids are separated from the water. Settled solids are pumped to the aeration tank for reuse or to the sludge dewatering unit for further treatment. The sludge dewatering unit consists of a preliminary thickener to reduce the water content to 92 percent followed by a vacuum filter to reduce the water content to 70 percent. The sludge from the vacuum filter is loaded on trucks for disposal.

Clarifier effluent water is pumped through filters to a chlorine contact chamber. The filters utilize anthracite and sand media to reduce suspended solids content to two parts per million. Chlorine is injected into the chlorine contact chamber from a chlorinator unit.

The effluent water from the chlorine contact chamber is pumped to a degasifier unit. The degasifier unit reduces dissolved carbon dioxide content to 10-15 mg/l and dissolved oxygen content to 0.2 mg/l and consists of a column packed with Rashig Rings, a vacuum pump, and a degasified water collection sump. Treated water is pumped from the sump to the injection pumps or to a backwash storage tank.

The backwash storage tank has sufficient capacity to supply the water required for one backwash of the operating filters. Backwash waste water is discharged to the aeration tank. The treated water leaving the plant is pressurized for injection into the geothermal reservoir.

After the first five years of plant operation, power plant cooling water will be essentially agricultural drain or New River water which has been conditioned for use in the cooling system where the total dissolved solids are concentrated to about four times the original value. The cooling water has had the great majority of suspended solids removed, been aerated in the cooling tower operation and been chlorinated to prevent biofouling.

Blowdown (max. flow - 1.6 cfs) from the cooling system would be conveyed to the Chevron New River Water Treatment Plant (at the Clark Road crossing of the New River) in an 3.5 inch pressurized underground pipeline. It would be combined with New River water at Point 1 on the block process flow diagram (Fig. B.D). The blowdown can be entered at this stage of the water treatment process because suspended solids removal, aeration and chlorination have already been accomplished. Therefore, the blowdown is a much "cleaner" water than raw New River water.

The addition of this much "cleaner" blowdown into the Chevron treatment plant would have several advantages. The primary benefit would be the reduction in the diversion of New River water needed to support the Chevron/SCE geothermal flash power plant. Since the blowdown is "cleaner", operation and maintenance expenses for the water treatment facility could be reduced.

Laboratory and pilot studies will be necessary to determine the compatibility of the cooling tower blowdown with the New River water prior to combining the two streams in an operating treatment facility. If the tests are successful, the blowdown could be dispersed of as outlined above. If difficulties did arise, the blowdown could be treated in separate facilities and injected into the reservoir in separate wells.

REFERENCES FOR APPENDIX B

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(3) Hinkel, R. D. (Southern California Edison). Impermeable Asphalt Concrete Pond Liner. Unpublished.

(4) Lambe, T. W. and R. V. Whitman, Soil Mechanis, J. Wiley and Sons, Inc., 1969.

(5) Buckeye Develops Unique Solution of Leaky Lagoon at Foley Mill. Pulp and Paper Magazine. October 1975.

(6) Carville, C., (Fugro, Inc.). Personal Communication, February 1976.

APPENDIX C

FLOOD HAZARD AREA WITHIN THE HEBER G-OVERLAY ZONE

(Note: The Floodplain is Indicated by the Darkened Area Along the New River).

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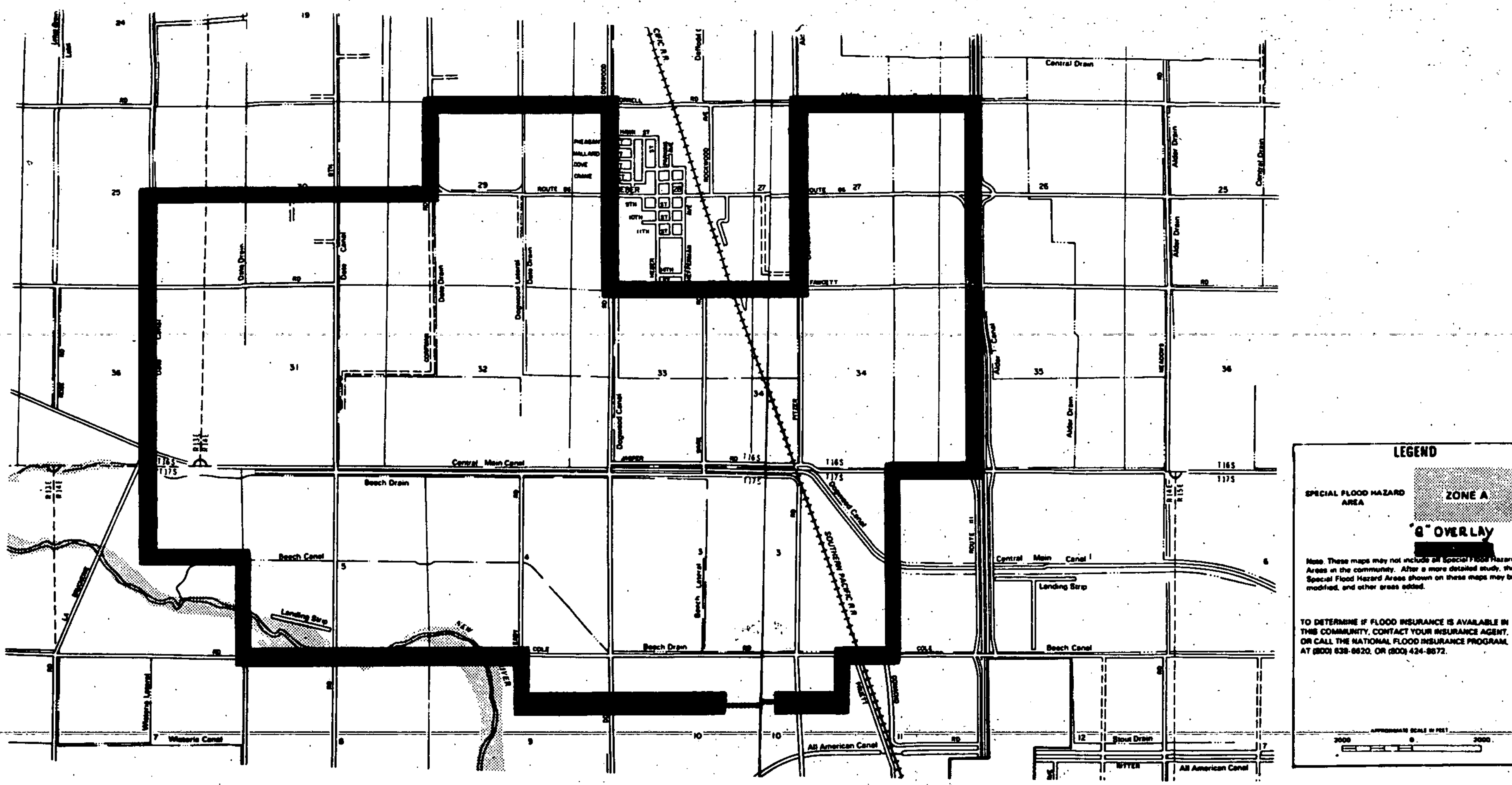


Fig. C.1. Flood hazard area within the G-overlay zone.

APPENDIX D

RESULTS OF DRIFT SALT DEPOSITION AND CONCENTRATION CALCULATIONS

The ORFAD model was run utilizing two sets of meteorological data: two years of surface meteorological data from Blythe, California, on a NOAA weather tape and 12 months of the 22 months of meteorological data collected at the Heber site by SDG&E.* The results using Heber data should be more appropriate, since these data should reflect most closely the local wind, temperature, and humidity conditions. However, the Heber site data was less complete than the Blythe data, with only 79% data recoverability compared to 99% at Blythe.

The estimation of drift deposition and ambient concentration of salt particles was performed for six cases. It was assumed that for the first five years of operation that the TDS content of the drift is equal to the blowdown solids content of 4000 ppm. After five years, the TDS content of the drift was assumed to increase to 20,000 ppm. For each of these two cases three different drift rates were assumed: 0.002%, 0.008%, and 0.1% of the circulating water rate. These three rates can be considered to represent a state-of-the-art drift eliminator, a standard drift eliminator, and no drift eliminator.

Each case was run twice to yield both a near-field view and an expanded view of the impacts. The purpose of the near-field (to 1.5 miles) study was to detail the region where impacts are maximum. ORFAD allows specification of up to 19 deposition distances which lie equidistant between deposition boundaries. The deposition value given by the model at each of the 19 distances is an average value of the deposition for the entire interval between boundaries.

The salt particulate concentrations calculated using the Blythe weather data are given in Figure D.1, Figure D.2, and Table D.1 for the near-field view and in Figure D.3, Figure D.4, and Table D.2 for the expanded view. The maximum impacts occur to the north and northeast of the cooling tower. The maximum impact occurs for the 20,000 ppm and 0.1% drift case. The maximum annual average salt concentration for this case is 250 $\mu g/m^3$ which is well in excess of the annual TSP standard of 75 $\mu g/m^3$. In fact, this 75 $\mu g/m^3$ level is exceeded out to 0.2 miles from the tower. All other cases are below the annual standard, even for the 0.1%, 4000 ppm case. It appears that the very high drift rate of 0.1% is unacceptable when the drift water contains 20,000 ppm of dissolved solids.

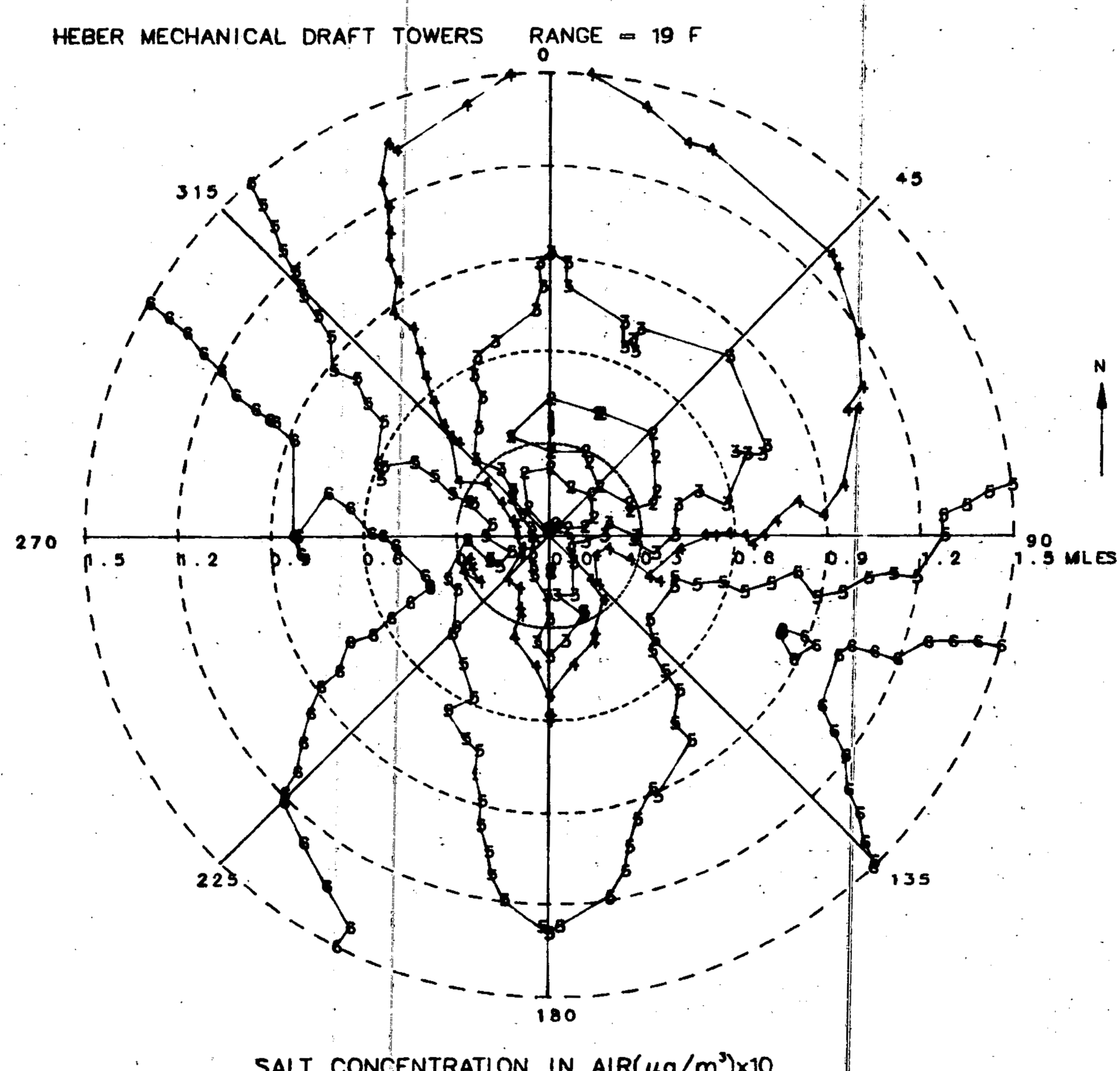


Fig. D.1 Near-field cooling tower salt particulate concentrations in air for the 4,000 ppm case (Blythe weather data).

ES-5283

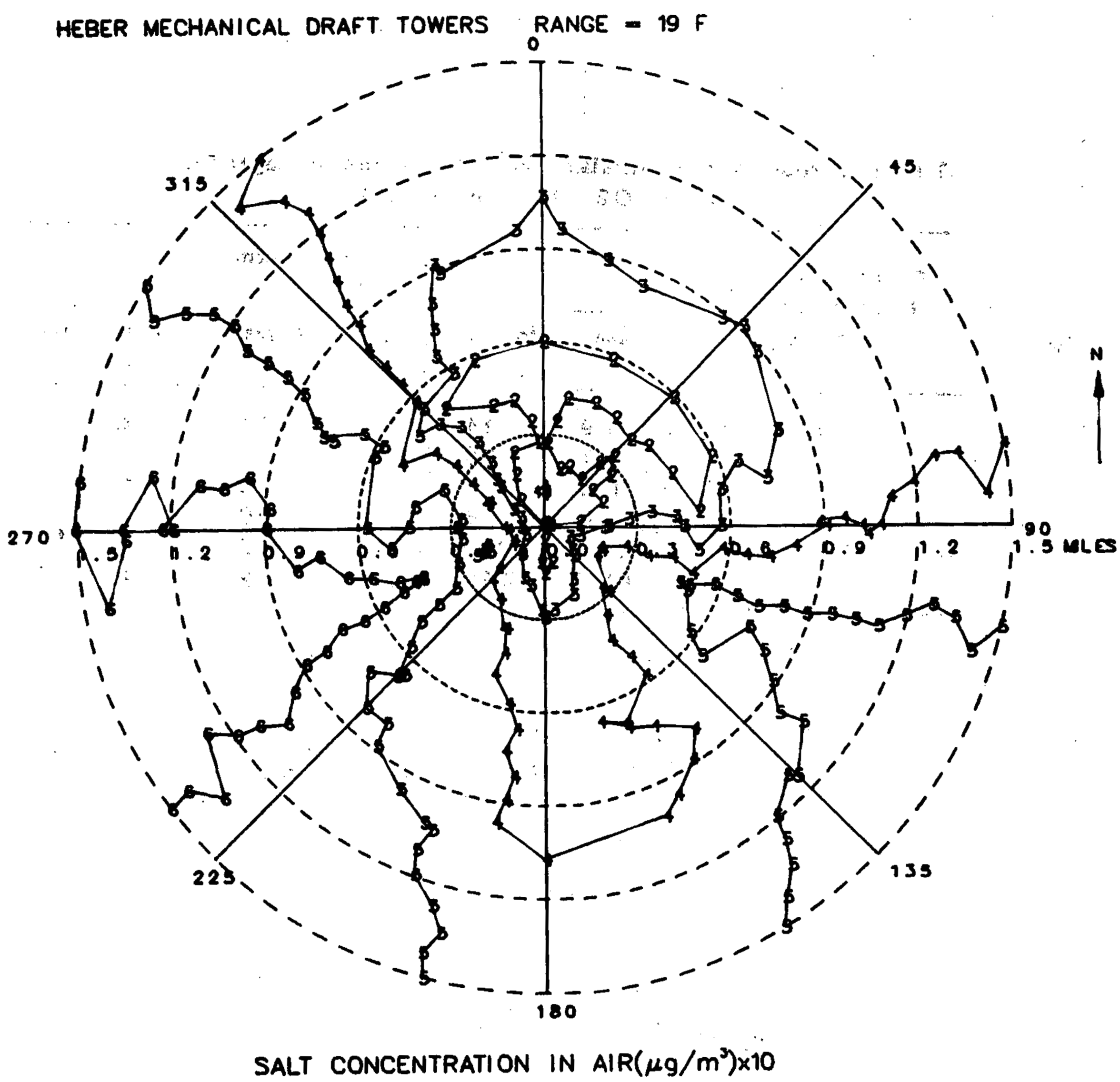
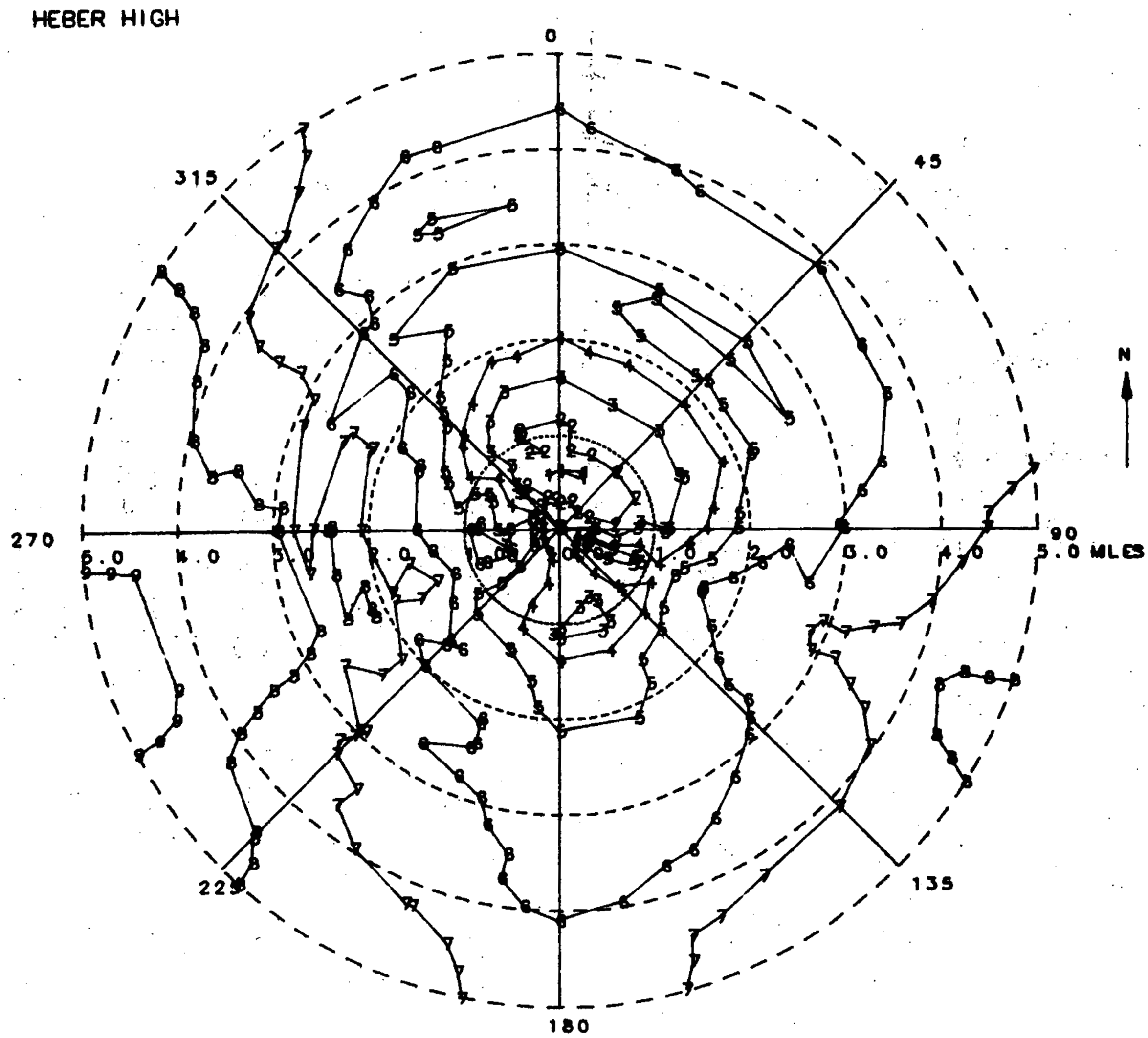


Fig. D.2 Near-field cooling tower salt particulate concentrations in air for the 20,000 ppm case (Blythe weather data).

Table D.1. Near-field salt particulate concentrations corresponding to Fig. D.1 and Fig. D.2 (Blythe weather date)

Period of operation	Cooling water TDS content ppm	Drift rate %	Salt particulate concentration ($\mu g/m^3$)					
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6
First 5 years	4,000	0.002	0.9	0.4	0.2	0.1	0.05	0.02
		0.008	3.7	1.8	0.9	0.5	0.2	0.1
		0.100	45.0	22.5	11.2	5.6	2.8	1.4
After 5 years	20,000	0.002	5.0	2.5	1.2	0.6	0.3	0.15
		0.008	20.0	10.0	5.0	2.5	1.2	0.6
		0.100	250.0	125.0	62.5	31.2	15.6	7.8

ES-5284



SALT CONCENTRATION IN AIR($\mu g/m^3$)x10

Fig. D.3 Expanded view of cooling tower salt particulate concentrations in air for the 4000 ppm case (Blythe weather data.

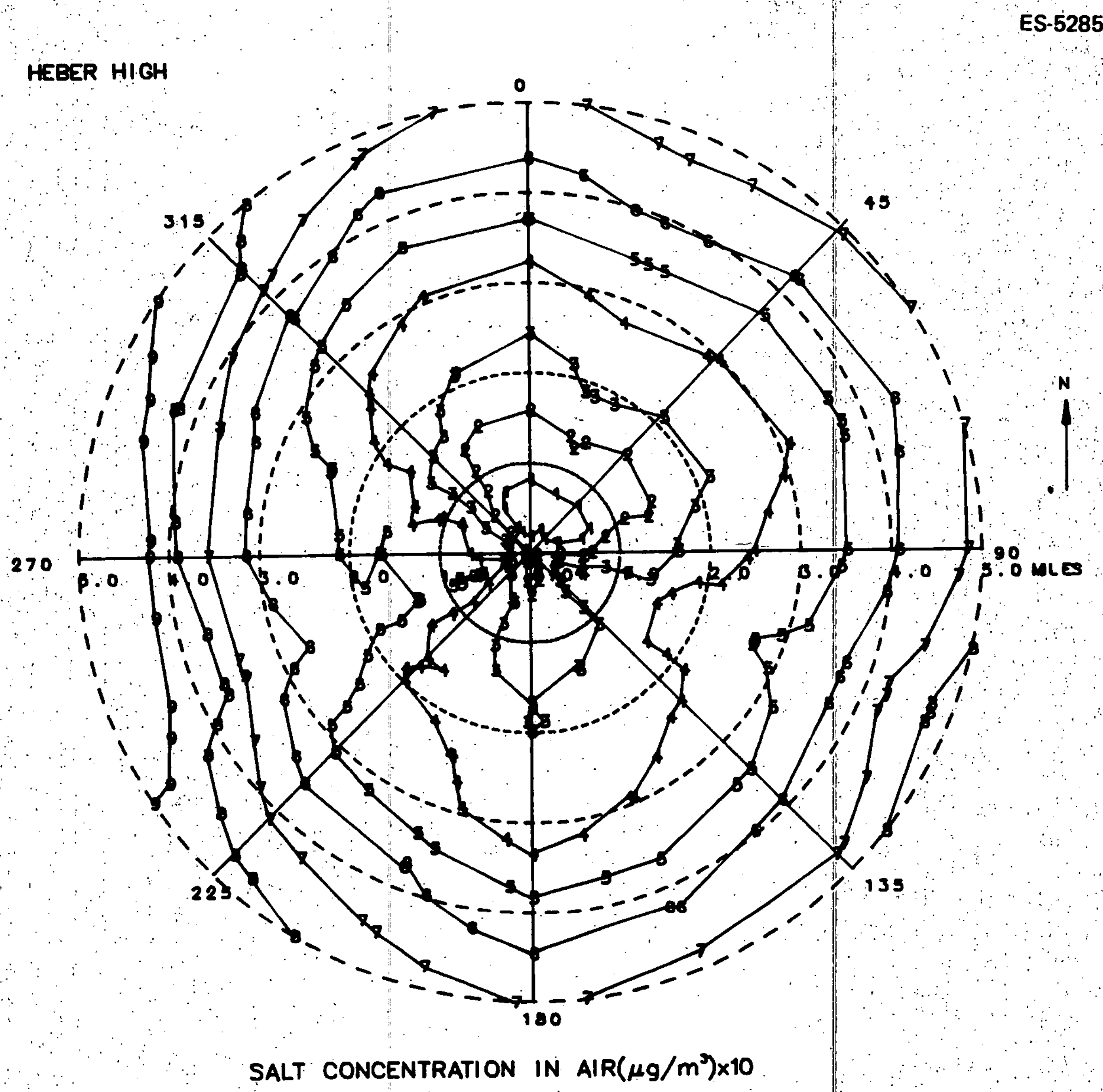


Fig. D.4 Expanded view of cooling tower salt particulate concentrations in air for the 20,000 ppm case (Blythe weather data).

Table D.2. Salt particulate concentrations corresponding to Fig. D.3 and Fig. D.4 (Blythe weather data)

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Salt particulate concentration ($\mu g/m^3$)						
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6	Isopleth 7
First 5 years	4,000	0.002	1.25	0.62	0.31	0.15	0.07	0.03	0.01
		0.008	5.00	2.5	1.25	0.62	0.31	0.15	0.07
		0.100	60.0	30.0	15.0	7.5	3.7	1.8	0.9
After 5 years	20,000	0.002	2.0	1.0	0.5	0.25	0.12	0.06	0.03
		0.008	8.0	4.0	2.0	1.0	0.5	0.25	0.12
		0.100	100.0	50.0	25.0	12.5	6.2	3.1	1.6

The results of the salt concentration calculations using the Heber site data are contained in Figure D.5, Figure D.6, and Table D.3 for the near-field view and in Figure D.7, Figure D.8, and Table D.4 for the expanded view. These results indicate that the maximum salt concentration occurs to the east and east-southeast of the tower location rather than north as was the situation using the Blythe data. In both the 0.1% drift, 20,000 ppm case and the 0.1%, 4000 ppm case the annual TSP standard is exceeded. Use of the Heber site meteorological data produced a higher estimated maximum concentration (about 50%) than that which was estimated with the Blythe weather data. This could be due to a greater persistence of wind direction towards the location of the maximum concentration in the Heber site data. Another possibility is that the numerous substantial gaps in the Heber data, where meteorological measurements were not recovered, produced a certain amount of bias in the final results. Despite the differences in the maximum concentration predicted with the two sets of data, the concentrations at a mile or more away from the tower along the direction of maximum concentration were quite similar.

The results of the ORFAD salt drift deposition calculations for the Blythe weather data are contained in Figure D.9, Figure D.10, and Table D.5 for the near-field view and in Figure D.11, Figure D.12 and Table D.6 for the expanded view. The major direction of the deposition is to the north and the northeast of the tower. These results show that the major portion of the salt deposition occurs extremely close to the cooling tower. This is demonstrated in Figure D.13 which gives the change in drift deposition with distance in the direction of maximum impact. It is apparent that the two worst cases for drift deposition are those with the drift rate of 0.1%. The case with 0.008% drift and 20,000 ppm approaches the impact of the 0.1%, 4000 ppm case even though its emissions are much smaller. This is because the higher dissolved salt content in the drift water at 20,000 ppm will increase the droplet density slightly, as well as increase the deposition velocity. Salt particles produced by droplets evaporating to dryness will be larger in the 20,000 ppm case and thus fall faster.

ES-5286

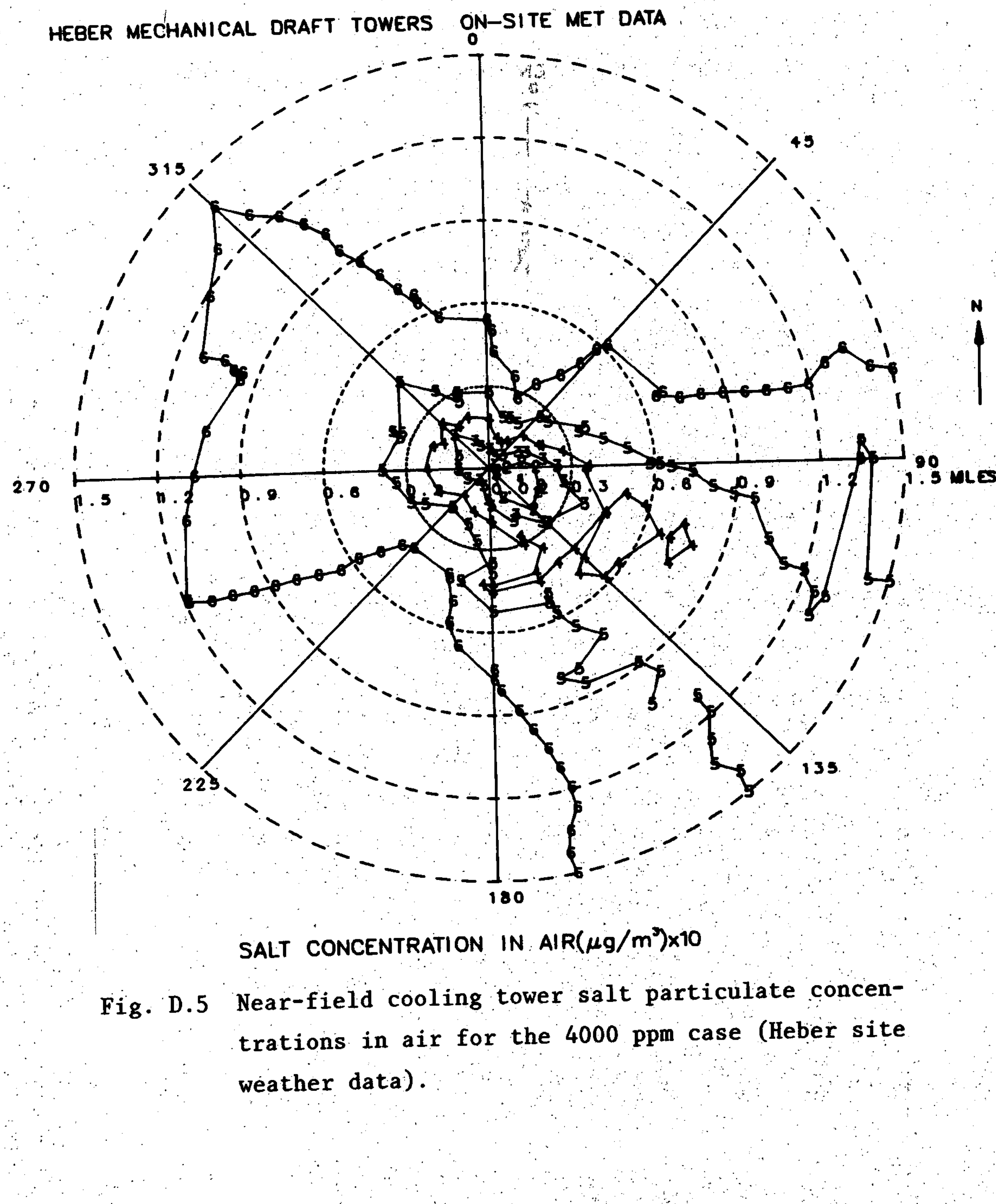


Fig. D.5 Near-field cooling tower salt particulate concentrations in air for the 4000 ppm case (Heber site weather data).

ES-5287

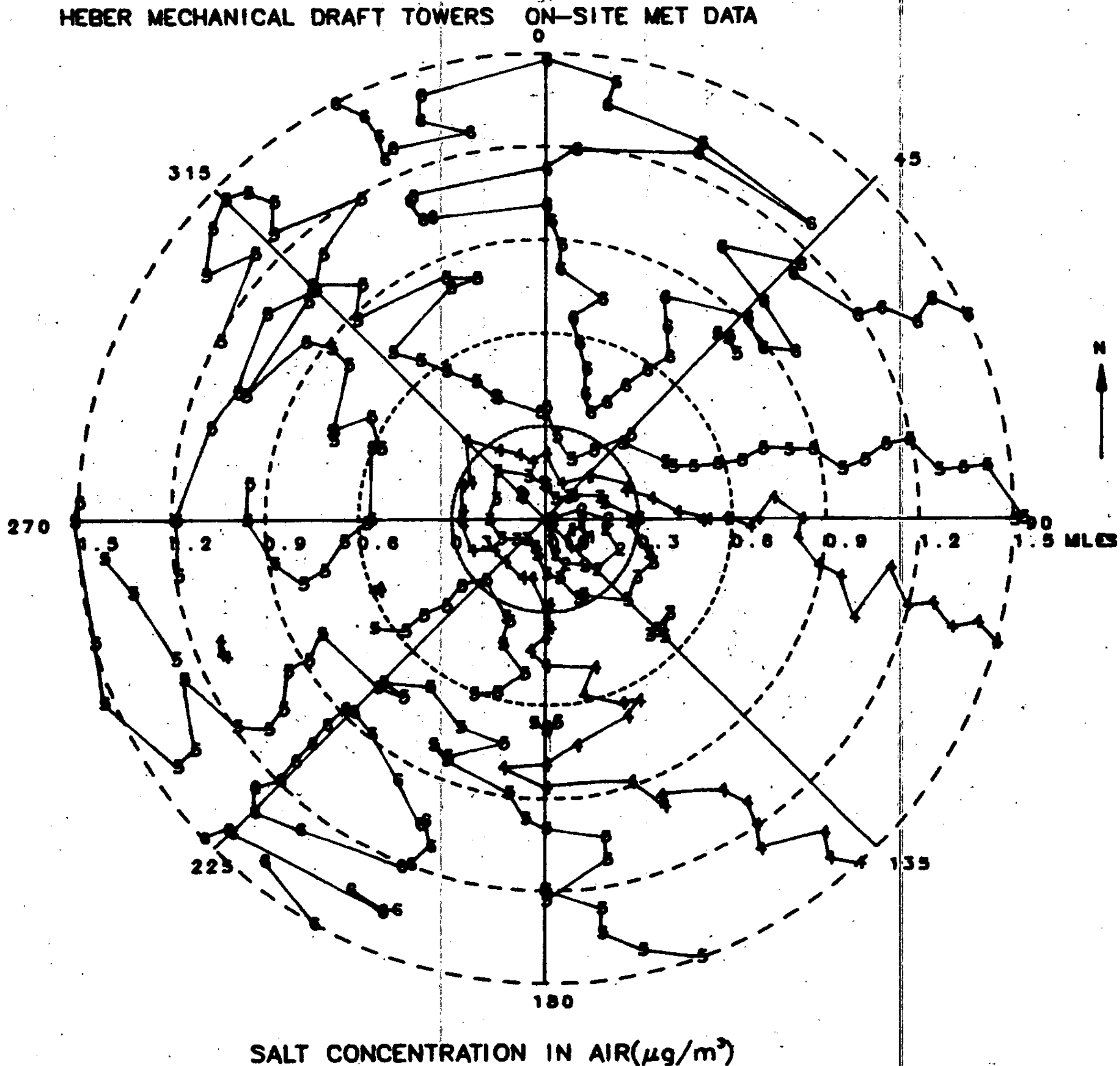


Fig. D.6 Near-field cooling tower salt particulate concentrations in air for the 20,000 ppm case (Heber site weather data).

ES-5288

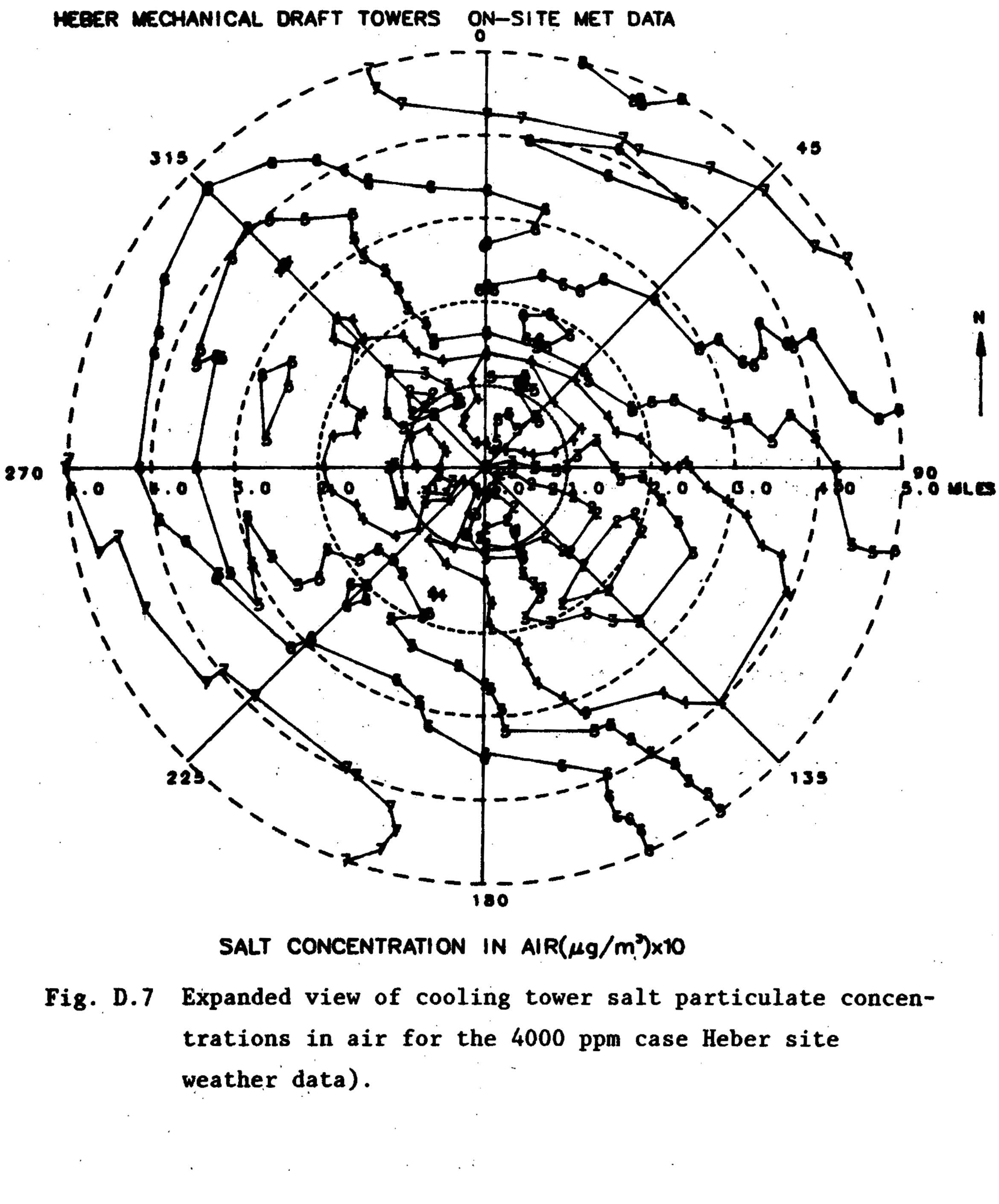


Fig. D.7 Expanded view of cooling tower salt particulate concentrations in air for the 4000 ppm case Heber site weather data).

Table D.3. **Near-field salt particulate concentrations corresponding to Fig. D.5 and Fig. D.6 (Heber site weather data)**

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Salt particulate concentration ($\mu g/m^3$) Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6
First 5 years	4,000	0.002	2.2	1.1	0.6	0.3	0.2	0.1
		0.008	9.0	4.5	2.2	1.1	0.6	0.3
		0.100	112.0	56.0	28.0	14.0	7.0	3.5
After 5 years	20,000	0.002	10.0	5.0	2.5	1.2	0.6	0.3
		0.008	40.0	20.0	10.0	5.0	2.5	1.2
		0.100	500.0	250.0	125.0	62.5	31.2	15.6

ES-5289

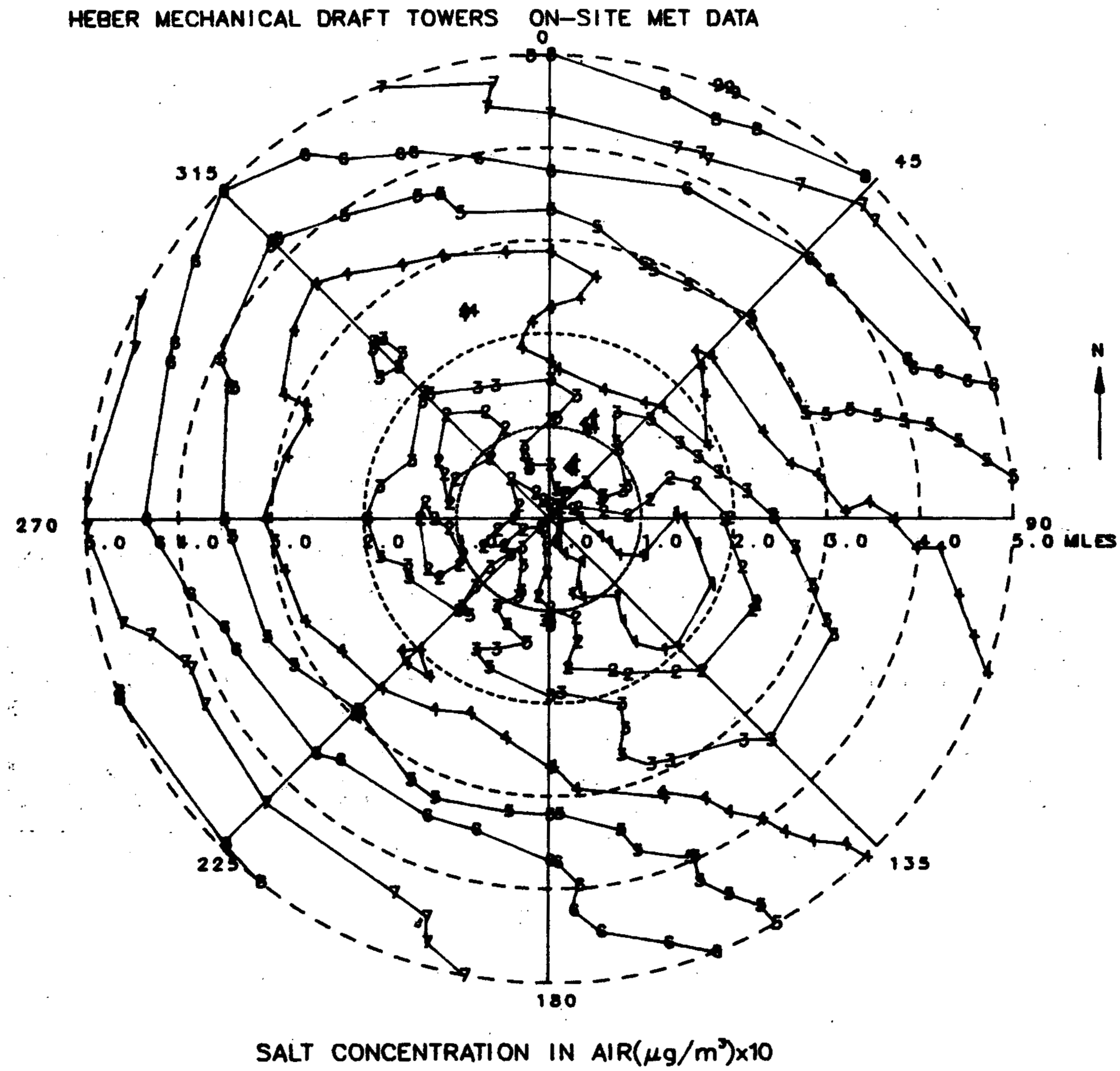


Fig. D.8 Expanded view of cooling tower salt particulate concentrations in air for the 20,000 ppm case (Heber site weather data).

Table D.4. Salt particulate concentrations corresponding to Fig. D.7 and Fig. D.8 (Heber site weather data)

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Salt particulate concentration ($\mu g/m^3$)						
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6	Isopleth 7
First 5 years	4,000	0.002	1.0	0.5	0.25	0.12	0.06	0.03	0.01
		0.008	4.0	2.0	1.0	0.5	0.25	0.12	0.06
		0.100	50.0	25.0	12.5	6.2	3.1	1.5	0.8
After 5 years	20,000	0.002	2.0	1.0	0.5	0.25	0.12	0.06	0.03
		0.008	8.0	4.0	2.0	1.0	0.5	0.25	0.12
		0.100	100.0	50.0	25.0	12.5	6.2	3.1	1.5

ES-5290

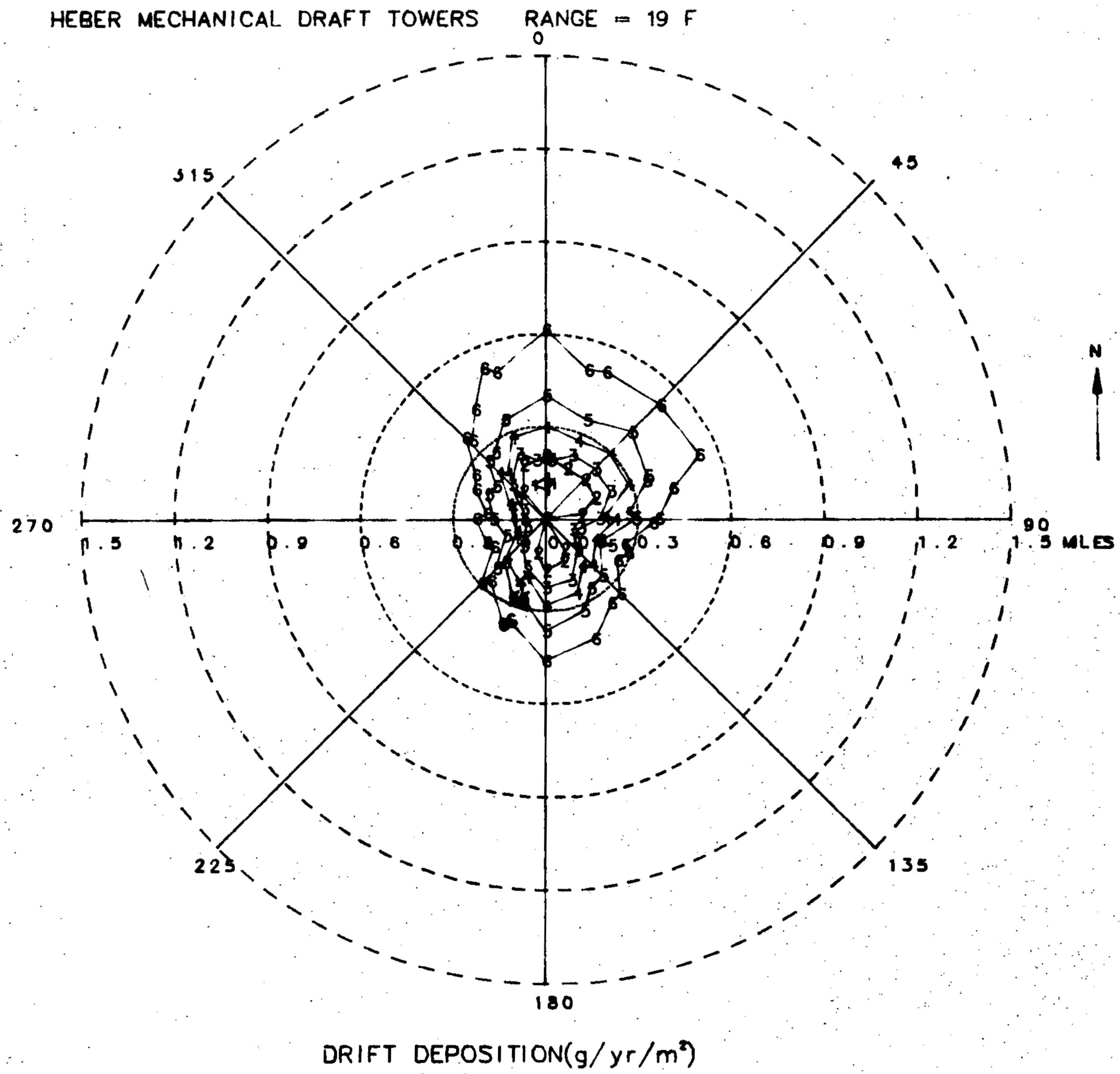


Fig. D.9 Near-field deposition for the 4,000 ppm case (Blythe weather data).

ES-5291

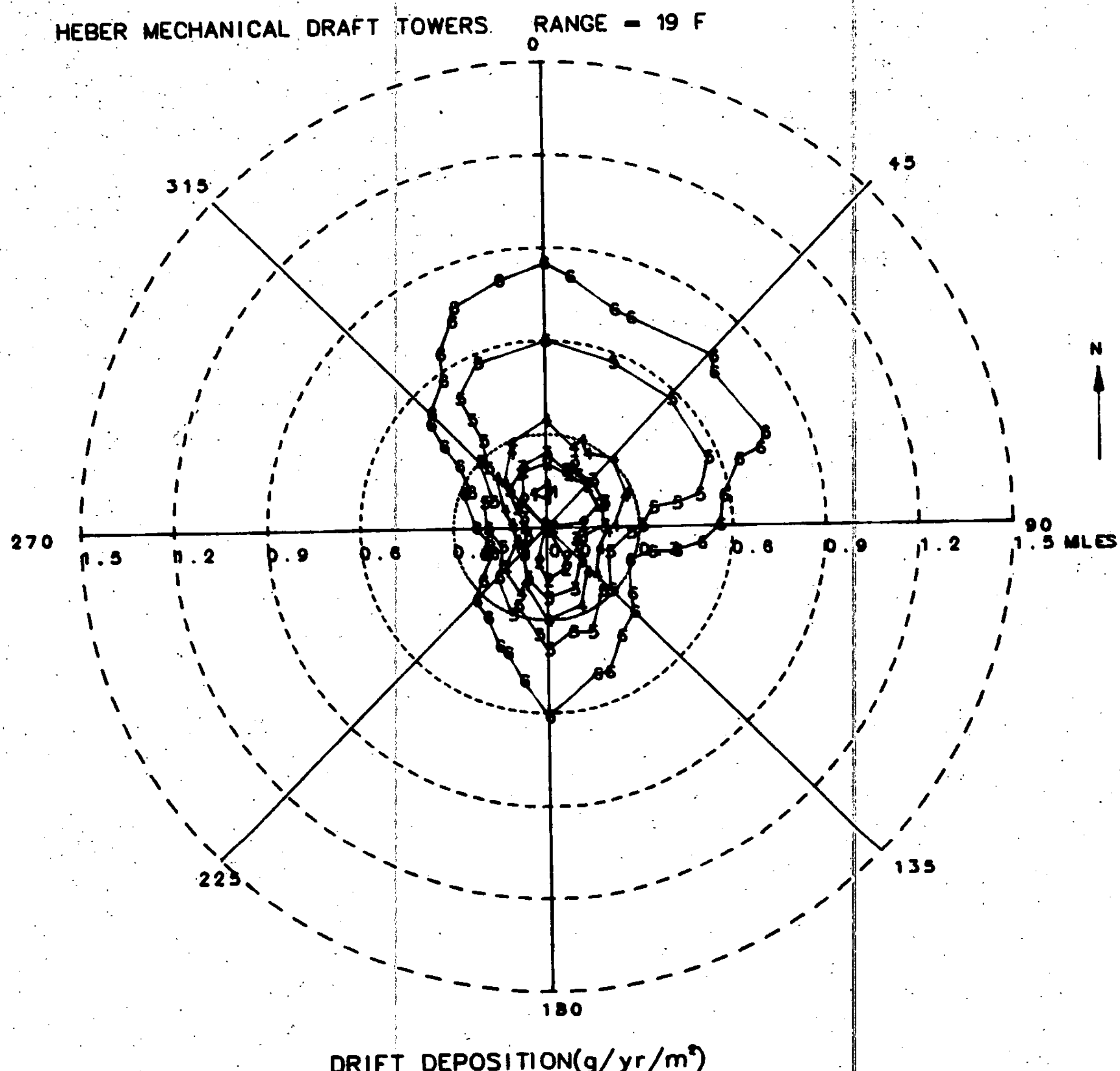
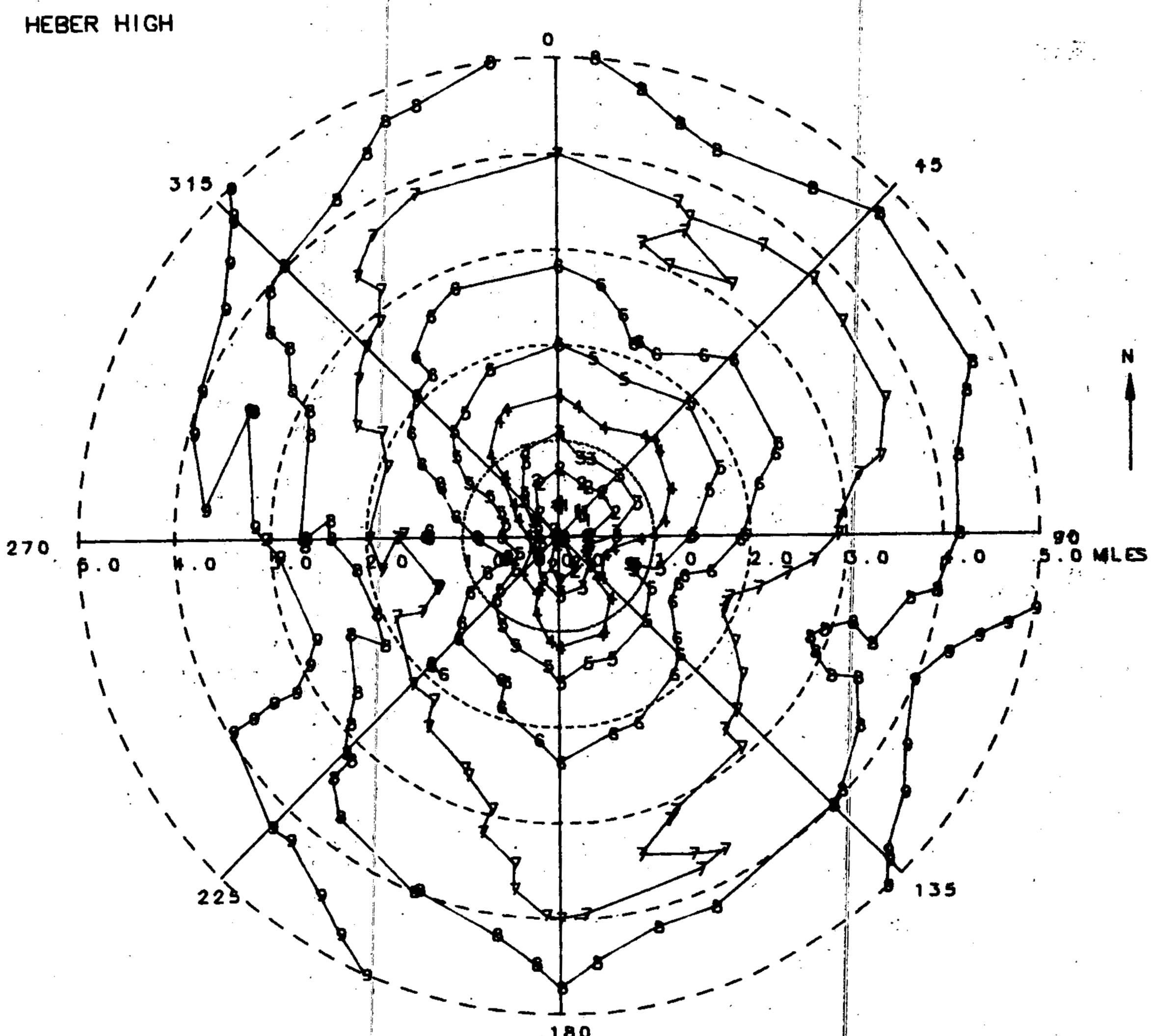


Fig. D.10 Near-field deposition for the 20,000 ppm case (Blythe weather data).

Table D.5. Near-field drift salt deposition concentrations corresponding to Fig. D.9 and Fig. D.10 (Blythe weather data)

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Annual drift salt deposition (g/m^2)					
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6
First 5 years	4,000	0.002	17.5	78.8	4.4	2.2	1.1	0.6
		0.008	70.0	35.0	17.5	8.8	4.4	2.2
		0.100	875	438	219	110	55	27
	(Area in ha)		(2)	(12)	(24)	(40)	(67)	(135)
After 5 years	20,000	0.002	100.0	50.0	25.0	12.0	6.2	3.1
		0.008	400.0	200.0	100.0	50.0	25.0	12.5
		0.100	5000	2500	1250	625	312	156
	(Area in ha)		(2)	(12)	(22)	(43)	(121)	(231)

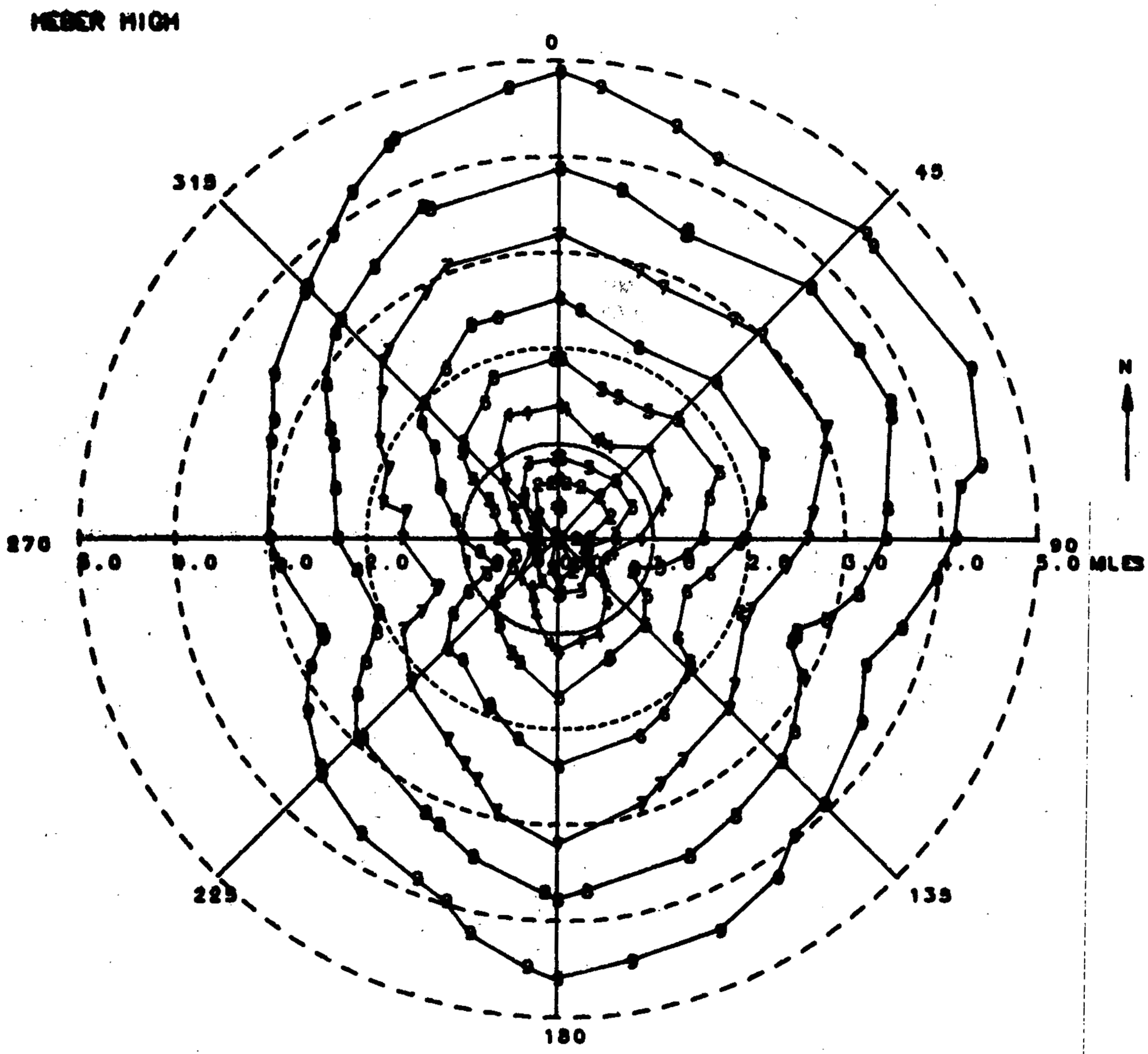
ES-5367



DRIFT DEPOSITION(g/yr/m²)x10

Fig. D.11 Expanded view of drift deposition for the 4000 ppm case (Blythe weather data).

ES-5368



DRIFT DEPOSITION(g/yr/m²)

Fig. D.12 Expanded view of drift deposition for the 20,000 ppm case (Blythe weather data).

Table D.6. Drift salt deposition concentrations corresponding to Fig. D.11 and Fig. D.12 (Blythe weather data)

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Drift salt deposition (g/m^2)						
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6	Isopleth 7
First 5 years	4,000	0.002	1.6	0.8	0.4	0.2	0.1	0.05	0.02
		0.008	6.4	3.2	1.6	0.8	0.4	0.2	0.1
		0.100	80.0	40.0	20.0	10.0	5.0	2.5	1.2
	(Area in ha)		(<50)	(135)	(283)	(664)	(1360)	(2705)	(6150)
After 5 years	20,000	0.002	12.5	6.2	3.1	1.5	0.7	0.4	0.2
		0.008	50.0	25.0	12.5	6.2	3.1	1.5	0.7
		0.100	600	300	150	125	62	31	15
	(Area in ha)		(<50)	(104)	(279)	(678)	(1536)	(3105)	(5000)

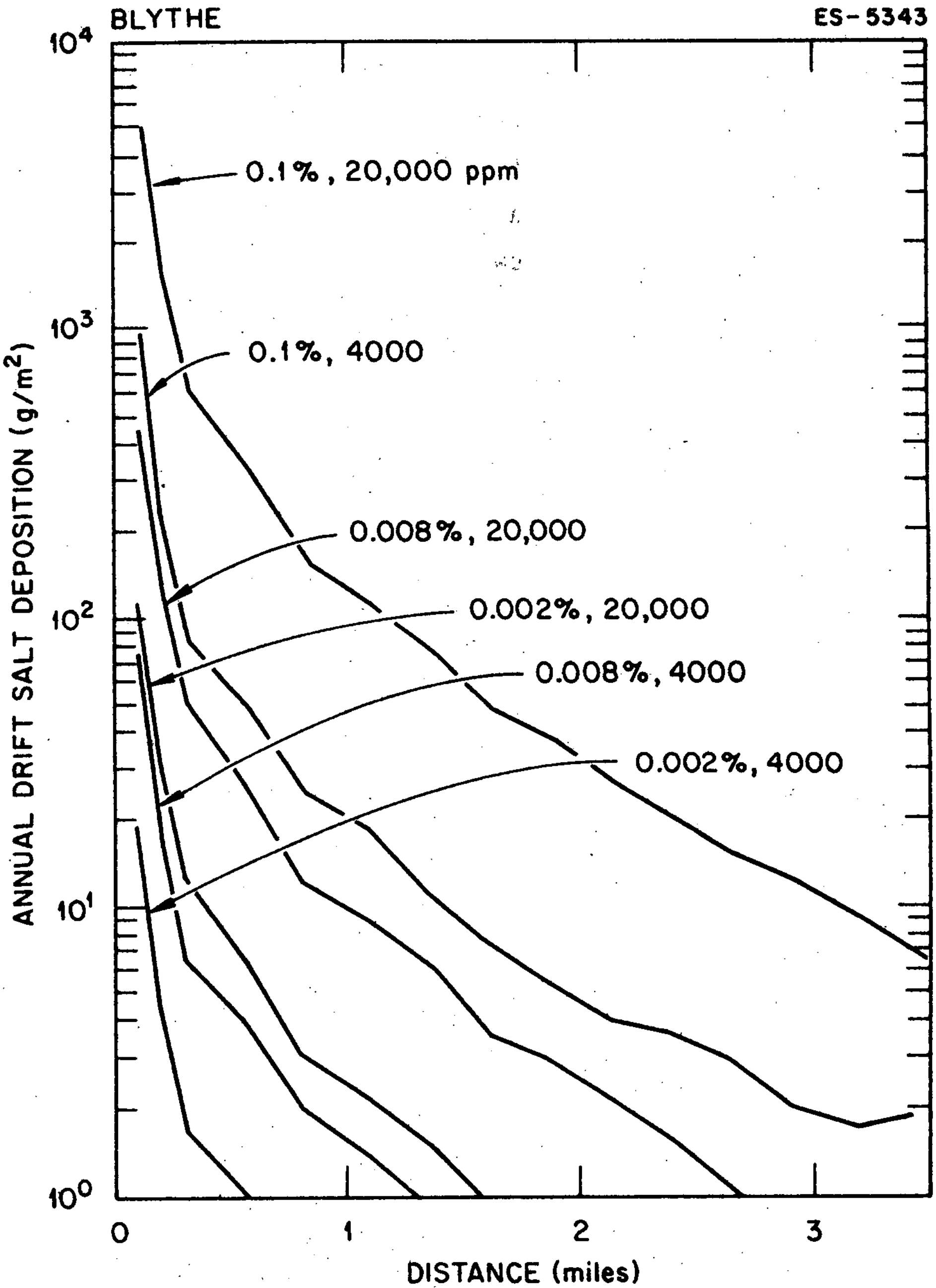
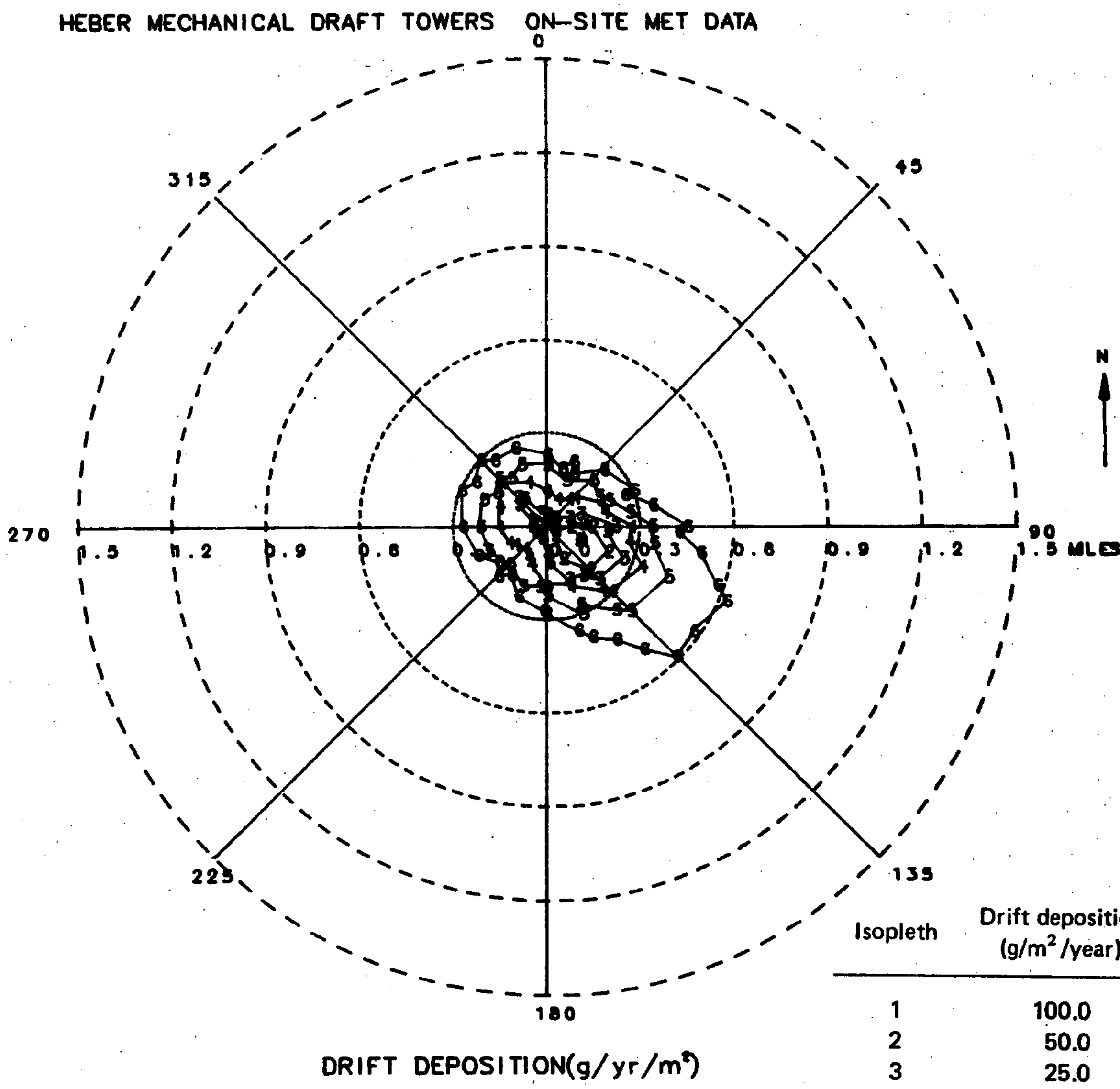


Fig. D.13 Drift deposition versus distance from cooling tower in the direction of the maximum for each combination of drift rate and cooling water TDS content (Blythe weather data.

The corresponding results for the Heber site weather data are contained in Figure D.14, Figure D.15, and Table D.7 for the near-field view and in Figure D.16, Figure D.17, and Table D.8 for the expanded view. The major direction of impacts is to east and east-southeast as compared to the north for the Blythe weather data. Again, the major portion of the drift deposition impacts occur close to the tower as indicated in Figure D.18. The two cases with drift rates of 0.1% result in the maximum deposition.

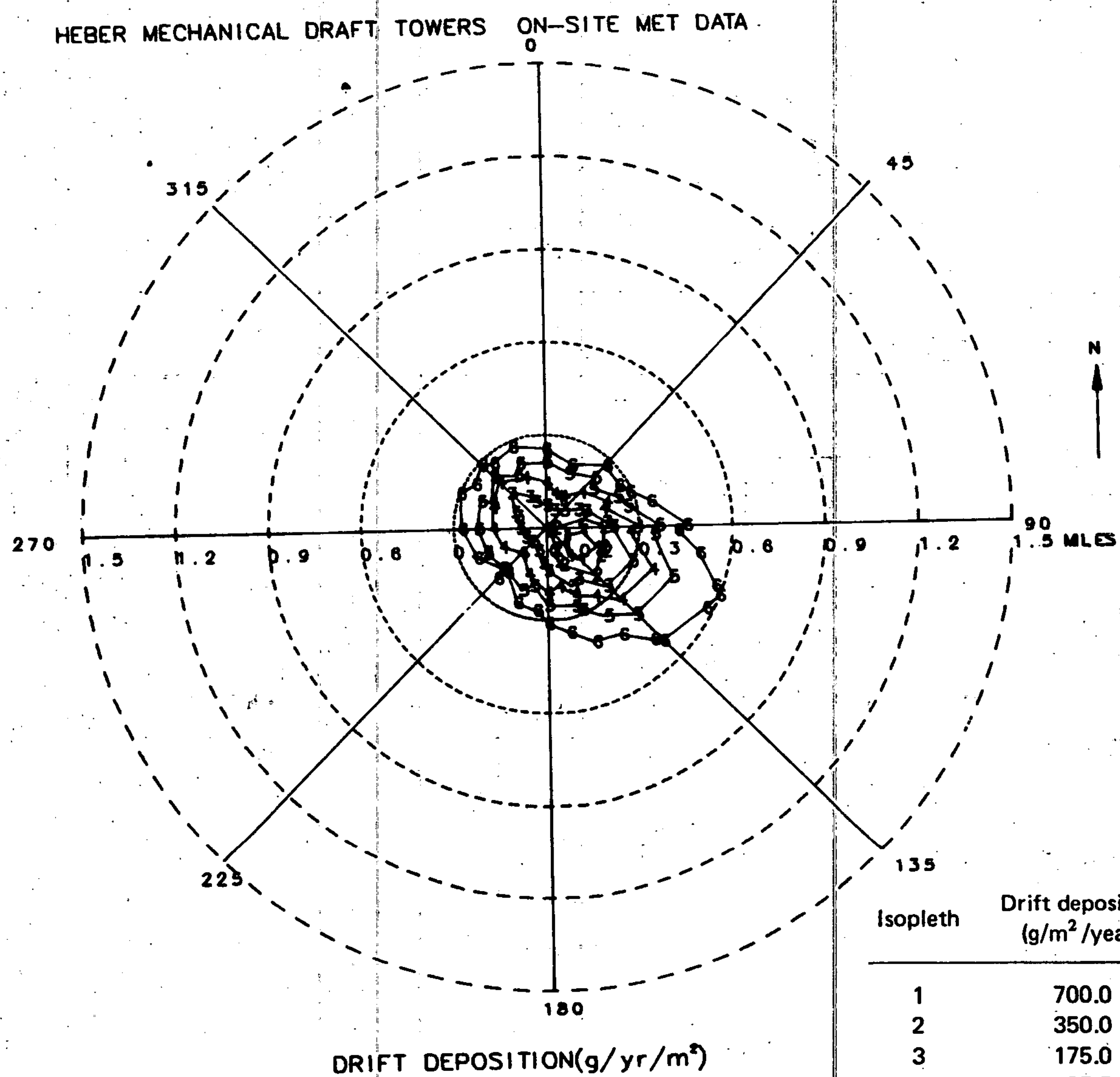
ES-5369



Isopleth	Drift deposition (g/m^2/year)
1	100.0
2	50.0
3	25.0
4	12.5
5	6.2
6	3.1

Fig. D.14. Near-field drift deposition for the 4000 ppm case (Heber site weather data).

ES-5370



Isopleth	Drift deposition (g/m² /year)
1	700.0
2	350.0
3	175.0
4	87.5
5	43.8
6	21.9

Fig. D.15. Near-field drift deposition for the 20,000 ppm case (Heber site weather data).

Table D.7. Near-field drift salt deposition concentrations corresponding to Fig. D.14 and Fig. D.15 (Heber site weather data)

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Annual drift salt deposition (g/m^2)					
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6
First 5 years	4,000	0.002	25.0	12.5	6.2	3.1	1.5	0.8
		0.008	100.0	50.0	25.0	12.5	6.2	3.1
		0.100	1250.0	625.0	312.5	156.2	78.1	39.0
	(Area in ha)		(<2)	(6)	(17)	(35)	(53)	(90)
After 5 years	20,000	0.002	175.0	87.5	43.6	21.8	10.9	5.4
		0.008	700.0	350.0	175.0	87.5	43.6	21.8
		0.100	8750	4375	2188	1094	547	274
	(Area in ha)		(<2)	(4)	(12)	(26)	(46)	(87)

ES-5371

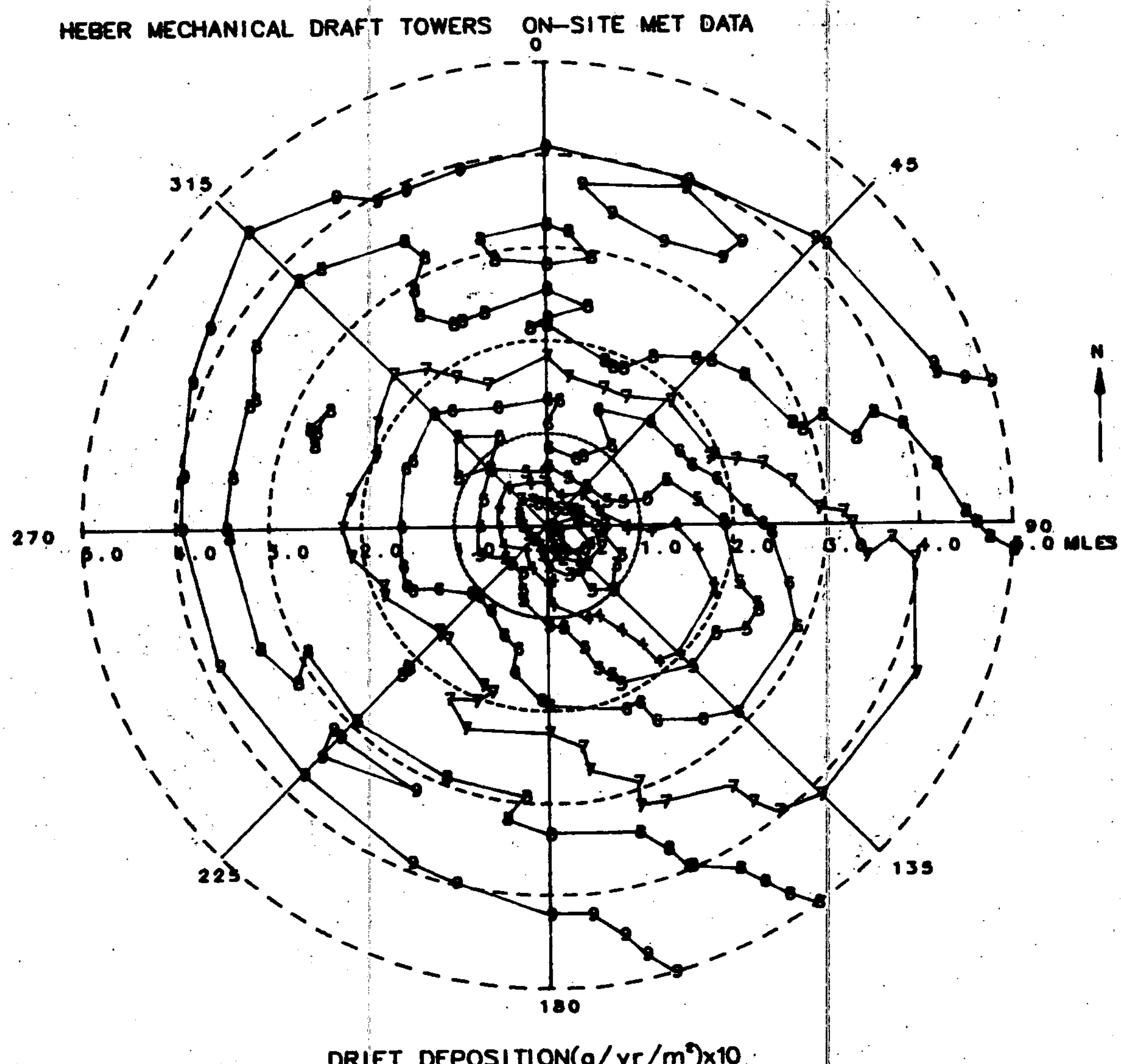


Fig. D.16 Expanded view of drift deposition for the 4000 ppm case (Heber site weather data).

ES-5372

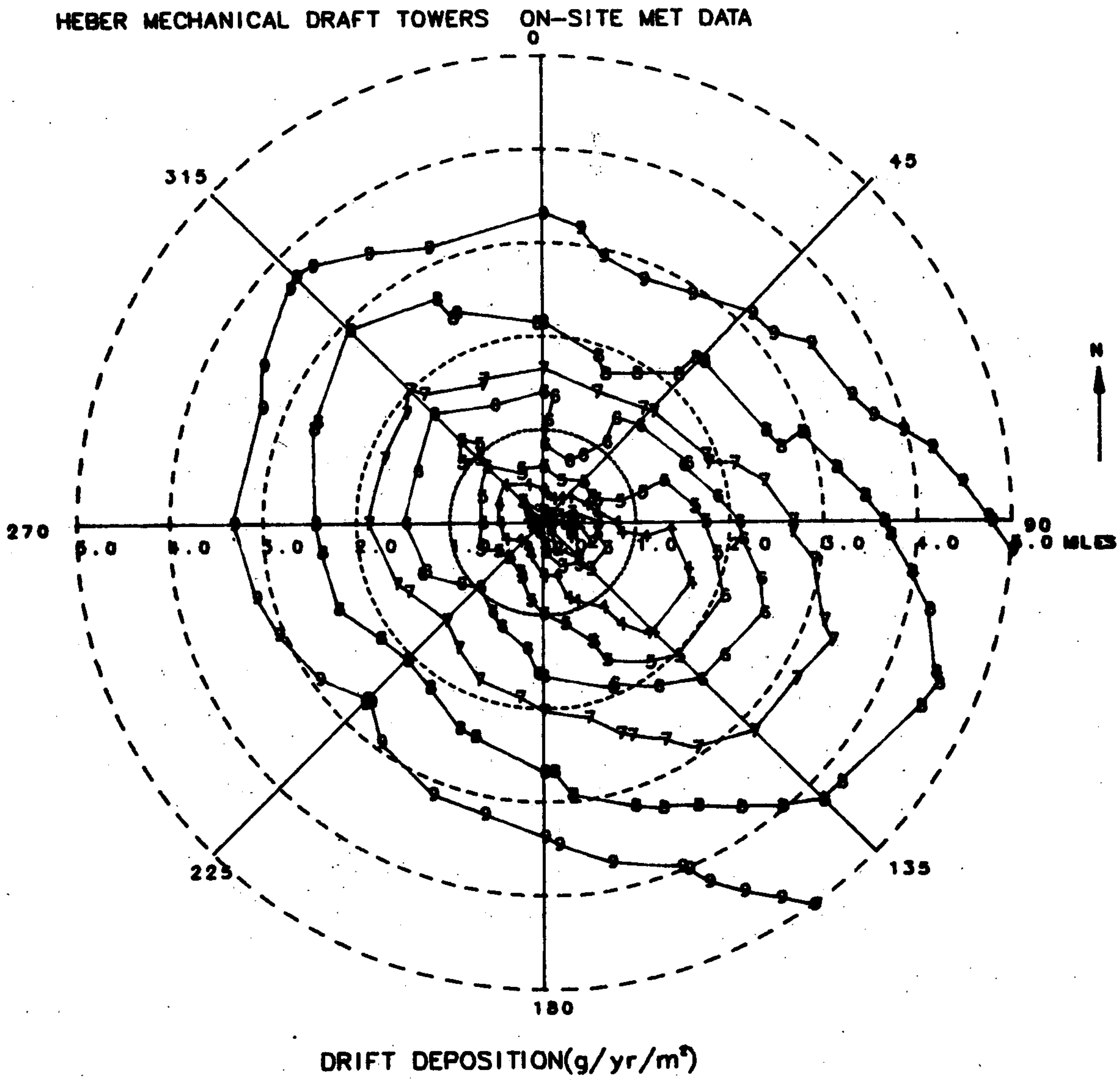


Fig. D.17 Expanded view of drift deposition for the 20,000 ppm case (Heber site weather data).

Table D.8. Drift salt deposition concentrations corresponding to Fig. D.16 and Fig. D.17 (Heber site weather data)

Period of operation	Cooling water TDS content (ppm)	Drift rate (%)	Annual drift salt deposition (g/m^2)						
			Isopleth 1	Isopleth 2	Isopleth 3	Isopleth 4	Isopleth 5	Isopleth 6	Isopleth 7
First 5 years	4,000	0.002	2.0	1.0	0.5	0.25	0.12	0.06	0.03
		0.008	8.0	4.0	2.0	1.0	0.5	0.25	0.12
		0.100	100.0	50.0	25.0	12.5	6.2	3.1	1.5
	(Area in ha)		(<40)	(70)	(150)	(595)	(1105)	(2420)	(4743)
After 5 years	20,000	0.002	18.0	9.0	4.5	2.2	1.1	0.06	0.03
		0.008	72.0	36.0	18.0	9.0	4.5	2.2	1.1
		0.100	900.0	450.0	225.0	112.5	56.2	28.1	14.0
	(Area in ha)		(<30)	(66)	(96)	(423)	(890)	(1931)	(3300)

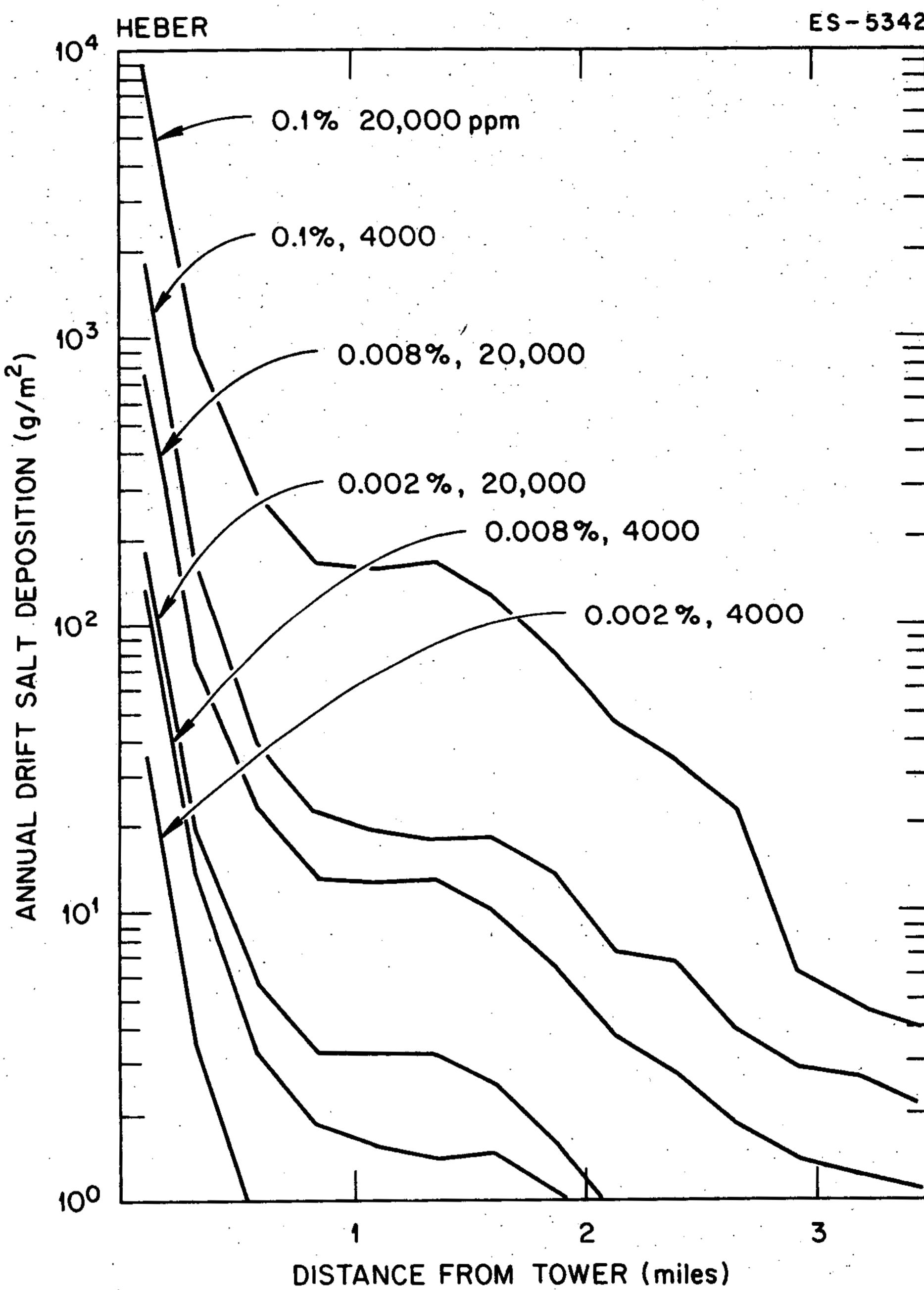


Fig. D.18 Drift deposition versus distance from cooling tower in the direction of the maximum for each combination of drift rate and cooling water TDS content (Heber site weather data).

APPENDIX E

ANALYSIS OF THE EFFECTS OF SALT DRIFT ON CROPLANDS

Appendix E - Analysis of the Effects of Salt Drift on Croplands

The following analysis utilizes information on salt deposition resulting from operation of cooling towers for the Heber binary demonstration plant presented in Section 5.5 and Appendix D. The towers will be operated with 4000 ppm drift salinity for at least the first five years; thereafter they will be operated with drift salinity of 20,000 ppm. Alternative designs resulting in three drift loss rates are examined: 0.1%, 0.008%, and 0.002% of circulation water. Two sets of meteorological data were used to estimate salt deposition (see Appendix D). The following analysis considers results from both sets of meteorological data for all combinations of drift salinity and loss rate. Tables which present the estimated salt depositions and Figures which illustrate the deposition isopleths for all combinations of meteorology, salinity and loss rates may be found in Appendix D. For both salinities, salt deposition at 0.1% drift loss is 12.5 times greater than at 0.008% and 50 times greater than for 0.002%. Maximum deposition will occur with 20,000 ppm and 0.1% drifts; minimum deposition will be at 4000 ppm and 0.002% drift.

From Tables D.4 and D.6 (Appendix D) which describe the salt deposition within a 2.4 km (1.5 mi.) radius of the cooling towers, the maximum annual salt deposition at 0.1% drift and 20,000 ppm is estimated to be 5000 g/m^2 (44,600 lbs/acre) with Blythe meteorology and 8750 g/m^2 (78,050 lbs/acre) with Heber site data. These maxima will affect only a few hectares. Maximum depositions affecting the same area for 0.002% and 4000 ppm will be 17.5 g/m^2 (156 lb/acre) for Blythe data and 25 g/m^2 (225 lbs/acre) for Heber site data.

Deposition of salt drift from cooling towers on agricultural land is of particular concern because accumulation of salts in the rooting zone interferes with the plant's ability to take up water and nutrients and reduces germination success (Richards 1969, Poljakoff-Mayber and Gale 1975). Deposition of airborne salt on crops also has a potential to cause foliar damage due to uptake of salt by leaves (Moser 1975, Hindawi et al. 1976). Salinization of soils is a continual hazard in the Imperial Valley where irrigation is a prerequisite for agriculture and irrigation water is relatively saline. The average salinity of irrigation water in the Heber region is about 1000 ppm (EIR 1978). Considering that the average annual irrigation rate is 17,000 m^3/ha (5.6 acre-feet/ acre), present irrigation practices add about 17,060 kg/ha (15,230 lbs/ acre) of salt each year. Salt accumulation is controlled by leaching soluble salts from the rooting zone with a fraction of the irrigation water. Most fields in the Imperial Valley are underlain by drainage tiles to a depth of 2 m to achieve maximum efficient leaching.

As detailed in Appendix F, the leaching requirement, or the fraction of irrigation water which must pass through the root zone, is a function of the salinity of the irrigation water (ECiw) and the desired salinity of the soil paste at the bottom of the root zone (ECdw). In the Imperial Valley, the bottom of the rooting zone is essentially the depth at which the drainage tiles are installed, which is 2 m. Because the average salinity throughout the rooting zone is lower than that at the bottom, most moderately salt tolerant crop species cultivated in the Imperial Valley will produce economical yields at tile depth salinities (measured as electrical conductivity, EC_{dw}) between 8 and 12 mmhos/cm (Bernstein 1964, Richards 1968, Hernsmeier 1980). Some salt tolerant crops such as barley, beets or cotton will produce at EC_{dw} of 20 mmhos/cm (Bernstein 1964, Richards, 1969).

As the salinity of the irrigation water increases, more water must be leached through the root zone to maintain a given root depth salinity (Appendix F). Operation of the cooling towers will deposit an increment of salt as drift on the surrounding croplands, which will effectively raise the salinity of the irrigation water being applied to these lands. Figure E.1 illustrates the estimated leaching requirements to maintain an EC_{dw} of 8, 12 and 20 mmhos/cm with salt depositions from zero to 10,000 g/m^2/yr. The assumptions and method of calculation of these curves are detailed in Appendix F. The salt depositions, plotted along the ordinate in Figure E.1 may be compared with those in Tables D.4 through D.7 (in Appendix D) to determine the leaching requirement necessary to maintain a specified EC_{dw} for the estimated salt depositions for both sets of meteorological data and all combinations of drift salinity and drift loss rates. For example, from Table D.5, a drift salinity of 20,000 ppm and a drift loss rate of 0.1% will result in an estimated

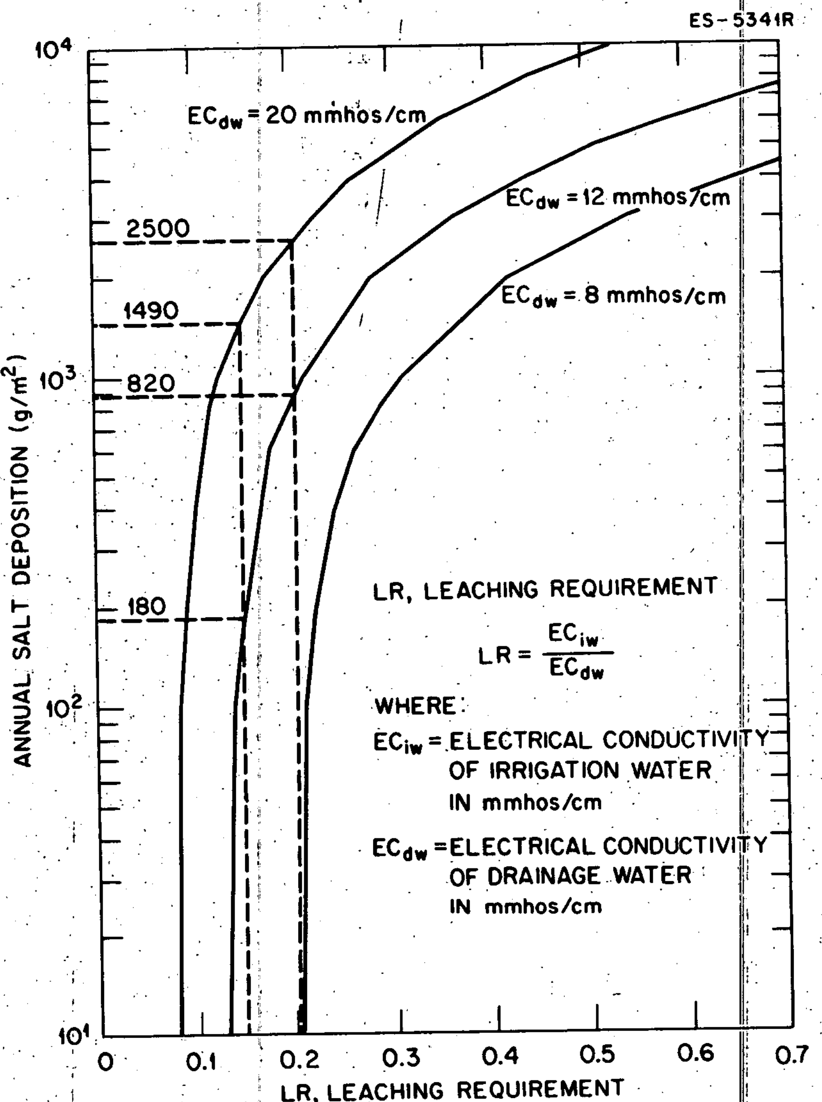


Fig. E.1. Leaching requirement to maintain slainities of the root depth (EC_{dw}) at 8, 12, and 20mmhos/cm as a result of deposition from cooling towers (in g/m^2 per year).

salt deposition of 2500 $g/m^2/yr$ over about 12 ha. From Figure E.1, this deposition would require a leaching fraction of 49% to maintain an EC_{dw} of 8 mmhos/cm on those 12 ha; a leaching requirement of 32% to maintain an EC_{dw} of 12 mmhos/cm; and a 20% leaching fraction to maintain 20 mmhos/cm.

Accumulation of salts in the agricultural soils surrounding the cooling towers would not occur if it were feasible to increase the leaching fraction sufficiently to flush the salts from the soils. However, this is not always the case in the Heber vicinity. Maximum achievable leaching fractions for the three major agricultural soils in the project vicinity (shown in Fig. I.1 in Appendix I) are: Imperial silty clay, 5%; Holtville silty clay, 15%; and Imperial-Glenbar silty clay loam, 20% (Hernsmeier 1980). Present irrigation practices on the Imperial silty clay maintain the EC_{dw} well above 20 mmhos/cm and maintain the other two soils between 8 and 12 mmhos/cm (Hernsmeier 1980).

The Imperial silty clays are presently at their maximum achievable leaching rates which are not now able to maintain the EC_{dw} at 20 mmhos/cm. The relationship of these soils to the project site may be found in Fig. I.1 (Appendix I). Estimated maximum drift deposition on these soils at 0.1% drift and 20,000 ppm salinity is 140 $g/m^2/yr$ for Blythe meteorology and 55 $g/m^2/yr$ for Heber site meteorology. About 75 ha (185 acres) of these soils would be affected by these levels. A deposition of 140 $g/m^2/yr$ would increase the EC_{dw} by 5 mmhos/cm each growing season; 55 $g/m^2/yr$ would increase it by 3 mmhos/cm each year. Since these soils are probably at their maximum desirable salinity, additional salt deposition (from 0.1% drift) could cause crop yield reductions on about 75 ha of Imperial silty clays. At all the other drift rates and salinities, deposition on the Imperial silty clays are well below 20 g/m^2 and should not cause major soil salinity increases.

The other two major agricultural soils are maintained between 8 and 12 mmhos/cm. Table E.1 presents the salt depositions (from Figure E.1) at which the indicated maximum achievable leaching fractions of 15% (for Holtville silty clay) and 20% (for Imperial-Glenbar silty clay loams) would be insufficient to maintain EC_{dw} of 8, 12 and 20 mmhos/cm. Table E.2 presents the estimated areas which would exceed these depositions

Table E.1. Annual salt depositions (g/m^2) at which leaching requirements of 15% and 20% would not be sufficient to maintain EC_{dw} at the three indicated salinities of 8, 12, and 20 mmhos/cm[a]

EC_{dw} (mmhos/cm)	Annual salt depositions (g/m^2)	
	At 15% leaching fraction requirement	At 20% leaching fraction requirement
8	[b]	100
12	180	820
20	1490	2500

[a]Leaching requirements of 15% and 20% are approximately the maximum achievable fractions for the Holtzville silty clays and the Imperial–Glenbar silty clay loams.

[b]A leaching fraction of 15% is insufficient to maintain EC_{dw} at 8 mmhos/cm even with present irrigation water salinity of 1.5 mmhos/cm.

Table E.2. Area in ha over which the critical depositions from Table E.1 would be exceeded for both meteorologies and combinations of two drift salinities and three drift rates

Drift salinity (drift rate) [ppm(%)]	Salt deposition (g/m^2)				
	100	180	820	1490	2500
Blythe data					
20,000 (0.1)	700[a]	200	30	20	12
20,000 (0.008)	24	15	0	0	0
20,000 (0.002)	2	0	0	0	0
4,000 (0.1)	40	30	3	0	0
4,000 (0.008)	0	0	0	0	0
4,000 (0.002)	0	0	0	0	0
Heber data					
20,000 (0.1)	450	250	44	22	15
20,000 (0.008)	20	12	0	0	0
20,000 (0.002)	3	<2	0	0	0
4,000 (0.1)	45	30	4	0	0
4,000 (0.008)	<2	0	0	0	0
4,000 (0.002)	0	0	0	0	0

[a] Listing of areas in ha begins here.

for both meteorologies and all combinations of drift salinity and loss rate. It is evident that at 20,000 ppm salinity and 0.1% drift loss rate significantly large areas will experience increased EC_{dw} salinities. As the EC_{dw} approaches 12 mmhos/cm, moderately salt tolerant species will produce poor yields. Above 20 mmhos/cm only the most salt tolerant crops will grow well. Much smaller areas are affected by 4000 ppm and 0.1% and by 20,000 ppm with 0.008% drift. For 0.002% drift at both salinities, and for 0.008% at 4000 ppm, essentially no adverse effects from salinization of croplands would be expected.

In addition to accumulation of salts in the rooting zone, deposition of salt drift on croplands has the potential to cause foliar injury to crop species. Several factors affect the potential for damage, including sensitivity of crop species, concentration of salt in the drift and duration of exposure (Moser 1975). Limited data are available which relate salt deposition to increased salt uptake by leaves and to foliar damage. Mulchi and Armbruster (1974) reported extensive foliar damage and reduced yields to corn and soybeans after three to five week exposures to levels equivalent to 37 $g/m^2/yr$ and 74 $g/m^2/yr$. Maas (1980) determined that short term exposures of soybeans, tomatoes and green peppers to levels of salt equivalent to 13 g/m^2yr caused damage to all species when relative humidities exceeded 70% and that levels of about 33 $g/m^2/yr$ caused damage at relative humidities below 70%.

Because foliar damage is related to salt uptake, which is itself related to leaf structure and morphology, it is difficult to extrapolate data from one crop species to another. However, all crop species tested thus far have exhibited damage to short term exposure to depositions below 100 $g/m^2/year$. Although it cannot be stated with certainty, it may be comfortably speculated that areas receiving long-term exposure to over 100 g/m^2 are likely to exhibit some crop damage from airborne salt from the cooling towers. From Table E.2, from 450 to 700 ha will receive depositions above 100 g/m^2 with drift loss rates of 0.1% and salinity of 20,000 ppm. Between 40 and 45 ha will experience in excess of 100 $g/m^2/up$ at 4000 ppm and 0.1% drift. For .008% drift at 20,000 ppm, between 20 and 24 ha would receive over 100 $g/m^2/yr$. For 0.008% drift and 4000 ppm, and for 0.002% drift at both salinities, from none to less than 3 ha will be exposed to depositions of 100 $g/m^2/year$.

In summary, salt deposition from 0.1% drift and 20,000 ppm drift salinity will probably cause significant adverse effects to between 450 and 700 ha (depending upon which meteorologic data is used) from both accumulation of salt in soils and crop damage due to impaction of salt on foliage. At 4000 ppm and drift loss of 0.1%, between 40 and 45 ha will be adversely affected. The potential for crop damage at 0.008% drift is much less at both salinities; at 20,000 ppm drift salinity, possibly 20 to 24 ha could be adversely affected, and at 4000 ppm, less than 2 ha would receive sufficient salt to cause adverse effects to crops. At the state of the art technology of 0.002% drift loss, adverse effects on croplands due to salt deposition would be negligible.

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APPENDIX F

METHODOLOGY FOR CALCULATING THE LEACHING FRACTION

APPENDIX F — METHODOLOGY FOR CALCULATING THE LEACHING FRACTION

Leaching of soluble salts from the root zone is essential in irrigated regions. The leaching fraction, or the amount of irrigation water which must pass through the root zone to remove the salts, is related to the salinity of the irrigation water and the desired salinity of the water drained from the bottom of the rooting zone, which is a factor of the salinity tolerance of the crop being irrigated. Salinities of irrigation water and drain water are generally measured by electrical conductivity and are expressed as millimhos/cm.

A rough estimate of the leaching requirement may be obtained from the following equation:

$$LR = \frac{ECiw}{ECdw} \qquad (1)$$

Where: EC_{iw} is the electrical conductivity of the irrigation water in mmhos/cm

EC_{dw} is the electrical conductivity of the drain water at the bottom of the root zone, in mmhos/cm

For example many field crops cultivated in the Imperial Valley will tolerate EC_{dw} = 8 mmhos/cm. Irrigation with water of conductivity at 2 mmhos would require a leaching rate of 25%; that is, 25% of the irrigation water applied must pass through the rooting zone to maintain an electrical conductivity at the bottom of the root zone of 8 mmhos.

The simple relationship described by equation (1) assumes:

1. no rainfall
2. no removal of salt by the crop
3. no precipitation of salt in the soils

Because these are seldom zero the leaching fraction described by equation (1) is a maximum.

To estimate the leaching fractions corresponding to the various salt depositions in Fig. E.1, the salt increment was assumed to be added to the salt in the present annual irrigation volume of 17063 m^3/ha (5.6 acre-feet/acre). The resultant increased conductivity of the irrigation water as mmhos/cm was used to determine the new leaching fraction required with the drift salt increment for each desired EC_{dw}. This method of calculation results in conservatively high leaching fractions because the additional irrigation water necessitated by the higher leaching fraction would provide some dilution. The desired EC_{dw} used are those which are currently maintained on various agricultural soils in the Heber region.

APPENDIX G

EFFECTS OF SALT DEPOSITION ON NATURAL VEGETATION COMMUNITIES

The closest natural vegetation to the Heber project site is between 1.5 and 2.4 km (1 and 1.5 miles) to the southwest. As discussed in the text of Section 5.4.1, direct injury to natural vegetation from deposition of airborne salt on the foliage is not expected to occur at any of the three alternative drift loss rates discussed in Appendix D. However, because the natural vegetation communities do not experience the benefit of regular leaching practiced on the nearby croplands, salt deposition from the cooling towers has the potential to cause salinization of soils over the operating life of the Heber plant. Table G.1 presents the predicted annual salt deposition to which the natural communities could be exposed for two sets of meteorological data and for each combination of drift salinity and drift loss rate discussed in Appendix D.

Most of the common plant species which occur in the natural vegetation communities along the New River exhibit some degree of salt tolerance. Table G.2 presents the salinity tolerance ranges for many of the commonly occurring plant species in the natural riparian communities. Salt tolerances for natural vegetation are generally reported in the literature as dry-weight percentage of salt in the soil. To relate the dry-weight salt percentage to the electrical conductivity of the soil saturation extract, it is necessary to know the saturation percentage of the soil in question in order to determine the volume of water in which the salt would be dissolved. The relationship is described in the footnote to Table G.2. Obviously soils which have a higher saturation percentage contain more water to dilute salts. For example, a soil with 0.2% dry weight percent salt which has a saturation percentage of 75% would have a saturation extract conductance of 4.1 mmhos/cm; a soil with the same dry-weight percentage of salt, but with a saturation percentage of 40% would have a saturation extract conductance of 7.8 mmhos/cm. In Table G.2, the tolerance ranges reported as dry-weight percentages have been converted to saturation extract salinities by assuming a saturation percentage of 40%, which would apply to the majority of the soils in the Heber region.

Many of the soils in the riparian communities are naturally saline to varying degrees. The Indio silty clays adjacent to the New River (see Fig. I.1 in Appendix I) exhibit salinities between 12 and 19 mmhos/cm

Table G.1. Estimated annual salt deposition in g/m^2 according to two meteorological data sets at the natural riparian vegetative communities from operation of the Heber mechanical draft towers

Drift loss (%)	Annual salt deposition (g/m^2)	
	At 4,000 ppm drift salinity	At 20,000 ppm drift salinity
Blythe data		
0.1	2.5–4.8	22–37
0.008	0.2–0.4	1.8–2.9
0.002	0.05–0.1	0.6–1.2
Heber data		
0.1	2.4–2.7	17–33
0.008	0.2	1.3–1.8
0.002	0.05	0.3–0.5

Table G.2. Salinity ranges of plant species present in the natural communities along the New River, expressed as dry-weight percentage of salt in soils[a]

Highly salt-tolerant species	
Allenrolfea spp.: iodine bushes, inkweed	2.5 to 6%
Distichlis spp.: salt grasses	0.5 to 5.5%
Suaeda spp.: sea blight	0.5 to 3%
Moderately salt-tolerant species	
Tamarix spp.: salt cedar	0.2 to 2%
Atriplex canescens: four-wing saltbush	to 2%
Pluchea spp.: arrow weeds	0.6 to 2% in upper soil profile 0.1 to 0.5% in lower profile
Prosopsis juliflora: common mesquite	0.4 to 2%
Nonsalt-tolerant species	
Larrea tridentata: creosote bush	0.03%
Atriplex polycarpa: cattle saltbush	0.04 to 0.5%

[a]The dry-weight percent of salt in a soil may not be directly related to the electrical conductivity (EC) of the saturation extract without knowledge of the volume of water present in the soil at saturation, which is expressed as the saturation percentage. The relationship is described by the following equations:

$$P_{sw} = ppm/10{,}000 = 0.064 \times EC \times 10^3$$

$$P_{ss} = (P_{sw} \times P_w)/100$$

Where P_{sw} is the percent salt in the soil water; P_{ss} is percent salt in the soil; P_w is the percent of water in the soil, or the saturation percentage; EC is the electrical conductivity of the saturation extract, usually expressed as $EC \times 10^3$ (in mmhos/cm).

Obviously, soils that have a higher saturation percentage contain more water to dilute salts. For example: a soil with 0.2% dry-weight percent salt that has a saturation percentage of 75% would have a conductance equal to 4.1 mmhos/cm; however, a drier soil with the same dry-weight salt percentage and a saturation percentage of 40% would have a conductance of 7.8 mmhos/cm.

Source: Marks 1950, USDA 1969, Hunt 1966, Vasek & Barbour 1977, Ungar 1974, Henrickson 1977.

(Perrier et al 1974). These soils support a highly salt tolerant vegetation cover of iodinebush, saltgrasses and sea blight (see Section 4.4.1 and Table G.2). The Meloland and Imperial-Glenbar soils, which lie above the immediate river floodplain have natural salinities of 5 to 7 mmhos/cm and 4 to 9 mmhos/cm respectively (Perrier et al 1974). These soils support a moderately salt tolerant vegetation community of salt cedar, saltbush, arrowweed and mesquite (see Table G.2). Scattered individuals of creosote bush also occur on the soils above the immediate floodplain. Creosote bush has a very low salt tolerance (Marks 1955, Vasek and Barbour 1977) and it is undoubtedly very near the upper end of its salinity tolerance range; it probably exists in isolated pockets of lower soil salinity.

The potential increase in soil salinity in the natural communities may be roughly estimated for the 30-year life of the plant from the predicted annual salt depositions in Table G.1 and soil moisture data from Perrier et al. (1974). An explanation of the estimation method and assumptions which underlie it may be found in Appendix H. Table G.3 presents the estimated salinity increases and resulting soil for three drift loss rates. Because estimated depositions for the two meteorologies did not differ significantly, the maximum depositions used to arrive at the salinities in Table G.1 apply to either meteorology. Because maximum salt depositions and no leaching were assumed, the values in Table G.1 may be considered maxima for the saturation extract conductivities. At 0.002% drift and 0.008% drift, the predicted increase over 30 years in conductivities of 0.4 and 1.5 mmhos/cm, respectively should not raise soil salinities above the tolerance levels for most of the plant species which occur in the riparian communities. However, a few individuals of creosote bush may be eliminated from the riparian areas nearest to the towers at 0.008% drift loss.

At 0.1% drift, soil conductivities in the riparian communities could be increased by an estimated 18.5 mmhos/cm, during the 30 year life of the power plant, resulting in severe salinization of soils. The conductivity for the Indio silty clay along the river could increase to nearly 40 mmhos/cm; the conductivities for Indio loam, the Melolands soils and the Imperial-Glenbar silty clay loams could reach 24 mmhos/cm.

Table G.3. Estimated increases and resulting soil salinities of the saturation extracts for the major soil types of the riparian vegetative community near the Heber project site resulting from 30 years of operation of the Heber mechanical draft cooling towers for drift loss rates of 0.002%, 0.008% and 0.1%[a]

Soil	Natural salinity[b] (mmhos/cm)	Predicted increase in soil conductivity at maximum salt deposition (in mmhos/cm) for drift loss rates (in %s) indicated			Resultant soil conductivity (in mmhos/cm)		
		0.002%	0.008%	0.1%	0.002%	0.008%	0.1%
Indio loam and Meloland soils[b]	5-7	0.4	1.5	18.5	5.4–7.4	6.5–8.5	23.5–25.5
Indio silt clay[b]	12-19	0.4	1.5	18.5	12.4–19.4	13.5–20.5	30.5–37.5
Imperial — Glenbar[c] silty clay loam	4-9	0.4	1.5	18.5	4.4–9.4	5.5–10.5	22.5–27.5

[a]Maximum annual salt depositions from Table 5. . have been used to estimate total salt deposition after 30 years of 74.5 g/m^2 (570 lbs/acre) at 0.008% drift and 949 g/m^2 (8465 lbs/acre) at 0.1% drift. Maximum deposition will occur for Blythe meteorology. It is assumed that the towers will operate with 4000 ppm salinity drift for 5 years and 20,000 for the remaining 25 years. Refer to Appendix E for an explanation of the method of calculation of increased soil salinities.

[b]The natural salinities are summarized from USDA 1973 and Perrier et al. (1974).

[c]Assume soil saturation percentages of soil = 40%.

These salinities are within the tolerance range of several highly salt-tolerant species present in the riparian communities (Table G.2); however they could approach or exceed salinity tolerances for moderately salt-tolerant species such as mesquite, arrowweed and some of the saltbushes and they will certainly exceed the range for creosote bush. Many of these dominant shrub species, and the excellent wildlife cover they provide, will be eliminated from the riparian habitats affected by the drift from 0.1%. Whether these species will be replaced by highly salt tolerant species is not certain. The halophytes like iodinebush, sea blight and salt grass apparently require high soil moisture (Marks 1955, Richards 1969, and Vasek and Barbour 1977) and may not readily colonize soils outside of the immediate floodplain. Also the lower growth form of these halophytes does not provide the same wildlife cover as the larger shrubs. Furthermore, although the salinity increases in Table G.3 represent maxima for the soil saturation extracts, actual moisture content in a soil under field conditions may be one-half to one-fourth of the saturation percentage (Richards, 1969), resulting in more severe salt stress to plants than is indicated by the conductance values in the table. It is possible that even some very salt-tolerant halophytes could be eliminated by salt stress due to drift deposition at 0.1%.

Because of the variety of assumptions built into the drift models (see Sect. 5.5 and Appendix D) and into the estimated soil salinity increases, it is difficult to accurately predict how much of the riparian habitat would be exposed to salt deposition sufficiently high to cause significant soil salinization. The adverse effects from 0.1% drift described above might be expected to affect riparian habitats up to five kilometers from the towers. This could represent about 50 ha. (125 acres) of natural habitat.

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APPENDIX H

METHODOLOGY FOR CALCULATING SALINITY INCREASES IN NATURAL SOILS

APPENDIX H – METHODOLOGY FOR CALCULATING SALINITY INCREASES IN NATURAL SOILS

Table G.3 (Appendix G) presents predicted salinity increases in natural vegetation communities along the New River as a result of salt drift deposition. This appendix details the assumptions and method of calculation utilized.

The soil salinities presented in the table are expressed as electrical conductivities of the saturation extract (denoted by the symbol EC_e) and are in units of millimhos/cm. The saturation extract is the solution extracted from a soil at saturation, the condition when all available pore spaces are filled with water. The saturation percentage (SP) is the percent moisture (as weight) present in a soil at saturation. Conductance is related to the parts per million of salt dissolved in the soil water such that:

$$EC = S/K \qquad (1)$$

where

EC = conductance in micromhos/cm

S = parts per million dissolved salts

K = constant = 0.64

The data for the natural soil salinities in Table 5.7 are from the U.S. Soil Conservation literature. For all soils, saturation percentages of 40% were assumed. This is based on Soil Conservation Service data for the Indio loams, Indio silty clay and Meloland soils; for the Imperial-Glenbar silty clay loam a 40% saturation percentage is reasonable (Black 1968).

The salt contributed by drift may be added to salts naturally present in the soil to obtain the salt concentration (in parts per million) in the soil water. The new EC_e may then be calculated according to the relationship in equation 1. However, to calculate the salt concentrations, the volume of water present in the soil must be known. To estimate this volume an active rooting zone depth of 20 cm was assumed. This is based on data from other sites for some of the shrubs which occur in the New River riparian habitats (Wallace and Romney 1972; NRC 1978). Although some of the halophytes in the New River riparian habitats are phreatophytes, which have deep root system, many other halophytes exhibit a shallow root system as an adaption to high salinity soils at depth (Daubenmire 1969). Furthermore, a 20 cm depth assures a some what conservative prediction of increased soil salinities.

Assuming a 20 cm depth and a saturation percentage of 40%, 1 m^2 of soil 20 cm deep would have 80 liters of water. Drift deposition expressed as g/m^2 may be assumed to be dissolved in the soil water to yield an increase in salinity in mg/liter (or parts per million). This can be converted to the new EC_e by the relationship in equation 1. For example in Table G.3 at 0.008% drift the 30 year deposition of 74.5 g/m^2 (or 74500 mg/m^2) is dissolved in 80 liters to yield 931 parts per million. The new EC_e will be increased by 931/0.64 or 1500 micromhos/cm (1.5 millimhos/cm).

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APPENDIX I

SOIL CONSERVATION SERVICE COMMUNICATION

United States Department of Agriculture
Soil Conservation Service
2828 Chiles Road
Davis, CA
95616
(916) 758-2200

April 16, 1980

Kathleen M. Oakes
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, TN 37830

Dear Ms. Oakes:

In response to your request of February 28, 1980, for soils information for use in preparation of the environmental evaluation of the proposed geothermal power plant near Heber, California, we are enclosing a soils map and list of soil series names. We have included all soils found in the Geothermal Overlay Zone. The soils considered as prime farmland are colored green for easy identification.

Contact us if we can be of further assistance. Locally you may wish to contact our District Conservationist, Mr. Wayne Flanagan, 1282 Broadway, El Centro, CA 92243, phone (714) 352-7886.

Sincerely,

Francis C. H. Lum

FRANCIS C. H. LUM
State Conservationist

Enclosures

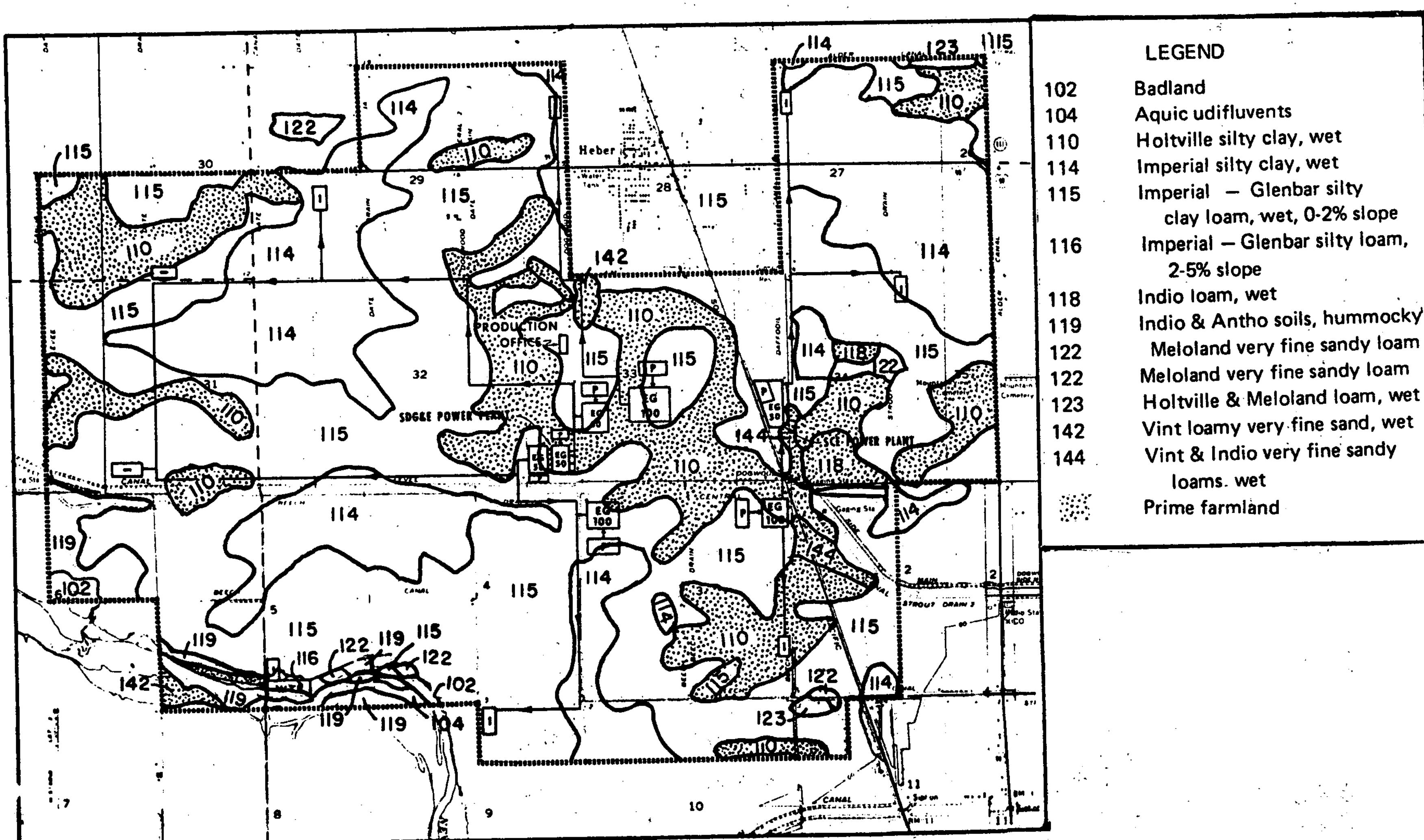

Fig. I.1. Complete Soil Conservation Service map.