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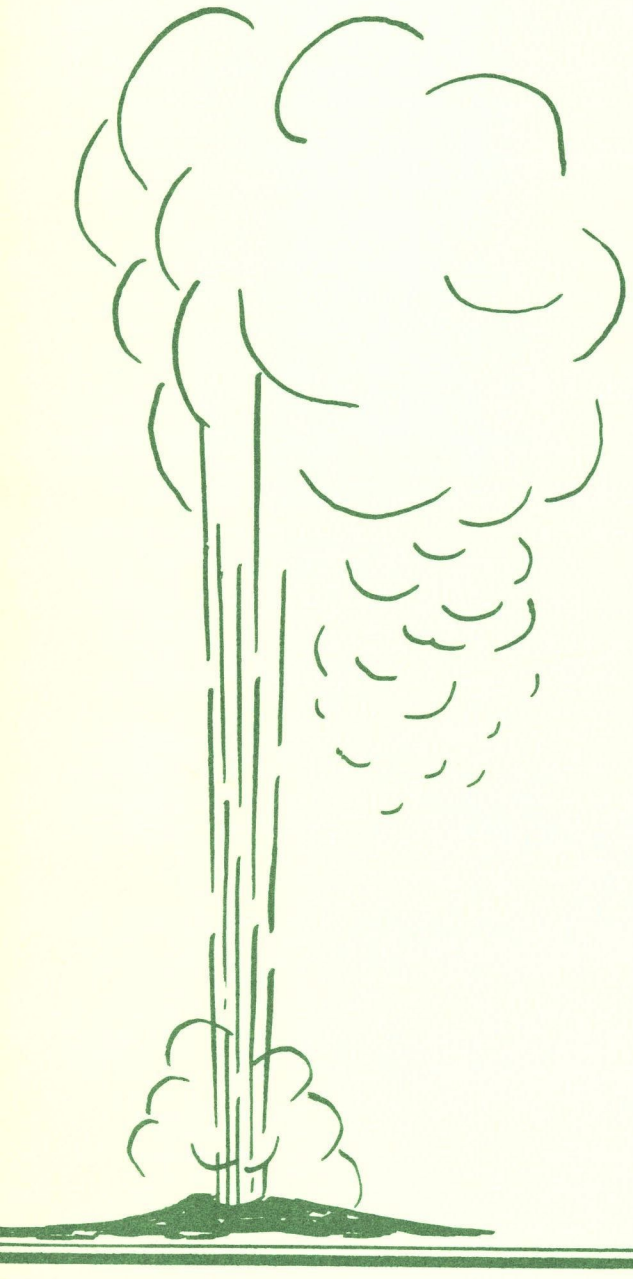

BACA GEOTHERMAL DEMONSTRATION PROJECT

Quarterly Technical Progress Report for the Period
April 1, 1980—June 30, 1980

December 1980
Date Published

Work Performed Under Contract No. FC03-78ET27163

WESTEC Services, Inc.
Albuquerque, New Mexico

U. S. DEPARTMENT OF ENERGY

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BACA GEOTHERMAL DEMONSTRATION PROJECT

QUARTERLY TECHNICAL PROGRESS REPORT

FOR PERIOD APRIL 1, 1980 - JUNE 30, 1980

Prepared By

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505 Marquette, N.W.
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Date Published - December 1980

Prepared For

UNION GEOTHERMAL COMPANY OF NEW MEXICO

AND

PUBLIC SERVICE COMPANY OF NEW MEXICO

UNDER CONTRACT NO. GEO-CSL-25

Work Sponsored By

THE U.S. DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY

UNDER COOPERATIVE AGREEMENT NO. DE-FC03-78ET27163

ABSTRACT

The purpose of this quarterly technical progress report is to document work completed on the Baca 50 Megawatt (MWe) Geothermal Demonstration Power Plant Project, Baca Location No. 1, New Mexico, during the period of April 1, 1980 to June 30, 1980. The work was performed by Union Geothermal Company of New Mexico and Public Service Company of New Mexico under the support and cooperation of the U.S. Department of Energy. Topics covered in this quarterly report include progress made in the well and steam production systems, the power plant and transmission systems, and in the project data management program.

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SECTION 1: INTRODUCTION

1.1 Introduction

The following section is offered to provide introductory information on the Baca Geothermal Demonstration Power Plant (GDPP) Project. Briefly outlined in this section are the history of the Federal Government's involvement in this Geothermal Deomonstration Project; a summary of the objectives of the project; and an outline of the Project Cooperative Agreement briefly describing the Project Management Plan and the Work Breakdown Structure.

1.2 Project Definition

The project is organized and largely cost-shared under a cooperative agreement which brings together the U.S. Department of Energy, Public Service Company of New Mexico, and Union Geothermal Company of New Mexico as partners in a joint undertaking. This demonstration project plays a significant role in the Geothermal Commercialization Plan of the Federal Government's Coordinated Program of Research and Development in Geothermal Energy. The goal of the federal government's geothermal energy program is to stimulate the economic, reliable, operationally safe, and environmentally and socially acceptable commercial development of this energy resource. Therefore, in keeping with this overall goal, the Baca GDPP Project has the following objectives:

1.2.1 Overall Project Objective

The overall objective of the GDPP Project is to stimulate commercial development of hydrothermal (liquid-dominated geothermal) resources in the United States. While technological capability to utilize these resources has been available for at least a decade, the actual risks and benefits associated with such utilization have not been known. Without specific data obtained from actual operation of a commercial-scale hydrothermal facility, potential participants may well be reluctant to pursue hydrothermal options. Financial institutions and investors require accurate risk and project cost data before committing large amounts of capital. Utilities need hard data on the availability and reliability of a geothermal-based steam supply. A full-scale demonstration plant such as the Baca GDPP should thus provide such requisite data to the commercial sector.

1.2.2 Specific Project Objectives

Achievement of the overall project objective requires attainment of the following specific objectives:

1.2.2.1 Verify Reservoir Performance

Unlike a coal, oil, or nuclear-fueled power plant, a geothermal plant is more closely dependent on a single energy supplier for its entire useful life. Consequently, a major risk that potential developers see in hydrothermal utilization relates to reservoir performance. Reservoir energy potential must be accurately modeled to assure that a sufficient production rate will be available for the intended use. Further, accurate modeling requires a clear understanding of the geologic features of the reservoir (porosity, permeability, etc.) in order to predict fluid transport within the reservoir. Of prime concern then is the long-term performance of the reservoir system. Unless confidence in modeling long-term performance can be established, hydrothermal development may be hampered, primarily by reluctance of the financial community to fund such ventures, and the unwillingness of utilities to risk investment in an "unproven" energy resource.

1.2.2.2 Demonstrate Economically Feasible Commercial-Scale Power Generation

A prime objective of the GDPP Project is to demonstrate that hydrothermal resources can be utilized to produce electric power on an economically competitive commercial scale. Besides demonstrating technological capability, it must be simultaneously shown that power so generated is economically feasible and reliable, and can be integrated into existing system operations. A further requirement is to demonstrate that environmental and legal (licensing) considerations can be satisfactorily addressed at reasonable cost and in a reasonable time frame.

To accomplish this economic objective, the project Cooperative Agreement (see Section 1.4) provides for a five-year operational demonstration period, during which all aspects of plant performance, environmental impact, and costs will be reported.

1.2.2.3 Provide Information Communication

Information generated from the GDPP Project can be influential in stimulating all aspects of geothermal resource development. Major sources of project data will include the power plant, the production system, and all associated engineering, geological, geophysical, subsurface, environmental, legal and financial data. Potential users of these data include industrial organizations such as utilities, resource developers, architect-engineering firms, and equipment manufacturers. Financial institutions also rank high as desired potential data users. Additional anticipated data users include research and academic groups, technical support and field support service organizations, resource conservation and regulatory agencies, and special interest groups. Each of these generic groups will have specific information requirements necessary to influence decisions affecting their future involvement in geothermal projects. The data management element of the GDPP Project is focused on satisfying this informational need.

1.3 Project Initiation

The U.S. Department of Energy (DOE) has initiated a Geothermal Demonstration Program that includes utilization of a liquid-dominated hydrothermal resource for large scale electric power generation. Program Opportunity Notice (PON) EG-77-N-03-1717 was issued in September, 1977, soliciting proposals for construction and operation of such a plant in a cooperative venture with DOE. The PON required that the demonstration plant use only geothermal energy from a liquid-dominated resource for generation, meet all applicable regulatory and environmental requirements, and include a program for the collection, reduction, and public dissemination of all data appropriate to the project. In response to the PON, two proposals were submitted to DOE. Of these, the proposal for the Baca Geothermal Demonstration Power Plant (GDPP) development was judged to be the more complete and most likely to attain the project objectives. The Baca Location No. 1 Known Geothermal Resource Area (KGRA) was considered to represent a good example of the relatively low salinity, high temperature type of reservoir common to many KGRA's. On the basis of DOE's evaluation, the proposal for development of the Baca resource from Union Oil Company of California and Public Service Company of New Mexico was accepted on July 5, 1978, for the geothermal demonstration program.

1.4 Project Cooperative Agreement

As a result of the acceptance of the Baca GDPP Project Proposal, a project Cooperative Agreement was entered into by the U.S. Department of Energy and the project Participant (comprised of Public Service Company of New Mexico and Union Geothermal Company of New Mexico). The final agreement was signed in August 1979, providing for joint participation in the Baca GDPP Project between DOE and the Participant. The final agreement calls for a schedule which includes a five-year operational phase commencing with firm operation of the generating plant. This operational phase was anticipated to last until approximately March 1, 1987, under the original schedule.

The Cooperative Agreement sets forth a Project Management Plan to monitor and direct the progress of the project, and ensure that budgetary and schedule constraints are adhered to. The Project Management Plan provides for a DOE Project Manager (DPM) and a Participant Project Manager (PPM). The role of the DPM is to provide planning, direction, and control of the project within established project objectives, schedule and cost estimates. The Participant's project management team is headed by an Operating Committee composed of Union Geothermal Company of New Mexico (Union) and Public Service Company of New Mexico (PNM) technical managers and executives. Authority is delegated by the Operating Committee to the PPM, who is the primary liaison with DOE. An organization chart for the GDPP Project is shown in Figure 1.1. The Work Breakdown Structure (WBS) is displayed in Figure 1.2.

Work on specific areas in the project Work Breakdown Structure is assigned to functional managers that report functionally to the PPM and administratively to their departments in Union or PNM.

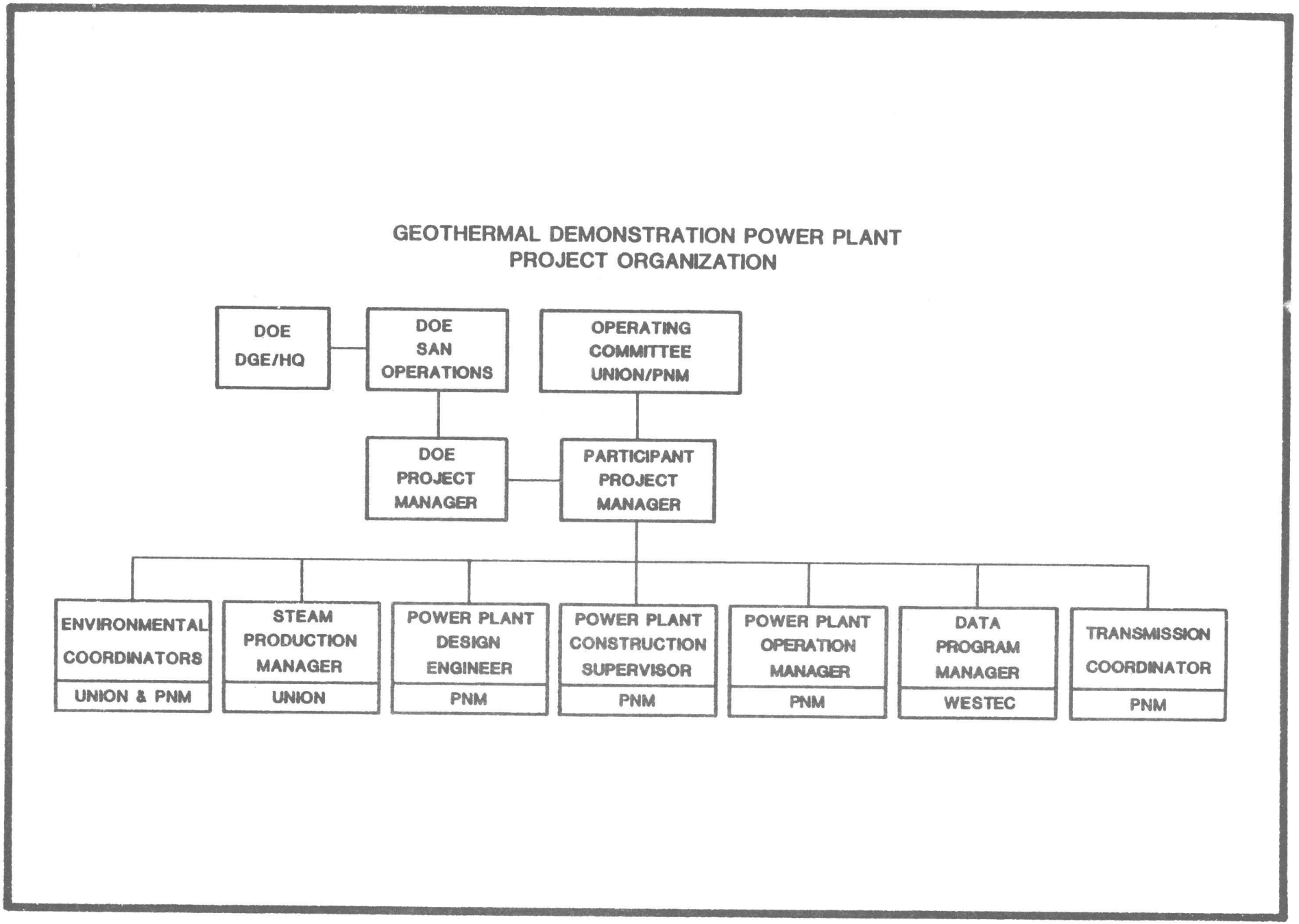

FIGURE 1.1 GDPP PROJECT ORGANIZATION CHART

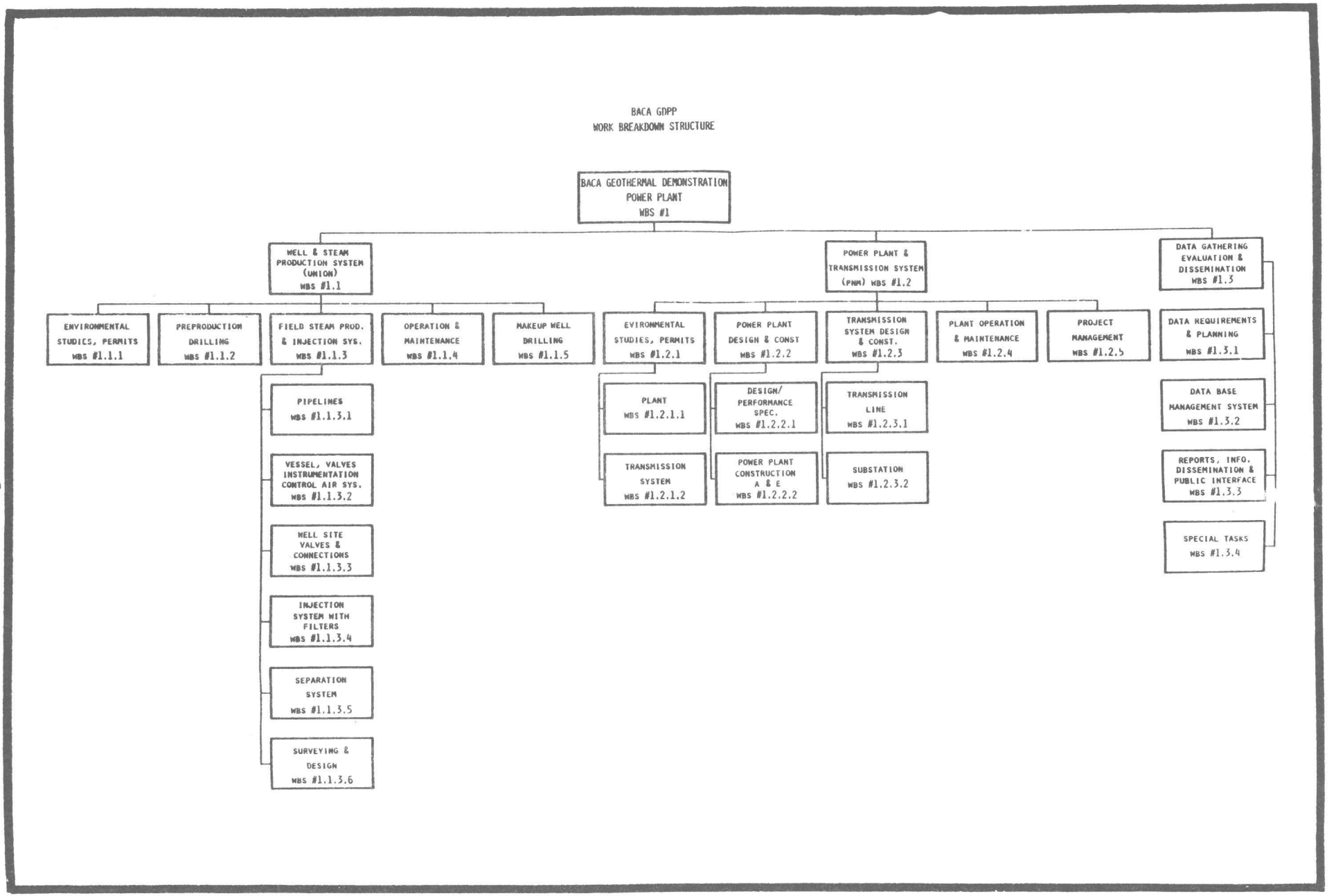

FIGURE 1.2 WORK BREAKDOWN STRUCTURE

WBS 1.1 consists of the Well and Steam Production System Task. This includes well drilling, design and construction of the gathering system, associated environmental monitoring and permitting, geologic exploration, surveying, production system operation during the demonstration period, and other wellsite-related tasks. Union is responsible for work in this task area.

WBS 1.2 encompasses the Power Plant and Transmission System Task. This includes power plant and transmission system design and construction, environmental studies and permits for the power plant and transmission corridor, construction management, and power plant operation during the demonstration period. PNM is responsible for work in this task area.

WBS 1.3 comprises the Data Gathering, Evaluation and Dissemination Task, wherein project data and information are acquired, analyzed, and distributed on request to information users. This task is solely funded by DOE. It is administered by the Participant Project Manager in close cooperation with the DOE Project Manager. Work on this task is performed by WESTEC Services, Inc., under a subcontract with the Participant.

1.5 Scope of the Report

The purpose of this Quarterly Technical Progress Report is to record the progress made by Union Geothermal Company of New Mexico (Union) and Public Service Company of New Mexico (PNM) toward attainment of the project objectives during the period of April 1, 1980, through June 30, 1980. The report is intended to provide an overview of experienced progress made in major project areas rather than an in-depth treatment of methodology, technical features, or findings. Treatment of these more specific topics and other subjects will be covered in later topical reports.

1.6 Summary of Progress: April 1, 1980, to June 30, 1980

Power plant engineering and procurement activities progressed on schedule, with engineering approximately 75 percent complete by the end of the quarter.

Environmental monitoring activities were delayed at the beginning of the quarter by a late Spring thaw. Thereafter, monitoring proceeded on schedule. Additional meteorological stations were purchased and erected and water quality monitoring was expanded to include additional sites. Data collection continued.

Completion of the DOE permitting process (FEIS and ROD) on May 5, 1980, was nine months behind schedule. PNM originally applied to the NMPSC for a Certificate of Public Convenience and Necessity on February 18, 1980. As the NMPSC had not yet responded to the application, a supplementary application for interim permission to begin plant construction was submitted to the NMPSC immediately following publication of the DOE ROD on May 5, 1980. At the end of the quarter, the NMPSC proceedings on PNM's requests were underway with no issued decision.

On May 6, 1980, a power plant construction contract was awarded by PNM. Due to the lack of a Certificate of Public Convenience and Necessity, however, site work during the remainder of the quarter was limited to earthwork, below grade concrete work, and site preparation.

Union's well drilling activities for the quarter began following issuance of the ROD. Well production rate testing and injectivity tests continued on existing wells throughout the quarter. Efforts by Union to secure approval from the State Engineer of water rights for the project are proceeding. Production and injection for the transfer system piping layout and design progressed on schedule.

The power transmission line corridor was finalized and preliminary survey work was initiated during the quarter. The in-service date for the transmission line has been changed from July 1981 to September 1981 due to delays in performing these surveys. Design of special transmission support structures was completed during the quarter.

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SECTION 2: WELL AND STEAM PRODUCTION SYSTEM

2.1 Introduction

This section summarizes work completed during the quarter under the Work Breakdown Structure Task WBS 1.1, Well and Steam Production System. Primary responsibility for work on this subsystem of the Baca GDPP project rests with Union Geothermal Company of New Mexico (Union).

2.2 Summary of Progress

Drilling operations, suspended by Union during April and May pending issuance of the DOE Record of Decision, were resumed at the end of the quarter. Well injectivity testing continued and was completed on existing wells Baca No. 12 and Baca No. 14, and production testing on Baca No. 19 was completed in May. Data gathering continued on these wells during the quarter.

Piping system design continued with the completion of an investigation into expansion loop alternatives. Piping system component purchases continued through the quarter.

2.3 Licensing and Permitting

Union's licensing and permitting effort has been chiefly directed at securing approval from the State Engineer for water rights transfers. The water is needed to support drilling activities during construction and for injection water make-up during plant operation.

A hearing on applications for the appropriation of water for beneficial use, and transfer of existing water rights from adjoining Union owned lands, was held on April 10 and 11, 1980 before representatives of the State Engineer's Office. Union filed a "Brief in Support of Applications to Appropriate Underground Waters" with the State Engineer on May 26, 1980. A ruling on the appropriation is anticipated in mid-July, 1980.

In addition, Union routinely applies for and receives permits for well drilling operations. During the quarter, Notice of Intention for redrilling of Baca No. 18 was filed with the New Mexico Oil Conservation Division on April 21, 1980. Also, a Permit to Drill was received for Baca No. 20 from the New Mexico State Engineer.

2.4 Preproduction Drilling and Testing

Union is responsible for the development of the geothermal field and the production of steam from the liquid-dominated resource, including drilling, preproduction flowrate testing, injectivity testing and interference/communication testing of the wells.

2.4.1 Drilling

No new drilling or drilling rig operations were performed during April and May, pending issuance of DOE's Record of Decision. Drilling commenced on June 27, 1980, with the spudding of Baca No. 20. Well pad site preparation was initiated at Baca No. 21 during this quarter in anticipation of drilling in the third quarter of 1980. Well locations are shown on the accompanying Figure 2.1.

2.4.2 Well Testing

A two-phase continuous production flow test begun March 26, 1980, on Baca No. 19 was terminated on May 14, 1980. The test was to determine what effect the large volume water flush/injection test performed in December 1979 had on the producibility of the well. The large volume flush was performed to clean out the well, which had exhibited a cyclic production rate in earlier tests. During this test the cyclic rate of production was again noted, indicating the production rate cycling was not due to casing plugging. The cycle was regular with a period of about six hours. The flow rate ranged from about 96,600 kg/hr (213,000 lb/hr) at 45 N/cm^2 (65 psig) to 20,900 kg/hr (46,000 lb/hr) at 6.1 N/cm^2 (10 psig). Union is analyzing the test results in an effort to understand this cyclic phenomenon. The produced fluid from Baca No. 19 was later used in injection tests on both Baca No. 12 and No. 14.

An injectivity test was performed on Baca No. 12 on May 5 and 6, 1980. Fluid was injected at a rate of 1500 liters per minute (400 gpm) with no positive wellhead pressure experienced during a continuous 33.75-hour period, indicating this well could accept this injection rate. A number of downhole wireline pressure/temperature surveys were run concurrently with water injections. Spinner surveys were also conducted. Periodic pressure/temperature surveys are currently being run in the well to measure heat recovery in the formation. Reservoir engineering personnel are reviewing and evaluating all data obtained to date. The pressure/temperature survey run on May 12, 1980, in Baca No. 12 indicated a maximum temperature of 216C (422F) at 1070m (3500 foot) depth. A pressure/temperature survey on June 9, 1980, indicated that the temperature had built up to 230C (450F) between the depths of 910m (3000 feet) and 1980m (6500 ft). This survey completed the data gathering program following injectivity testing of Baca No. 12.

An injectivity test was performed on Baca No. 14 on June 2 through 5, 1980. After 67.75 hours of continuous injection at a rate of 760 liters per minute (200 gpm), no positive wellhead pressure was noted, indicating this well could accept this injection rate.

2.5 Production System Engineering

Union will provide production and injection system piping, steam separators (flash tanks), steam scrubbers and associated pumps, valves and controls for the Baca GDPP Project. Union has in-house expertise in the design and construction of single and two-phase fluid handling systems by virtue of their extensive experience in both domestic and foreign geothermal development projects.

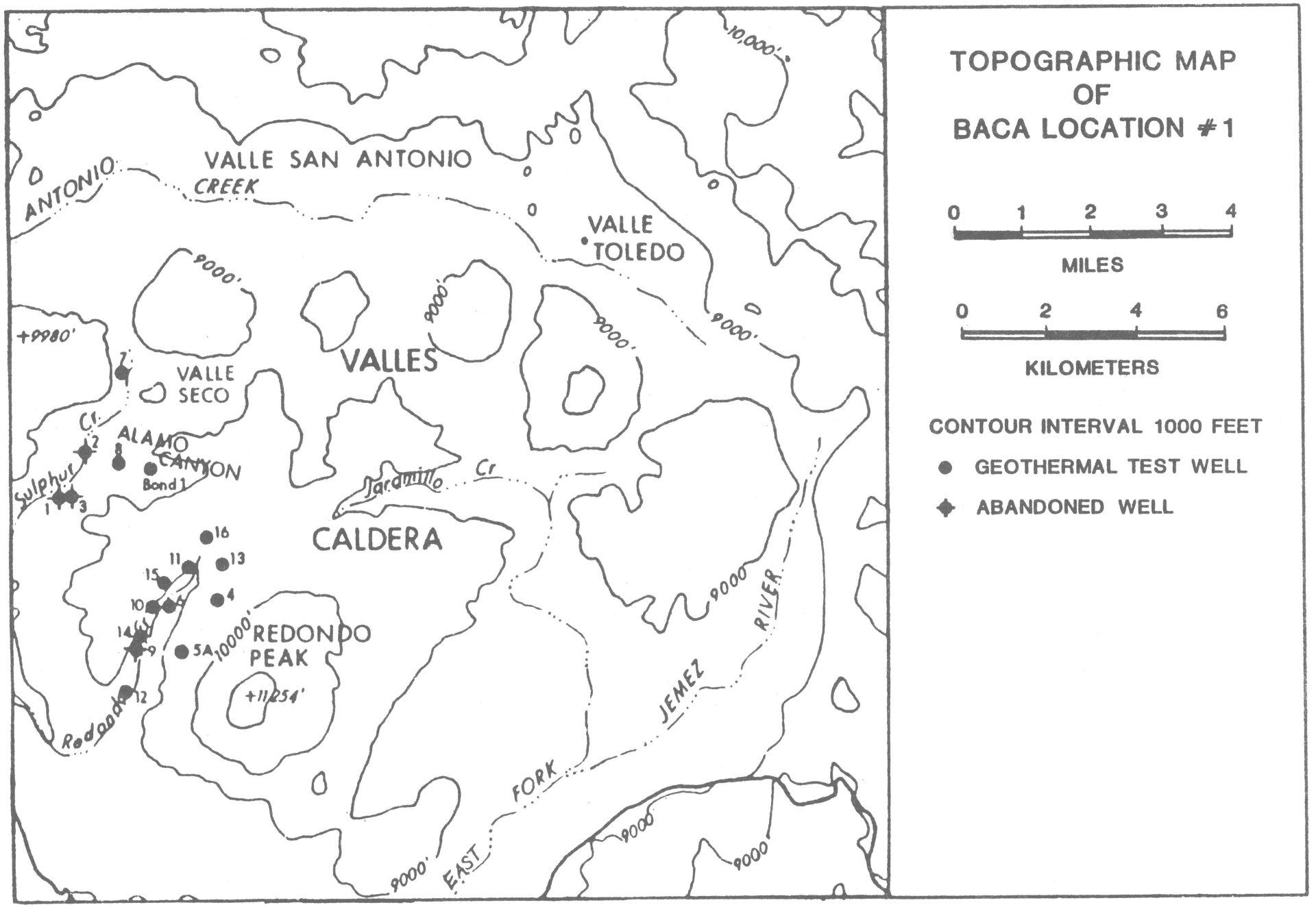

Figure 2.1. Topographic Map of Baca Location #1 showing Well Locations.

During this reporting period, Union was involved in the following engineering activities:

2.5.1 Design Documents

All piping and instrument diagrams, and heat and mass flow balances were revised to reflect current well productivity rates, flash rates, and equipment data. The layout map of the production system has been updated, and is included herein as Figure 2.2.

Union met with General Electric Company, PNM, and Bechtel Power Corporation engineers during the quarter to resolve questions on the maximum production system/turbine loading rate.

2.5.2 Piping Design

Piping stress analysis and pressure drop computer programs have been incorporated into Union's timesharing computer system and will be used for design of the gathering system piping. A Union report utilizing these programs analyzed the piping stresses and pressure drops in expansion loops with 90^{o} and 45^{o} elbows. The report concluded that horizontal loops were preferred over vertical loops, and that vertical loops in piping where two-phase flow is present should have two 45^{o} elbows on the upstream side to reduce slugging. These recommendations will be incorporated into the satellite separator piping system.

2.5.3 Equipment Purchases

Union placed orders for production and injection system gate valves and butterfly valves during this period. Requisitions for piping, fittings, supports, and additional valves are in progress.

Union purchased and installed a security station for the project site entrance, and contracted security services for the project site during the quarter.

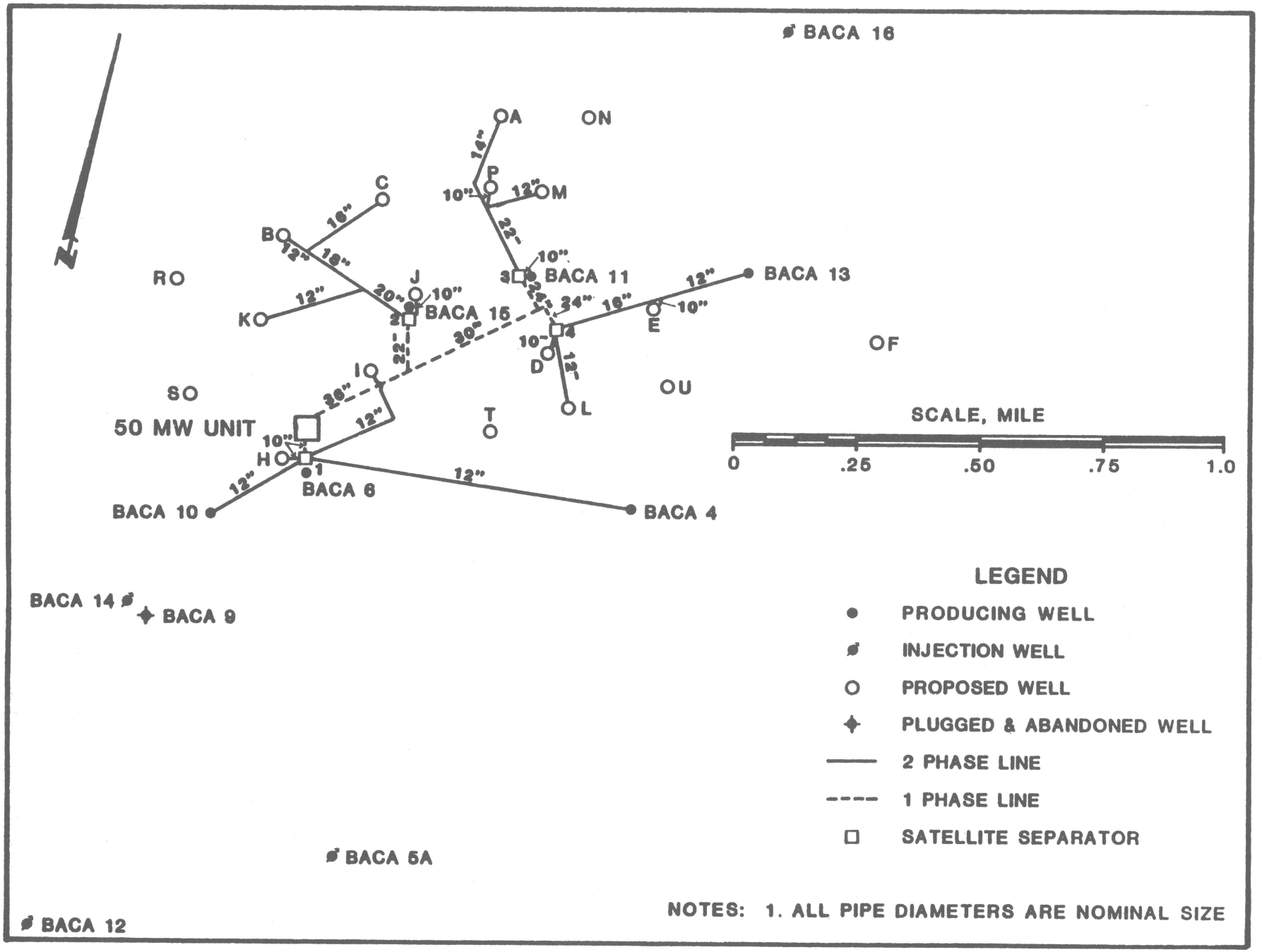

Figure 2.2. Conceptual Fluid Production Pipeline System. **Source: Union Geothermal Company of New Mexico**

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SECTION 3: POWER PLANT AND TRANSMISSION SYSTEM

3.1 Introduction

This section summarizes work in progress during the quarter under the Work Breakdown Structure Task WBS 1.2, the Power Plant and Transmission System. PNM is primarily responsible for work under this task; major PNM sub-contractors are M.M. Sundt Construction Company and Bechtel Power Corporation.

3.2 Summary of Progress

PNM awarded a general construction contract on May 6, 1980, to M.M. Sundt Construction Company. Award of the contract had been postponed until receipt of the DOE Record of Decision. Construction progress thereafter was limited by delays in obtaining a Certificate of Public Convenience and Necessity from the New Mexico Public Service Commission.

Equipment procurement and power plant engineering proceeded according to schedule.

The transmission line corridor alignment was finalized and a right-of-way survey permit was obtained from the U.S. Forest Service.

3.3 Legal and Institutional

Following the issuance of the DOE Record of Decision on May 5, 1980, PNM petitioned the New Mexico Public Service Commission (PSC) for an interim construction permit to allow construction work to begin, pending issue of the Certificate of Public Convenience and Necessity. Intervenors, including the Pueblo Indians and environmental groups, petitioned the PSC to disallow PNM's request on the basis of environmental degradation and infringement of religious freedom. The New Mexico State Attorney General's Office intervened in the case to represent the consumers. At the end of the quarter, the PSC was considering the matter and had scheduled public hearings in July 1980.

3.4 Power Plant Design and Construction

The major PNM contractors working on Baca power plant design and construction effort during the quarter were Bechtel Power Corporation (Bechtel), F. M. Fox and Associates, and M.M. Sundt Construction Company. Included in this section are progress reports on power plant engineering, equipment procurement and plant site preparation and construction work performed by PNM and these subcontractors.

3.4.1 Power Plant Engineering

By the end of the second quarter Bechtel, the power plant design subcontractor, had issued 248 of a total of 356 engineering drawings for construction. Plant design and piping layout progressed on schedule; however, future progress depends on timely receipt of vendor drawings on the turbine and steam control valves. General Electric Company (GE), the turbine-generator vendor, has not released certified drawings of the turbine-generator control logic and steam control valves according to the contract schedule. Without certified drawings, Bechtel cannot finalize piping layout or supports on several plant systems. The condenser vendor, Ecolaire Condenser, revised condenser piping connection locations during this quarter, necessitating revision of piping system drawings by Bechtel. Overall, Bechtel estimated their engineering and support services to be 75 percent complete at the end of the quarter.

3.4.2 Procurement

Progress was made in major procurements by PNM, through Bechtel's design and procurement agreement, specifically in the award of service contracts and of equipment purchases.

3.4.2.1 Service Contracts

Upon issue of the DOE Record of Decision on May 5, 1980, PNM awarded the General Construction Services contract to M.M. Sundt Construction Company (Sundt) on May 6, 1980. This contract includes foundation and caisson placement, erection of the powerhouse structure, and equipment erection. Sundt was released to begin site preparation work on June 6, 1980.

A contract for materials testing services was awarded to F.M. Fox and Associates in May 1980 to support the work being performed by Sundt.

3.4.2.2 Equipment Purchases

As part of the overall power plant engineering design effort, Bechtel prepares specifications, solicits bids, and evaluates proposals for all power plant equipment under the terms of their engineering subcontract with PNM. Proposal summaries, with purchase recommendations, are then submitted to PNM for approval.

At the end of the quarter, Bechtel estimated their procurement effort to be 51 percent complete. Equipment purchased by Bechtel (as agent for PNM) during the quarter included:

Fiberglass-Reinforced Plastic Circulating Water Pipe
ANSI B31.1 Relief Valves
Air Compressor and Filters
Air Receiver and Shop Fabricated Tanks
ANSI Material Pipe Supports
Standby Diesel-Generator Set
General Service Butterfly Control and Manual Valves
480-Volt Load Center
480-Volt Motor Control Centers
5-kV Cable
Plant Annunciator System
Thermowells and Thermocouple Assemblies
Pressure Switches
Rubber Expansion Joints
Sample Nozzles

3.4.3 Plant Site Preparation and Construction

Due to the delays in obtaining a Certificate of Public Convenience and Necessity from the Public Service Commission, power plant construction activities during the quarter were limited to earthwork and site preparation.

Sundt, the general construction contractor, completed fifty-one caissons for the powerhouse foundation, and started work on the retaining wall uphill from the cooling tower location. Material and equipment shipments were received and stored on-site and a concrete batch plant was erected on-site that provided concrete for the caissons and will continue to provide concrete for the remainder of the construction effort.

3.5 Transmission System

Electrical power generated by the Baca GDPP will be routed to a PNM substation near Los Alamos, New Mexico, approximately 35 km (22 miles) east of the power plant facility. Progress in design and construction of the transmission system is described in the following sections.

3.5.1 Right-of-Way

Following issuance of the DOE Record of Decision, PNM applied to the U.S. Forest Service for a right-of-way survey permit for the transmission corridor. Two alternative corridors had been studied, and with the ROD came a decision to use the northerly of the two routes due to its lower impact on the environment. This routing is shown in Figure 3.1. The factors affecting PNM's decision to use this routing will be discussed in detail in a future topical report.

With the corridor established, PNM submitted preliminary maps of the right-of-way to the Forest Service of that portion of the corridor on Forest Service land. PNM completed vertical and horizontal control surveys of the right-of-way during the quarter.

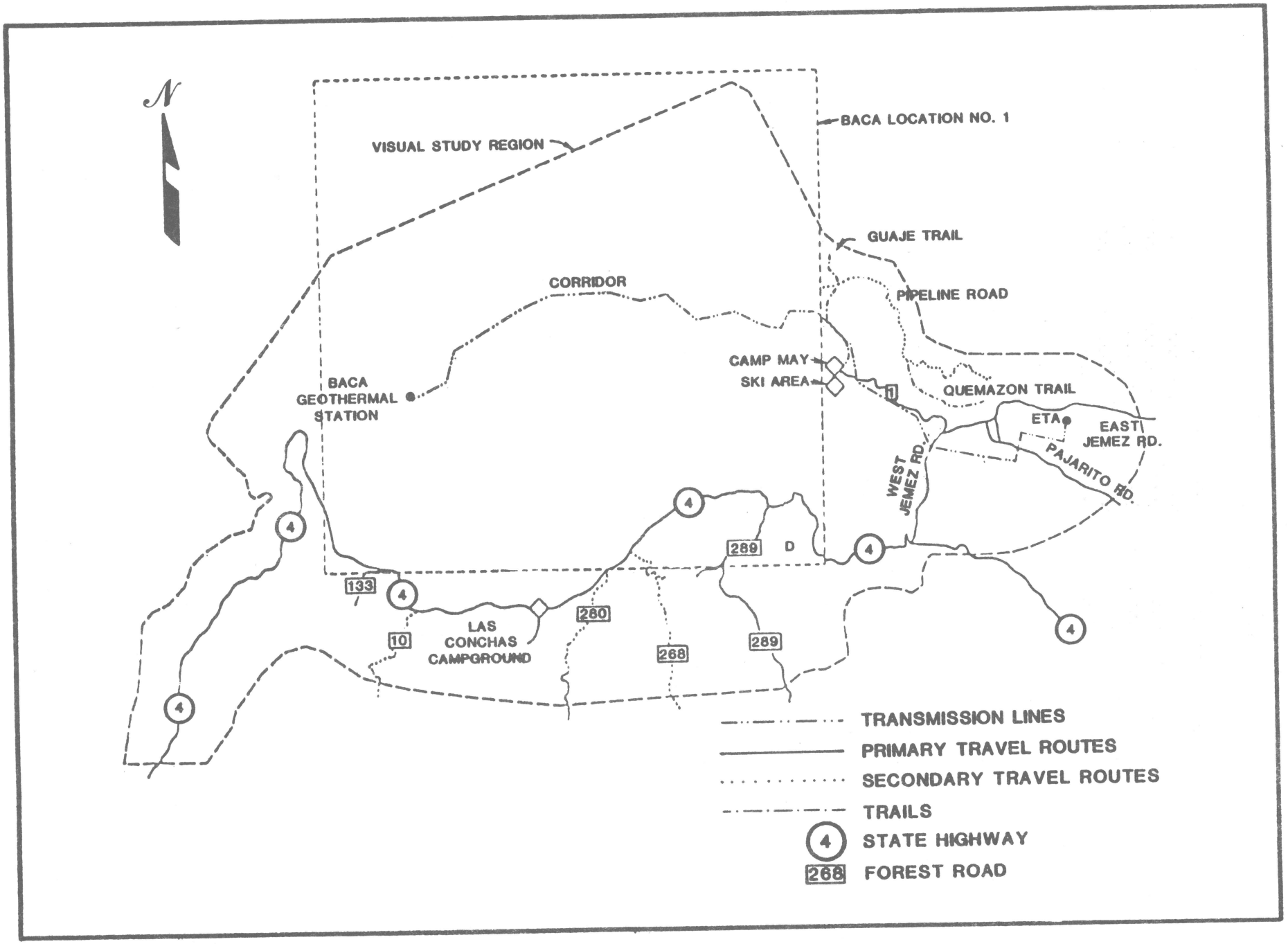

Figure 3.1 Transmission Corridor

3.5.2 Transmission Line Design and Procurement

PNM completed design of the special support structures required for the transmission line on May 1, 1980. Transmission line materials had been ordered to support the July 1981 transmission line in-service date; however, delays in performing the transmission line surveys necessitated a change in the in-service date to September 1981. Accordingly, the material order was cancelled in May 1980 and will be re-ordered in August 1980, with an April 1981 delivery date specified.

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SECTION 4: ENVIRONMENTAL MONITORING

4.1 Introduction

Environmental monitoring programs have been established by the Participant and WESTEC to record baseline conditions and subsequently to monitor the effects of geothermal development. Progress and activities in these programs are discussed in the following sections.

4.2 Summary of Progress

Surface water quality monitoring of Redondo Creek and nine additional points on the Jemez watershed continued on schedule during the quarter, with the exception of three samples scheduled for April 1980 that were postponed due to inclement weather.

High surface run-off (due to melting snow) delayed hydrology monitoring scheduled to be performed during this quarter. This work was re-scheduled for July 1980.

The air quality and meteorology monitoring program was expanded with the acquisition and erection of two 30 meter (100 foot) high towers to supplement existing recording stations. Data acquisition from the new towers began in June 1980 and continued throughout the quarter at the existing stations.

Programs to identify and monitor the native flora and fauna in the project area continued during the quarter, though heavy snow cover on higher elevations delayed monitoring of elk and small mammal transects until late in the quarter. Revegetation of disturbed areas continued with planting of 900 seedling trees and reseeding of open areas with native grasses and wildflowers.

Fieldwork was completed on an archaeological survey of the wellfield area and was initiated on portions of the transmission line corridor.

4.3 Water Quality

Surface waters in the plant and wellfield areas and in the Jemez watershed are monitored for flow rate and water quality on a monthly basis.

Union monitors Redondo Creek at a site near Baca No. 12, effectively downstream from both the plant site and wellfield, and at six additional sites in the Jemez watershed. Monitoring at these seven sites continued on schedule during this quarter.

WESTEC presented a water quality monitoring program for Participant approval in early April 1980. This program was designed to supplement Union's monitoring program by adding three new sampling sites. In late April 1980, DOE requested that one of WESTEC's three planned surface water monitoring sites be relocated along the Jemez River north of

the Jemez Pueblo and that two additional sampling stations be added to WESTEC's surface water monitoring program. The relocated Jemez River sampling site was included in the May 1980 sampling. A decision regarding the acceptability of the two additional sampling stations will be made by the Participant during the next quarter, based on a cost proposal being prepared by WESTEC.

WESTEC's surface water sampling for April 1980 was postponed due to problems with inclement weather and sample filtration equipment. The samples were collected from the three sites (including the relocated Jemez River site) on May 12 and 13, 1980. The June 1980 sampling was completed for the three sites on June 20. Analysis of the surface water samples was contracted to CORE Laboratories of Albuquerque.

4.4 Hydrology

The effects of geothermal fluid withdrawal on groundwater levels and quality are monitored through sampling of local springs and observation wells.

Union's groundwater monitoring program includes six springs measured for discharge rate and water quality changes, and twelve observation wells in which depth to water is periodically recorded. Sampling frequency is typically two to three times per year, to include spring and fall. Union's Spring 1980 sampling was postponed due to high run-off conditions and is to begin in mid-July 1980 when accurate groundwater measurements can be made. High surface run-off conditions (due to melting snow) have the effect of diluting samples, with resultant loss of accuracy.

WESTEC's groundwater monitoring program includes biannual sampling at Jemez Springs and at wells in Valle Grande and Valle San Antonio. The high run-off conditions prevailing during this quarter forced postponement of sampling until the next quarter.

4.5 Air Quality/Meteorology

Air quality and meteorology data are being collected continuously on and around the Baca Location to provide a basis for hydrogen sulfide (H_2S) dispersion modeling and to establish baseline data prior to power plant start-up. PNM and WESTEC have developed complementary data collection programs in order to provide a broad data base.

During this quarter, PNM installed an acoustic sounder station, designed to obtain upper level atmospheric data, at the mouth of Redondo Canyon. Operation of the station will begin in July 1980. The PNM mini-sonde program (tracking of balloon releases for vertical temperature data) and the H_2S "tab" program, for monitoring relative H_2S concentrations, are both continuing to gather data on schedule.

Data continued to be collected from PNM's 200-foot meteorological tower located near the plant site in Redondo Canyon and from the Central Monitoring Station located next to the tower. One PNM mobile meteorological station was moved onto the Baca location on May 12, 1980, and is recording at the Union temporary field office site. A second PNM mobile meteorological station was relocated to the Baca location on June 13, 1980.

WESTEC purchased two 30 meter (100 foot) tall meteorological towers during the quarter and erected them on land leased by Union but outside the immediate plant site area. One tower is located near the well pad for Baca No. 19 and the other is located near the crest of Redondo Border. These site locations were selected to aid in the understanding of air flow in the complex terrain, particularly cross-valley air flow. The two sites are necessary to define the cross-ridge transport from the Redondo Creek drainage into the Sulphur Creek Basin, and will help define cooling tower plume transport from the plant site.

Erection of the meteorology towers and mechanical weather stations at both sites was completed during the week of June 23, 1980. The tower heights at the lower and upper sites are 34 meters (110 feet) and 27 meters (90 feet), respectively. Both sites provide excellent exposure with clearances of 8 to 10 meters (25 to 30 feet) above tree tops. Recording charts will be available for the first month of operation (late June through late July 1980) by the end of July 1980.

4.6 Floral Studies

The WESTEC floral monitoring program focuses on assessment of the effects of cooling tower emissions on the local ecosystems, while supplementing Participant vegetation studies.

WESTEC biologists visited the Baca Project site and met with representatives of PNM in April 1980 to discuss the floral monitoring program. A draft sampling and analysis plan was then prepared for Participant review, and approved shortly thereafter.

WESTEC field biologists performed the first field sampling at the end of June 1980. Vegetation transects were established and permanently marked, with samples collected on most transects. The remainder will be collected during July 1980.

Laboratories were contacted for cost proposals to perform the required chemical analysis of vegetation and soil samples. Nelson Laboratories of Stockton, California, was selected, and their analysis of samples collected during the initial sampling effort will be completed during the next quarter.

4.7 Revegetation

As part of the environmental impact mitigation program set forth in the Final Environmental Impact Statement, disturbed areas not in general use will be returned to their original vegetated state. Seven hundred seedling trees were obtained by Union from the U.S. Forest Service on April 30, 1980, and an additional 200 seedlings were obtained in May 1980. Planting of the trees was completed by Union during May 1980 around the wellsites of Baca No. 13 and Baca No. 4. All newly cut areas were planted with mixed grasses and wildflowers.

4.8 Faunal Studies

An inventory of the types and quantities of fauna in the general plantsite area was conducted by PNM during the quarter. Wellfield sites, both disturbed and undisturbed, were monitored by Union. Small mammal trapping was delayed from May until June due to poor weather conditions. Monitoring of elk transects also was delayed until June due to snow cover on the upper portion of the transects. Spring monitoring for both programs was completed in June. Bird monitoring continued on schedule during this quarter.

The PNM survey of the transmission corridor for potential endangered species habitats began in mid-June 1980. Completion is anticipated by July 30, 1980. PNM is working with the U.S. Forest Service to identify potential habitats of the Jemez Mountain Salamander, an endangered species. Habitat areas identified in the survey will be avoided by the transmission corridor routing wherever possible.

4.9 Archaeological Surveys

The Office of Contract Archaeology (OCA) of the University of New Mexico has been contracted by Union for the purpose of identifying and cataloging historically significant sites in the wellfield area. OCA resumed fieldwork in Redondo Canyon in May when weather conditions permitted. All fieldwork was completed and analysis of collected materials is continuing. The first draft report from OCA is expected to be completed on schedule during the next quarter.

The PNM archaeological inventory survey of the transmission corridor, originally scheduled to begin in early Spring, was delayed due to a late Spring thaw. The survey began in mid-June 1980, with completion expected by July 30, 1980. The survey has identified potentially significant sites in the portion of the corridor on U.S. Forest Service land, which are avoided in the final corridor alignment. Any significant archaeological sites identified on the portion of the corridor in the Baca Location will be avoided or excavated to mitigate possible adverse effects.

SECTION 5: DATA GATHERING AND DISSEMINATION

5.1 Introduction

Work performed under the Work Breakdown Structure Task WBS 1.3, the Data Gathering and Dissemination Task, has been sub-contracted by the Participant to WESTEC Services, Inc. (WESTEC). All funding for this segment of the project comes from DOE. The data management subcontract places primary responsibility for data collection with the Participant, while the data subcontractor is to compile, store, evaluate and report the project data. In addition to the information communication function, the data subcontractor supplements the data gathering efforts of the Participant in the areas of ecology, hydrology and meteorology, and supports the Participant's efforts in the areas of project promotion and public relations.

5.2 Summary of Progress

Compilation and approval of executive summaries of sixty-one historical project documents was approximately 80 percent complete at the end of the quarter, and the summaries are expected to be issued next quarter. Data acquisition continued in areas of on-going activity, including well testing and environmental monitoring.

Existing reservoir and well log data were analyzed by the subsurface data management subcontractor to determine project data file formats. An equation-of-state program was developed for modeling the water-carbon dioxide mixture in the hydrothermal fluid in reservoir simulations, and was used in preliminary analysis of well data. Geological and geophysical data on the Baca geothermal reservoir were compiled to develop a conceptual model of the reservoir in its predevelopment state.

Generic audiences targeted for receiving project data were identified and community survey worksheets were developed as part of the Information Communication Plan. These worksheets will determine what information content and form is acceptable to each generic audience. Distribution of the worksheets to the geothermal community is expected in the next quarter.

Work continued in developing the format for the standard financial analysis reports to be distributed to the financial community. Sources and types of data available from the Participant were investigated by the financial data analysis subcontractor.

Documentation of the legal and regulatory aspects of the overall resource development effort continued with emphasis on the Record of Decision process.

Development of the data base management system centered on system structure and data requirements definition, which will in turn define hardware requirements.

WESTEC, in conjunction with DOE, prepared technical papers for presentation at the Electric Power Research Institute (EPRI) Fourth Annual Geothermal Conference and for publication in the proceedings of the Geothermal Resources Council 1980 Annual Meeting. Requests from outside the project for information on the project were answered routinely as received.

5.3 Executive Summaries

WESTEC continued to prepare executive summaries of sixty-one historical project documents (technical, financial, environmental, etc.) obtained by DOE under the terms of the Cooperative Agreement. During this quarter, the first twenty executive summaries were approved by the Participant for public release; summaries 21-40 were put in final draft form for approval; and summaries 41-61 were resubmitted to the Participant for first draft approval. A proposed cover for the summary package was also submitted for approval in June 1980. These summaries will be distributed to parties interested in hydrothermal resource utilization.

5.4 Information Communication Planning

The primary objective of the Baca Data Gathering and Dissemination Task is to identify the potential project information user groups and to provide them with the quantitative bases for assessing the technological and economical risks and benefits associated with involvement in a geothermal development project such as the Baca GDPP Project.

Progress made in the Information Communication Planning effort during this quarter is described in the following paragraphs.

A two-day working session was held during April 1980, bringing together the combined expertise of WESTEC's team to work on the Information Communication Plan and the Industrial and Financial Community Survey. At this meeting, further definition and structure of generic audiences and their information needs were established and coordinated with all team members; preliminary community survey content and format was clarified and ideas were merged with all team members into a draft survey form and procedure; and the objectives and information needs of the Information Communcation Plan were reviewed with all team members.

A draft geothermal community survey was generated for the ten information user communities defined during the April 1980 working session. The first draft of the survey package (consisting of six functional worksheets and one corporate perspective worksheet) was discussed with WESTEC team members at a follow-up planning session in San Diego on June 5 1980 and comments from that meeting will be incorporated into a second draft. A limited mailing list is being compiled for the mailing of the survey. The draft survey worksheets and mailing list will be submitted to the Participant during the following quarter.

5.5 Data Base Development

Data base development is composed of activities necessary to provide an automatic data processing capability for the electronic storage and retrieval of project-generated information. This task consists of the general areas of system definition, system design, and system installation and operation. Progress made during the quarter in the areas of system definition and system design are desribed in the following paragraphs.

Two major automatic data processing system (ADP) alternatives were identified as preferred choices for supporting the data base development: procuring a stand-alone mini-computer system or contracting for computer timesharing services. These ADP alternatives were chosen on the basis of an evaluation of incremental cost differences as a function of computer usage time. The following basic criteria were taken into consideration in making this choice: 1) the cost for a stand-alone system is fixed at the total capital cost of the hardware regardless of the computer usage; 2) the cost for computer timesharing services is heavily dependent on the amount of computer connect time, input/output transactions, and permanent storage space; and 3) low computer usage favors the timesharing alternative, while high computer usage favors the stand-alone alternative.

To get the automatic data processing system functioning in a timely manner, a decision was made to contract initially for computer timesharing services during the slower development phase of the Data Management Task. During this period, data will be gathered on actual computer timesharing costs as a function of computer usage time and a reevaluation of the alternatives will be made utilizing these data.

5.6 Legal and Regulatory Constraints Impacts

WESTEC is compiling a history and analysis of legal and regulatory constraints impacts on the project as a guide for future geothermal development.

During June 1980, WESTEC met in Washington, D.C., with the DOE staff involved in producing the Baca Project Record of Decision (ROD), which was issued on May 5, 1980. These meetings provided necessary input to the documentation of the history of the Record of Decision.

5.7 Financial Analyses

WESTEC is to provide financial analyses appropriate to the needs of specific user communities identified in the Information Communication Plan (see Section 5.4). Work in this area has been subcontracted by WESTEC to Coopers & Lybrand, Certified Public Accountants.

During April 1980, representatives of Coopers & Lybrand met with representatives of PNM and Union to discuss the types, sources, and availability of financial information on the Baca Project to be used to develop the standard financial analysis reports for the financial community. Their initial conclusion was that a prospectus format should be used for financial analysis reporting.

5.8 Geological and Geophysical Data Management

Systems Science and Software, Inc. (S^3) is subcontracted by WESTEC to evaluate new and previously developed geological and geophysical data on the Baca reservoir and develop a computerized project data file for this data. Accordingly, S^3 reviewed existing data contained in the historical reports furnished by the Participant. In the absence of any new data, however, it was decided to delay the development of the Geo-Data File until implementation of the Reservoir Data File (see Section 5.9.4) is well along.

5.9 Subsurface Data Management

WESTEC has contracted S^3 to store, evaluate and disseminate reservoir engineering data including well tests, interference tests and geophysical and hydrological data and to simulate the characteristics of the Baca geothermal reservoir via an S^3 proprietary computer program. The following is a summary of these efforts.

5.9.1 Reservoir and Well Test Data

S^3 will perform pressure transient analyses of well test data to determine reservoir properties. Accordingly, S^3 personnel reviewed the well test data and the pressure transient analyses presented in the Participant's historical reports, and also a report by Dr. Malcom Grant, of the New Zealand Department of Science and Industrial Research, in which he reviewed the Baca well test data. While the Participant report tentatively concluded that the Baca reservoir consists of two separate reservoirs (one liquid-dominated, the other a single-phase steam reservoir), Dr. Grant proposed that the observed well test and interference test results could be accounted for by a single, two-phase reservoir if it is realized that the reservoir is high in CO_2 gases. During this quarter, S^3 initiated an independent analysis of the data to resolve this basic question. S^3 analyzed downhole pressure and temperature surveys for several wells using an equation-of-state package they developed for reservoir modeling (see Section 5.9.2).

5.9.2 Equation-of-State Development

S^3 evaluated the information available on the Baca reservoir fluid chemistry and on CO_2 solubility. It became apparent that the CO_2 component of the Baca reservoir fluid must be included in its thermodynamic description. During this quarter, S^3 assembled thermodynamic data on water-steam-CO_2 systems, defined the requirements for an adequate treatment of the Baca reservoir fluid, and proceeded with the development of an equation-of-state package which will eventually be used in the MUSHRM computer simulation studies of the Baca geothermal system. Although further work must yet be done for the package to function as a subroutine in the reservoir simulator, it was used in an analysis of the pressure and temperature profiles measured in the Baca wells.

5.9.3 Reservoir Case History

S^3 is developing a case history for the Baca geothermal reservoir system. During this quarter, they have approached this general task from two directions: (1) compilation of information on the geologic setting and the sequence of events in the formation of the Valles Caldera, and (2) development of a conceptual model of the Baca geothermal reservoir system. The geological information serves as a framework within which the evolving data base must be interpreted.

The compilation of geological and geophysical information includes information supplied in the original Participant historical reports, and related scientific literature (especially U.S. Geological Survey publications and data generated at the Los Alamos Scientific Laboratory as part of their Hot Dry Rock Project). During the next quarter, S^3 plans to start documenting pertinent parts of the compiled information as part of the reservoir case history task.

5.9.4 Reservoir Data File

During the reporting period, S^3 proceeded on the assimilation and compilation of data for the Reservoir Data File. Historical data from the Participant, in the form of reports, charts, etc., were reviewed for content and form of information. These preliminary analyses were necessary to help determine the format for recording the information in the Reservoir Data File. The Reservoir Data File consists of several files: a General Information File, an Individual Well File for each well in the system, the Interference Tests Data File, and the Core Data File.

The General Information File records definitions, notations, and other data which will be used by the other three files. The format of this file has been determined and pertinent data has been recorded.

On the basis of the preliminary examination of the historical data provided by the Participant, Baca No. 15 was chosen as a sample well for establishing the format for the Individual Well Files. Data for Baca No. 15 were recorded according to that initial format; however, as additional well files were established, it became clear that modifications to the file structure were necessary. Accordingly, such modifications were incorporated.

During this reporting period, no work was done in establishing either the Core Data File or the Interference Tests Data File. Data which should be included in these files has been noted when encountered during the review of the information provided by the Participant, but no structure for either of these files has been finalized.

For all the files included in the Reservoir Data File, it has been recognized that the possibility exists that some data may be either questionable, approximate, or possibly just not available. Accordingly, the data recorded in the files will be coded to reflect any uncertainties or unavailability.

5.10 Production System Data Management

WESTEC will compile and translate production system engineering data furnished by the Participant into generic design criteria that will be useful to other resource developers. During this quarter, WESTEC reviewed Union's preliminary production system design data.

5.11 Power Plant Data Management

During this quarter, WESTEC initiated review of Participant engineering design, system reliability, capital and operational cost parameters that were used to evaluate electric generation expansion plans and support commercialization strategies, for incorporation into a computer sensitivity analysis of these variables.

5.12 Project Promotion/Public Relations

WESTEC coordinates with the Participant's public relations personnel and provides specific public relations services necessary to stimulate interest in the project and promote data availability in support of the project's primary objectives. A summary of activities in these areas follows.

5.12.1 Information Requests

WESTEC received requests from groups outside the project for existing project data. Based on a verbal agreement with DOE and the Participant, any historical data requested will be furnished at the requestor's expense.

5.12.2 Presentations and Symposia

In a coordinated effort with the Participant to stimulate information user interest in the project, WESTEC submitted technical papers to the Participant, which were jointly authored with DOE, for public release approval. These papers were subsequently submitted to the Geothermal Resources Council (GRC) and to the Electric Power Research Institute (EPRI). The EPRI paper was presented by WESTEC's Data Project Manager in June 1980 at the Fourth Annual EPRI Geothermal Conference. The GRC paper was not selected by the GRC Program Committee for oral presentation, but will be published in the proceedings of the 1980 GRC Annual Meeting. A display is planned for the GRC Meeting exhibit area, and a project brochure will be printed for distribution at this meeting.

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