GL00495

Salton Sea Scientific Drilling Project

Archival Reference

Geothermal Division

U.S. Department of Energy

DRAFT

January 21, 1991

SALTON SEA SCIENTIFIC DRILLING PROJECT

ARCHIVAL REFERENCE

PREFACE

This report provides an archival reference to the scientific information and other pertinent documents and materials associated with the Salton Sea Scientific Drilling Project (SSSDP). This archiving process ensures that valuable technical data and information obtained during the life of the project can be retrieved, organized and maintained as a historical record for future reference. This paper describes the background of the project and the process used for archiving the materials.

BACKGROUND

The Salton Sea Scientific Drilling Project (SSSDP) was the first major drilling project to be performed by supplement to the Interagency Accord on Continental Scientific Drilling, involving all three signatories (the U.S. Department of Energy (DOE), U.S. Geological Survey (USGS), and the National Science Foundation (NSF)). The purpose of the interagency accord was to achieve a better basic understanding of the earth's continental crust. The project was designed to investigate (through drilling and testing) subsurface physical and chemical conditions of rocks and fluids of the Salton Sea geothermal area, located in California's Imperial Valley. It was initially conceived by researchers to collect subsurface scientific information and evaluate the geothermal potential beneath the known hydrothermal system of the Salton Sea Geothermal Field.

SUMMARY OF THE SALTON SEA SCIENTIFIC DRILLING PROJECT

Goals

The goals of the SSSDP were established based upon the common interests of the participating signatories. Those interests relate directly to solving certain national problems, such as ensuring adequate supplies of energy, efficient development of water and mineral resources, basic understanding of the earth's thermal systems, and protection against natural hazards. Specifically, the goals of the deep scientific drilling project within the Salton Sea geothermal system were to:

- Better define the volume of the Salton Sea hydrothermal system and test for an extension of the system to greater depths.
- Improve hydrothermal energy resource estimates.
- Develop better understanding of the genesis of hydrothermal ore deposits.
- Investigate the possibility of natural occurrence of "superconvection."
- Study the origin, nature, and occurrence of earthquake swarms generated during hydrothermal convection.
- Evaluate the productivity of the deep hydrothermal system.

Project Implementation

The project evolved from efforts by researchers and geothermal industry scientists who believed that significant benefits could be derived from drilling deeper into the Salton Sea geothermal system. Two of these researchers, Dr. Wilfred A. Elders of the University of California, Riverside (UCR), and Dr. Robert W. Rex of Republic Geothermal, Inc., presented the merits of such a drilling effort to various members of Congress. In cooperation with UCR, Republic initially proposed the deepening of one of their wells at Niland, California, from 12,000 to 18,000 feet to study a high-pressure/high temperature environment never before encountered by geothermal wells.

At the time of the proposal, it was recognized that neither the NSF nor DOE had a clear mandate to fund the activity, nor were sufficient funds available. DOE's Geothermal Technology Division (DOE/GTD) initiated several meetings with NSF, USGS, and DOE's Office of Basic Energy Sciences (DOE/OBES). They agreed that DOE/GTD had the management skills and technological expertise to pursue the engineering aspects of the project, while the NSF, USGS, and DOE/OBES had sufficient mandate to pursue the scientific aspects.

By December of 1983, DOE/GTD determined that under federal procurement regulations, a contract could be granted only through the competitive bidding process. DOE/GTD set up a Federal Steering Committee, comprised of DOE/GTD, DOE/OBES, NSF, and USGS, and developed guidelines for soliciting outside participation. Project responsibilities were delegated to DOE's San Francisco Operations Office (DOE/SAN). A graphic presentation of the management plan is depicted in Figure 1.

A request for proposals (RFP) was issued in March of 1984 by DOE/SAN, which solicited industry participation in the drilling and engineering phase of the project. The RFP called for drilling to a depth 6,000 feet below the depth at which a temperature of 300°C was first encountered. It also required proposers to provide extensive opportunities for scientific investigations while drilling, followed by a period of 12 months of further well availability for downhole scientific experiments. Proposers could offer to deepen an existing well or to drill a new well, provided that the 300°C horizon was no deeper than 12,000 feet.

Congressional funding for the drilling and engineering phase was appropriated in FY 1984 to DOE/GTD based upon the original proposal by Republic Geothermal to deepen the Niland hole from 12,000 to 18,000 feet. Congress appropriated $5.9 million for the project. Following the federal procurement process, Bechtel National, Inc. was selected as prime contractor. Because of time constraints placed upon Republic and its field development partner (Parsons Engineering), Republic withdrew its offer for deepening the Niland well.

Test Site

The site selected for the deep test well, designated as "State 2-14," was located on a Kennecott Corporation exploration prospect situated approximately 4 miles southwest of the town of Niland, California (See Figure 2). The drilling phase began on October 23, 1985. The scientific test well was drilled to a total depth of 10,564 feet, reached on March 17, 1986.

Industry Contractors

Industry contractors for the SSSDP and their associated responsibilities were:

- Bechtel National, Inc. - (a subsidiary of Bechtel Engineers and Constructors). Responsible for overall project management; reporting to DOE; permit application; site preparation; design and drilling of the wells; surface facilities design and construction; site support and maintenance; environmental monitoring; data acquisition; and resource evaluation.
- Berkeley Group, Inc. - Responsible for providing well designs and specifications to Bechtel.
- GeothermEx, Inc. - Responsible for developing and supervising the tests and measurements plan, and providing preliminary analysis of geothermal resource potential to Bechtel.
- Kennecott Corporation - (an operating company of the Standard Oil Company, Ohio). Responsible for providing two permitted well sites for the scientific and injection wells.
- Well Production Testing, Inc. - Responsible for providing on-site drilling and engineering consulting services to the U.S. Department of Energy's San Francisco Operations Office, including review of well designs and specifications.

Other Participants

Other organizations participating in the SSSDP included:

- Brookhaven National Laboratory
- Carnegie Institution
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Science Foundation
- Sandia National Laboratory
- United States Geological Survey
- University of California at Berkeley
- University of California at Riverside
- University of Maryland
- University of Pennsylvania

Accomplishments of the SSSDP

Major accomplishments of the SSSDP include:

Phase One:

- Drilling the well to a depth greater than 10,000 ft.
- Attempting to core 10 percent of the borehole and obtaining 722.1 ft of core.
- Conducting two successful flow tests.
- Obtaining fluid samples.
- Obtaining logging data.
- Testing new downhole wireline tools.
- Preparation of a draft final project report by Bechtel National, Inc.
- AGU meeting highlighting the scientific results.

Phase Two:

- Obtaining additional logging data.
- Obtaining additional fluid samples.
- Conducting 19 day step-rate flow test.
- Conducting 44 hour pressure buildup test.
- Restoring holding pond and disposing of wastes.

A comprehensive chronology of events for both phases of the SSSDP is listed in Table 1.

Phase One of the project consisted primarily of drilling, coring, logging, short term flow tests, and fluid sample tests. A maximum depth of 10,564 feet was reached, and a total of 722.1 linear feet of core was cut at different depths. Suites of logs were run at various times throughout Phase One. Coring operations are listed in Table 2, and well logging operations are summarized in Table 3. The two short-term flow tests conducted indicated flow-zones with commercial reservoir potential. The first flow test was prompted by encountering a lost circulation zone (34-66 barrels per hour) between 6,119 and 6,160 feet on December 22, 1985. The test, conducted December 28th to 31st, produced uncontaminated formation fluid with a maximum flow rate of 600,000 lbm/hr at a wellhead pressure of 180 psi and temperature of 104°C. After being shut in for six hours the bottomhole temperature recorded was 305°C and bottomhole pressure was 2,492 psi.

The second short term flow test, from March 20th to 22nd, 1986, produced formation fluids from several zones (the well was at total depth) that were contaminated with large volumes of drilling fluid and additives required to control lost circulation. The maximum flow established was 700,000 lbm/hr at a wellhead pressure of 450 psi and temperature of 238°C. After shutting in the well a temperature/pressure survey recorded a pressure of 4,287 psi and temperature of 353°C at a depth of 10,400 feet.

For more details on Phase One activities the reader is referred to the papers in the SSSDP special section of Volume 10 (1986) of the Geothermal Resources Council Transactions (see bibliography).

Phase Two involved well repairs, a longer term flow test, additional logging and fluid sampling and restoration of the site. The long-term flow test was conducted June 1st through 19th, 1988. A maximum flow rate of 768,000 lbm/hr was achieved. A Horner plot analysis of the well test data indicated a reservoir transmissivity of 233,600 md-ft. For more information on Phase Two activities refer to Bechtel National's report, "Salton Sea Scientific Drilling Program Phase 2 Well Rework and Flow Testing."

Research Reports

Scientific investigators have written a variety of reports outlining operations of the SSSDP and the results of the associated research. Three reports by Elders (1986, 1987, and 1988) offer general descriptions of the project. Management of the project is outlined by Aducci (1986). Operations and coring are described by Nicholson (1986). Results of Phase Two flow tests are presented and analyzed by Bechtel (1988). Geochemical studies are reported by Goff (1987), McKibben et. al. (1986), Zukin et. al. (1987) and others. Harper and Rabb (1986) summarizes the SSSDP drilling activity, and Nicholson (1986) outlines the coring operations. For more information on these and other research reports refer to the bibliography at the end of this paper.

Archiving Process

Materials documenting DOE/GTD's management of the SSSDP were gathered at DOE Headquarters. These materials included the files, reports, correspondence, notes and related materials of three DOE program managers - Ronald S. H. Toms, Raymond H. Wallace, Jr., and Allan Jelacic, who replaced Mr. Wallace to close out the project (See figure 1). The materials also contained distribution copies of reports sent to the managers. From all accounts, the materials collected essentially constitute a near complete management history of the SSSDP.

DOE/GTD was assisted in organizing and archiving these materials by Meridian Corporation. The materials were separated into two distinct groups - management materials and research materials. The larger group, management materials, contains materials related to the management of the project. The second group, research materials, contains research reports, presentation of research information, and research proposals.

Because of the large amount of material, each group was divided further. The management group contains 8 sub-topics:

- Issues - contains questions, referrals, etc. from industry representatives, the public, and Congressional members about the SSSDP. Most inquiries are from Congressional members.
- Interagency Relations - contains materials dealing with organization, management, and activities of participating groups outside DOE/GTD.
- Media Coverage - published nontechnical reports/news items about the SSSDP.
- Site Operations - information from all sources involved in the project dealing with management activities at the site.
- Progress Reports - all relevant management reports from sources within the project.

- Contracts - RFPs, proposals and contractual documents associated with performance of the project.
- Planning/Scheduling/Organization - information from all sources within the project - especially referring to meetings.
- Budget - contains all information on the budget for the SSSDP from planning though conclusion of the project.

The research group of materials contains 2 sub-topics:

- Reports - contains all research-oriented documentation of results from SSSDP research.
- Proposals - proposals for SSSDP research, regardless of whether or not the proposal was accepted.

All documents are sorted chronologically by the original date of the document. In other words, a letter written on the 6th of the month, but received on the 10th of the month, is filed under the 6th day of the month. Undated materials are included in the back of each respective file.

All materials are held at Meridian; inquiries will be handled on an individual basis using the best descriptive category to find a particular piece of information. Copies of material totalling less than 10 pages will be provided free of charge; larger requests will be handled at cost. Inquiries should be referred to:

SSSDP Archivist
Geothermal Division
Meridian Corporation
4300 King Street, Suite 400
Alexandria, VA 22302
(703) 998-3600

The core samples and well logs are stored at the DOE Core and Sample Repository in Grand Junction Colorado. The contact person there is:

Richard Dayvault, Curator
DOE Core and Sample Repository
P.O. Box 2567
Grand Junction, CO 81502
(303) 248-6375

SALTON SEA SCIENTIFIC DRILLING PROGRAM MANAGEMENT PLAN

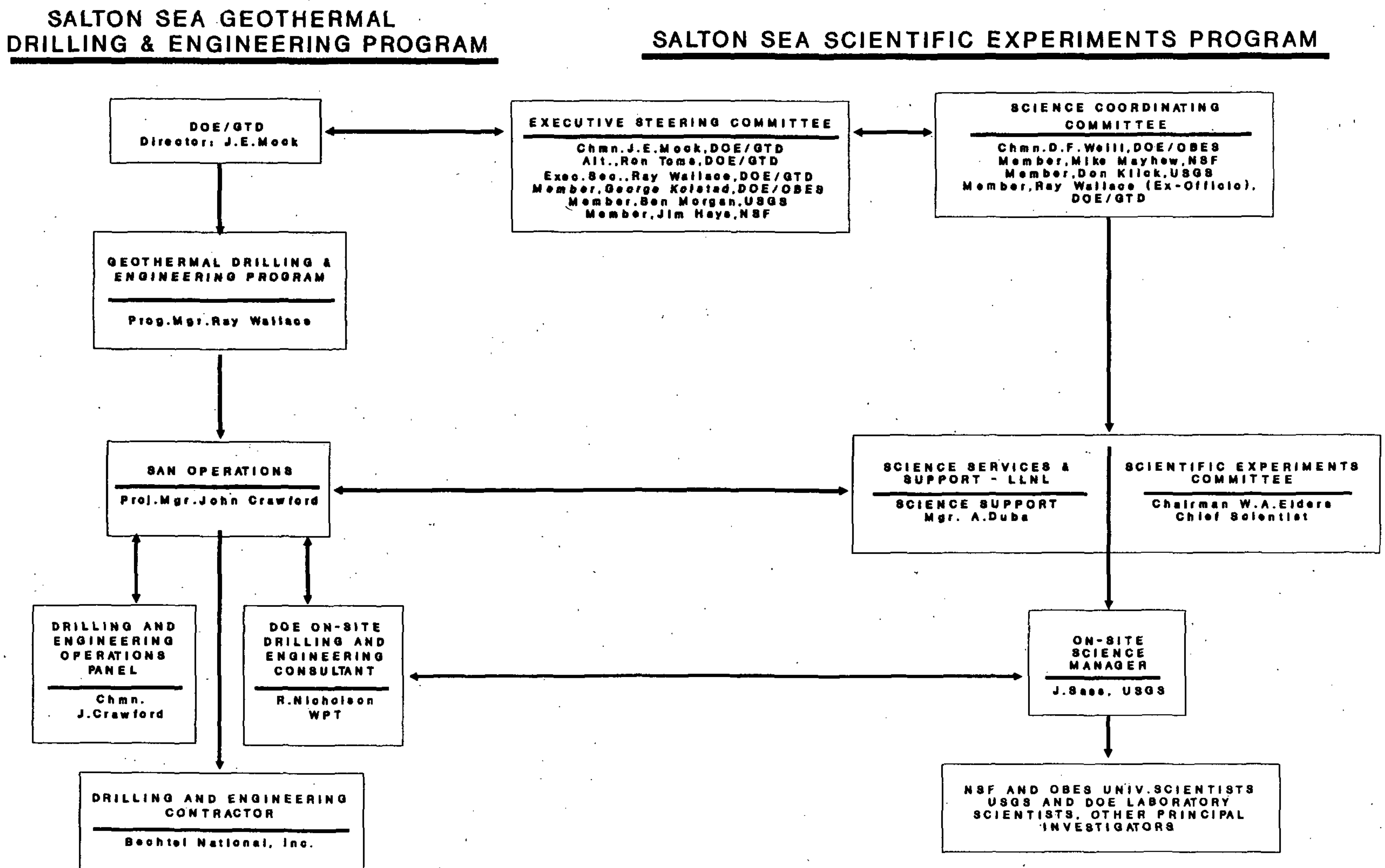

FIGURE 1

(AS OF 1986)

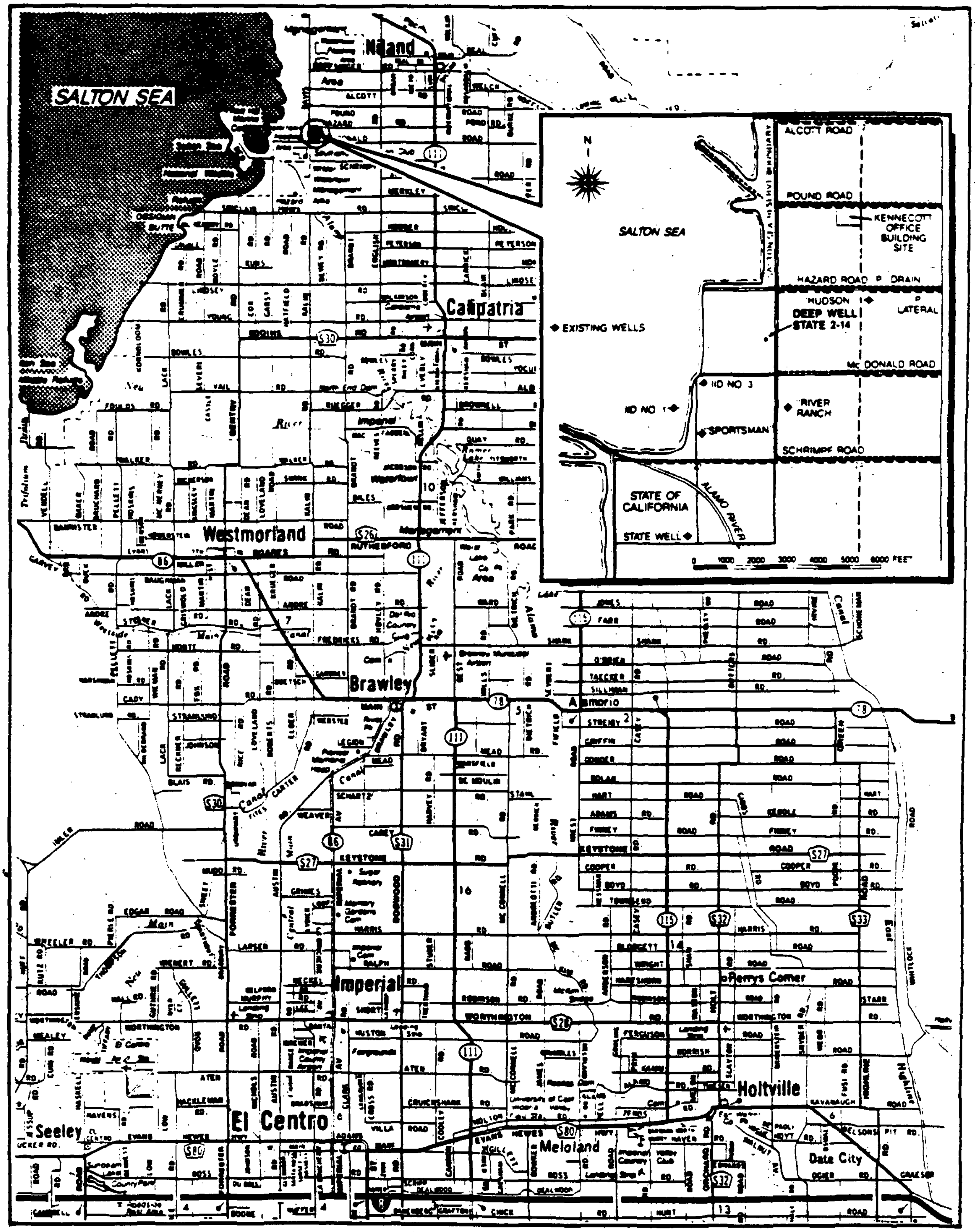

Figure 1: Location of State 2-14 and neighboring wells.

TABLE 1. SSSDP SUMMARY OF EVENTS ON STATE 2-14 WELL

PHASE ONE:

DATE	DEPTH (Feet)	ITEM
10/23/85	0	Spud, 40" hole
10/25/85	150	Set 30" casing, drill 17#1/2" hole
10/28/85	1032	Ream to 26", set 20" casing
10/31/85	1553 - 1578	Core #1, 24.6 feet, 98.4% recovery
11/01/85	1983 - 2013	Core #2, 29.2 feet, 97.3% recovery
11/02/85	2448 - 2478	Core #3, 30 feet, 100% recovery
11/04/85	2970 - 3030	Core #4, 59.6 feet, 99.3% recovery
11/05/85	3028	Schlumberger & USGS logs
11/05/85	3028	Decide to extend casing point to 3500′
11/08-09/85	3080 - 3089	Fish for cones, 1′ junk basket core #5
11/11/85	3107 - 3167	Core #6, 55 feet, 91.6% recovery.
11/12/85	3470 - 3505	Core #7, 34 feet, 97% recovery
11/15/85	3515	Set 13-3/8" casing, continue to drill 12-1/4" hole
11/19/85	3790 - 3850	Core #8, 57 feet, 95% recovery
11/20/85	4007 - 4067	Core #9, 60 feet, 100% recovery
11/21/85	4241 - 4301	Core #10, 60 feet, 100% recovery
11/22/85	4301 - 4337	Core #11, 36 feet, 100% recovery
11/24/85	4684	Injectivity test
11/25/85	4643 - 4680	Core #12, 37 feet, 100% recovery
11/26/85	4680	USGS Bottom Hole Temperture (BHT)
11/26/85	4680 - 4686	Core #13, 2 feet, 33.3% recovery
11/27-28/85	4710	Fish for stabilizer blades, 6" junk basket; Core #14, 5 feet

TABLE 1. (Continued)

DATE	DEPTH (feet)	ITEM
12/02/85	5188 - 5218	Core #15, 30 feet, 100% recovery
12/04/85	5418	Injectivity test, 2 USGS temperature logs
12/05-06/85	5422 - 5424	Fish for parted BHA
12/07/85	5574 - 5591.5	Core #16, 17.5 feet, 100% recovery
12/08/85	6000	Schlumberger logs
12/09-12/85	6000	USGS logs (BHT)
12/13-16/85	6000	Set 9-5/8" casing, cont. drilling, 8-1/2" bit
12/19/85	6027 - 6034	Core #17, 7 feet, 100% recovery, start directional drilling
12/23/85	6227	Decide to flow test, shut-in well
12/27/85	6227	USGS BHT & logs
12/28-31/85	6227	Flow test: Surface sampling, surface temperature and pressure, flow rate, max. flow established 600,000 lb/hr.
12/31/85 - 01/02/86	6227	Shut-in, downhole sample, BHT
01/02/86	6227	Continue drilling 8-1/2" hole
01/03/86	6506 - 6517	Core #18, 11 feet, 100% recovery
01/05/86	6637	Lost circulation
01/06/86	6758 - 6771	Core #19 (blind), 8 feet, 61.5% recovery
01/06-10/86	6771	Cement lost circulation zone (LCZ), wait on cement (WOC), drill ahead
01/11/86	6820	Lost circulation, cement LCZ
01/14/86	6880 - 6889	Core #20 (blind), 3.5 feet, 38.8% recovery
01/16/86	7100 - 7109	Core #21, 7 feet, 77.7% recovery
01/18/86	7300 - 7313	Core #22, 11.5 feet, 88.5% recovery
01/19/86	7547 - 7577	Core #23, 28.5 feet, 95% recovery

TABLE 1. (Continued)

DATE	DEPTH (feet)	ITEM
01/20/86	7708 - 7738	Core #24, 30 feet, 100% recovery
01/22-27/86	7737 - 7781	Directional drilling
01/28/86	8133 - 8162	Core #25, 19 feet, 65.5% recovery
01/31/86	8395 - 8401	Core #26, 7 feet, 100% recovery
02/01/86	8585 - 8604	Core #27, 12 feet, 63.2% recovery
02/03/86	8800 - 8807	Core #28, 4 feet, 57.1% recovery
02/05/86	9004 - 9027	Core #29 (blind), 4.5 feet, 19.6% recovery
02/07/86	9095 - 9098	Core #30 (blind), 3 feet, 100% recovery
02/08/86	9098	LCZ, WOC, drill ahead
02/10/86	9248 - 9254	Core #31, 3.5 feet, 58.3% recovery. Well flowing @ 9254′, 400 bbl gain
02/11/86	9453	Button broken on bit, ran junk sub to recover button, lost circ., LCM.
02/13/86	9453 - 9458	Core #32, 2.3 feet, 46% recovery
02/14/86	9458 - 9473	Core #33, 5 feet, 33.3% recovery
02/15/86	9473	USGS Temperature Survey
02/17-23/86	9473	LCZ, WOC 4 stage cement job using Haliburton
02/23/86	9473 - 9475	Core #34 (blind), 1 foot, 50% recovery
02/25-27/86	9517	RIH stuck pipe @ 9458, spot diesel, recondition well, drill ahead
02/28/86	9694 - 9698	Core #35, 3.5 feet, 87.5% recovery
03/02/86	9907 - 9912	Core #36, .75 feet, 15% recovery
03/03/86	10,000	Reached target depth
03/07/86	10,350	Film destroyed in multishot survey
03/08/86	10,475	USGS Temp and caliper, total lost circulation, LCM/cement

TABLE 1. (Continued)

DATE	DEPTH (feet)	ITEM
03/10/86	10,475	Schlumberger dual induction log
03/11-12/86	10,475	Rig up Haliburton, WOC Drill Pipe plugs with cement
03/13-14/86	10,475	USGS logs
03/15-16/86	10,475	Cement, condition hole, set 7" liner from 5748 - 10,148, drill out cement
03/17/86	10,564	Reach total depth
03/19/86	10,564	Install well head valves
03/20-22/86		2nd flow test 580,000 lb/hr
03/22-23/86		USGS Kuster runs T, P, Spinner, LANL/SANDIA, Leutert, USGS/LBL downhole sampling
03/25/86		Reinject brine, USGS WRD nuclear logs
03/28-29/86		LBL, VSP
03/30/86		Dialog Casing Caliper
03/30-31/86		LLNL downhole gravity
04/01/86		USGS Temperature Log, Beginning of shut-in period

PHASE TWO:

DATE	DEPTH (Feet)	ITEM
08/87		Repair well
08/31/87		12 hour flow test
05/23/88		Mud pit cleaned
05/88		Flow test facility completed
06/01/88		19 day flow test begun
06/05/88		Temperature and pressure survey
06/12/88		Temperature and pressure survey

TABLE 1. (Continued)

DATE	DEPTH (feet)	ITEM
06/14/88		Temperature and pressure survey
06/19/88		19 day flow test completed
06/20/88		Temperature and pressure survey
06/20-22/88		44 hour pressure buildup test
02/80		Pond cleanup and waste disposal completed
02/08/89		Pond site inspected by state
02/17/89		State declares site acceptable
02/89		Site turned back to Kennecot

TABLE 2. SSSDP CORING SUMMARY

Core #	Interval Cored Start (FT)	Interval Cored End (FT)	Total Cored (FT)	Core Recovered (FT)	Core Recovered (%)	General Description
1	1553.0	1577.6	24.6	24.6	100.0	Mudstone: indurated.
2	1983.0	2013.0	30.0	30.0	100.0	Conglomerate: indurated granular, minor mudstone and siltstone, with calcite veins, galena, sphalerite, and chalcopyrite.
3	2447.0	2477.0	30.0	30.0	100.0	Mudstone and siltstone: indurated, with minor sandstone, some calcite veining.
4	2970.0	3030.0	60.0	59.6	99.3	Sandstone and claystone: fractured, with epidote and chlorite, and contains sulfide-bearing veins with well crystallized chalcopyrite, and traces of hematite.
5	3080.0	3087.0	24.0	0.0	0.0	Rock recovered with junk.
6	3107.0	3167.0	60.0	55.0	91.0	Sandstone: laminated, containing pyrite and calcite veins, epidote, and chlorite.
7	3470.0	3505.0	35.0	34.0	97.0	Claystone: minor calcite veins and traces of disseminated pyrite.
8	3790.0	3850.0	60.0	57.0	95.0	Mudstone: indurated, some granular conglomerate, sandstone and siltstone, scarce veining.
9	4007.0	4067.0	60.0	61.0	100.0	Mudstone: indurated, some granular conglomerate, sandstone, and siltstone, scarce veining.
10	4241.0	4301.0	60.0	59.0	100.0	Mudstone: indurated, granular conglomerate, sandstone and siltstone, anhydrite porphyroblasts, lower part contains calcite, epidote, and sulfide veinlets.
11	4301.0	4334.0	33.0	33.0	100.0	Sandstone: with calcite, epidote and sulfide-bearing veins.
12	4643.0	4676.0	33.0	33.0	100.0	Sandstone and siltstone: abundant epidote with specular hematite in veins, extensively fractured.
13	4676.0	4686.0	6.0	3.5	59.0	Sandstone and siltstone: contains much epidote, I cm veins of specular hematite, and large chalcopyrite crystals.
14	4718.0	4718.6	0.6	0.6	100.0	Mudstone: epidotized (rock recovered with junk.)
15	5188.0	5218.0	30.0	30.0	100.0	Mudstone: black, aphanitic, indurated with pyrite.
16	5574.0	5591.0	17.0	17.0	100.0	Mudstone: indurated, with brecciated fractures, abundant epidote and hematite, and traces of sulfides.
17	6026.0	6044.0	18.0	18.0	100.0	Mudstone: some epidote, with quartz veins and traces of pyrite.
18	6506.0	6517.0	11.0	11.0	100.0	Claystone: grayish, with minor epidote.
19	6758.0	6771.0	13.0	8.0	61.5	Sandstone and siltstone: grayish-green.
20	6880.0	6889.0	9.0	3.5	38.9	Mudstone: indurated, laminated dark grey to light grey.
21	7100.0	7109.0	9.0	7.0	77.7	Mudstone: indurated, with minor amounts of siltstone; authigenic minerals include chlorite, hematite, and anhydrite.
22	7300.0	7313.0	13.0	11.5	88.5	Mudstone: indurated, with minor amounts of siltstone; authigenic minerals include chlorite, hematite, and anhydrite.
23	7547.0	7577.0	30.0	28.5	95.0	Mudstone: medium grey, indurated, with a single narrow bed of apidotized siltstone.
24	7704.0	7734.0	30.0	30.0	100.0	Mudstone: moderately indurated, containing anhydrite porphyroblasts.

TABLE 2. SSSDP CORING SUMMARY (Cont'd...)

Core #	Interval Cored Start (FT)	Interval Cored End (FT)	Total Cored (FT)	Core Recovered (FT)	Core Recovered (%)	General Description
25	8133.0	8161.0	28.0	28.0	100.0	Siltstone: dark, with minor sandstone, contains mica and epidote along fractures.
26	8395.0	8402.0	7.0	7.0	100.0	Mudstone: black, containing chalcopyrite.
27	8585.0	8604.0	19.0	12.0	63.2	Sandstone: grey, with abundant epidote along inclined bedding.
28	8800.0	8807.0	7.0	4.0	[illegible]	Mudstone: primarily hornfelsic, minor quartzitic sandstones wtih greenchist facies alteration minerals.
29	9004.0	9027.0	23.0	4.5	19.6	Mudstone: primarily hornfelsic, minor quartzitic sandstones with greenschist facies alteration minerals.
30	9095.0	9098.0	3.0	3.0	100.0	Shale: with interbedded fine grained sandstone, numerous fractures lined with epidote, chlorite, pyrite, and pyrrhotite.
31	9248.0	9253.0	5.0	3.5	70.0	Mudstone: hornfelsic, with minor quartzose sandstone exhibiting greenschist alteration.
32	9453.0	9458.0	5.0	2.3	46.0	Mafic intrusive: fairly fresh, fine-grained diabasic texture, containing minor pyrite, epidote and quartz inclusions.
33	9458.0	9473.0	15.0	5.0	33.0	Mafic intrusive: aphanitic, containing brecciated contact with hornfelsic, epidote-rich mudstone.
34	9473.0	9477.0	4.0	2.0	50.0	Mudstone: hornfelsic.
35	9694.0	9698.0	4.0	3.5	88.0	Quartzite: epidote-rich.
36	9907.0	9912.0	5.0	.8	13.0	Hornfels: fractured, black, silicified and cherty.
	TOTAL		821.2	720.4	87.8	

TABLE 3. CHRONOLOGY OF SSSDP LOGS

DATE	LOG TYPE	ORGANIZATION	INTERVAL (FT)
11/5/85	Dual Induction	Schlumberger	1032 - 3000
11/5/85	Formation Compensated Density	Schlumberger	1032 - 3000
11/5/85	Compensated Neutron	Schlumberger	1032 - 3000
11/5/85	Gamma Ray	Schlumberger	1032 - 3000
11/5/85	Sonic	Schlumberger	1032 - 3000
11/5/85	4-Arm Caliper	Schlumberger	1032 - 3000
11/5/85	Resistivity Temperature	USGS	1032 - 3000
11/5/85	Natural Gamma Ray	USGS	1032 - 3000
11/6/85	Resistivity Temperature	USGS	1032 - 3000
11/6/85	Caliper	USGS	1032 - 3000
11/6/85	Televiewer	USGS	1032 - 3000
11/6/85	Resistivity Temperature	USGS	1032 - 3000
11/6/85	Caliper	USGS	1032 - 3000
11/6/85	Acoustic DT (3 ft. spacing)	USGS	1032 - 3000
11/6/85	Acoustic DT (2 ft. spacing)	USGS	1032 - 3000
11/7/85	Waveform	USGS	1032 - 3000

TABLE 3. CHRONOLOGY OF SSSDP LOGS (Continued)

DATE	LOG TYPE	ORGANIZATION	INTERVAL (FT)
11/7/85	Resistivity Temperature	USGS	1032 - 3000
11/7/85	Natural Gamma	USGS	1032 - 3000
11/7/85	Gamma Spec.	USGS	1032 - 3000
11/7/85	Resistivity Temperature	USGS	1032 - 3000
11/13/85	Dual Induction	Schlumberger	3000 - 3515
11/13/85	Formation Compensated Density	Schlumberger	3000 - 3515
11/13/85	Compensated Neutron/Gamma Ray	Schlumberger	3000 - 3515
11/13/85	Sonic and Gamma Ray	Schlumberger	3000 - 3515
11/13/85	4-Arm Caliper	Schlumberger	3000 - 3515
12/4/85	Resistivity Temperature	USGS	3515 - 6000
12/9/85	Resistivity Temperature	USGS	3515 - 6000
12/9/85	Dual Induction Log	Schlumberger	3515 - 6000
12/9/85	Formation Compensated Density	Schlumberger	3515 - 6000
12/9/85	Compensated Neutron	Schlumberger	3515 - 6000
12/9/85	Gamma Ray	Schlumberger	3515 - 6000
12/9/85	Sonic	Schlumberger	3515 - 6000

TABLE 3. CHRONOLOGY OF SSSDP LOGS (Continued)

DATE	LOG TYPE	ORGANIZATION	INTERVAL (FT)
12/9/85	4-Arm Caliper	Schlumberger	3515 - 6000
12/10/85	Resistivity Temperature	USGS	3515 - 6000
12/10/85	Caliper	USGS	3515 - 6000
12/10/85	Televiewer	USGS	3515 - 6000
12/10/85	Natural Gamma	USGS	3515 - 6000
12/11/85	Gamma Spec	USGS	3515 - 6000
12/11/85	Acoustic DT	USGS	3515 - 6000
12/11/85	Waveform # 1	USGS	3515 - 6000
12/11/85	Waveform # 2	USGS	3515 - 6000
12/11/85	Caliper	USGS	3515 - 6000
12/11/85	Resistivity Temperature	USGS	3515 - 6000
12/12/85	Caliper	USGS	3515 - 6000
12/12/85	Neutron	USGS	3515 - 6000
2/15/86	Temperature	USGS	6000 - 9400
3/8,9/86	Temperature	USGS	0 - 10500
3/9/86	Caliper	USGS	(Tool Malfunctioned)

TABLE 3. CHRONOLOGY OF SSSDP LOGS (Continued)

DATE	LOG TYPE	ORGANIZATION	INTERVAL (FT)
3/10/86	Dual Induction	Schlumberger	6020 - 8819
3/12/86	Temperature	USGS	Tool hangs at 8600
3/12,13/86	Televiewer	USGS	6000 - 7000
3/13,14/86	Acoustic Waveform	USGS	6000 - 7000
3/27/86	Temperature	USGS	0 - 10200
3/29,30/86	Gamma Ray/Neutron	USGS	5690 - 10000
3/30/86	Casing Caliper	Dia-Log	0 - 5700
3/31-4/1/86	Temperature	USGS	0 - 10000

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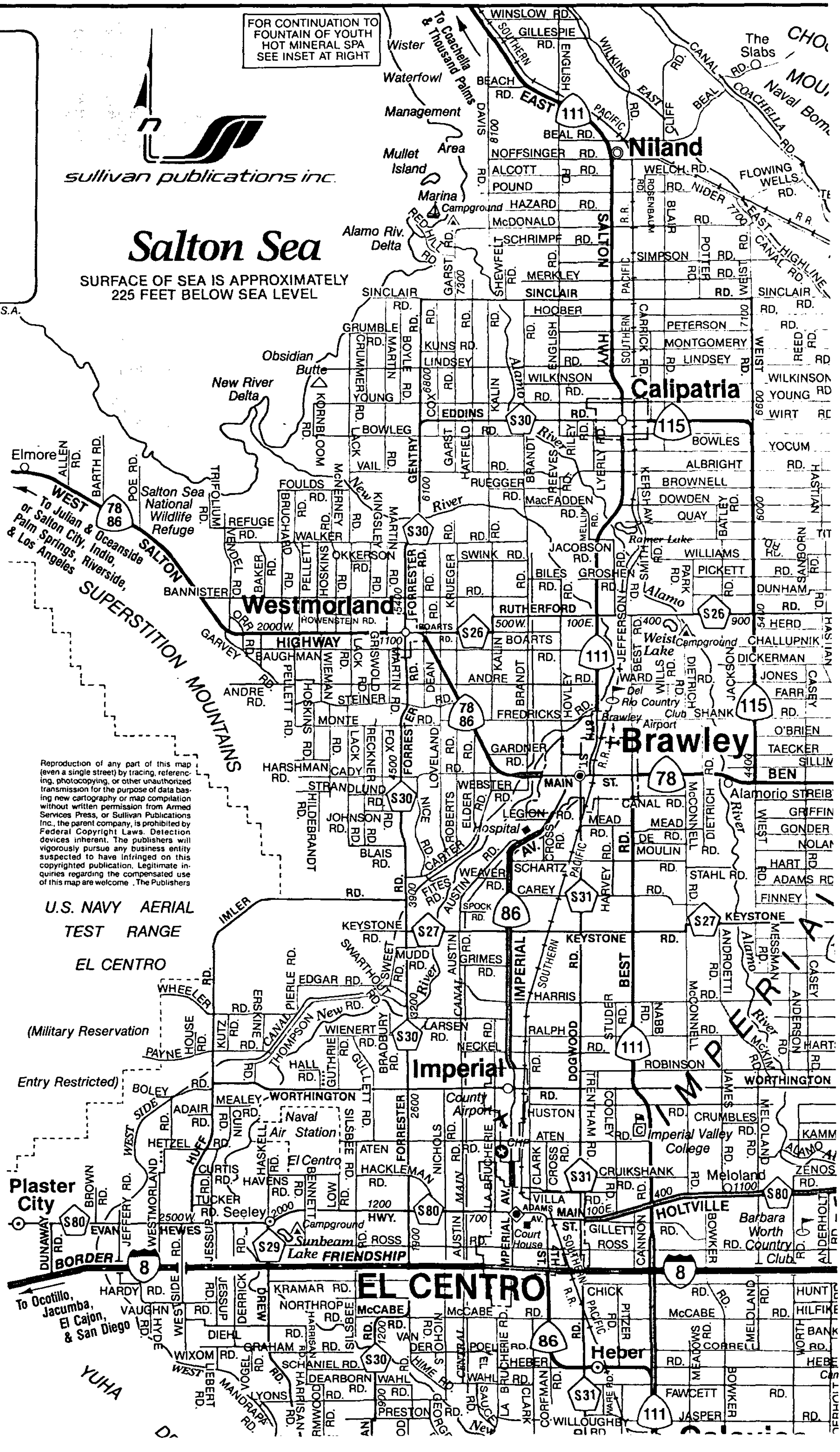
MAP OF IMPERIAL VALLEY AND VICINITY

- (8) Interstate Hwy.
- (78) State Highway
- (S80) County Route
- 800 Address System
- City Boundary
- Rivers
- Canals
- Increasing Population

SCALE 0 — 6 MILE; 0 — 10 KM

INTED JULY 1988 PRINTED IN U.S.A.



AL VALLEY
IDEX
nd TOWNS

CONVERSION FACTORS

Length:	1 centimeter (cm)=0.3937 inch (in.) 1 meter (m)=3.281 feet (ft) 1 kilometer (km)=0.6214 mile (mi)
Area:	1 m^2=10.76 ft^2 1 km^2=0.3861 mi^2
Volume:	1 liter (L)= 0.2642 gallon (gal) 1 km^3=0.2399 mi^3
Mass:	1 kilogram (kg)=2.205 pounds (lb)
Flow rate:	1 L/s = 15.85 gal/min
Temperature:	degrees Celsius (°C)=5/9(degrees Fahrenheit [°F]-32) Kelvins (K)=°C+273.15
Temperature gradient:	1°C/km=0.05486°F/100 ft
Energy:	1 joule (J)=0.2390 calorie (cal) 1 J=9.485×10^{-4} British thermal unit (Btu) 1 J=2.777×10^{-4} watt-hour (W·hr) 10^{18} J=0.9485 quad (10^{15} Btu) 1 MW_t for 30 yr=9.461×10^{14} J
Power or work:	1 watt (W)=1 J/s 1 megawatt (MW)=3.154×10^{13} J/yr
Heat flow:	1 mW/m^2=2.390×10^{-8} cal/cm·s 1 mW/m^2=2.390×10^{-2} heat-flow unit (HFU)
Thermal conductivity:	1 W/m·K=2.390 mcal/cm·s·°C

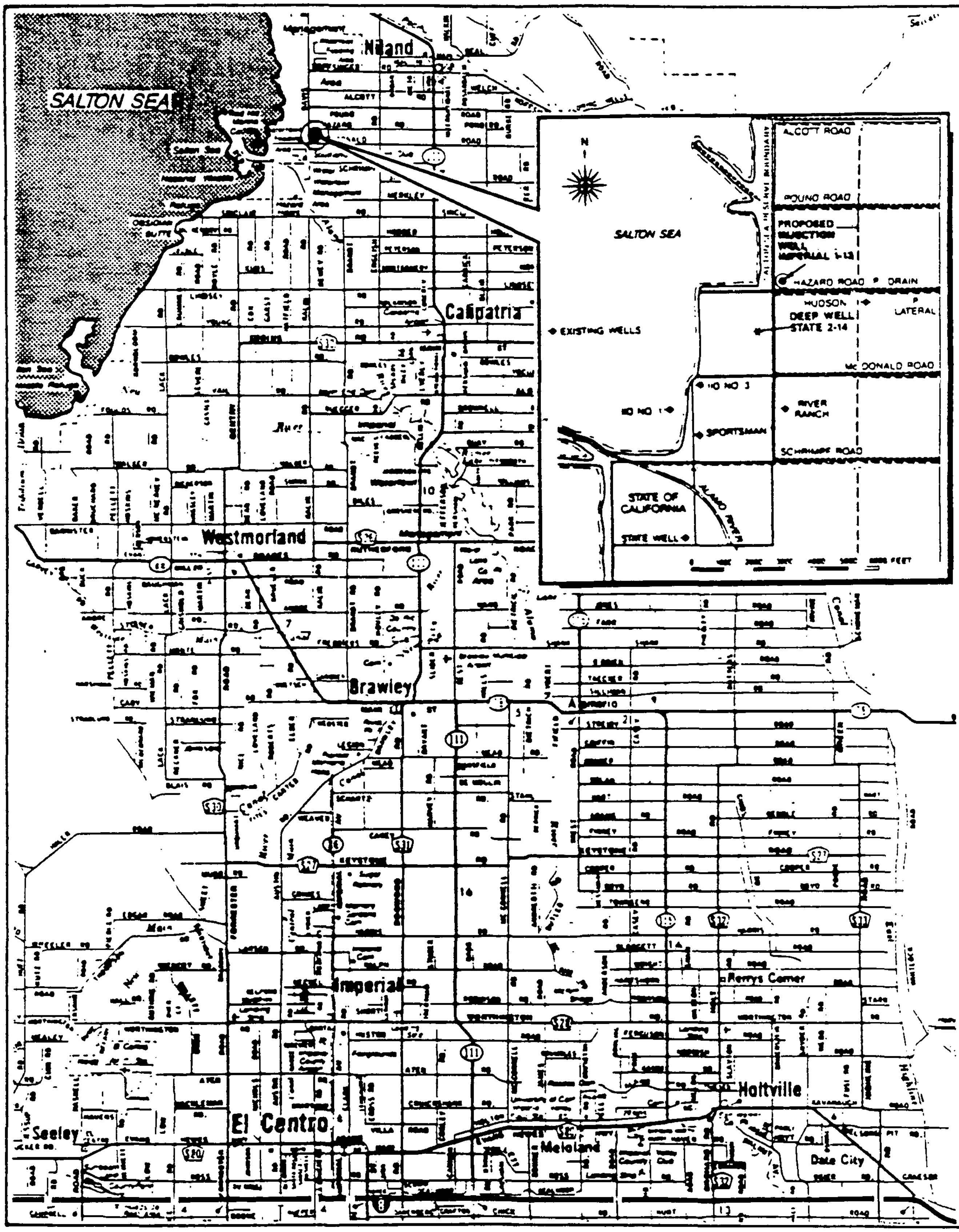


Figure 1-2 SSSDP Project Site Location