

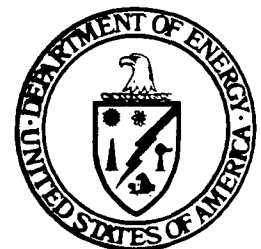
# **SALTON SEA SCIENTIFIC DRILLING PROGRAM**

**Report of the Second Quarter  
FY 1985**

**June 1985**

**U.S. DEPARTMENT OF ENERGY**

**Office of Renewable Energy Technologies  
Geothermal and Hydropower  
Technologies Division**



**SALTON SEA SCIENTIFIC**

**DRILLING PROGRAM**

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(January through March)  
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## EXECUTIVE SUMMARY

This report is the second in a series of quarterly progress reports distributed by the U.S. Department of Energy, Geothermal and Hydropower Technologies Division (DOE/GHTD), that presents the status of the Salton Sea Scientific Drilling Program (SSSDP). Since the first report was issued (for the period Oct. 1, 1984 - Dec. 31, 1984), major elements of the program have been redirected. New cost projections for the overall project indicated that a significant cost overrun would occur under the original scope of work. At the end of this quarter, the program is continuing, but with a reduced scope of work for both scientific and engineering research that focuses on gathering as much scientific information as possible from the thermal regime beneath the currently producing Salton Sea reservoir, while maintaining costs within available funding.

The first quarterly report described in detail the background of the SSSDP from its infancy within the context of the Continental Scientific Drilling Program (CSDP) and the Deep Sea Drilling Program (DSDP). This report addresses the major events that have led to the new program emphasis, the present funding and operational status of the program, and the current "best estimate" time schedule for completion.

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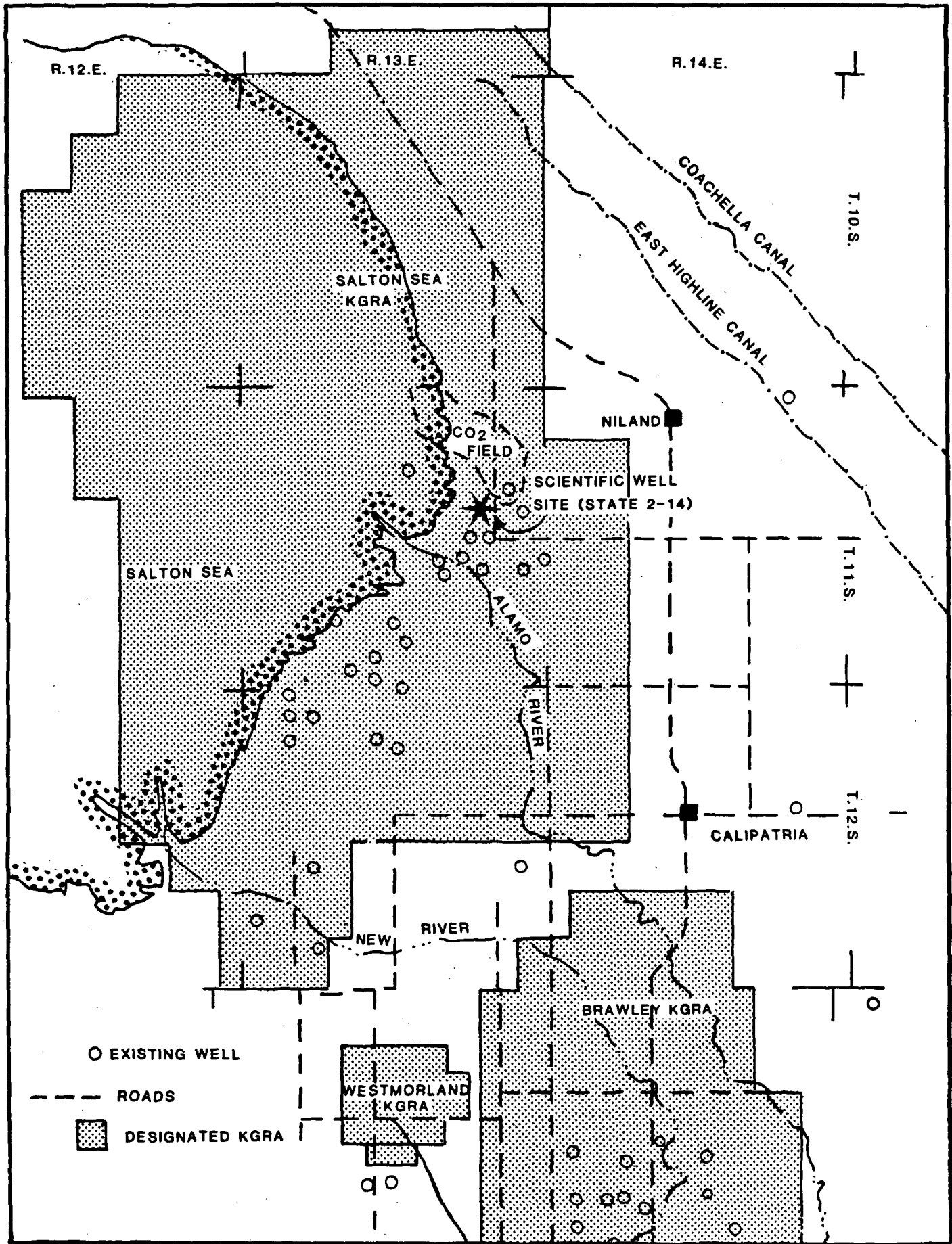
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## INTRODUCTION

The Salton Sea Scientific Drilling Program (SSSDP) has been organized as a joint effort of the U.S. Department of Energy (DOE), U.S. Geological Survey (USGS), and the National Science Foundation (NSF) to study the deeper thermal regime of the Salton Sea geothermal system that underlies currently producing reservoirs.

The program was conceived by university and industry scientists as a frontier exploration project to penetrate deeper into the Salton Sea hydrothermal system. The purpose of the project, as originally proposed, was to deepen a well of opportunity and drill into the "roots" of the Salton Sea hydrothermal system into much higher temperature regions than have been penetrated by industry wells. Although major elements of this project have been changed, the main objectives remain: (1) to add to the scientific body of knowledge about the Earth's thermal processes and related phenomena, and (2) to test the unknown regions below the known part of the Salton Sea hydrothermal system to better characterize the ultimate energy potential of the system.

The site selected for the scientific test-well is located four miles southwest of the town of Niland, California along the southeastern shore of the Salton Sea (Figure 1). Samples and data gathered from the drilling will be released to the public domain for further study by university, industry and government researchers.



**Figure 1: SSSDP LOCATION MAP**

## PROGRAM PLAN

### Background

The Salton Sea Scientific Drilling Program continues to evolve. Since the initial concept was proposed to NSF and DOE in April of 1983, the intent and objectives of the program have remained intact, while proposed mechanisms to achieve the objectives have undergone changes. A brief recap of events leading to the present status of the program are as follows:

- April 1983 - NSF and DOE received unsolicited proposals from Republic Geothermal, in cooperation with the University of California at Riverside, to deepen a Republic well at Niland, California from 12,000 to 18,000 feet to study the deep thermal regime of the Salton Sea hydrothermal system. Neither NSF nor DOE had mandates or funds available for the study.
- September 1983 - Congress authorized DOE Geothermal and Hydropower Technologies Division (DOE/GHTD) to investigate the Deep Salton Sea thermal regime and appropriated \$5.9 million of FY 1984 funds.
- December 1983 - DOE determined that a contract could not be sole-sourced to Republic. Moreover, Republic and its field development partner, Parsons Engineering, could no longer offer their well as a well-of-opportunity and withdrew their offer.
- March 1984 - DOE's San Francisco Operations office (DOE/SAN) issued an RFP soliciting industry participation in the Drilling and Engineering phase of a proposed program. The RFP outlined a program to spud a new well or deepen an existing well to a depth of 6000 feet below the level of the 300°C isotherm, to a maximum depth of 18,000 feet.
- April 1984 - A preproposal conference was held at DOE/SAN.
- May 1984 - Proposals were received and evaluated.
- June 1984 - Bechtel National, Inc. was selected from the proposers for further negotiations. Bechtel would be the prime contractor and Kennecott Corporation, in cooperation with Bechtel, would provide the well sites on their leaseholds in the Salton Sea field. Republic Geothermal, Inc. was included as a subcontractor to Bechtel, but later withdrew from the project.
- August 1984 - An SSSDP informational meeting was held at the Geothermal Resources Council annual meeting in Reno, Nevada to inform the science community of the management plan, project schedule and procedures for submitting scientific proposals.
- October 1984 - The SSSDP groundbreaking ceremony was held.

- November 1984 - Fifty-seven scientific and engineering proposals were received by the Science Coordinating Committee and evaluated by the Scientific Experiments Committee to determine the feasibility, timeliness and potential for success of each experiment. These proposals were then evaluated for scientific merit by a joint DOE/OBES-NSF/EAR Peer Review Panel and ranked.
- December 1984 - "A workshop on down-hole testing, measuring and fluid sampling was held at DOE/SAN to identify available and developable equipment.

By the end of calendar year 1984, a management scheme (Figure 2) and a tentative schedule for the program had been developed. The schedule projected the award of a drilling contract by March of 1985, with drilling anticipated to commence during the following month. Completion of drilling of the scientific and injection wells was planned for August, with the scientific hole then made available for testing and experimentation for approximately one year.

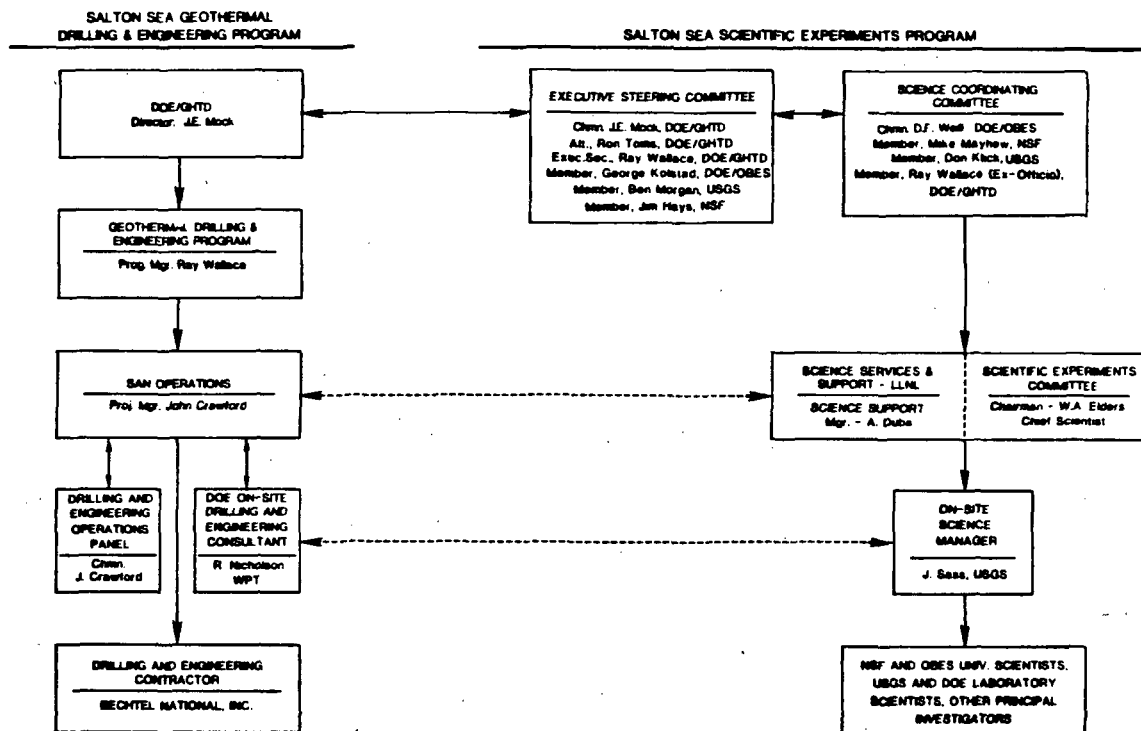


Figure 2: SSSDP MANAGEMENT PLAN



Revised Program

On January 24, 1985, DOE/SAN issued a "stop work" order to Bechtel after new cost projections for the drilling and engineering part of the project indicated the probability of a large overrun. The higher cost projections resulted from a combination of factors, including more stringent safety requirements imposed on well designs by the California Division of Oil and Gas, and a reevaluation of costs based upon new advice from an industry review panel. The new items associated with the projected higher cost include:

- 9-5/8" production casing from surface to 6000 feet
- 7" slotted liner from 6,000 to 10,000 feet
- higher capacity wellhead
- design and fabrication of new surface brine treatment facility

Existing project elements contributing to the higher costs include:

- coring requirements (15% of the total interval drilled )
- cost of drilling, completing and testing the injection well
- flow testing and resource evaluation

As a result of the more stringent standards placed upon well designs and the new projections for other project costs, a total cost of \$9.8 million was estimated for the originally proposed project. A breakdown of the revised estimates is shown in Table 1.

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<u>ITEM</u>	<u>COST (x10<sup>6</sup>)</u>
● Scientific well drilling and logging	\$4.6
● Injection well drilling and logging	1.4
● Surface facilities (brine treatment)	1.6
● Site operations	1.0
● Plug and abandonment	0.7
● Resource evaluation	0.5
 TOTAL	 \$9.8

Table 1. Revised estimates of the total cost of the original plan for the SSSDP.

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Since the original cost-type contract for the Drilling and Engineering part of the project was signed for \$5.3 million, it became obvious that other options needed to be addressed, including changes in the scope of work. The options considered were:

- (1) Seek additional funding and conduct the full program as originally outlined;
- (2) Scale down the scope of work to fit the available budget; and
- (3) Abandon the project.

Option number one would have entailed placing the project on hold to explore other funding sources, because additional Federal funds were unlikely to be appropriated in the foreseeable future. This option was disfavored in view of uncertainties such as the timing of major project activities vs. available funds, and the likelihood that major objectives of the project would not be realized before early termination due to depletion of the limited funds available.

Option number three was considered inappropriate, because the original intent of Congress was to provide for exploring the "roots" of a known geothermal system. Abandoning the project would not only have wasted the money already expended on planning, but more importantly would not have carried out the Congressional mandate.

Option number two was selected as the most desirable course of action. Since the original concept of the project was to gather scientific information on the deeper thermal regime, the scientific aspects of the project became the major focus. Engineering studies for comprehensive resource evaluation became secondary objectives and thereby were reduced in scope.

#### Scientific Experiments Program

The original project, as proposed to Congress, was intended to be an "add-on" experiment to a proposed commercial geothermal well that was to have been

deepened from an initial depth of 12,000 feet to a final depth of 18,000 feet, thereby providing rock and fluid samples for scientific study from a "unique pressure-temperature environment never before investigated". The deepened well was also to have tested the hypothesis of much higher flow rates (super-convection) due to the effects of higher pressures and temperatures.

Although the original plan of deepening a commercial well had to be abandoned, the concept of gathering scientific information from a hotter, deeper part of the Salton Sea hydrothermal system remains the primary goal of the study. The most important objective of the project continues to be obtaining a coordinated suite of information, including: drill cuttings, cores, fluid samples, temperature, pressure and flow measurements, and a comprehensive suite of wireline logs for release to the public domain.

To date, 60 proposals have been received by the various funding agencies and are under consideration by the Science Coordinating Committee (SCC). The scientific proposals were submitted by potential investigators to NSF (12 proposals), USGS (14 proposals), DOE/OBES (18 proposals), and DOE/GHTD (24 proposals), with the understanding that limited funding would be available. Some proposals were submitted to more than one agency.

The proposals that have been submitted to the various funding agencies and that are under consideration by the Science Coordinating Committee have been assigned to various categories and subsequently ranked for technical merit, relevance and timeliness (Table 2).

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<u>CATEGORY</u>	<u>DESCRIPTION</u>	<u>NUMBER OF PROPOSALS</u>
I	requires solid samples	28
II	requires fluid samples	18
III	involves downhole logging or instrumentation	13
IV	involves reservoir testing	6
V	modeling and data analysis	10
VI	involves surface geology or geophysics	5
VII	involves development of instruments and drilling technology.	4

TABLE 2: SUMMARY OF SCIENTIFIC PROPOSALS BY CATEGORY

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Drilling and Engineering Program

The original plan for the DOE/GHTD-contracted Drilling and Engineering part of the SSSDP included: (1) drilling and completing a scientific well to an estimated depth of 10,000 feet; (2) drilling and completing an injection well to 4000 feet; (3) performing short-term and long-term flow testing (collection of fluid and gas samples); (4) coring selected intervals (1500 feet of total core); (5) obtain temperature, pressure, and flow measurements, and a comprehensive suite of wireline logs; (6) plug and abandonment (including site restoration); and (7) Resource Evaluation.

Projected cost overruns have greatly affected the proposed drilling and engineering activities within the program. Due to increased cost estimates, a number of the major activities within this part of the program have either been reduced in scope or eliminated. A comparison of the original program vs the proposed program under the reduced work scope is shown in Table 3. Items of major significance are elimination of the injection well, brine treatment facilities, and intermediate and long-term flow tests.

<u>COMPONENT</u>	<u>ORIGINAL PLAN</u>	<u>REVISED PLAN</u>
● SCIENTIFIC WELL -	estimated total depth = 10,000 ft. 8.5in. bottom-hole diameter drilling time = 195 days	- same as original plan
● INJECTION WELL -	estimated total depth = 4,000 ft. 8.5in. bottom-hole diameter 41 days to completion	- no injection well; brine holding pond, 1.1 million gallon capacity
● BRINE TREATMENT -	facility with necessary separators, tanks, filters, silencer, piping, etc., for testing and treatment of brine before reinjection	- limited to simplified well-head facilities
● PRODUCTION TESTING -	1x30 day flow test in scientific well; 1x30 hour flow test from the injection well.	- 1 x 24 hour test in scientific well below 6000 ft.
● DATA COLLECTION -	approximately 1500 feet of core; cuttings, geophysical logs, and production logs from the completed well.	- coring costs not to exceed \$1 million; other data sets - same as original plan
● ENVIRONMENTAL REQ. -	plug and abandonment of scientific well and injection well; site restoration.	- plug and abandonment of scientific well; site restoration; brine pond reclamation

TABLE 3: Comparison of Current SSSDP Plan with Original Plan Contracted by DOE

A preliminary tests and measurements plan entitled, "Resource Evaluation Plan-March 1985," was prepared and submitted to DOE by Bechtel and its subcontractor GeothermEx, Inc. The purpose of the plan was to outline the methodology to be used during data acquisition, and the procedures to be followed for a determination of resource potential based upon the original SSSDP plan. The plan describes the collection of the necessary data for resource evaluation through logging, coring, sampling and flow testing.

This plan spells out the sampling frequency, method of collection, data processing, and analytical procedures for each data set. The data sets include:

- Rock cuttings and cores
- Brine and formation gases
- Borehole geophysical logs
- Borehole pressure, temperature and flow data
- Fluid mass flow and wellhead transient pressure data
- Data from other wells.

The integration and interpretation of data is presented in a logic sequence leading to a final determination of recoverable resources and well deliverability.

In order to ensure the ability to accurately measure certain down-hole physical conditions and to obtain fluid samples, Sandia National Laboratories has been funded by DOE/GHTD to develop down-hole mechanical (Kuster) tools to be lowered on nonconducting cable (slick-line). The development program focuses upon the special problem of obtaining down-hole temperature, pressure and flow measurements in an environment of up to 500°C and under highly corrosive conditions. Sandia will also be developing a down-hole power control unit and an interface device to be used with a 2-liter capacity down-hole fluid sampler developed by Los Alamos National Lab.

A preliminary drilling plan including well design is being finalized by Bechtel and its subcontractor, The Berkeley Group, Inc. A draft of the plan, which is a companion report to the Resource Evaluation Plan, has been developed based upon the original scope of work that included drilling and testing of both the scientific and injection wells. The plan includes specifications of equipment, and outlines procedures to be used for the drilling phase of the program. Modification of that plan will be necessary when a final well design is agreed upon between DOE, Bechtel and the California Division of Oil and Gas.

U.S. Geological Survey (USGS) activities have centered on two elements of support for the overall SSSDP scientific program. One element was the critical need for full-time, on-site representation of the scientific community's needs and interests during and immediately following drilling. The USGS has taken this responsibility as its contribution to SSSDP scientific support for the other Federal agencies involved. John Sass of the Survey at the USGS's Flagstaff, Arizona office has agreed to be the SSSDP On-Site Science Manager. Sass has organized an on-site staff to provide a crew of two at the drilling site at all times to work with the DOE drilling team. They will closely coordinate their

activities with the Chief Scientist.

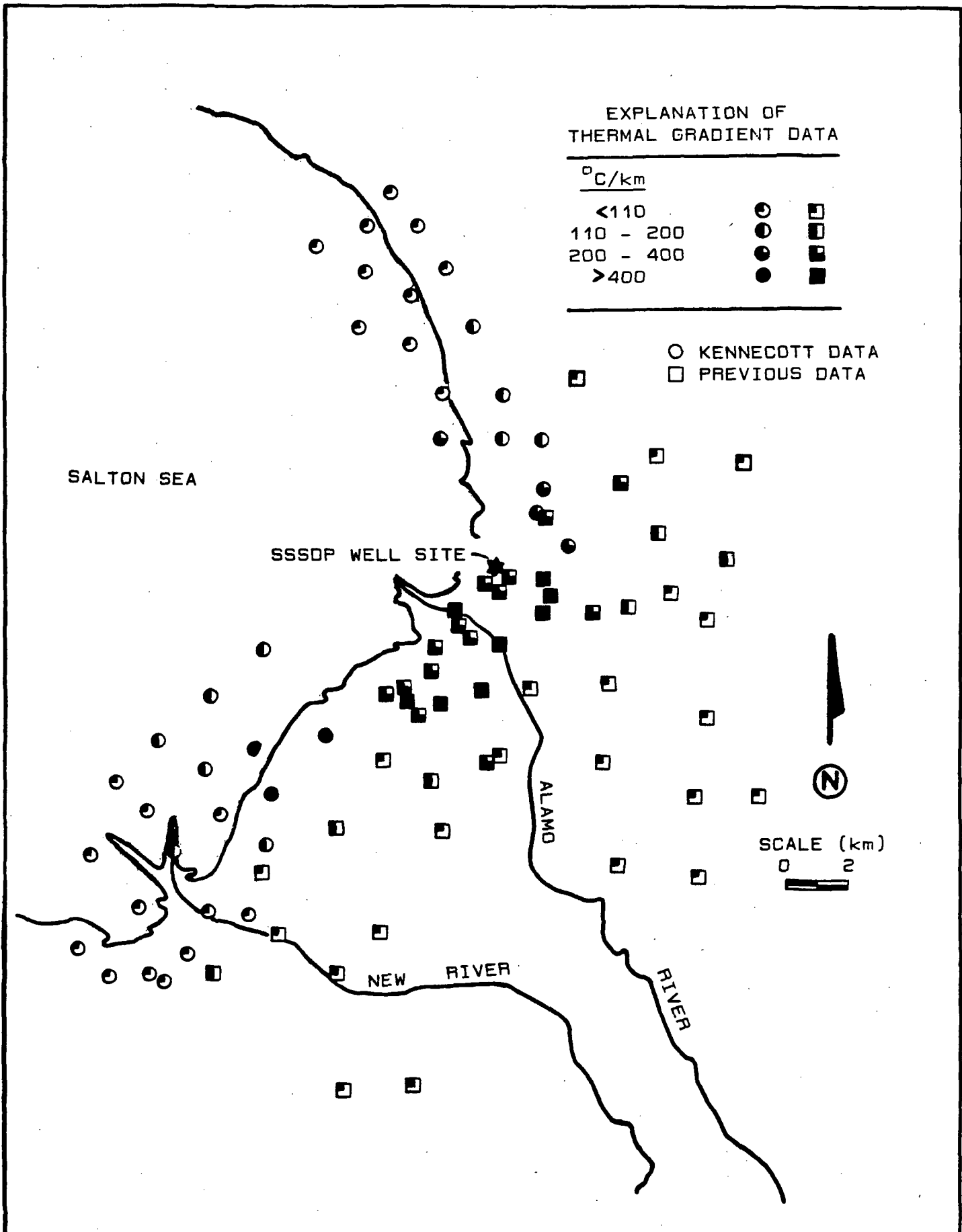
The other element of USGS support addresses geophysical and related borehole logging for scientific purposes. The USGS will perform as much of this logging as is within their capability, particularly high-temperature research logging, to help reduce program costs.

The USGS will work closely with DOE and Bechtel to establish a definitive well-logging program. A suite of research geophysical logs will be obtained in addition to other possible specialty logs such as borehole televiewer logs. Copies of strip-chart records will be made available to other parties within a few weeks of the logging. Digitized data require a longer processing period.

Lithologic and temperature data obtained by Kennecott Corporation from 41 shallow geothermal gradient wells, both onshore and offshore near the eastern and southeastern margin of the Salton Sea (Figure 3), have been combined with information from other nearby wells, and have been used by Lawrence Livermore National Laboratory (LLNL) researchers Newmark, Kasameyer, and Younker, to construct a preliminary model of deep thermal conditions in the Salton Sea Geothermal Field (SSGF). Bottom hole temperatures recorded in the 41 shallow (76.2 m) holes ranged from 26°C to above 75°C. Thermal gradients, measured over the lower 46 m in the holes, range from less than 50°C/km to over 500°C/km, and appear to be consistent with gradients measured in deep wells drilled within the SSGF. Data obtained from the shallow holes is consistent with early models, suggesting that the thermal anomaly is centered in the Salton Buttes vicinity.

#### Revised Project Schedule

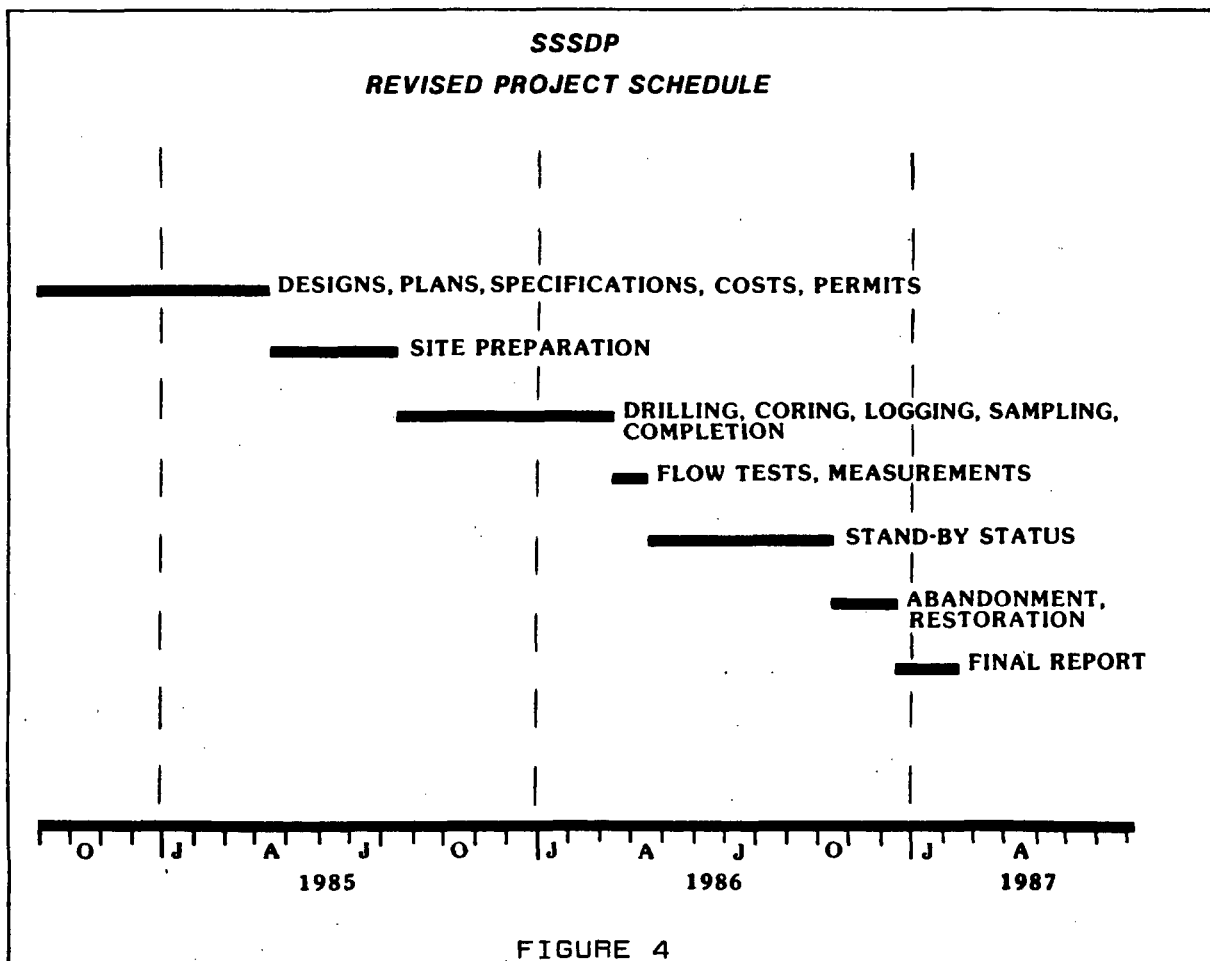
Continuation of the program, even under the reduced scope of work, will provide a significant contribution to scientific knowledge. However, some delays to the project schedule have been experienced. A summary of the revised "best estimate" schedule is shown on Figure 4. Under this new schedule, drilling



**FIGURE 3: Shallow Thermal Gradient Measurements within the Salton Sea Geothermal Field (modified from LLNL data)**



operations are planned to begin in August 1985. The time available for flow tests and measurements has been greatly reduced in order to reduce cost. In addition, the time available after well completion for experimentation by researchers has been reduced. Site abandonment and restoration will occur toward the end of 1986 under the present schedule.



**SIGNIFICANT COMMITTEE MEETINGS**

ESC Meeting; January 31, 1985

The fifth meeting of the Executive Steering Committee (ESC) was held on January 31, 1985. The major topics of discussion were the escalation of estimates for the overall project cost, the drilling plan, and the tests and measurements plan that had been prepared by Bechtel through its subcontractors (BGI and GeothermEx). The cost estimates were developed with consideration of

recommendations from a Bechtel industry advisory group. It was reported during the meeting that the project, under its original scope of work, would probably cost a great deal more (\$9.8 million) than previously projected (\$5.3 million). Factors contributing to the higher cost projections were discussed. Representatives of the Science Coordinating Committee (SCC) present at the meeting expressed concern that the science community should have more active participation in further SSSDP planning.

SCC/SEC/DOE-SAN Meeting; February 7, 1985

On February 7, 1985 a meeting of the Science Coordinating Committee (SCC), Scientific Experiments Committee (SEC) and DOE/SAN was convened in Burlingame, California. The purpose of the meeting was to (1) discuss the routine business set before the committee, (2) address the plans for the well design, and (3) discuss current problems associated with the science community's input to SSSDP programming.

The meeting resulted from the Executive Steering Committee meeting of January 31, 1985, where new cost projections for the original program had been presented. The ESC had requested input from the SCC/SEC for recommended changes to the original plan that would enable a scientific program to be carried out within the existing budget.

The first part of the meeting addressed the ESC's request for input from the science community. Discussions ensued concerning the preliminary nature of the revised cost estimates and the relationship of the science plan to the drilling and engineering plan. The view was expressed that the science program should be prepared independent from the drilling and engineering program. The point was made that efforts to coordinate science with drilling and engineering should be done through DOE/SAN. This part of the meeting ended after it was decided to continue with the development of the science plan and funding actions

on the 60 science proposals until March 1 when more accurate cost projections would be available.

The second part of the meeting was devoted to discussions concerning prudent Imperial Valley scientific well design factors and projected costs. The provisional drilling, casing and cementing designs were presented by DOE's On-Site Drilling and Engineering consultant.

The final discussions of the meeting concerned the duties of the On-Site Science Manager and the protocol to be followed for sample collection, distribution and curation.

#### ESC Meeting; March 13, 1985

The sixth meeting of the ESC was convened on March 13, 1985. The major focus was on making critical policy decisions to assure continuation of the program while meeting as many of the research objectives as possible. The status of the program was reviewed in relation to the original intent of the Congressional mandate. Alternatives to the original plan were discussed and a consensus was reached to proceed with the program, if at all possible, within the original budget to achieve an acceptable level of scientific benefit. In decisions involving safety vs cost, it was emphasized that safety considerations would prevail. An outline of the current program was developed at the meeting, and a Project Reformulation Task Force was appointed.

#### SSSDP Reformulation Task Force Meeting; March 26, 1985

The Project Reformulation Task Force, comprised of representatives from various SSSDP committees and DOE personnel that was created at the sixth ESC meeting, met on March 26, 1985 at DOE/SAN with Bechtel and Kennecott representatives to modify the original SSSDP plans in order to meet the needs of the scientific community within the current funding level. The "SSSDP Project

Reformulation Task Force" was created to investigate drilling and engineering trade-offs, reduce costs and maintain the scientific integrity of the project. In addition, the task force was to confirm the requirements of the land-use permits issued to Kennecott Corporation by the California State Lands Commission.

DOE/SAN and DOE/GHTD proposed several trade-offs for cost reduction that diminished total estimated costs to a baseline value of \$6.4 million. The baseline value represented an estimate of a scope of work that would be necessary to maintain the integrity of the science plan and also conform to specified well completion guidelines imposed by the California Division of Oil and Gas (CDOG). After the baseline estimate for the reduced scope of work was established, the task force then identified other parts of the program where cost savings could be achieved. The areas identified were:

- (1) Well Casing Design: Well design in the baseline estimate included a string of 18-5/8" casing that might be eliminated resulting in a cost savings between \$100K to \$300K. Bechtel and Kennecott representatives later reached an agreement with CDOG officials to eliminate this item and compensate with other design changes.
- (2) Coring: Estimated coring costs within the baseline plan were \$1.24 million for attempting 1500 feet of coring using a conventional core barrel of 30 foot length. The task force estimated that a 45 percent reduction in coring (and tripping) costs might be gained by using a core barrel of 60 foot length. Based upon this idea, and the fact that coring is the highest single priority item of the project, it was decided to maintain a coring budget of \$1 million and evaluate using the longer barrel.

These two recommended alterations to the baseline program reduced the total estimated cost of the project to a level of \$5.86 million. Other conclusions reached by the task force were:

- The 195 day estimated drilling time is a conservative estimate, and savings could result if difficulties are not encountered.
- The coring plan will be more fully developed to conform to program needs and assist in managing the coring budget.
- A process for making on-site drilling and operational decisions will be developed in order to meet all science objectives in an efficient manner.

- Fluid sampling and flow testing plans shall be developed in order to ensure that both science objectives and permit requirements will be met.
- Geophysical well logging will be performed by the USGS. The USGS, DOE, and Bechtel will cooperate in preparing a logging plan.
- NSF, USGS, and DOE/OBES will take immediate steps to finalize the Scientific Experiments Package under the guidance of the SCC and SEC.

The task force recommended that the Executive Steering Committee approve the revised baseline plan for the SSSDP, and that the ESC request the Scientific Experiments Committee and the Science Coordinating Committee to finalize the Scientific Experiments Package in accordance with the revised baseline plan. This decision to proceed was critical to NSF and DOE/OBES in order to allow them to proceed to obligate FY-1985 funding for science proposals by their April 15 deadline.

#### SUMMARY

The Salton Sea Scientific Drilling Program is continuing with the expectation of meeting acceptable scientific goals. After cost projections indicated that the original program could not be completed within the existing budget, several steps were taken to analyse the project objectives and rescope the work. The rescoping included the elimination of several program elements (such as an injection well and surface brine treatment facilities), and reducing the emphasis on resource evaluation in order to maintain the integrity of the science program. Significant alterations to the program have resulted in the development of a revised approach that places emphasis on the gathering of as much integrated scientific information as possible from the Salton Sea geothermal system.