GL00871

M-X/RES PROJECT

GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

PHASE I

BRIEFING FOR

M-X/RES PROJECT OFFICE

WASHINGTON, D.C.

NOVEMBER 6, 1980

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MX-062

M-X/RES PROJECT
GEOTHERMAL TASK

BRIEFING PARTICIPANTS

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EG&G, IDAHO, INC.	BOB STIGER TOM LAWFORD

M-X/RES GEOTHERMAL TASKS

BRIEFING FORMAT

INTRODUCTION	DOE/DGE	R.A. GRAY
MANAGEMENT STRUCTURE	DOE/ID	L.L. MINK
GEOTHERMAL ASSESSMENT	ESL/UURI	P.M. WRIGHT D.L. NIELSON
APPLICATIONS DEVELOPMENT	EG&G	T.W. LAWFORD
ILLUSTRATIVE SCENARIO	ESL and EG&G	P.M. WRIGHT D.L. NIELSON T.W. LAWFORD
SCHEDULE AND EXPENDITURES	DOE/NV	A.J. ROBERTS
SUMMARY	DOE/NV	J.N. FIORE
RESPONSE	M-X/RES PROJECT OFFICE ,DOE, CONTRACTORS	

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

INTRODUCTION

GEOTHERMAL ENERGY EXPECTATIONS FOR M-X/RES

OBJECTIVES

STRATEGY OVERVIEW

WORK ELEMENTS OVERVIEW

GEOTHERMAL ENERGY EXPECTATIONS FOR M-X/RES

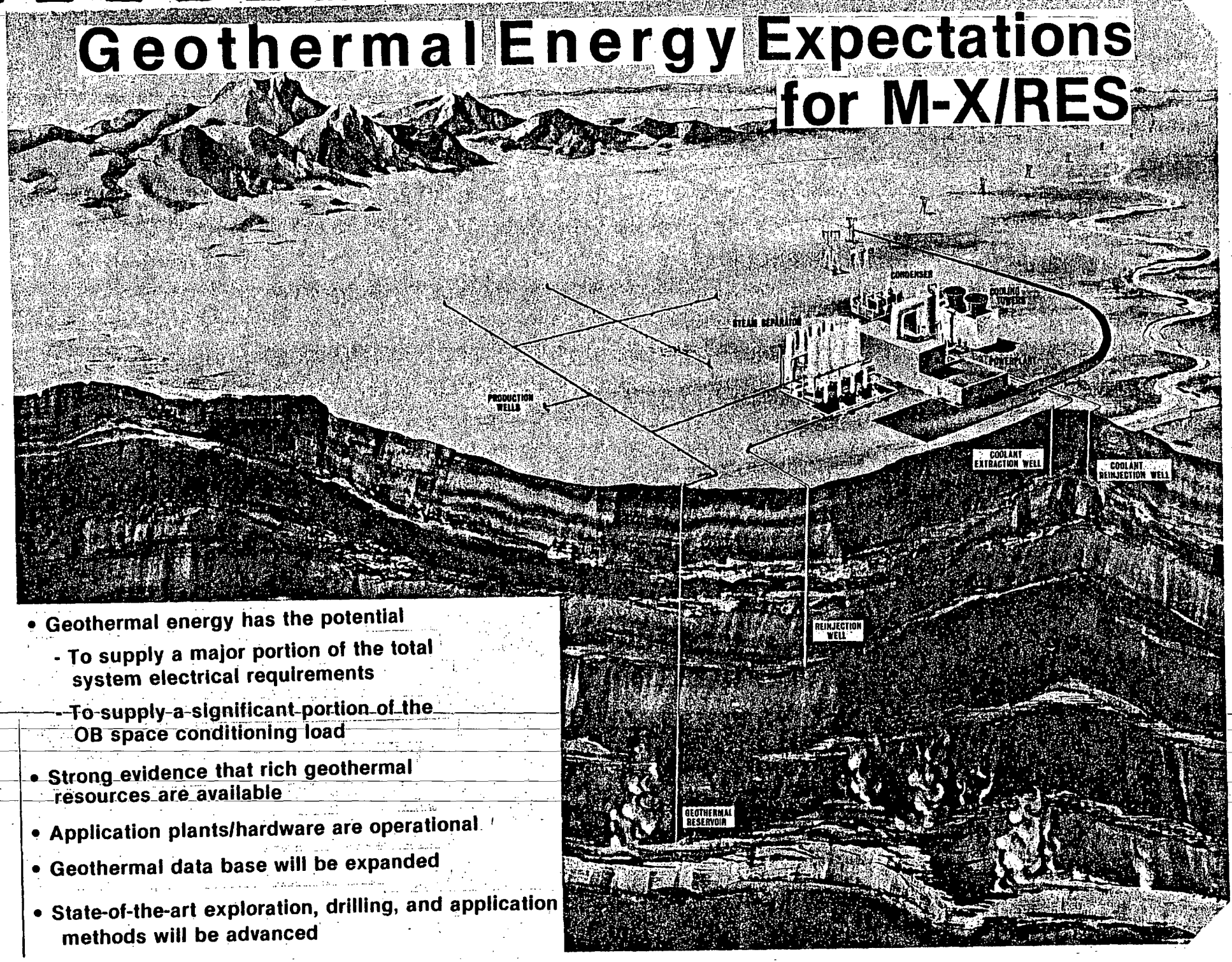
Geothermal resources are abundant in Nevada and Utah. We presently know of resources that are high enough in temperature for electrical power generation immediately north and northwest of the M-X deployment area in Nevada and immediately east of the M-X deployment area in Utah. In addition, there are numerous geothermal occurrences such as thermal springs and wells within the deployment area. Although much exploration, reservoir confirmation drilling and application feasibility work remain to be done, we can say with confidence that there is high potential for geothermal energy to supply a major portion of both the electrical power requirements and the space conditioning load for the M-X system and its support facilities.

At the present time, the geothermal potential of Nevada and Utah is almost completely undeveloped, although there are some development plans. While there are presently no operating power plants in either state, there are plans by Utah Power & Light Co. and Phillips Petroleum Co. to generate 20 MWe from the geothermal reservoir at Roosevelt Hot Springs, Utah by 1983, with 120 MWe to be on line by 1986. In addition, there are plans to develop electrical generating capacity in the range 10 to 50 MWe from one or more of the known reservoirs in northern Nevada by 1984. The Milford candidate Operating Base site lies within about six miles of the Thermo Hot Springs Known Geothermal Resource Area (KGRA), where Republic Geothermal, Inc. has found temperatures of 175-205^{0}C in deep drilling, and the Beryl candidate Operating Base site is within a few miles of several hot wells and springs at Lund and Newcastle, having known temperatures as high as 146^{0}C. There is no present development of resources at either of these candidate OB sites.

The lack of present development in Nevada and Utah reflects, among other things, current uncertainties in predicting reservoir properties such as temperature, chemistry, productivity and lifetime that can only be resolved by sufficient drilling and flow testing. These technical uncertainties adversely affect confidence in economic analyses. There is a much greater degree of confidence associated with design and operation of geothermal plants. Although each plant whether for electrical power generation or direct application of the geothermal energy, requires custom design, hardware is commercially available. In addition, development of geothermal resources poses few environmental problems.

Assessment of and development of applications for geothermal resources for the M-X System will require procedures and personnel that are very similar to those in on-going DOE/DGE geothermal programs. Implementation of the M-X/RES Geothermal Task as outlined in this briefing will be greatly facilitated by the DOE/DGE infrastructure. Our principal needs at present are funding and approval to proceed.

Geothermal Energy Expectations for M-X/RES



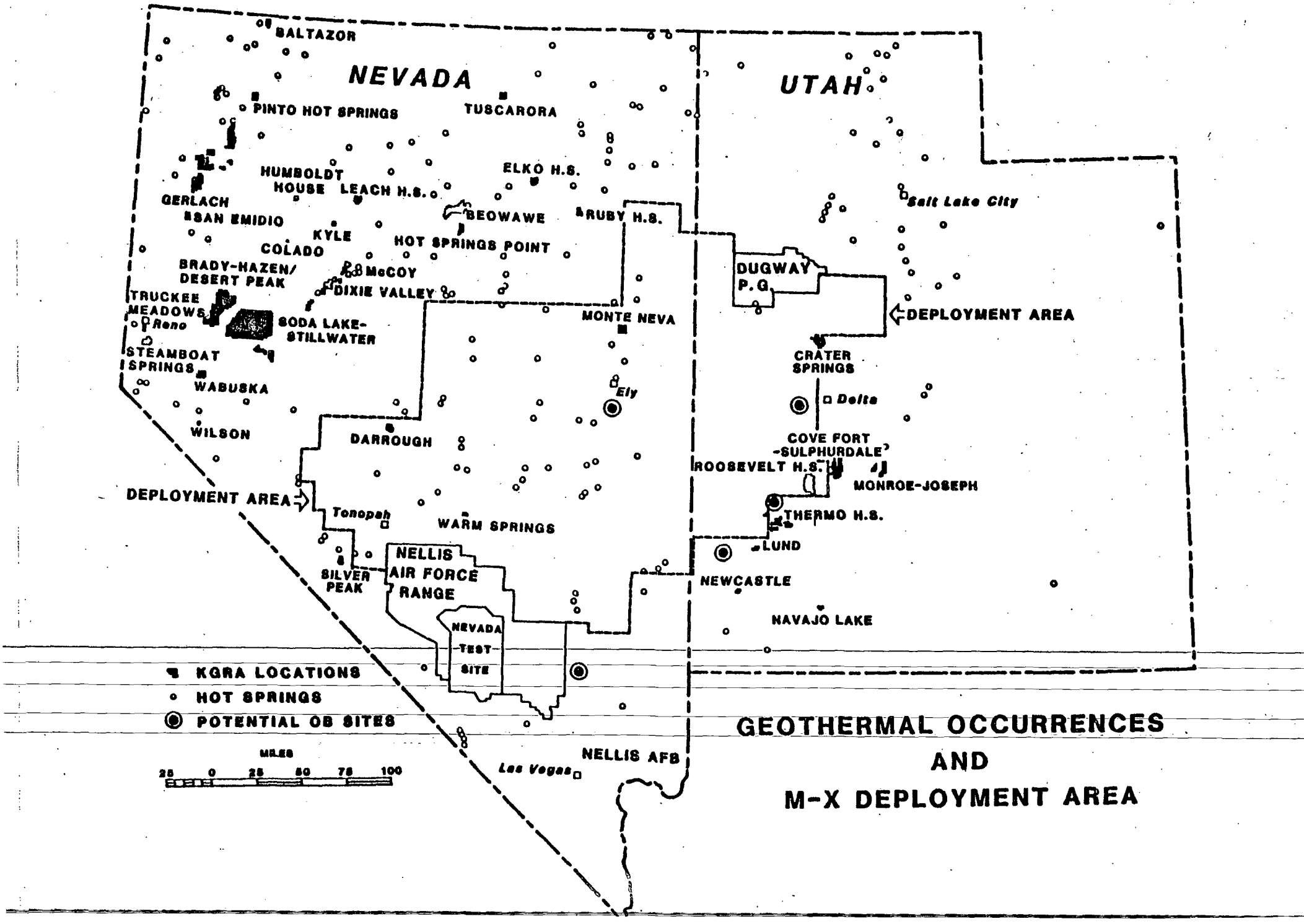
- Geothermal energy has the potential
  - To supply a major portion of the total system electrical requirements
  - To supply a significant portion of the OB space conditioning load
- Strong evidence that rich geothermal resources are available
- Application plants/hardware are operational
- Geothermal data base will be expanded
- State-of-the-art exploration, drilling, and application methods will be advanced

KNOWN GEOTHERMAL OCCURRENCES AND THE M-X DEPLOYMENT AREA

This map shows the M-X deployment area and the candidate Operating Base sites along with locations of known geothermal reservoirs, hot springs and other occurrences. KGRAs are shown as blocks. These are generally areas where there is potential for occurrence of temperatures high enough to support electrical power generation ($T \geq 150^{o}C$). The most important of these KGRAs in terms of electrical power potential for the M-X/RES Project are Roosevelt Hot Springs in Utah, and Dixie Valley, Steamboat Springs, Desert Peak, Humbolt House, and Beowawe in Nevada. In the presentation that follows, we will refer to these particular KGRAs as the "Initial High-Temperature Sites."

Areas of occurrence of thermal springs and/or wells are shown on the map by circles. These thermal wells or springs verify the existence of low- and moderate-temperature geothermal resources within the deployment area and help to indicate the potential for direct applications of geohtermal energy for M-X/RES purposes. In addition, there is believed to be potential for discovery of high-temperature resources at depths under many of these thermal wells and springs.

Industry's exploration activities have not been as intensive within the deployment area as they have been immediately outside of the deployment area. Industry has, quite naturally, explored first in those areas where surface evidence of high-temperature geothermal reservoirs is most obvious. More intensive industry exploration work is predicted within the deployment area over the next 10 years. This work, along with the exploration work that will be carried out for the M-X/RES Project, will result in discovery of resources that are unknown today.


NEVADA
UTAH
BALTAZOR
PINTO HOT SPRINGS
TUSCARORA
HUMBOLDT HOUSE
LEACH H.S.
ELKO H.S.
GERLACH
SAN EMIDIO
BEOWAWE
RUBY H.S.
KYLE
COLADO
HOT SPRINGS POINT
BRADY-HAZEN/ DESERT PEAK
McCOY
DIXIE VALLEY
TRUCKEE MEADOWS
Reno
SODA LAKE-STILLWATER
MONTE NEVA
STEAMBOAT SPRINGS
WABUSKA
Ely
WILSON
DARROUGH
DEPLOYMENT AREA
Tonopah
WARM SPRINGS
NELLIS AIR FORCE RANGE
SILVER PEAK
NEVADA TEST SITE
Las Vegas
NELLIS AFB
Salt Lake City
DUGWAY P.G.
DEPLOYMENT AREA
CRATER SPRINGS
Delta
COVE FORT -SULPHURDALE
ROOSEVELT H.S.
MONROE-JOSEPH
THERMO H.S.
LUND
NEWCASTLE
NAVAJO LAKE
KGRA LOCATIONS
HOT SPRINGS
POTENTIAL OB SITES
MILES
25 0 25 50 75 100
GEOTHERMAL OCCURRENCES
AND
M-X DEPLOYMENT AREA

DEFINITIONS

GEOTHERMAL ASSESSMENT - EXPLORATION, DRILLING, FLOW TESTING AND RESERVOIR ENGINEERING TO DISCOVER, CONFIRM, AND PRODUCE A RESERVOIR

GEOTHERMAL APPLICATION - USE OF ENERGY IN GEOTHERMAL FLUIDS PRODUCED AT THE SURFACE FROM A RESERVOIR

KGRA - KNOWN GEOTHERMAL RESOURCE AREA - AN AREA LEGALLY DEFINED AND NAMED BY THE U.S. GEOLOGICAL SURVEY THAT HAS SIGNIFICANT POTENTIAL FOR GEOTHERMAL DEVELOPMENT

EXPLORATION - USE OF GEOLOGY, GEOCHEMISTRY, GEOPHYSICS, HYDROLOGY, AND DRILLING FOR RESOURCE DISCOVERY

- RECONNAISSANCE
- DETAILED

DISCOVERY SITE - A GEOTHERMAL SITE WHERE A SUCCESSFUL WELL HAS BEEN DRILLED AND FLOW TESTED

CONFIRMED RESERVOIR - A DISCOVERY SITE WHERE DRILLING AND FLOW TESTING HAVE PROVEN A PRODUCIBLE RESERVOIR

RESERVOIR ENGINEERING - PREDICTION OF RESERVOIR TEMPERATURE, PRODUCTION SCENARIO AND LIFETIME BASED ON ANALYSIS OF TEMPERATURE, PRESSURE AND FLOW RATE DATA OBTAINED DURING FLOW TESTING

EXPLORATION DRILLING - DRILLING FOR PURPOSES OF OBTAINING GEOLOGIC INFORMATION OR FOR MAKING A DISCOVERY

- GRADIENT DRILLING

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DEFINITIONS

CONFIRMATION DRILLING - DRILLING A LARGE ENOUGH DIAMETER WELL THAT FLOW TESTING CAN BE CARRIED OUT TO CONFIRM A RESERVOIR

PRODUCTION DRILLING - DRILLING WELLS TO DEVELOP SUFFICIENT PRODUCTION TO SUPPORT AN APPLICATION

HIGH TEMPERATURE - $T > 150^{\circ}C$

INTERMEDIATE TEMPERATURE - $90^{\circ}C < T \leq 150^{\circ}$

LOW TEMPERATURE - $T < 90^{\circ}C$

GEOTHERMAL ENERGY - NATURAL HEAT FROM THE EARTH

CONVECTIVE HYDROTHERMAL SYSTEM - A GEOTHERMAL SYSTEM IN WHICH THERE IS HEATING AND CONVECTION OF NATURALLY OCCURRING FLUIDS

CASCADING - USING THE SAME GEOTHERMAL FLUID SUCCESSIVELY IN MORE THAN ONE APPLICATION

HYBRID SYSTEM - AN APPLICATION WHERE PART OF THE ENERGY IS GEOTHERMAL AND PART IS FROM ANOTHER SOURCE SUCH AS COAL OR SOLAR

GEOTHERMAL ASSESSMENT AND APPLICATIONS

It is important to understand the difference between geothermal assessment and applications.

ASSESSMENT is mainly an earth science activity centered around (1) collecting adequate exploration data to site drill holes and wells, (2) drilling to confirm the existence of a reservoir, and (3) engineering analyses to determine reservoir temperature, flow rates, water chemistry and reservoir life.

By contrast, APPLICATION is the utilization of the geothermal fluid once it reaches the surface, and consists of (1) design, installation and operation of utilization hardware, (2) transmission and distribution of geothermal fluids and/or of electricity, (3) disposal of spent geothermal fluids on the surface or by reinjection into the ground, (4) institutional factors such as environmental protection, licensing, etc., and (5) the economics of the application.

M-X/RES PROJECT

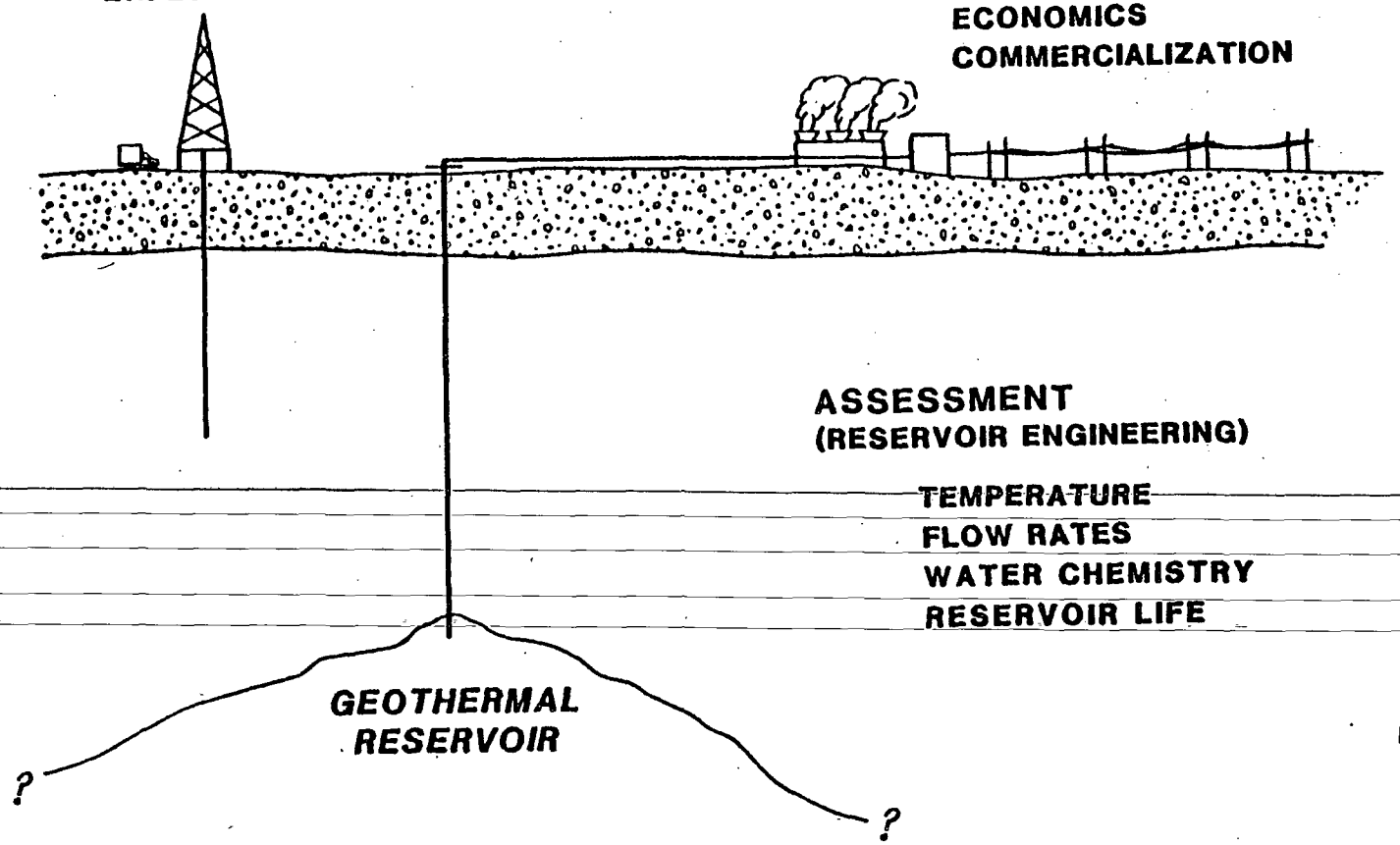
GEOTHERMAL TASK

ASSESSMENT
(GEOLOGY, GEOCHEMISTRY, GEOPHYSICS, HYDROLOGY)

- RECONNAISSANCE
- DETAILED EXPLORATION
- CONFIRMATION DRILLING
- PRODUCTION DRILLING
- STEP-OUT DRILLING
- EXPLORATION AND ASSESSMENT TECHNOLOGY

APPLICATIONS

- ELECTRICAL POWER GENERATION
- NON-ELECTRICAL APPLICATIONS
- CASCADED SYSTEMS
- HYBRID SYSTEMS
- HARDWARE
- TRANSMISSION AND DISTRIBUTION
- OPERATIONS AND MAINTENANCE
- ENVIRONMENTAL CONTROL
- ECONOMICS
- COMMERCIALIZATION



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PHASE I OBJECTIVES HIERARCHY

This chart brings the planned Phase I geothermal activities into perspective with the M-X/RES Project objectives by providing a hierarchy that translates the top-level Project objectives into specific geothermal objectives. The viability of the two Phase I Project objectives shown in the top box will be evaluated in the mid-1982 Decision Package, which in turn will be supported by the identification of feasible candidate RES systems including geothermal, solar, wind and others.

The overall Phase I geothermal objective of identifying feasible candidate geothermal applications systems will be accomplished by determining the technical viability of cost-effective and timely delivery of electric or non-electric energy to the M-X system. This can evaluated by characterizing appropriate geothermal resource sites and by determining the feasibility of use of these resources for power generation or direct application. Program elements to accomplish this objective will be tailored to satisfy the near-term schedule constraints of the M-X program while also addressing long-term commercial benefits and furthering the state of the art. Note that the objectives for characterizing resources and determining technical/cost/schedule viability are compatible with M-X/RES Project Work Breakdown Structure (WBS) Elements 2.3 and 3.1, respectively. The sub-objectives shown to support these two geothermal objectives are also compatible with third and fourth level WBS elements of the Geothermal Assessment and Application Development Task Plan, as shown on subsequent charts in this briefing.

Phase I as used in this briefing extends from the present time to June 1982, when the results of General Systems Engineering/Integration (GSE/I) are due. Phase II geothermal activities will be defined during Phase I after enough information has been developed on specific geothermal sites to determine the further work needed to develop those sites.

M-X/RES PROJECT GEOTHERMAL TASK

PHASE 1 OBJECTIVES HIERARCHY

DEFINE INTEGRATED RES OPTIONS THAT COULD
- **PROVIDE RELIABLE POWER FOR M-X**
- **ACCELERATE RES COMMERCIALIZATION**

DEVELOP DECISION PACKAGE BY MID '82 TO SUPPORT USAF DECISIONS ON
- **RES MIX**
- **RES ACQUISITION STRATEGIES**
- **COMMERCIAL INCENTIVES**

IDENTIFY FEASIBLE CANDIDATE SYSTEMS FROM OTHER RES TECHNOLOGIES

IDENTIFY FEASIBLE GEOTHERMAL APPLICATIONS SYSTEMS : DETERMINE HOW , AT WHAT COST, AND ON WHAT SCHEDULE GEOTHERMAL ENERGY COULD BE DELIVERED TO M-X , WHILE BENEFITING THE COMMERCIAL COMMUNITY

CHARACTERIZE GEOTHERMAL RESOURCE SITES IN OR ADJACENT TO THE M-X DEPLOYMENT AREA (2.3)
- **EXPLORE, CONFIRM, AND DEVELOP CASE STUDIES FOR GEOTHERMAL RESERVOIRS**
- **PLAN PHASE II ACTIVITIES**

DETERMINE PLANT FEASIBILITIES AND RESERVOIR SPECIFIC DESIGNS FOR ELECTRICAL AND DIRECT HEAT APPLICATIONS (3.1)
- **DEFINE CONCEPT, APPROACH**
- **DETERMINE PLANT FEASIBILITY FOR CONFIRMED RESERVOIRS**
- **PLAN SYSTEMS IMPLEMENTATION**
- **IDENTIFY COMMMERCIALIZATION IMPACTS**
- **PLAN PHASE II ACTIVITIES**

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M-X/RES GEOTHERMAL TECHNICAL APPROACH OVERVIEW (PHASE I)

Three major concurrent and independent geothermal activity paths are emphasized in the strategy shown on the accompanying chart. These activity paths are differentiated mainly on resource considerations. The greatest potential for electrical power generation exists at known geothermal sites outside of the deployment area. Path 1 is designed to investigate M-X/RES applications at these sites. At the same time, there is potential for discovery of currently unknown resources within the deployment area that could be used for electrical power generation, and Path 3 will investigate these possibilities. Several of the candidate Operating Base sites lie near known geothermal occurrences, mostly of low to intermediate temperature. Use of these resources to provide space conditioning will be investigated in Path 2. But because it is not economic to pipe low-temperature fluids for direct application more than 5 to 10 miles, low- to intermediate-temperature exploration activities will be confined to these distances from the candidate Operating Bases.

The activity paths are designed to support the M-X/RES Decision Package of mid-1982. Strategies are being developed to specify in detail the activities in each path while making maximum use of existing information and state-of-the-art geothermal technologies. The activities in these three paths will be supplemented by generic plant studies, implementation planning, and commercialization analyses to provide close compatability with other RES candidate system development efforts. Details of the three activity paths follow below.

The top path (1) is one of high confidence level and should assure a role for geothermal energy in M-X/RES. It emphasizes electrical power generation, although use of direct thermal energy through cascading will also be investigated. The 6 sites in the "Initial High-Temperature Sites" category are reasonably well known. Recent dicussions have uncovered the fact that plant design data which M-X/RES may be able to purchase have been developed by consortia for some of the sites. It remains to: (1) screen the 6 sites by using both resource data and the results of generic parameterizations and consortia studies to select the 1 or 2 highest priority sites for cost-shared drilling/testing, (2) perform drilling and testing, and (3) translate the results into specific high-temperature candidate geothermal system design(s)/specification(s).

The middle path (2) pertains to exploration for reservoirs near the 5 candidate Operating Base Sites. This path is also likely to result in an M-X application. At present the Milford and Beryl candidate OB sites are known to be associated spatially with a geothermal resource, and potential for discovery at other OB sites is high. It is most likely that lower temperature fluids would be found at these sites that would

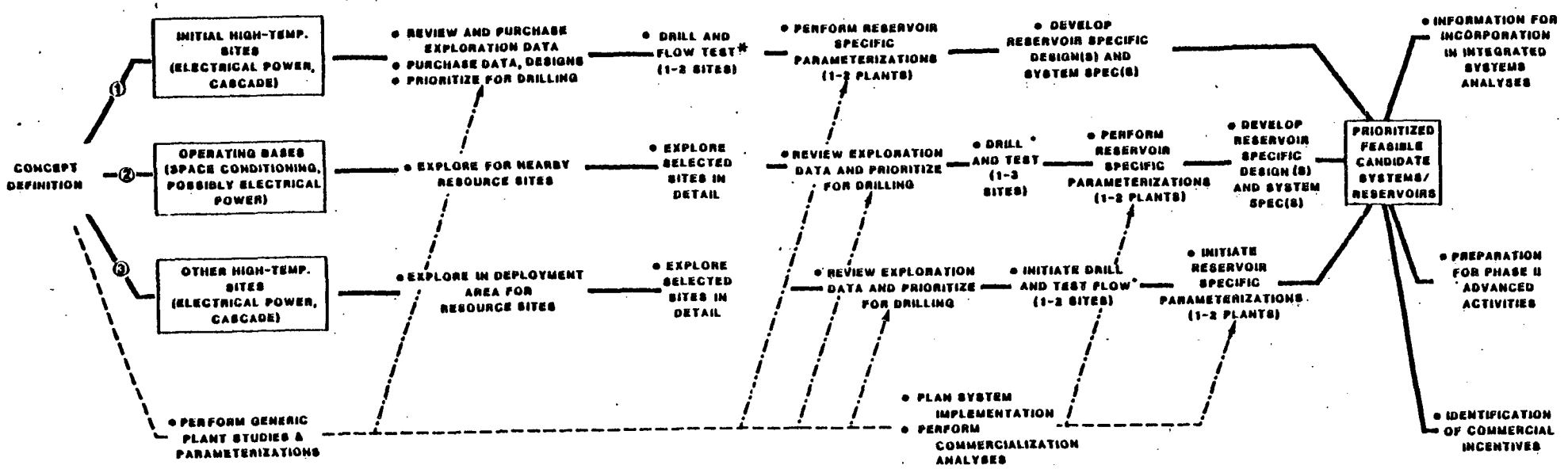
restrict application to space conditioning, although electrical power generation will be investigated. The Milford Candidate OB site, in particular, appears to have potential for electrical power generation. The activities along Path 2 begin with exploration and screening prior to conducting activities similar to those called for in Path 1. The results will be 1 or 2 OB reservoir specific system design(s) and system specification(s).

The lower path (3) involves exploration in the deployment area for high-temperature sites that are now unknown. It is anticipated that 1 to 2 sites will evolve from this path that will provide backup in the event that those applications in Path 1 yield lesser capability than required. Also, this category (a) has fewer associated transmission problems, (b) could support the option of an M-X/RES dedicated plant, (c) increases the likelihood of available geothermal power, and (d) provides a head-start for follow-on activities. The activities will lag those of the first two paths mainly because of funding restrictions. Accordingly, the corresponding parametrization studies will culminate later in Phase I and will be less refined than for the upper two paths; i.e., they will be provided as reservoir specific parameterizations rather than system designs/specifications. Design activities would therefore be continued into Phase II, along with appropriate extensions of the upper two paths.

Generic and parametric studies of electric power plants and space conditioning systems will be performed early in Phase I to provide direction and guidance for each of the three paths. This guidance will be in the form of engineering, economic feasibility, schedular, commercialization, and socio-institutional considerations.

Phase II activities for the three activity paths will involve drilling for reservoir testing, production drilling, detailed reservoir specific applications designs, and construction and start-up of geothermal utilization systems.

M-X/RES GEOTHERMAL TECHNICAL APPROACH OVERVIEW (PHASE I)



*AVAILABILITY OF FUNDS WILL LIMIT TOTAL NUMBER OF DEEP WELLS TO 2-3 DURING FY 1981 AND 3 TO 4 DURING FY 1982

DOE/DGE GEOTHERMAL PROGRAMS

The on-going geothermal program of the Department of Energy/Division of Geothermal energy offers an infrastructure that can effect timely and cost-effective implementation of the M-X/RES Geothermal Assessment and Applications Development Task. In fact, three of the DGE program elements were set up to accomplish geothermal reservoir assessment and confirmation in Nevada and Utah (the Industry Coupled Program, the State Coupled Program, and the User Coupled Drilling Program). The Electric Applications and Direct Heat Applications Programs support development and demonstration of new energy conversion technology. Use would be made of these program structures and of the experienced contractor personnel for the M-X/RES Project.

In addition, the M-X/RES Geothermal Assessment and Applications Development Task will support not only the above DGE Program elements but also DGE's technology development efforts (Exploration and Assessment Technology Program and Reservoir Engineering) and the several Industrialization programs.

DOE/DGE GEOTHERMAL PROGRAMS

- PROVIDE AN IN-PLACE INFRASTRUCTURE TO CARRY OUT M-X/RES GEOTHERMAL TASKS
- APPLICABLE PROGRAMS NOW OPERATING :

-INDUSTRY COUPLED PROGRAM:

Cost-shared exploration and drilling for high-temperature reservoirs with companies working in Nevada and Utah.

-STATE COUPLED PROGRAM:

Low-and intermediate-temperature geothermal assessment in Nevada and Utah.

-EXPLORATION AND ASSESSMENT TECHNOLOGY PROGRAM :

Development of new techniques and improvement of existing techniques.

-USER COUPLED DRILLING PROGRAM:

Cost -shared exploration and drilling for low-and intermediate-temperature reservoirs with private sector.

-RESERVOIR ENGINEERING :

Development of new techniques and application of existing techniques.

-ELECTRIC APPLICATIONS:

Design and construction of binary and flash demonstration plants and evaluation of loan guarantee applications from industry.

-DIRECT HEAT APPLICATIONS:

Design and construction of direct heat demonstration projects with private sector.

-INDUSTRIALIZATION PROGRAMS:

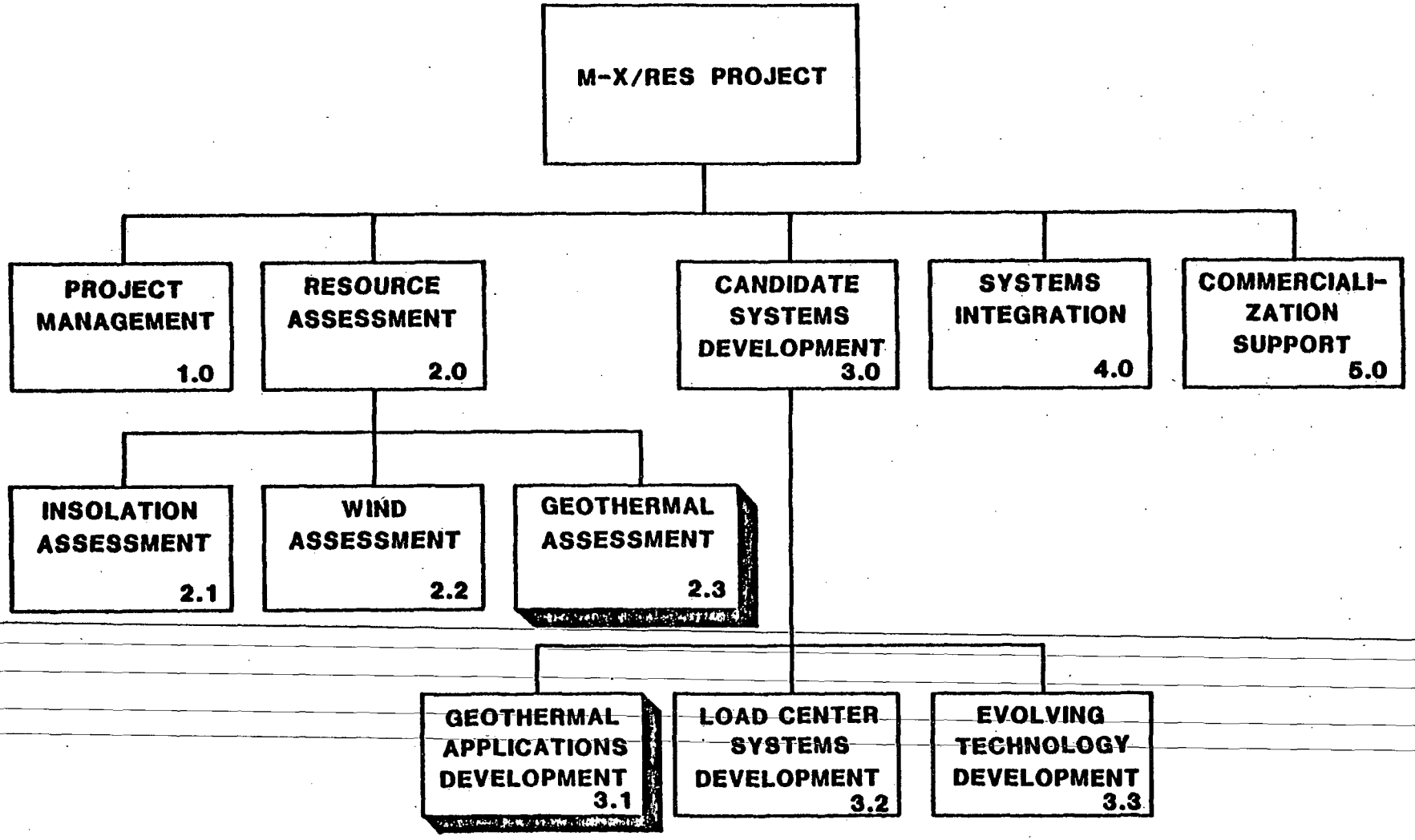
Commercialization of geothermal energy.

M-X/RES PROJECT WORK BREAKDOWN STRUCTURE

This chart illustrates the position of the Geothermal Assessment and Geothermal Applications Development work elements relative to the top-level M-X/RES Project work breakdown structure. Taken together, Geothermal Assessment (WBS 2.3) and Geothermal Applications Development (WBS 3.1) constitute what we have termed the "M-X/RES Geothermal Assessment and Applications Development Task."

MX/021

M-X/RES PROJECT
WORK BREAKDOWN STRUCTURE



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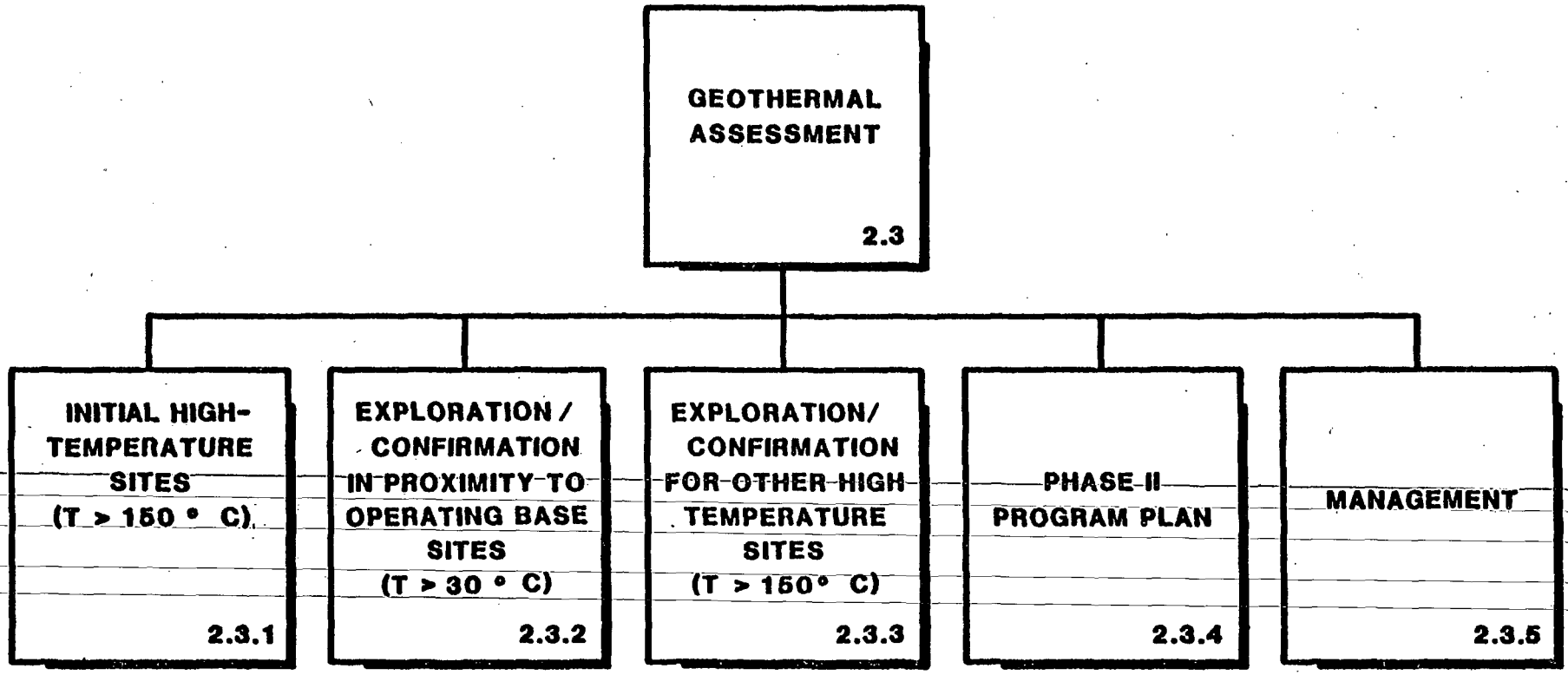
PHASE I GEOTHERMAL ASSESSMENT WORK BREAKDOWN STRUCTURE

This chart shows the third-level of the WBS pertaining to Geothermal Assessment. Elements 2.3.1, 2.3.2, and 2.3.3 reflect the three main elements of the strategy, i.e. the three separate activity paths as previously discussed.

M-X/RES PROJECT

GEOTHERMAL TASK

PHASE I GEOTHERMAL ASSESSMENT WORK BREAKDOWN STRUCTURE



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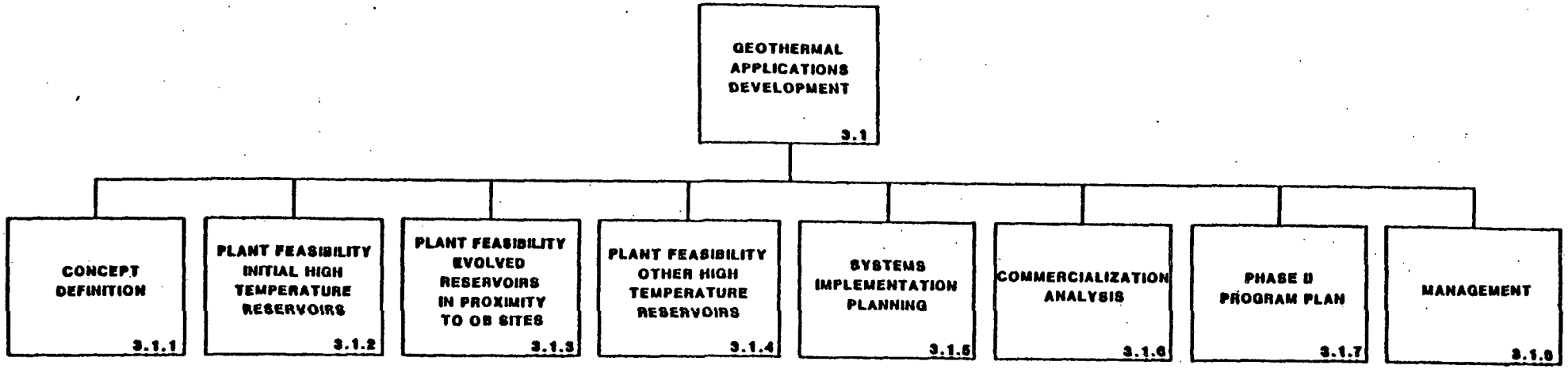
PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WORK BREAKDOWN STRUCTURE

This chart shows the third level of the WBS pertaining to Geothermal Applications Development. Plant feasibility studies are planned for the three activity paths previously discussed on the technical approach overview. Systems implementation planning will be performed at specific reservoir sites that are confirmed as a result of Geothermal Assessment activities. Commercialization analyses will be performed on all non-proprietary data and released to the geothermal community.

M-X/RES PROJECT

GEOTHERMAL TASK

PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WORK BREAKDOWN STRUCTURE



M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

MANAGEMENT STRUCTURE

FUNCTIONAL RELATIONSHIPS
AUTHORITIES/RESPONSIBILITIES
CONTRACTOR QUALIFICATIONS

FUNCTIONAL RELATIONSHIPS

This chart illustrates the functional relationships among the M-X/RES Project Office and some of its contractors and DOE/DGE and some of its contractors. DOE/DGE will communicate with and report to the M-X/RES Project Office on all aspects of the Geothermal Assessment and Applications Development Task. The DGE Project Manager will receive staff assistance from a special group, the Joint Task Group (JTG), that is composed of personnel from the Idaho (DOE/ID) and Nevada (DOE/NV) Operations Offices of DOE. The JTG serves mainly in planning, coordinating, and communicating functions for DGE, and has no line responsibility over technical aspects of Task implementation.

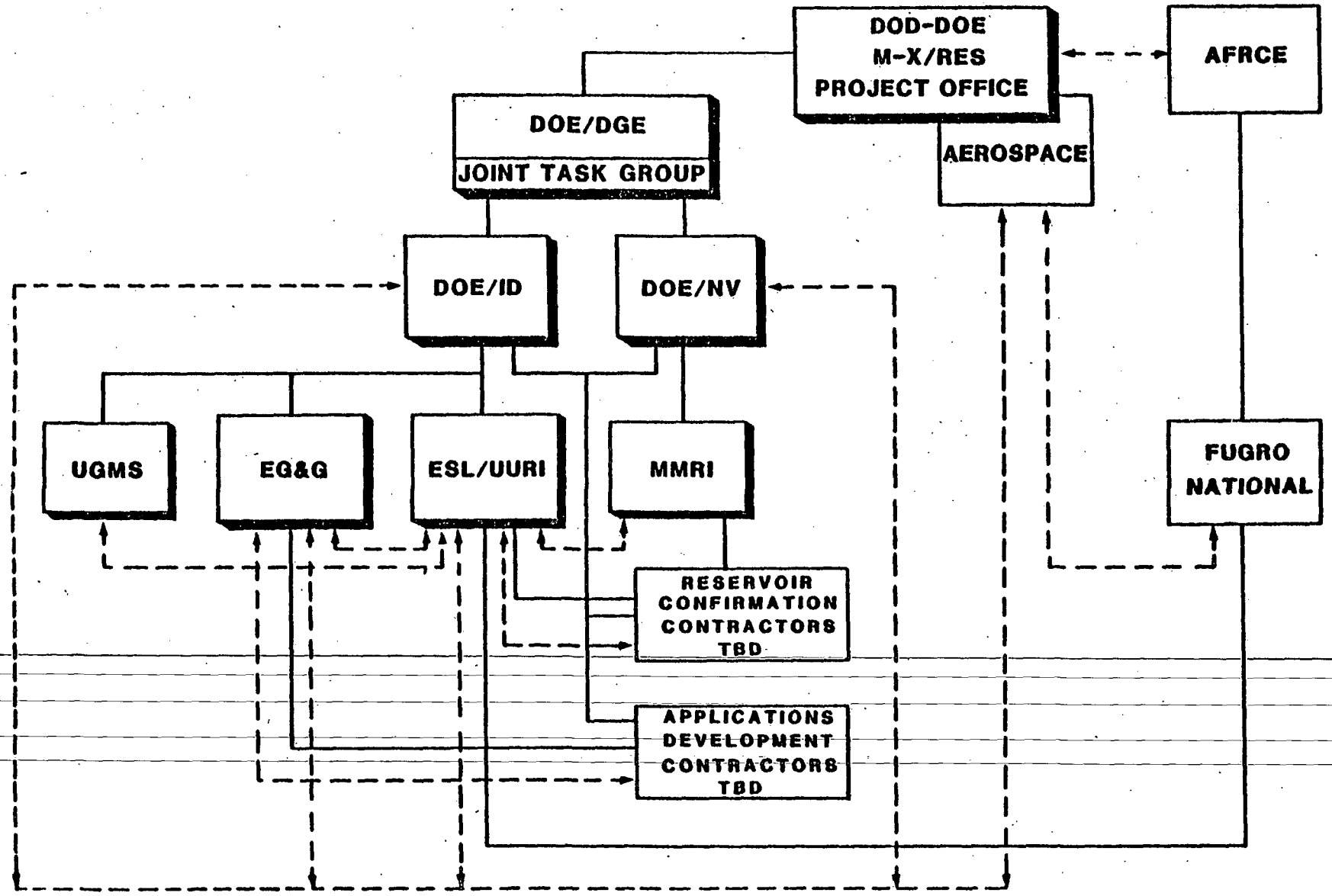
Implementation will be accomplished by carefully coordinated effort of DOE/ID and DOE/NV and their contractors. ESL/UURI wil serve as the primary support contractor to DOE/ID and the JTG. ESL will have basic responsibility for determining strategy and reviewing progress and results for the Geothermal Assessment portions of the Task, as well as for performance of some of the technical work elements. ESL will also coordinate procurement of existing earth science data from Fugro and from industry and will develop and maintain the M-X/RES Geothermal Data Base. ESL will analyse commercialization impacts of the geothermal work jointly with EG&G.

EG&G will bear basic responsibility for the Geothermal Applications Development portion of the Task. They will perform generic feasibility studies and conceptual design for potential geothermal use from typical reservoirs of the type expected in and near the M-X deployment area. As reservoir parameter data become more refined, EG&G will perform reservoir specific conceptual designs and systems specifications. They will also plan for implementation of geothermal utilization for Phase II. EG&G along with ESL will analyze commercial impacts of the M-X/RES geothemal data.

MMRI and UGMS will be the principal support contractors responsible for low- and intermediate-temperature geothermal assessment in the deployment area. They will also provide planning support for ESL and the JTG.

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

FUNCTIONAL RELATIONSHIPS



DOE/DIVISION OF GOETHERMAL ENERGY (DGE)

Authorization Document: Letter - D. Campbell to B. G. DiBona, dated 18 June 1980

Task Manager: Robert A. Gray COM. 202-633-8820, FTS 633-8820

Alternate : Harry N. Giles COM. 202-633-8820, FTS 633-8820

Provides overall guidance regarding policy, priorities, task direction, schedule and budget in accordance with M-X/RES Project Office requirements.

Assures effective and efficient implementation of the Geothermal Task Plan, of directions from the M-X/RES Project Office, and of applicable DOE orders and other Federal regulations.

Institutes planning activities and approves the Geothermal Task Plan and modifications to the Plan.

Provides funding to the DOE/Idaho and DOE/Nevada field offices.

Approves release of data to the public from the M-X/RES Geothermal Data File.

Coordinates with other national-level geothermal programs of the DOE and the U.S. Geological Survey. Incorporates results that are of benefit to the M-X/RES Project.

Reports to and maintains communication with the M-X/RES Project Office. Provides periodic schedular and expenditure progress reports, topical reports, and briefings.

M-X/RES PROJECT
GEOTHERMAL TASK

DOE/DGE RESPONSIBILITIES AND AUTHORITIES

TASK MANAGER - BOB GRAY

ALTERNATE - HARRY GILES

- PROVIDES OVERALL GUIDANCE FOR POLICY, PRIORITIES, TASK DIRECTION, SCHEDULE AND BUDGET
- ASSURES EFFECTIVE AND EFFICIENT IMPLEMENTATION OF GEOTHERMAL TASK PLAN
- APPROVES TASK PLAN AND MODIFICATIONS
- PROVIDES FUNDING TO DOE/ID AND DOE/NV
- APPROVES RELEASE OF GEOTHERMAL DATA TO PUBLIC
- COORDINATES WITH OTHER NATIONAL GEOTHERMAL PROGRAMS
- REPORTS TO M-X/RES PROJECT OFFICE

ID/NV JOINT TASK GROUP (JTG)

Authorization Document: Memo - B. G. DiBona to M. E. Gates, dated 25 July 1980

Principal Contact: Allen J. Roberts, DOE/NV COM 702-734-3171, FTS 598-3171

Alternate : Leland L. Mink, DOE/ID COM 208-526-0638, FTS 583-0638

Assists DOE/DGE Task Manager by:

Coordinating efficient and effective implementation and management of the Geothermal Task Plan in accordance with directions from the DOE/DGE Task Manager.

Coordinating preparation of the Geothermal Task Plan and of modifications to the Plan.

Coordinating the preparation of monthly schedular and expenditure progress reports and of technical reports and submitting them to DOE/DGE.

Coordinating the establishment and maintenance of the M-X/RES Geothermal Data File and making appropriate recommendations to DOE/DGE for release of data to the public.

Providing planning, technical review and briefing assistance to DOE/DGE as requested.

M-X/RES PROJECT GEOTHERMAL TASK

ID/NV JOINT TASK GROUP (JTG) RESPONSIBILITIES AND AUTHORITIES

PRINCIPAL CONTACT - ALLEN ROBERTS

ALTERNATE - ROY MINK

- ASSISTS DOE/DGE TASK MANAGER BY:
  - COORDINATING IMPLEMENTATION OF GEOTHERMAL TASK PLAN
  - COORDINATING PREPARATION OF TASK PLAN AND MODIFICATIONS
  - COORDINATING PREPARATION OF PERIODIC REPORTS
  - COORDINATING GEOTHERMAL DATA FILE
  - PROVIDING PLANNING, REVIEW AND BRIEFING ASSISTANCE AS REQUESTED

DOE/ID FIELD OFFICE

Authorization Documents: Memo - B. G. DiGona to M. E. Gates, dated July 25, 1980

Field Manager : Leland L. Mink COM 208-526-0638, FTS 583-0638

Associate Field Manager: Russell D. Lease COM 208-526-2401, FTS 583-2401

Contracts for and directs day-to-day implementation of:

1) Field exporation for geothermal resources of all temperatures in the State of Utah (through ESL and UGMS).

2) Reservoir confirmation including drilling for low- and intermediate-temperature reservoirs in the State of Utah (through ESL and UGMS).

3) Work supporting the conceptual definition of M-X geothermal applications, planning for implementation, and analysis of the impact on commercialization (through EG&G and ESL).

4) Technical planning and task review assistance; development and management of the M-X/RES Geothermal Data File; preparation, consolidation, and submission of monthly progress reports and of technical reports as necessary (through ESL, EG&G, and UGMS).

Consolidates contractor monthly schedular and expenditure progress reports, develops a management assessment of status and/or problems and recommended solutions, and implements these solutions after approval of DOE/DGE.

Reviews technical reports and approves their submittal to DOE/DGE and to the M-X/RES Project Office.

M-X/RES PROJECT
GEOTHERMAL TASK

DOE/ID RESPONSIBILITIES AND AUTHORITIES

FIELD MANAGER - ROY MINK
ASSOCIATE - RUSS LEASE

- CONTRACTS FOR AND DIRECTS DAY-TO-DAY IMPLEMENTATION OF:
  - FIELD EXPLORATION FOR RESERVOIRS OF ALL TEMPERATURES IN UTAH
  - RESERVOIR CONFIRMATION INCLUDING DRILLING FOR LOW- TO INTERMEDIATE-TEMPERATURE RESERVOIRS IN UTAH
  - CONCEPTUAL DEFINITION OF APPLICATIONS; PLANNING FOR IMPLEMENTATION; AND COMMERCIALIZATION ANALYSES IN NEVADA AND UTAH
  - TECHNICAL PLANNING AND REVIEW ASSISTANCE; DATA FILE MANAGEMENT; PERIODIC PROGRESS AND TECHNICAL REPORTING
- CONSOLIDATES PERIODIC CONTRACTOR PROGRESS REPORTS, ASSESSES STATUS AND PROBLEMS, IMPLEMENTS SOLUTIONS WITH APPROVAL OF DOE/DGE
- REVIEWS AND APPROVES CONTRACTOR TECHNICAL REPORTS

MX-077

DOE/NV FIELD OFFICE

Authorization Document: Memo - B. G. DiBona to M. E. Gates;
dated July 25, 1980

Field Manager : Joseph N. Fiore COM 702-734-3424, FTS 598-3424

Associate Field Manager: Allen J. Roberts COM 702-734-3171, FTS 598-3171

Contracts for and directs the day-to-day implementation of:

1) Field exploration for geothermal reservoirs of all temperatures in the State of Nevada (through MMRI).

2) Reservoir confirmation including drilling for low- and intermediate-temperature reservoirs in the State of Nevada (through MMRI).

3) Industry cost-shared drilling activities associated with potential reservoirs of all temperatures in Nevada and Utah utilizing ESL-approved work scopes and activities (Contractor(s) TBD).

4) Feasibility studies relating to the utilization of initial high-temperature reservoirs for the generation of electrical power, utilizing EG&G-approved work scopes and activities (through Contractor(s) TBD).

Consolidates contractor monthly schedular and expenditure progress reports, develops a management assessment of status and/or problems and recommended solutions, and implements these solutions after approval of DOE/DGE.

Reviews technical reports and approves their submittal to DOE/DGE and to the M-X/RES Project Office.

M-X/RES PROJECT
GEOTHERMAL TASK

DOE/NV RESPONSIBILITIES AND AUTHORITIES

FIELD MANAGER - JOE FIORE

ASSOCIATE - ALLEN ROBERTS

- CONTRACTS FOR AND DIRECTS DAY-TO-DAY IMPLEMENTATION OF:
  - FIELD EXPLORATION FOR RESERVOIRS OF ALL TEMPERATURES IN NEVADA
  - RESERVOIR CONFIRMATION INCLUDING DRILLING FOR LOW- TO INTERMEDIATE- TEMPERATURE RESERVOIRS IN NEVADA
  - INDUSTRY COST-SHARED EXPLORATION, CONFIRMATION AND PRODUCTION DRILLING IN NEVADA AND UTAH
  - FEASIBILITY STUDIES FOR UTILIZATION OF INITIAL HIGH-TEMPERATURE RESERVOIRS IN NEVADA AND UTAH
- CONSOLIDATES PERIODIC CONTRACTOR REPORTS, ASSESSES STATUS AND PROBLEMS, IMPLEMENTS SOLUTIONS WITH APPROVAL OF DOE/DGE
- REVIEWS AND APPROVES CONTRACTOR TECHNICAL REPORTS

NATIONAL GEOTHERMAL PROGRAM CONTRACTORS APPLIED TO M-X/RES

DOE/DGE's geothermal programs are supported by a number of contractors that have specific areas of expertise applicable to the M-X/RES Geothermal Task. These contractors have presently operating projects that are similar in scope and activities to those that the M-X/RES Geothermal Task will require. By implementing the M-X/RES Geothermal Task through existing DOE/DGE contractors an existing, experienced infrastructure will be used, thus facilitating accomplishment of the Task while at the same time ensuring the integration of M-X/RES geothermal results into the Federal geothermal technology development and commercialization programs and ensuring that the private sector is appraised of M-X/RES geothermal results.

Contractors that will be used on the M-X/RES Geothermal Task include:

Earth Science Laboratory Division/University of Utah Research Institute
Salt Lake City, Utah

EG&G, Idaho, Inc.
Idaho Falls, Idaho

Mackay Minerals Research Institute
Reno, Nevada

Utah Geological and Mineral Survey
Salt Lake City, Utah

M-X/RES PROJECT

NATIONAL GEOTHERMAL PROGRAM CONTRACTORS APPLIED TO M-X/RES

EARTH SCIENCE LABORATORY / UNIVERSITY OF UTAH RESEARCH INSTITUTE

EG&G, IDAHO, INC.

MACKAY MINERALS RESEARCH INSTITUTE

UTAH GEOLOGICAL AND MINERAL SURVEY

MX-037

GEOTHERMAL EXPERIENCE

- EARTH SCIENCE LABORATORY DIVISION
  UNIVERSITY OF UTAH RESEARCH INSTITUTE

  -CONTRACTOR TO DOE/ID

  -PROVIDES PRIMARY TECHNICAL SUPPORT FOR:
  - INDUSTRY COUPLED PROGRAM - NEVADA AND UTAH
  - STATE COUPLED PROGRAM - WESTERN U.S.
  - EXPLORATION TECHNOLOGY PROGRAM - NATIONWIDE
  - USER COUPLED CONFIRMATION DRILLING PROGRAM - NATIONWIDE

  - PROVIDES TECHNICAL SUPPORT FOR:
  - COMMERCIALIZATION - WESTERN U.S.
  - INDUCED SEISMICITY - ROOSEVELT HOT SPRINGS, RAFT RIVER
  - PROGRAM PLANNING

GEOTHERMAL EXPERIENCE

- EG&G, IDAHO, INC.
  - PRIME CONTRACTOR TO DOE/ID FOR OPERATION OF IDAHO NATIONAL ENGINEERING LABORATORY (INEL)
  - PROVIDES PRIMARY TECHNICAL SUPPORT FOR:
    - RAFT RIVER, ID, GEOTHERMAL BINARY ELECTRIC DEMONSTRATION PLANT
    - USER COUPLED CONFIRMATION DRILLING PROGRAM
    - PROGRAM PLANNING
    - DIRECT HEAT FEASIBILITY AND FIELD DEMONSTRATION PROGRAMS (PRDAs, PONs)
  - PROVIDES TECHNICAL SUPPORT FOR:
    - RESERVOIR ENGINEERING
    - COMMERCIALIZATION
    - GEOTHERMAL LOAN GUARANTY PROGRAM
    - ELECTRIC CONVERSION TECHNOLOGY

MX-045

GEOTHERMAL EXPERIENCE

- MACKAY MINERALS RESEARCH INSTITUTE (MMRI)
  - CONTRACTOR TO DOE/NV
  - PROVIDES TECHNICAL SUPPORT IN NEVADA FOR:
    - LOW-AND INTERMEDIATE- TEMPERATURE RESOURCE ASSESSMENT(STATE COUPLED)PROGRAM
    - COMMERCIALIZATION

- UTAH GEOLOGICAL AND MINERAL SURVEY (UGMS)
  - CONTRACTOR TO DOE/ID
  - PROVIDES TECHNICAL SUPPORT IN UTAH FOR:
    - LOW- AND INTERMEDIATE- TEMPERATURE RESOURCE ASSESSMENT (STATE COUPLED) PROGRAM
    - COMMERCIALIZATION

MX-047

RESPONSIBILITIES AND AUTHORITIES

EARTH SCIENCE LABORATORY DIVISION/UNIVERSITY OF UTAH RESEARCH INSTITUTE
(ESL/UURI)

Project Manager : Dennis L. Nielson COM 801-581-5141, FTS 588-5098

Alternate Contact: Phillip M. Wright COM 801-581-5283, FTS 588-5098

Contractor to DOE/ID.

Provides the Joint Task Group primary technical planning and coordination assistance for the M-X/RES Geothermal Task through DOE/ID.

Performs assigned technical portions of Geothermal Task including:

- development of exploration and reservoir confirmation strategies and data requirements;
- detailed exploration and reservoir confirmation at initial and other high-temperature sites, in cooperation with industry lease-holders;
- commercialization analyses, in conjunction with EG&G.

Assists in technical review of exploration, reservoir confirmation, and drilling activities.

Coordinates acquisition by other contractors of geoscience and related data from industry and private sources.

Establishes the central M-X/RES Geothermal Data File for the storage of all M-X/RES Geothermal data including properietary data. Organizes the release of non-proprietary data through public open-file with approval of the JTG.

Coordinates the flow of geothermal assessment data and analyses of those data to GSE/I.

M-X/RES PROJECT
GEOTHERMAL TASK

ESL/UURI RESPONSIBILITIES AND AUTHORITIES

PROJECT MANAGER - DENNIS NIELSON

ALTERNATE - MIKE WRIGHT

- PROVIDES THE JTG PRIMARY TECHNICAL, PLANNING AND COORDINATION ASSISTANCE THROUGH DOE/ID
- PERFORMS ASSIGNED TECHNICAL TASKS INCLUDING :
  - DEVELOPMENT OF EXPLORATION AND CONFIRMATION STRATEGIES
  - EXPLORATION AND RESERVOIR CONFIRMATION AT INITIAL AND OTHER HIGH-TEMPERATURE SITES
  - COMMERCIALIZATION ANALYSES
- ASSISTS IN TECHNICAL REVIEW OF EXPLORATION , CONFIRMATION AND DRILLING ACTIVITIES
- COORDINATES ACQUISITION OF GEOSCIENCE DATA FROM PRIVATE SOURCES
- ESTABLISHES A CENTRAL M-X/RES GEOTHERMAL DATA FILE AND RELEASES DATA TO PUBLIC AS APPROPRIATE
- COORDINATES FLOW OF ASSESSMENT DATA TO GSE/I

EG&G, IDAHO, INC.

Project Manager : Thomas W. Lawford COM 208-526-1844, FTS 583-1844

Alternate Contact: Charles R. Broadus COM 208-526-9141, FTS 583-9141

Contractor to DOE/ID.

Provides the Joint Task Group technical and planning assistance on the Applications Development portion of the M-X/RES Geothermal Task through DOE/ID.

Performs assigned technical portions of Geothermal Task, including:

- development of candidate geothermal applications;
- collection and analysis of geothermal applications data;
- reservoir engineering at assigned sites; and
- commercialization analysis, in conjunction with ESL.

Assists in technical review of applications development activities.

Purchases applications development data after approval of DOE/ID, and contracts for applications development studies as needed.

Releases appropriate geothermal applications data through public open-file.

Provides applications data and analysis to GSE/I with copy to ESL.

M-X/RES GEOTHERMAL TASK

EG&G RESPONSIBILITIES AND AUTHORITIES

PROJECT MANAGER - TOM LAWFORD

ALTERNATE - CHUCK BROADUS

- PROVIDES THE JTG TECHNICAL AND PLANNING ASSISTANCE THROUGH DOE/ID
- PERFORMS ASSIGNED TECHNICAL TASKS, INCLUDING :
  - DEVELOPMENT OF CANDIDATE GEOTHERMAL APPLICATIONS
  - COLLECTION AND ANALYSIS OF APPLICATIONS DATA
  - RESERVOIR ENGINEERING
  - COMMERCIALIZATION ANALYSES
- ASSISTS IN TECHNICAL REVIEW OF APPLICATIONS DEVELOPMENT ACTIVITIES
- PURCHASES APPLICATIONS DATA AND CONTRACTS FOR APPLICATIONS STUDIES
- RELEASES DATA TO PUBLIC AS APPROPRIATE
- PROVIDES APPLICATIONS DATA TO GSE/I

MACKAY MINERALS RESEARCH INSTITUTE (MMRI)

Primary Contact: Dennis T. Trexler COM 702-784-6691

Alternate : James L. Bruce COM 702-784-6691

Contractor to DOE/NV.

Provides technical proposals and planning assistance to ESL and the Joint Task Group through DOE/NV.

Performs assigned technical tasks, including:

- geothermal assessment for low- and intermediate-temperature geothermal systems at candidate Operating Base sites in Nevada.
- reconnaissance and detailed exploration for other high-temperature geothermal systems in the deployment area of Nevada.
- collection, reduction, and analysis of data from the above efforts and transmittal of these data and analyses to ESL.

Publishes data and analyses as appropriate to benefit the commercialization of geothermal resources.

Purchases existing geoscience data and subcontracts for surveys after coordination with ESL and approval of DOE/NV.

M-X/RES PROJECT
GEOTHERMAL TASK

MMRI RESPONSIBILITIES AND AUTHORITIES

PRIMARY CONTACT - DENNIS TREXLER
ALTERNATE - JIM BRUCE

- PROVIDES PLANNING ASSISTANCE TO ESL AND THE JTG THROUGH DOE/NV
- PERFORMS ASSIGNED TECHNICAL TASKS, INCLUDING:
  - ASSESSMENT FOR LOW- AND INTERMEDIATE-TEMPERATURE SYSTEMS AT OB SITES IN NEVADA
  - RECONNAISSANCE FOR OTHER HIGH-TEMPERATURE SITES IN DEPLOYMENT AREA OF NEVADA
  - TRANSMITTAL OF DATA TO ESL
- PUBLISHES AND RELEASES DATA TO PUBLIC AFTER APPROVAL OF JTG
- PURCHASES EXISTING GEOSCIENCE DATA

UTAH GEOLOGICAL AND MINERAL SURVEY (UGMS)

Primary Contact : Wallace Gwynn COM 801-581-3068

Alternate Contact: Peter J. Murphy COM 801-581-3065

Reports to DOE/ID.

Provides technical proposals and planning assistance to ESL and the Joint Task Group through DOE/ID.

Performs assigned technical tasks, including:

- geothermal assessment for low- and intermediate-temperature geothermal systems at candidate Operating Base sites in Utah.
- reconnaissance and detailed exploration for other high-temperature geothermal systems in the deployment area of Utah.
- collection, reduction, and analysis of data from the above efforts and transmittal of these data and analyses to ESL.

Publishes data and analyses as appropriate to benefit the commercialization of geothermal resources.

M-X/RES PROJECT GEOTHERMAL TASK

UGMS RESPONSIBILITIES AND AUTHORITIES

PRIMARY CONTACT - WALLY GWYNN

ALTERNATE - PETE MURPHY

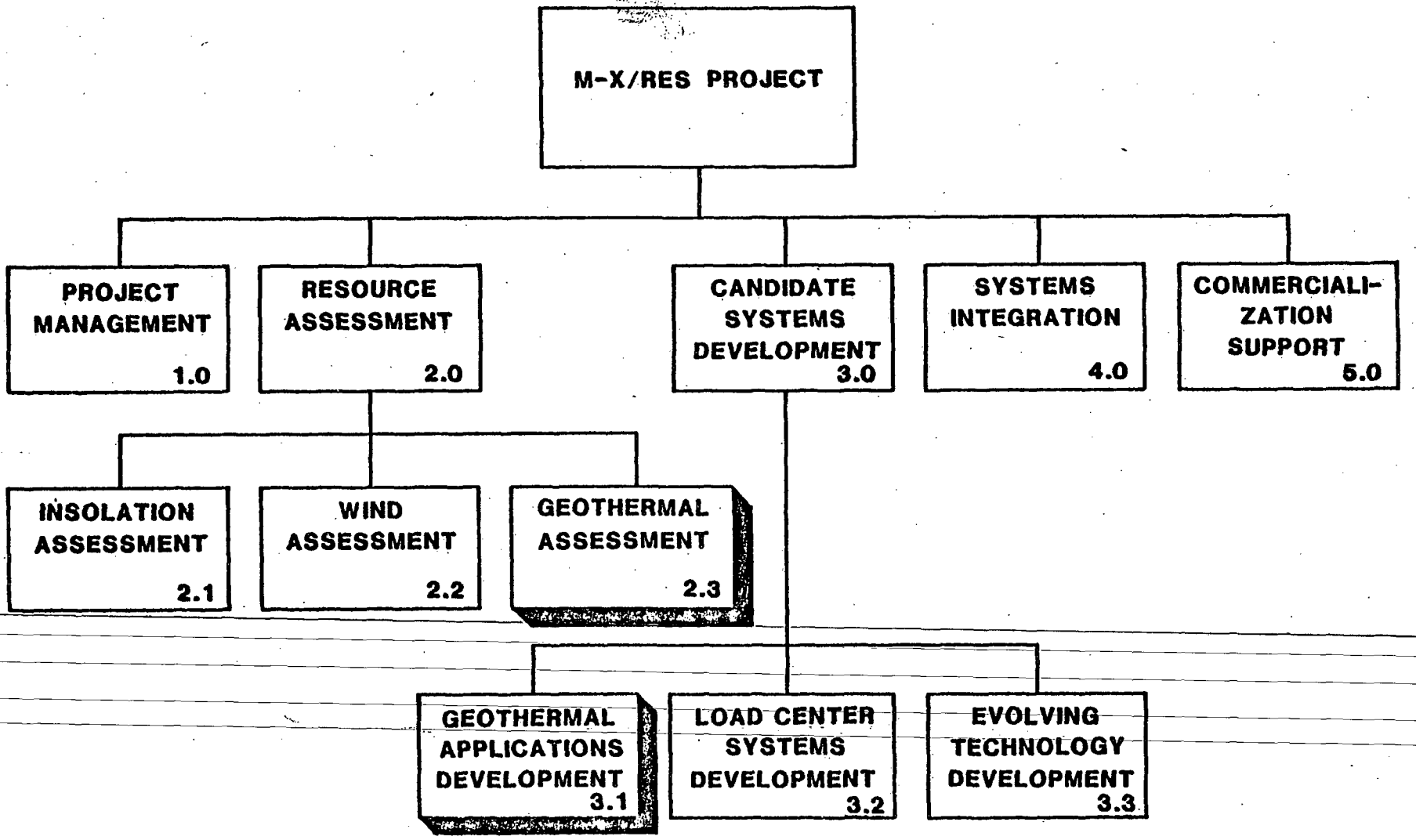
- PROVIDES PLANNING ASSISTANCE TO ESL AND THE JTG THROUGH DOE/ID
- PERFORMS ASSIGNED TECHNICAL TASKS, INCLUDING:
  - ASSESSMENT FOR LOW- AND INTERMEDIATE-TEMPERATURE SYSTEMS AT OB SITES IN UTAH
  - RECONNAISSANCE FOR OTHER HIGH TEMPERATURE - SITES IN DEPLOYMENT AREA OF UTAH
  - TRANSMITTAL OF DATA TO ESL
- PUBLISHES AND RELEASES DATA TO PUBLIC AFTER APPROVAL OF JTG
- PURCHASES EXISTING GEOSCIENCE DATA

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

GEOTHERMAL ASSESSMENT

NATURE OF GEOTHERMAL RESOURCES
EXPLORATION STRATEGIES & TECHNIQUES
WORK ELEMENTS
ELEMENT SCHEDULES

M-X/RES PROJECT
WORK BREAKDOWN STRUCTURE



MX/021

ASSESSMENT VS APPLICATIONS

Geothermal Assessment - Exploration, drilling, flow testing and reservoir engineering activities designed to discover, confirm and obtain production from a geothermal reservoir.

Geothermal Applications - Use of the energy in geothermal fluids produced from a geothermal reservoir.

MX/022

M-X/RES PROJECT

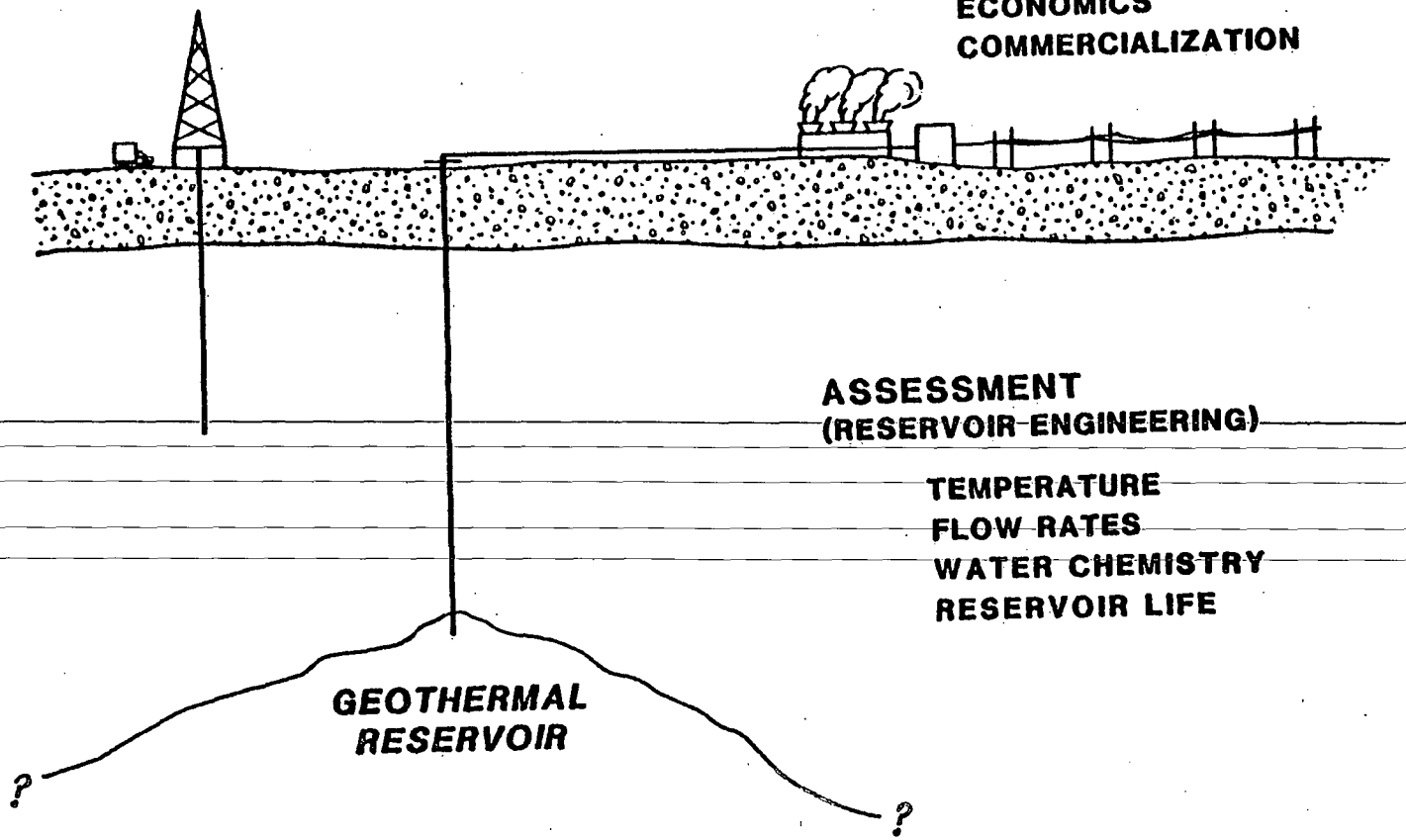
GEOTHERMAL TASK

ASSESSMENT
(GEOLOGY, GEOCHEMISTRY, GEOPHYSICS, HYDROLOGY)

- RECONNAISSANCE
- DETAILED EXPLORATION
- CONFIRMATION DRILLING
- PRODUCTION DRILLING
- STEP-OUT DRILLING
- EXPLORATION AND ASSESSMENT TECHNOLOGY

APPLICATIONS

- ELECTRICAL POWER GENERATION
- NON-ELECTRICAL APPLICATIONS
- CASCADED SYSTEMS
- HYBRID SYSTEMS
- HARDWARE
- TRANSMISSION AND DISTRIBUTION
- OPERATIONS AND MAINTENANCE
- ENVIRONMENTAL CONTROL
- ECONOMICS
- COMMERCIALIZATION



ASSESSMENT
(RESERVOIR ENGINEERING)

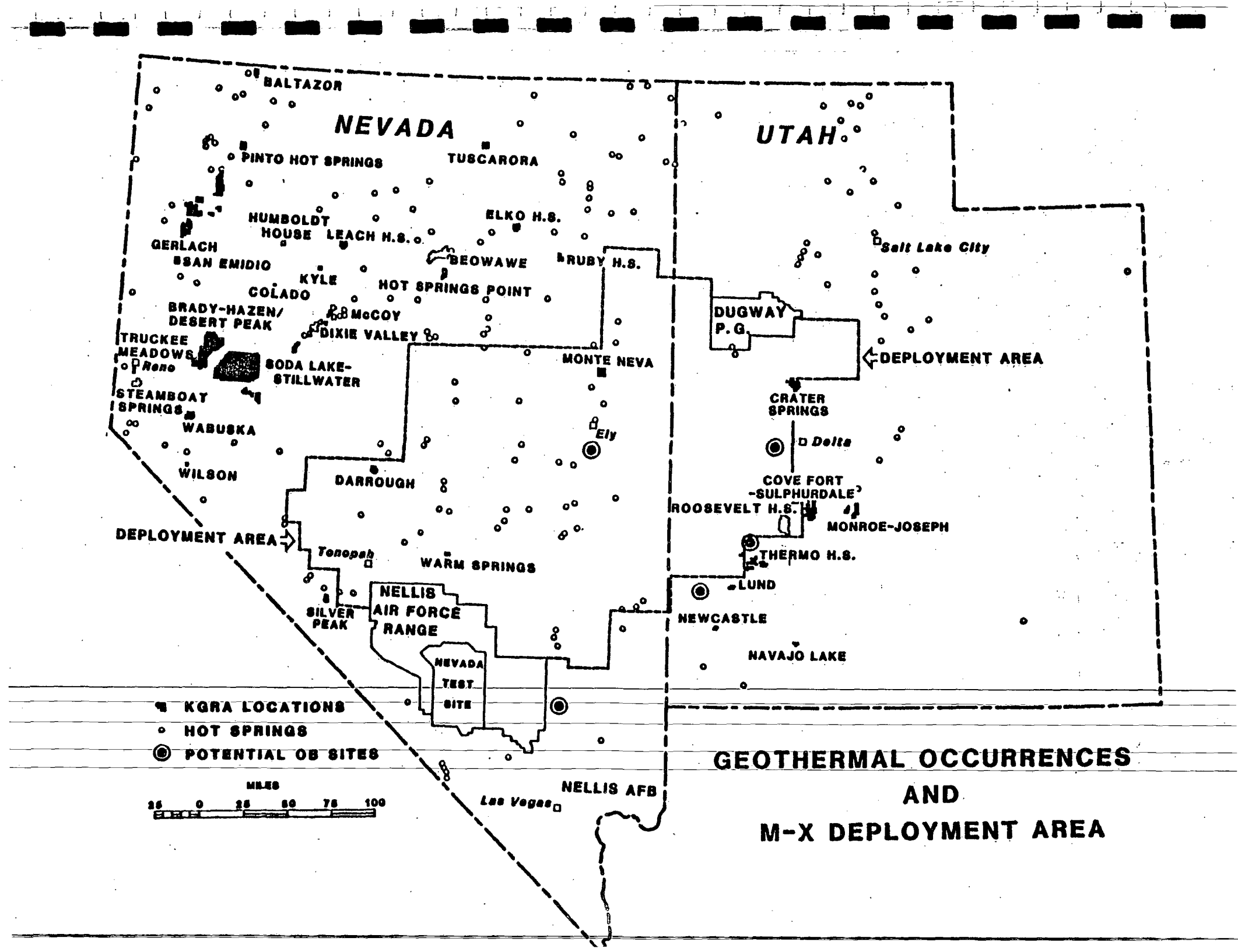
- TEMPERATURE
- FLOW RATES
- WATER CHEMISTRY
- RESERVOIR LIFE

MX-022

GEOTHERMAL OCCURRENCES AND M-X DEPLOYMENT AREA

The M-X deployment area is located in the Great Basin of Utah and Nevada. To the northwest of the deployment area are a series of geothermal systems and a zone of overall high heat flow that collectively make up the so called Battle Mountain Heat Flow High. Over the past 5 to 10 years the Battle Mountain Heat Flow High has been an area of concentrated exploration by industry for high-temperature hydrothermal systems; the deployment area itself has seen a much less intense exploration activity. However, as the map shows, there are numerous hot springs and wells within the deployment area, and exploration is certain to locate other occurrences that are not now known. Chances are good that one or more new high-temperature hydrothermal systems, suitable for electrical power generation, can be found within the deployment area, and that low- and intermediate-temperature hydrothermal systems, suitable for space conditioning and process heat, can be found in proximity to some of the candidate OB sites.

MX-0006

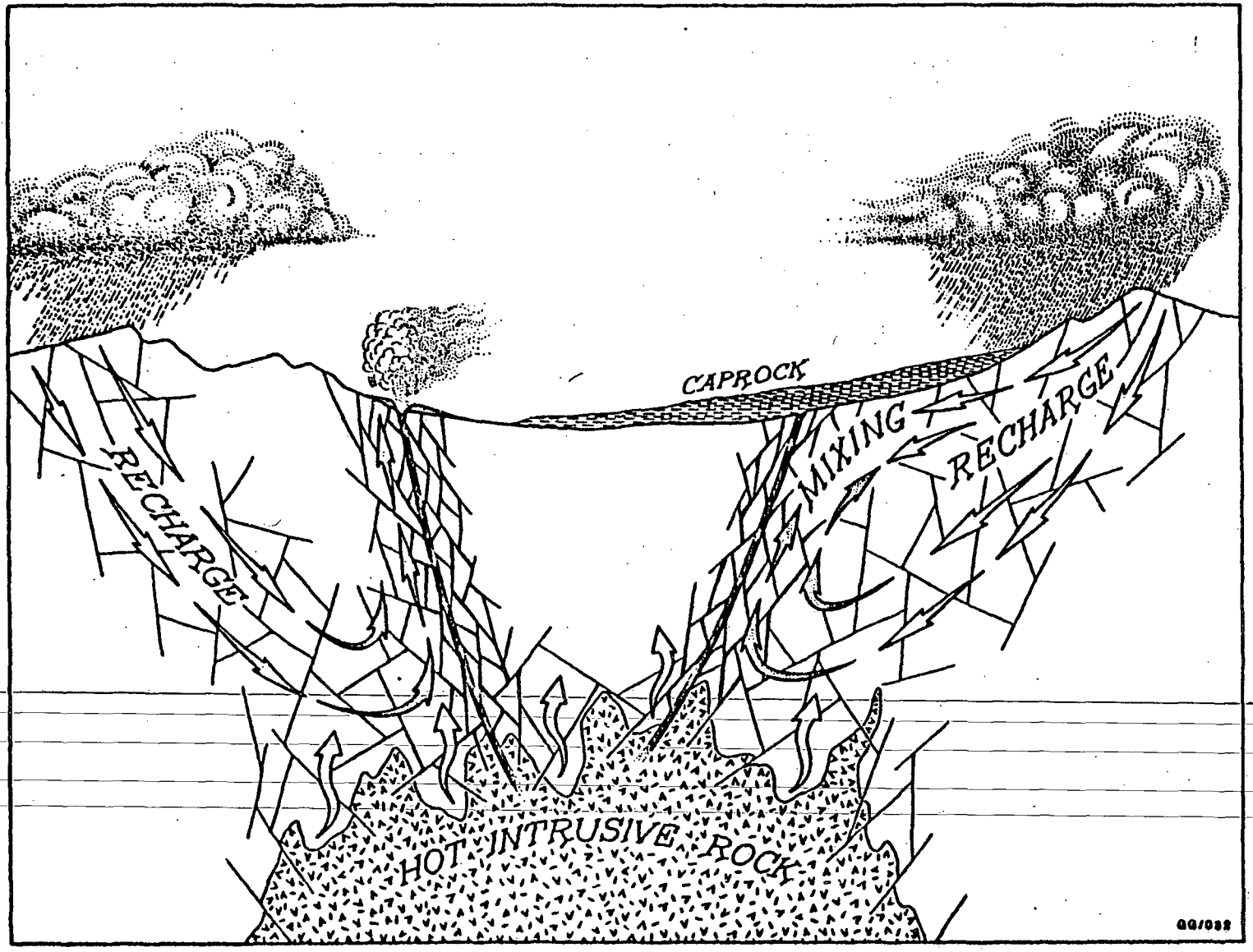

NEVADA
UTAH
BALTAZOR
PINTO HOT SPRINGS
TUSCARORA
HUMBOLDT HOUSE
LEACH H.S.
ELKO H.S.
GERLACH
SAN EMIDIO
BEOWAWE
RUBY H.S.
KYLE
HOT SPRINGS POINT
COLADO
BRADY-HAZEN/ DESERT PEAK
McCOY
DIXIE VALLEY
TRUCKEE MEADOWS
Reno
SODA LAKE-STILLWATER
MONTE NEVA
STEAMBOAT SPRINGS
WABUSKA
Ely
WILSON
DARROUGH
DEPLOYMENT AREA
Tonopah
WARM SPRINGS
NELLIS AIR FORCE RANGE
SILVER PEAK
NEVADA TEST SITE
Las Vegas
NELLIS AFB
Salt Lake City
DUGWAY P.G.
DEPLOYMENT AREA
CRATER SPRINGS
Delta
COVE FORT -SULPHURDALE
ROOSEVELT H.S.
MONROE-JOSEPH
THERMO H.S.
LUND
NEWCASTLE
NAVAJO LAKE
KGRA LOCATIONS
HOT SPRINGS
POTENTIAL OB SITES
MILES
25 0 25 50 75 100
GEOTHERMAL OCCURRENCES AND M-X DEPLOYMENT AREA

CONCEPTUAL MODEL OF HIGH-TEMPERATURE HYDROTHERMAL CONVECTION SYSTEM

This generalized conceptual model of a convective hydrothermal system shows processes that are common to most of the geothermal systems in the Great Basin. The hydrothermal system is recharged by meteoric (rain and snowmelt) waters that circulate to depth along permeable zones that are either provided by fracture systems or porous rock units. These waters are heated by the normal geothermal gradient or by hot intrusive rock as shown on the diagram. In much of the Great Basin, circulation of waters to depths of three kilometers or more are required to heat fluids to temperatures of 150^{o}C. If a molten or recently solidified intrusion exists at depth, then shallower chilling may reach even higher temperatures. The hot fluids ascend along fault zones to the surface or near surface where they may or may not crop out as hot springs. In many cases the waters are prevented from reaching the surface by impermeable caprock, by decrease in permeability, or by inadequate hydrologic head. Such systems do not appear at the surface as hot springs and are thus difficult to detect.

GG/032

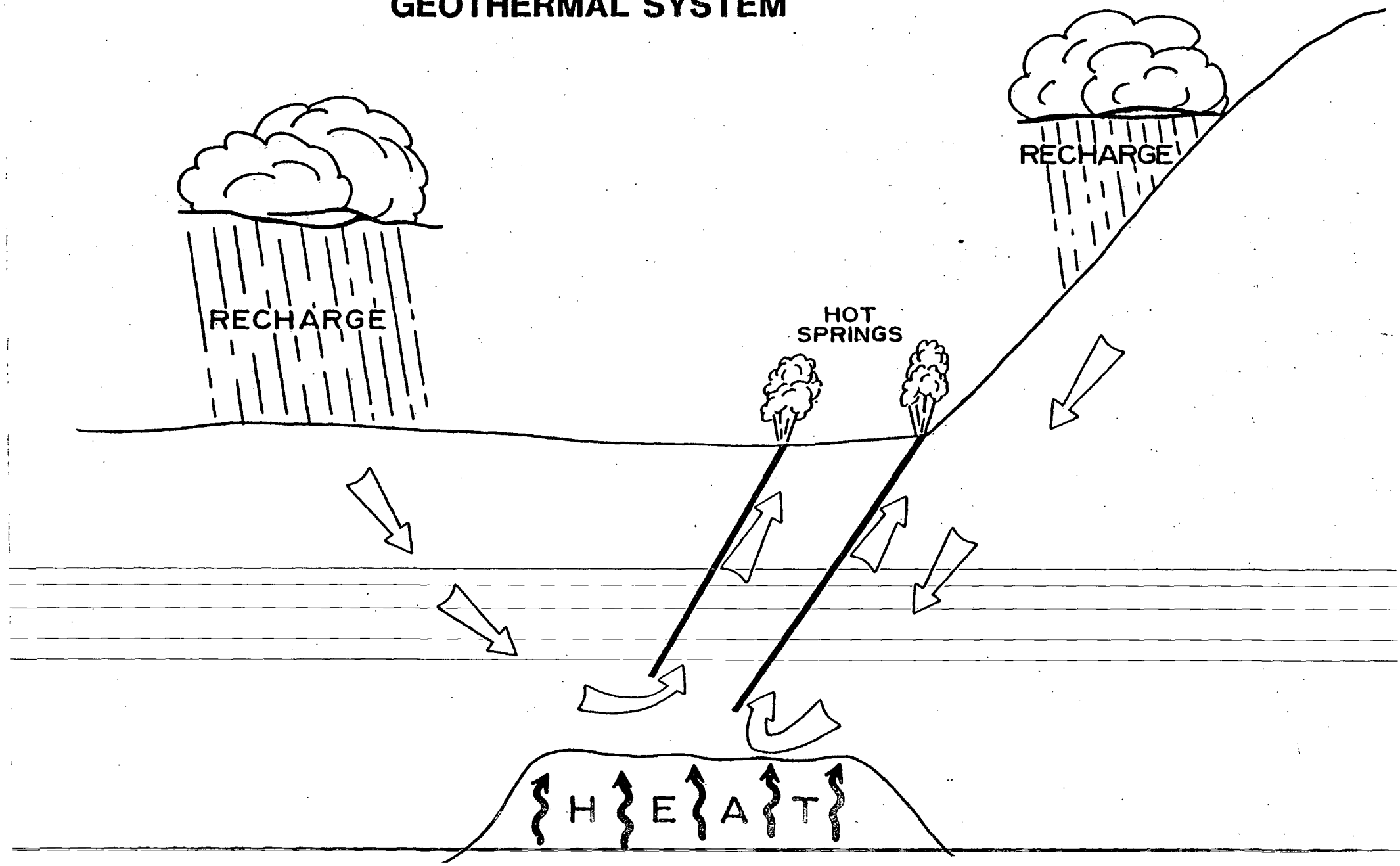
CONCEPTUAL MODEL OF HIGH-TEMPERATURE HYDROTHERMAL CONVECTION SYSTEM



FAULT-CONTROLLED DEEPLY CIRCULATING GEOTHERMAL SYSTEM

This generalized model is applicable to many of the geothermal occurrences in the Great Basin. It is the general case that the mountain blocks in the Great Basin are flanked by faults along which solid bedrock has been dropped down. The intervening valleys are filled with erosional debris from the mountain blocks, and solid bedrock is as deep as 10,000 feet beneath some valley floors. The range-bounding faults often act as conduits to allow deep circulation of ground water, which is heated by the normal increase in temperature with depth in the earth. The heated water rises in places along the faults, in some places reaching the surface as thermal springs, and in other places spreading out beneath the surface and being cooled by mixing with cool, shallow groundwater.

FAULT-CONTROLLED DEEPLY CIRCULATING GEOTHERMAL SYSTEM



TEMPERATURE CLASSIFICATION OF GEOTHERMAL SYSTEMS

Low-Temperature Geothermal Resource - A geothermal resource whose temperature is in the range ($5^{o}C$ above mean ambient air temperature) $\leq T < 90^{o}$.

Intermediate-Temperature Geothermal Resource - A geothermal resource whose temperature is in the range $90^{o}C \leq T \leq 150^{o}C$.

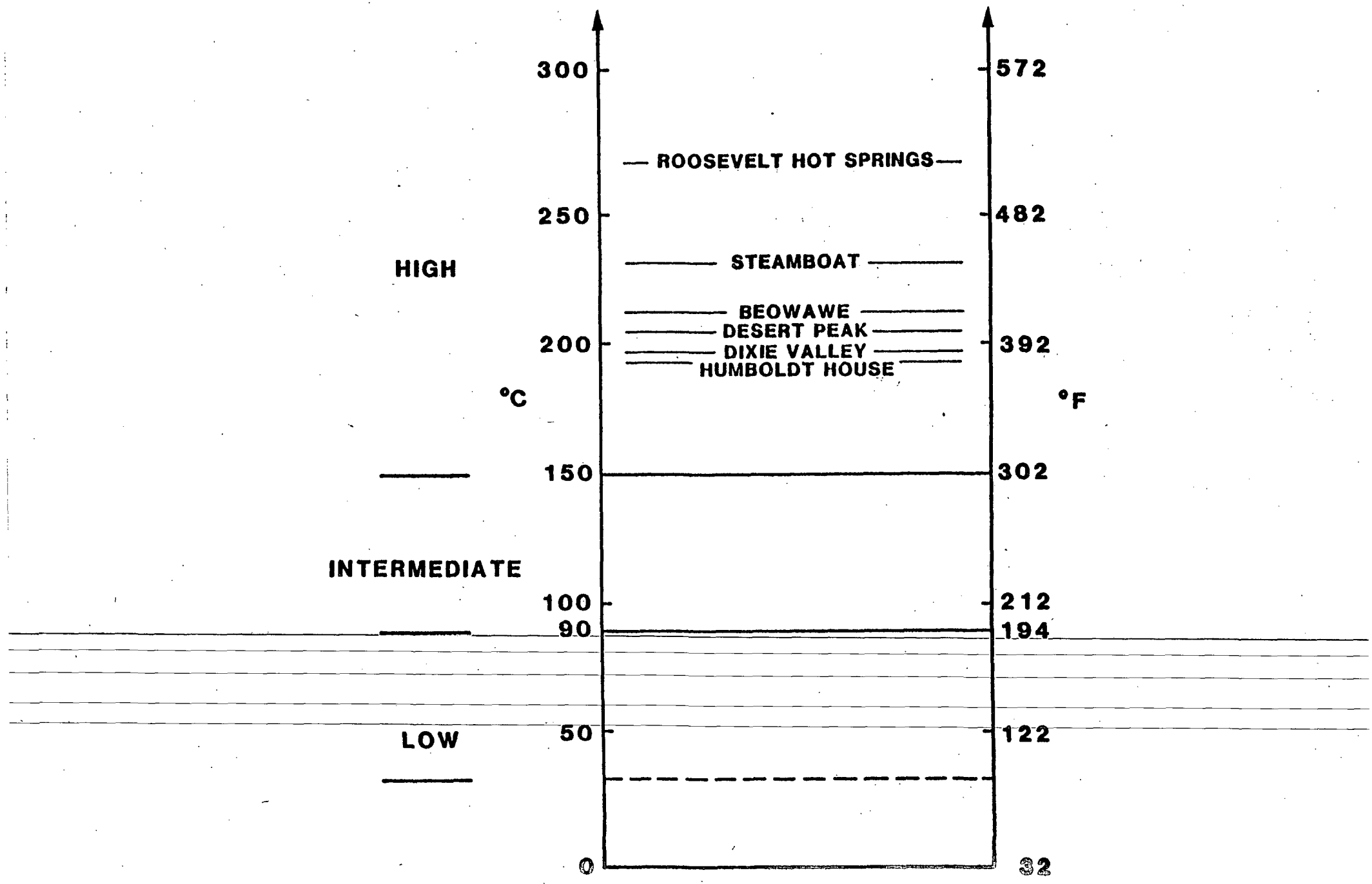
High-Temperature Geothermal Resource - A geothermal resource whose temperature is $T > 150^{o}C$.

High-temperature geothermal resources can potentially be used for electric power generation. Low- and intermediate-temperature resources are of use for space conditioning energy and process heat.

This chart shows temperatures for the six "Initial High-Temperature Sites[1]" as presently known. Some of the temperature data shown here are still company confidential.

[1] See M-X/RES Technical Approach Overview (Phase I) in INTRODUCTION.

TEMPERATURE CLASSIFICATION OF GEOTHERMAL SYSTEMS*



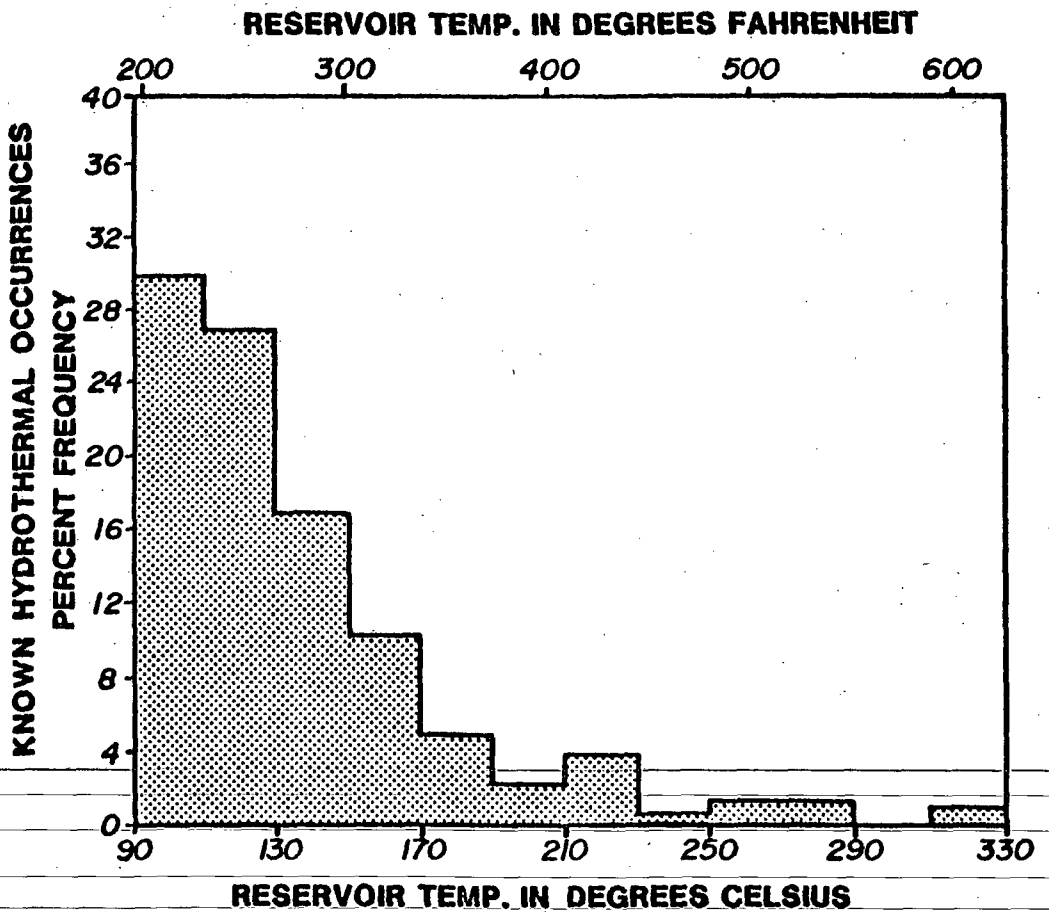
* INCLUDES SOME COMPANY-CONFIDENTIAL DATA.

FREQUENCY OF OCCURRENCE VS TEMPERATURE FOR GEOTHERMAL RESOURCES

The histogram showing frequency of occurrence of known hydrothermal systems in the U.S. as a function of temperature demonstrates a lognormal distribution. Such a distribution is characteristic of many natural resources. For example, the cumulative tonnage of copper in the world's resources increases exponentially as grade decreases.

There is at present no complete compilation of the number of low-temperature systems, but the trend represented by the graph is thought to continue for the low-temperature systems. Many of the high-temperature systems shown in the histogram are from the Great Basin of Utah and Nevada. Even though high-temperature reservoirs are more difficult exploration targets than the lower-temperature systems, as a result of the favorable geologic environment there is a higher probability of discovery of high-temperature reservoirs in the vicinity of the deployment area than in most other areas in the U.S.

FREQUENCY OF OCCURRENCE VS TEMPERATURE FOR GEOTHERMAL RESOURCES



GG-007

SUGGESTED HIGH-TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

The high-temperature hydrothermal exploration strategy shown is a generalized approach that is followed by many exploration groups although the specific mix of techniques used varies from group to group. The approach is designed to locate hidden hydrothermal systems in the Great Basin. It starts with a literature study and data compilation for large areas of 1,000 to 10,000 sq mi. From analysis of these data the exploration effort can be progressively concentrated to a district scale of 100 to 1000 sq mi and then down to a prospect scale of perhaps 10 sq mi. In addition, the strategy uses less expensive exploration activities in the early phases of exploration and the more expensive drilling and geophysical surveys in the latter phases.

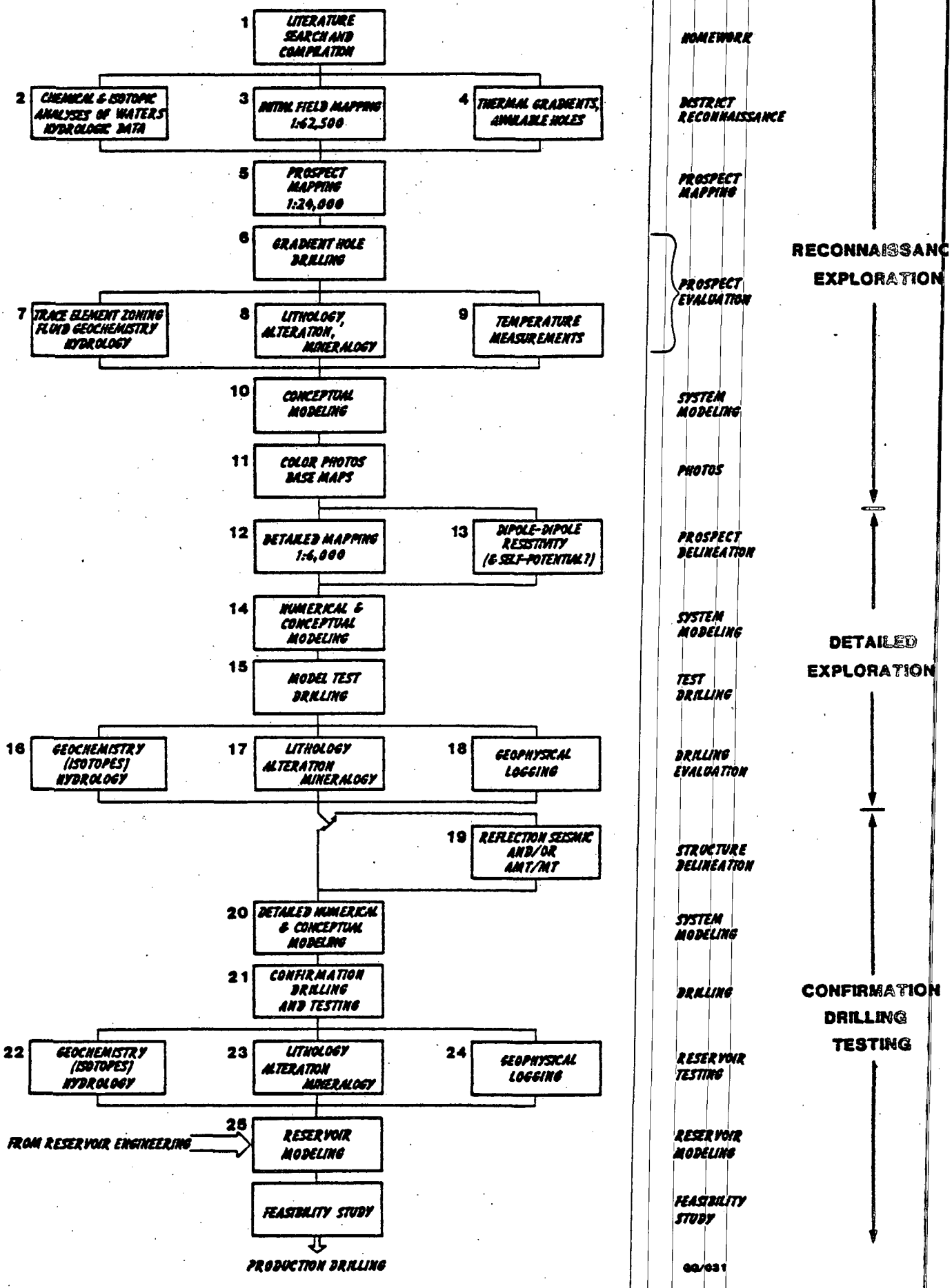
The strategy is based on the formulation and testing of conceptual models of the hydrothermal systems being sought. In any specific exploration effort, some steps in the sequence may be skipped, and many times it becomes necessary to add surveys not shown here to answer specific problems.

Progression through all twenty-five steps shown in the high-temperature strategy may take a year or more depending upon the commitment of the organization involved, availability of survey and drilling crews, competition, and weather, as well as other variables.

The initial activity in the geothermal assessment portion of the M-X/RES Geothermal Assessment and Applications Development Task is to refine the strategies for application to the Initial High-Temperature Sites, the Operating Base sites, and other high-temperature sites.

For the Initial High-Temperature Sites work can begin well into the strategy (approximately step #20) because for these sites much has been accomplished already through industry's exploration efforts, and first results can be expected in a time frame of several months.

SUGGESTED HIGH TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

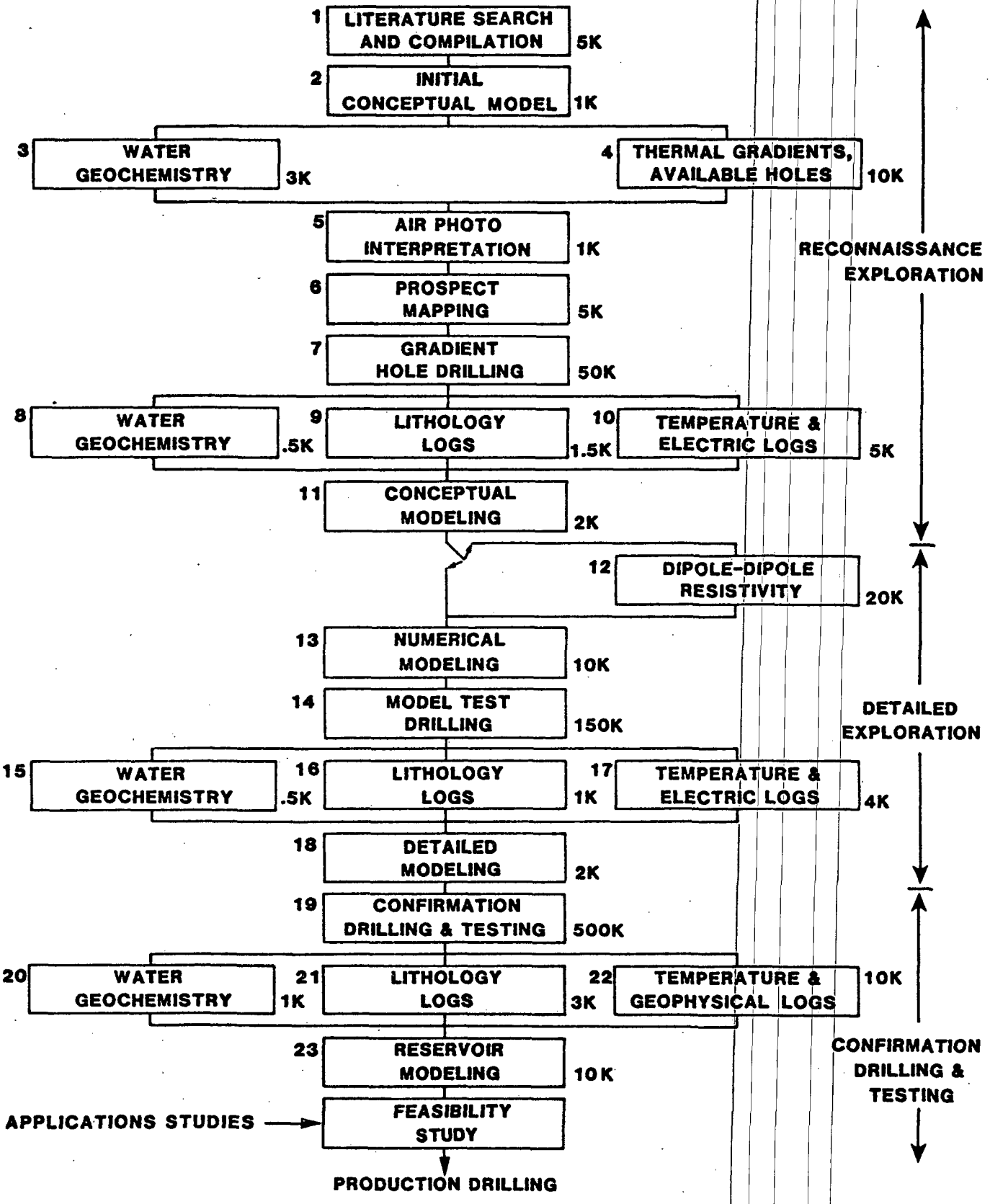


SUGGESTED LOW- AND INTERMEDIATE-TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

The low- and intermediate-temperature exploration strategy shown is similar to that shown for high-temperature systems. The same approach is used: starting with large areas, we narrow attention to prospects that have the best evidence of a viable reservoir, and work from the less expensive to the more expensive exploration procedures. The conceptual model approach is also applied, and steps in the exploration procedure may be skipped or new procedures added to solve specific problems.

Exploration in the vicinity the OB sites is site-specific. That is, instead of exploring large areas for the best geothermal systems, the exploration areas are predetermined. Thus many of the exploration procedures designed to narrow the area of search can be eliminated, and, if favorable evidence is found, detailed exploration can be quickly implemented. In addition, measurement of temperatures in geothermal holes being drilled by Fugro will speed up the exploration process at the OB sites, thereby allowing work to begin at step #7.

SUGGESTED LOW-AND INTERMEDIATE-TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

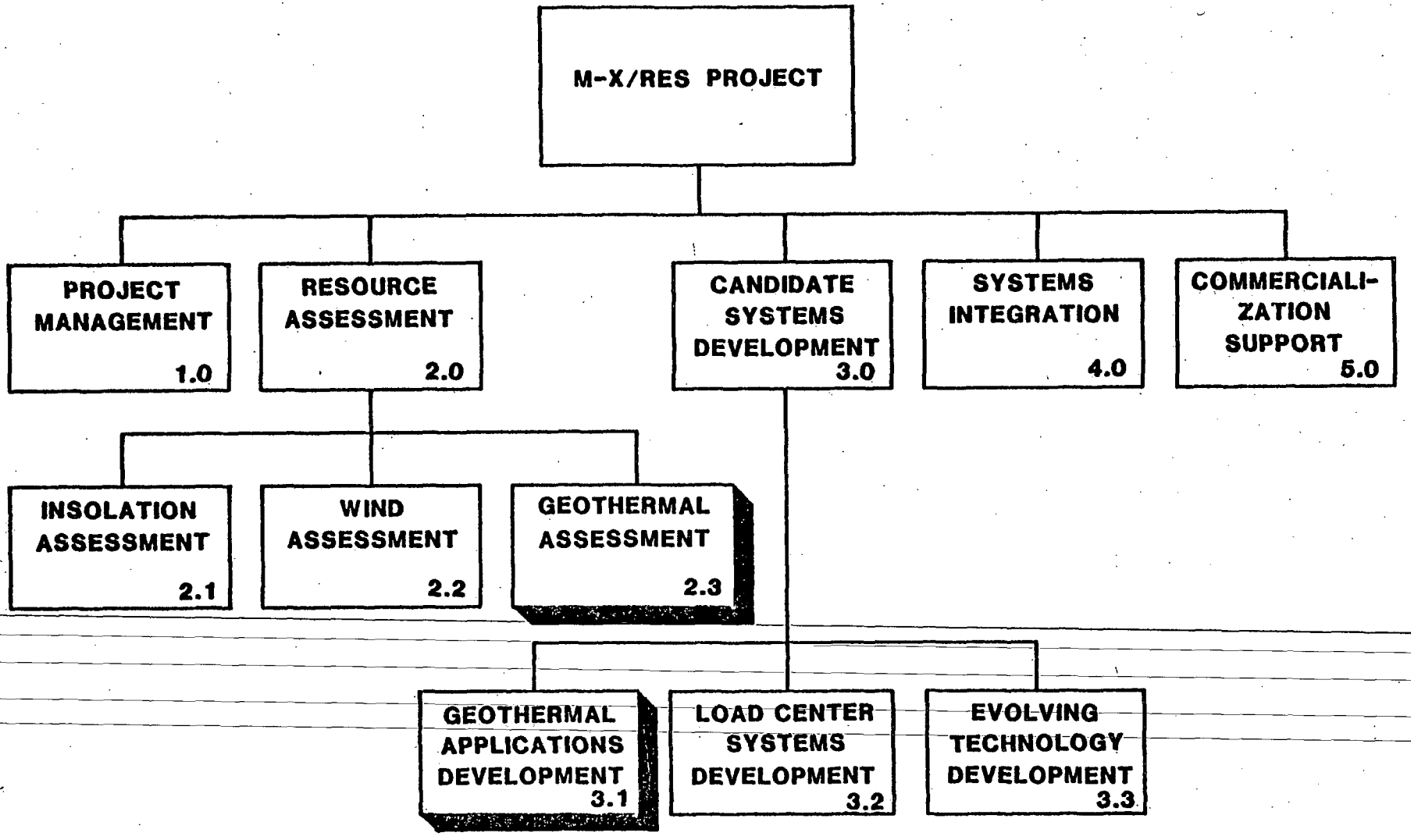


MX-034

M-X/RES PROJECT WORK BREAKDOWN STRUCTURE

The work breakdown structure for the entire M-X/RES project is shown. The following presentation will concentrate on Geothermal Assessment (WBS Element 2.3) and include a detailed work breakdown structure and schedule. Following that, Geothermal Applications Development (WBS Element 3.1) will be discussed.

M-X/RES PROJECT
WORK BREAKDOWN STRUCTURE



MX/021

This chart illustrates how the following discussion relates to the M-X/RES geothermal objectives and to the top-level M-X/RES objectives.

M-X/RES PROJECT GEOTHERMAL TASK

PHASE 1 OBJECTIVES HIERARCHY

DEFINE INTEGRATED RES OPTIONS THAT COULD
- **PROVIDE RELIABLE POWER FOR M-X**
- **ACCELERATE RES COMMERCIALIZATION**

DEVELOP DECISION PACKAGE BY MID '82 TO SUPPORT USAF DECISIONS ON
- **RES MIX**
- **RES ACQUISITION STRATEGIES**
- **COMMERCIAL INCENTIVES**

IDENTIFY FEASIBLE CANDIDATE SYSTEMS FROM OTHER RES TECHNOLOGIES

IDENTIFY FEASIBLE GEOTHERMAL APPLICATIONS SYSTEMS : DETERMINE HOW , AT WHAT COST, AND ON WHAT SCHEDULE GEOTHERMAL ENERGY COULD BE DELIVERED TO M-X , WHILE BENEFITING THE COMMERCIAL COMMUNITY

CHARACTERIZE GEOTHERMAL RESOURCE SITES IN OR ADJACENT TO THE M-X DEPLOYMENT AREA (2.3)
- **EXPLORE, CONFIRM, AND DEVELOP CASE STUDIES FOR GEOTHERMAL RESERVOIRS**
- **PLAN PHASE II ACTIVITIES**

DETERMINE PLANT FEASIBILITIES AND RESERVOIR SPECIFIC DESIGNS FOR ELECTRICAL AND DIRECT HEAT APPLICATIONS (3.1)
- **DEFINE CONCEPT, APPROACH**
- **DETERMINE PLANT FEASIBILITY FOR CONFIRMED RESERVOIRS**
- **PLAN SYSTEMS IMPLEMENTATION**
- **IDENTIFY COMMMERCIALIZATION IMPACTS**
- **PLAN PHASE II ACTIVITIES**

MX-028

PHASE I GEOTHERMAL ASSESSMENT WORK BREAKDOWN STRUCTURE

The Phase I work breakdown structure for Geothermal Assessment follows from the objectives of the M-X/RES Project and the Geothermal Assessment and Applications Development Task. Geothermal Assessment will be concentrated in three areas: 1) Initial High-Temperature Sites, 2) Operating Base Sites, and 3) Other High-Temperature Sites.

WBS 2.3.1

The Initial High-Temperature Sites are those that have been identified as being in the advanced stages of exploration and which show promise of being able to contribute electrical power to the M-X system. These areas are Roosevelt Hot Springs, Utah, and Dixie Valley, Steamboat Springs, Desert Peak, Humbolt House, and Beowawe in Nevada. As industry exploration proceeds, other sites could be added to this list. Large amounts of exploration data are presently available for these areas and it is thought that additional information could be readily purchased from companies that are exploring there. Formulation of optimum exploration and reservoir confirmation strategies will proceed after all available data have been collected and analyzed, companies have been contacted, and priorities have been established. Due to the limited funding available, effort must be concentrated in those areas that show the greatest potential for contributing power to the M-X system. Following the formulation of strategies, the DOE will contract with the companies who hold the land leases for detailed exploration or confirmation drilling and testing on a cost-shared basis. ESL will assist in this effort. This will both aid in the confirmation of these reservoirs and provide data that will be used in the M-X/RES Data Base Book and released to the geothermal community, if appropriate. The last element (2.3.1.4), termed "Site Evaluation," provides for a retrospective analysis of the program. During this portion, case studies of the procedures will be developed and advances in geothermal exploration and assessment technology will be evaluated and communicated to the geothermal exploration community.

WBS 2.3.2

The exploration and confirmation in proximity to the Operating Bases will follow the same general procedure as outlined for the Initial High-Temperature Sites. Differences are: 1) the activities will concentrate in the vicinity of the Operating Base sites, 2) the exploration targets will be both high-temperature systems suitable for electric power generation and low- to intermediate-temperature systems which could be applied to both space conditioning and process heat, and 3) the entire exploration procedure for low- to intermediate-temperature resources and the initial stages of the high-temperature exploration will be performed by the resource teams of Nevada (MMRI) and Utah (UGMS). The procedure will begin with an evaluation of the strategy to be employed, both from the standpoint of the prioritization of the sites and

in terms of the procedures to be employed. In general, the reconnaissance exploration and some of the detailed exploration will be done by MMRI and UGMS. However, if evidence of a high-temperature geothermal resource is found, attempts will be made to induce private industry to pick up the exploration under a cooperative agreement with the government. This could lead to cost-shared confirmation drilling and testing at favorable sites. The activity is divided in this fashion because high-temperature geothermal exploration expertise generally resides with private industry whereas appropriate exploration expertise for low- and intermediate-temperature systems rests with MMRI and UGMS, and because industry will likely be involved through lease holdings and through production of electrical power from any high-quality reservoirs found.

WBS 2.3.3

The component of the WBS that addresses exploration and confirmation for other high-temperature sites is based on the philosophy that most high-temperature exploration has been concentrated in areas of Nevada and Utah adjacent to the deployment area, leaving the deployment area itself much less thoroughly explored. The initial effort will be to work out a strategy and establish priorities in light of limited funds and the importance of the Initial High-Temperature Sites and the Operating Base Sites. The exploration under this element will be initiated by MMRI and UGMS. If indications of high-temperature geothermal systems are discovered, attempts will be made to attract companies to participate with the government in cost-shared exploration. At favorable sites this will lead to cost-shared confirmation drilling and testing. The final step will be a site evalution where case studies will be developed and improvements in exploration and assessment technology will be evaluated and transferred to industry.

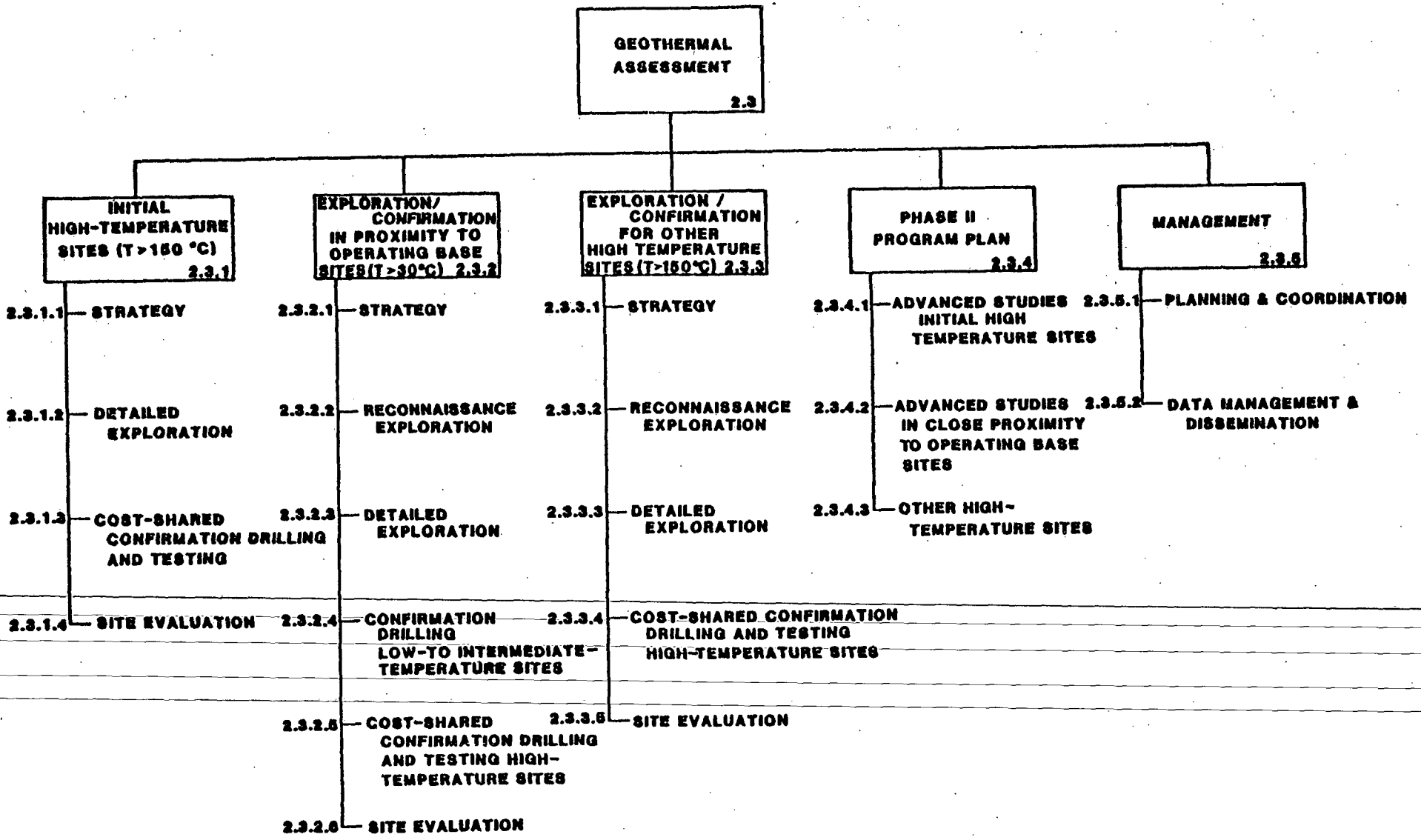
WBS 2.3.4

This element provides for the planning of activities to be done under Phase II of the Task, those which will follow the June, 1982 M-X/RES decision. This planning will address advanced studies at the Initial High-Temperature Sites and at the Operating Base Sites. In addition, the status of the Other High-Temperature Sites will be evaluated and recommendations for additional studies made.

WBS 2.3.5

This element addresses the management of the Geothermal Assessment portion of the Task. The specifics of management are addressed under the authorities and responsibilities of the individual participants and shown on functional relationships charts previously presented (see MANAGEMENT STRUCTURE). MX/026

PHASE I GEOTHERMAL ASSESSMENT WORK BREAKDOWN STRUCTURE



MX-026

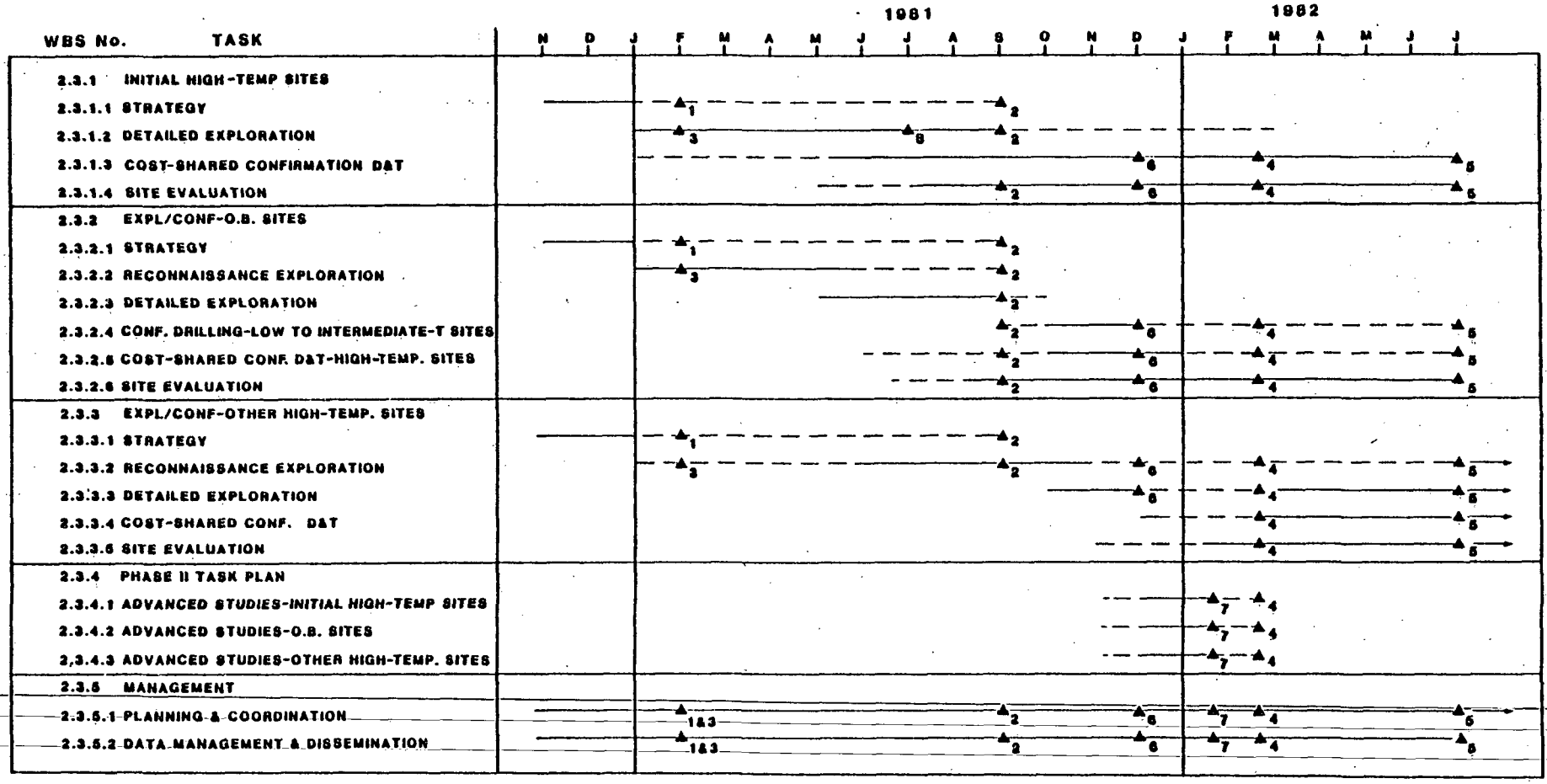
PHASE I GEOTHERMAL ASSESSMENT TASK AND MILESTONE SCHEDULE

The milestone schedule for Phase I of the Geothermal Assessment Task reflects the deliverables required by the M-X/RES Project. This schedule is compatable with the schedule developed for the Geothermal Applications Development portion of the Task. The due dates are also compatable with those established for the solar and wind evalutions.

The timing of the several activities reflects the need for early confirmation at one or more of the Initial High-Temperature Sites since these are the sites that have the highest probability of providing electrical power to the M-X system. Exploration and reservoir confirmation in the vicinity of the Operating Base sites is also a high priority activity. Reconnaissance exploration for this effort is scheduled to start in January, 1981 and will be run simultaneously with activities at the initial high-temperature sites. As mentioned previously, this work can be expedited by preservation of and temperature measurements in holes now being drilled by Fugro National at the candidate OB Sites, and by use of data previously collected by Fugro as part of the M-X site evaluation.

Exploration and confirmation at Other High-Temperature Sites will utilize present DOE contractors during its initial phases, but when evidence of a high-temperature geothermal system is found, efforts will be made to get private industry involved. In Utah these activities are scheduled to begin in June, after emphasis is first placed on exploration around the Milford, Beryl, and Delta candidate OB Sites, where geothermal manifestations are known to occur. In Nevada no geothermal manifestations are known near either the Coyote/Kane or Ely candidate OB Sites, so that exploration at these sites will likely be concluded sooner and exploration for other high-temperature sites can begin earlier, perhaps in March.

PHASE I GEOTHERMAL ASSESSMENT TASK AND MILESTONE SCHEDULE



1/ Strategy Presentation For Integrated Systems Analysis
2/ Preliminary Task Briefing
3/ Delivery Of Reservoir Data
4/ Detailed Task Briefing
5/ Final Report -Draft
6/ Preliminary Assessment Report
7/ Phase II Task Plan
8/ Interim Assessment and Design Report

——— CONCENTRATED ACTIVITY
— — — — PHASING IN & OUT AS APPROPRIATE

MX-035

GEOTHERMAL ASSESSMENT--PHASE II ACTIVITIES

Details of Phase II activities will be planned in the latter stages of Phase I, allowing sufficient time for data collection and study. However, it is possible to sketch in general what activities Phase II will contain.

Drilling will be emphasized to a greater extent in Phase II. By that time one or more of the sites should be candidates for drilling to develop production. In addition the geologic teams would be ready to put more effort into exploration if there were still encouragement for resource discovery.

GEOTHERMAL ASSESSMENT
PHASE II ACTIVITIES

- PRODUCTION DRILLING AT INITIAL HIGH-TEMPERATURE SITES
- PRODUCTION DRILLING AT OB SITES
- RESERVOIR CONFIRMATION DRILLING AND TESTING AT OTHER HIGH-TEMPERATURE SITES
- COMMERCIALIZATION ANALYSIS
- EXPLORATION AND ASSESSMENT TECHNOLOGY TECHNIQUE DEVELOPMENT
- CONTINGENCY PLAN FOR INCREASED POWER REQUIREMENTS

MX-081

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

GEOTHERMAL APPLICATIONS DEVELOPMENT

ELECTRIC POWER GENERATION

SPACE CONDITIONING

CASCADED APPLICATIONS

WORK ELEMENTS

ELEMENT SCHEDULE

Again reviewing the distinctions between geothermal assessment and applications:

ASSESSMENT is mainly an earth science activity centered around (1) collecting adequate exploration data to site drill holes and wells, (2) drilling to confirm the existence of a reservoir, and (3) engineering analyses to determine reservoir temperature, flow rates, water chemistry and reservoir life.

APPLICATION IS THE UTILIZATION OF THE GEOTHERMAL FLUID ONCE IT REACHES THE SURFACE, AND CONSISTS OF (1) DESIGN, INSTALLATION AND OPERATION OF UTILIZATION HARDWARE, (2) TRANSMISSION AND DISTRIBUTION OF GEOTHERMAL FLUIDS AND OF ELECTRICITY, (3) INSTITUTIONAL FACTORS SUCH AS ENVIRONMENTAL PROTECTION, LICENSING, ETC., AND (4) THE ECONOMICS OF THE APPLICATION.

M-X/RES PROJECT

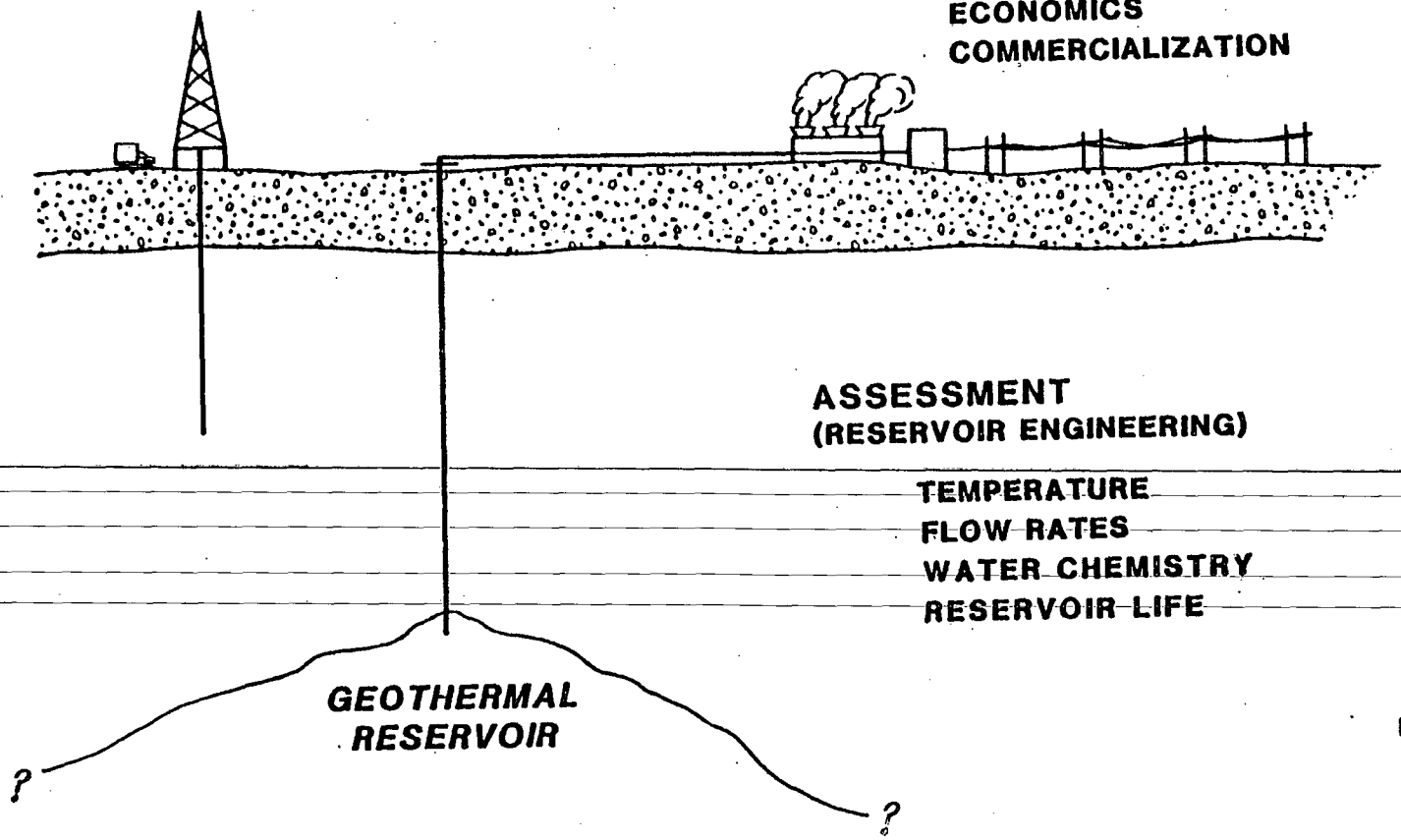
GEOTHERMAL TASK

ASSESSMENT
(GEOLOGY, GEOCHEMISTRY, GEOPHYSICS, HYDROLOGY)

- RECONNAISSANCE
- DETAILED EXPLORATION
- CONFIRMATION DRILLING
- PRODUCTION DRILLING
- STEP-OUT DRILLING
- EXPLORATION AND ASSESSMENT TECHNOLOGY

APPLICATIONS

- ELECTRICAL POWER GENERATION
- NON-ELECTRICAL APPLICATIONS
- CASCADED SYSTEMS
- HYBRID SYSTEMS
- HARDWARE
- TRANSMISSION AND DISTRIBUTION
- OPERATIONS AND MAINTENANCE
- ENVIRONMENTAL CONTROL
- ECONOMICS
- COMMERCIALIZATION



ASSESSMENT
(RESERVOIR ENGINEERING)

- TEMPERATURE
- FLOW RATES
- WATER CHEMISTRY
- RESERVOIR LIFE

MX-022

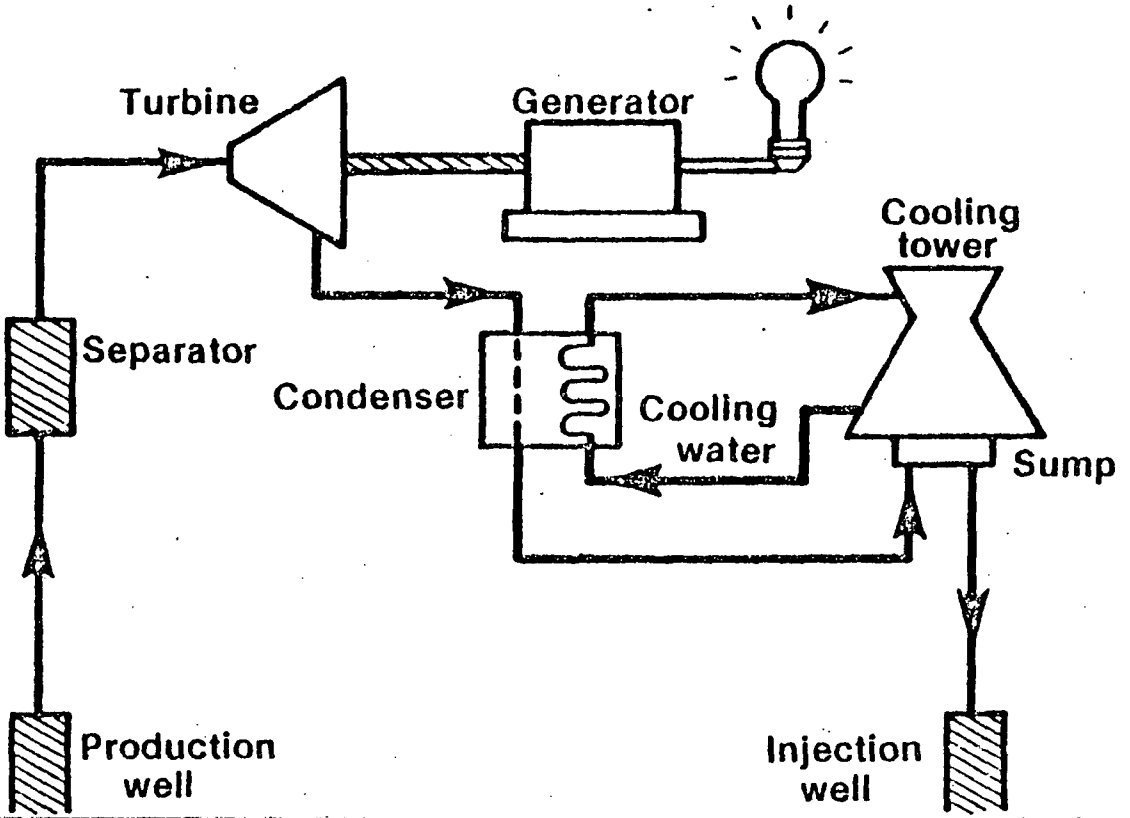
Electric Power Generation

- Dry steam system
- Flash steam system
- Binary system

ELECTRICAL GENERATION FROM A DRY STEAM RESERVOIR

Electrical generation from a dry steam geothermal reservoir is the most economical form of electrical generation from geothermal energy. Over 900 MWe of electricity are presently being produced by this method by Pacific Gas and Electric from the Geysers geothermal field north of San Francisco. Capacity factors from this field exceed 80%, and the power produced is the least expensive generated by PG&E. However, a geothermal reservoir which produces dry steam is extremely rare. Although it is speculative, the Dixie Valley reservoir in Northern Nevada may prove to be such a dry steam reservoir.

Dry Steam System



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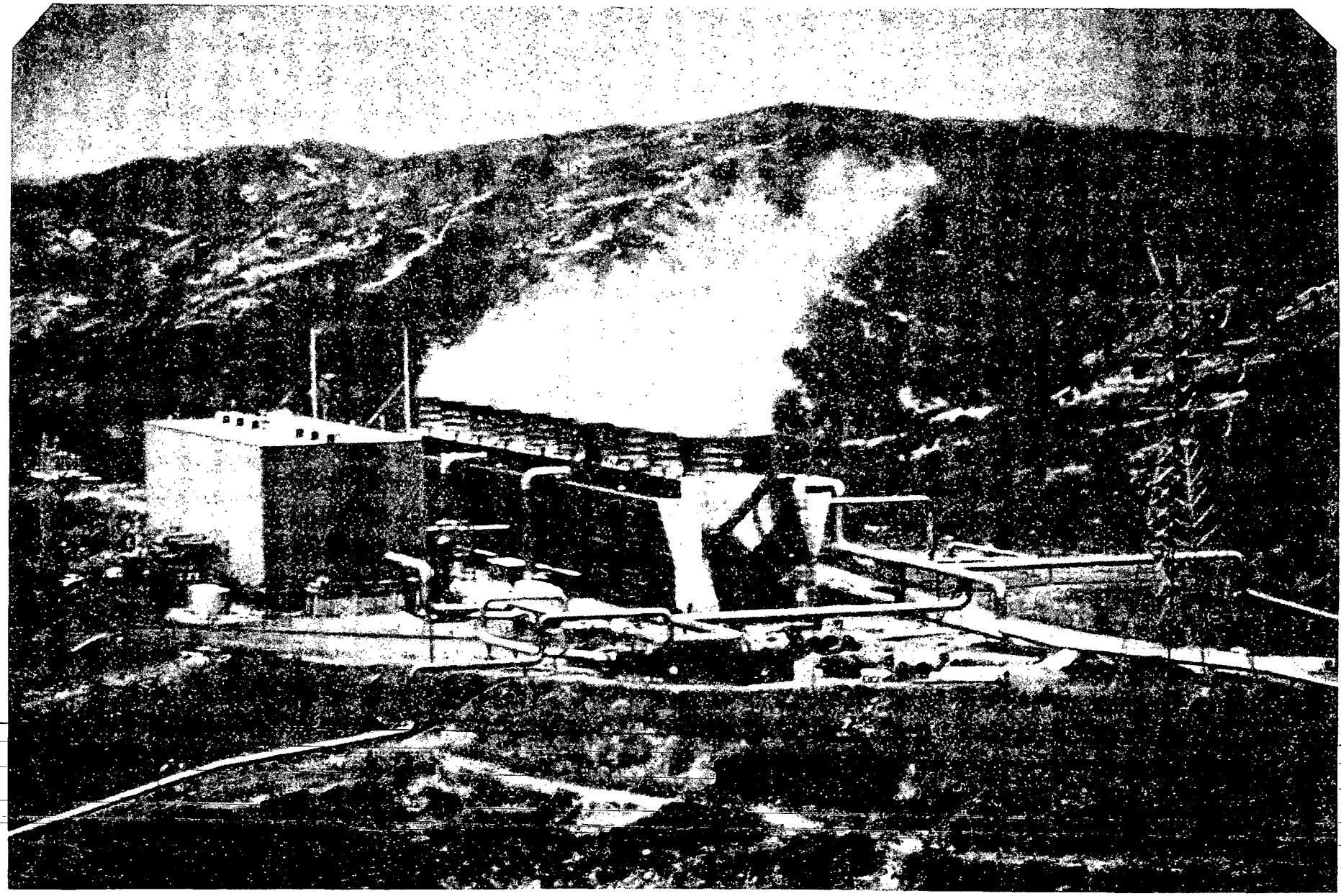
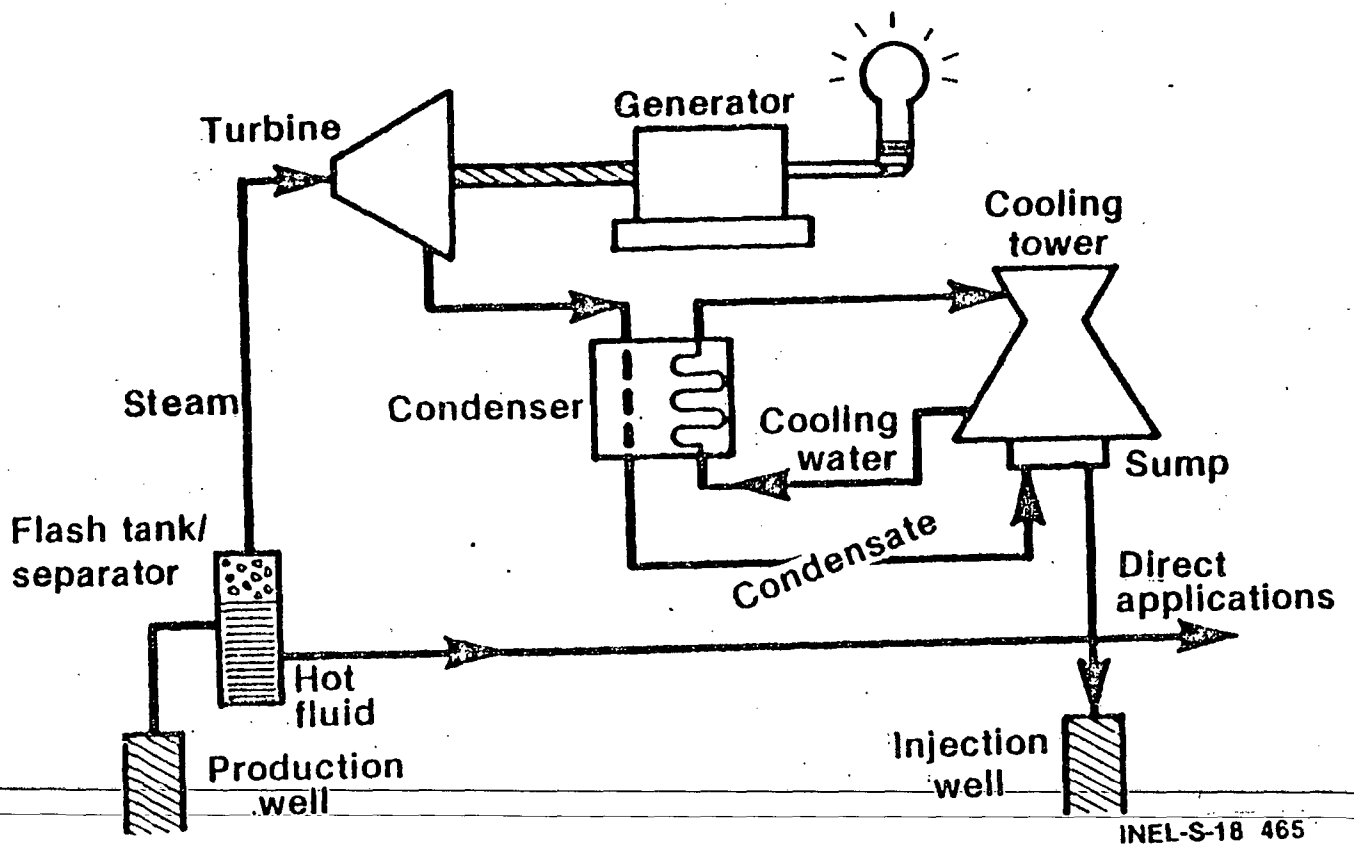
110 MWe DRY STEAM POWER PLANT AT THE GEYSERS, CA



ELECTRICAL GENERATION BY A FLASHED STEAM SYSTEM

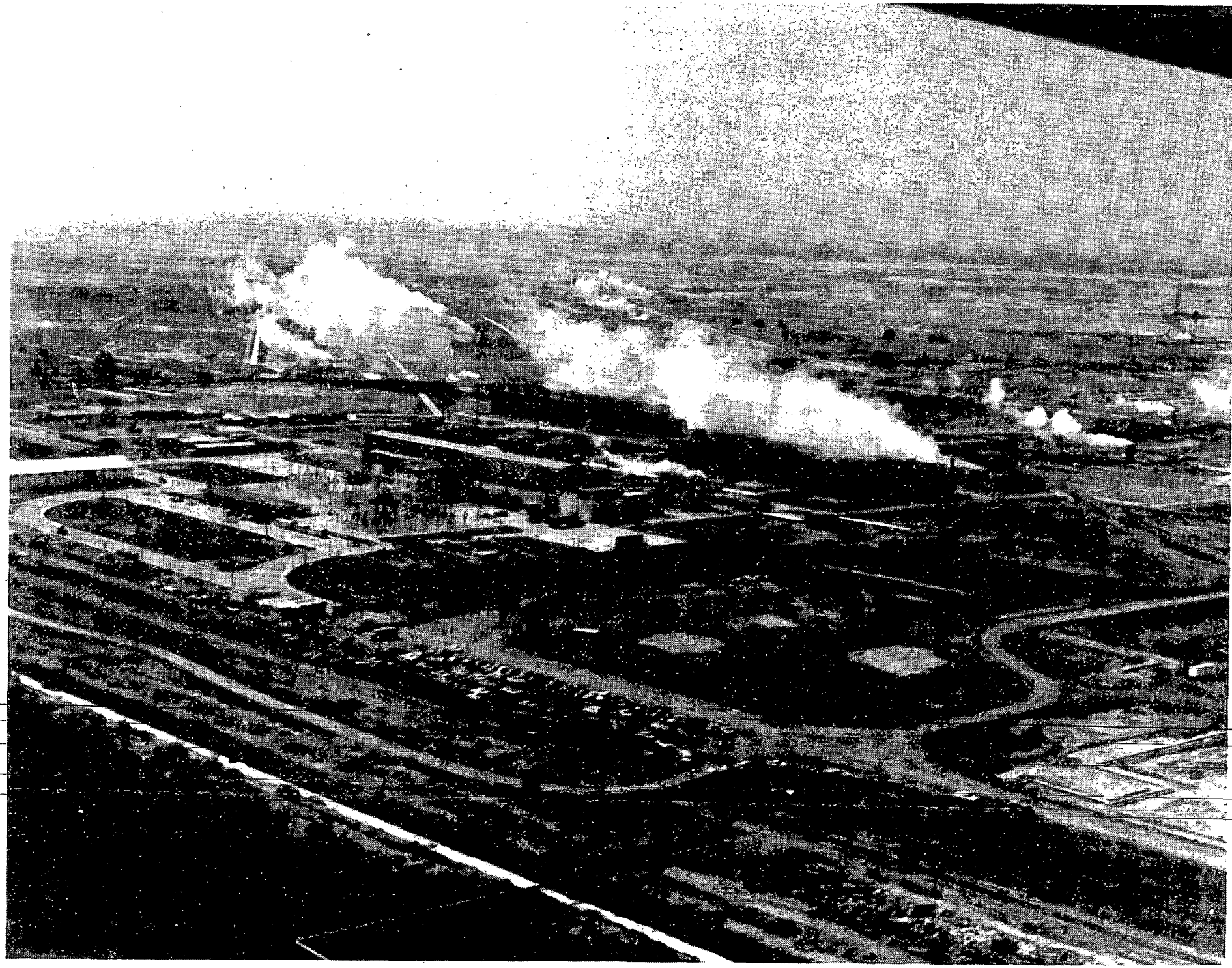
Most geothermal reservoirs are liquid dominated, meaning that either steam and hot water or hot water alone are produced from wells drilled into the reservoir. A simple extension of the dry steam technology is to add flash tanks/separators at either the wellheads or power plant to flash the hot fluids produced from the wells and separate steam from water upstream from the turbines. The performance of flash steam plants can be improved by adding a second stage (lower pressure) flash of the hot liquid leaving the first flash tanks. The hot geothermal liguid leaving the plant has the potential for direct applications in the form of either process heat for industrial processes or space conditioning. Flash steam power plants are in operation in Cerro Prieto, Mexico; Ahuachapan, El Salvador; Wairakki, New Zealand and Lardarello, Italy. In this country, a 10 MWe flash steam plant is undergoing startup in the Imperial Valley of California, and a 50 MWe demonstration plant is under construction at Bacca, New Mexico. Numerous other flash steam plants are in various stages of design and planning.

Flash Steam System



THE 75 MWe FLASHED STEAM PLANT AT CERRO PRIETO, MEXICO

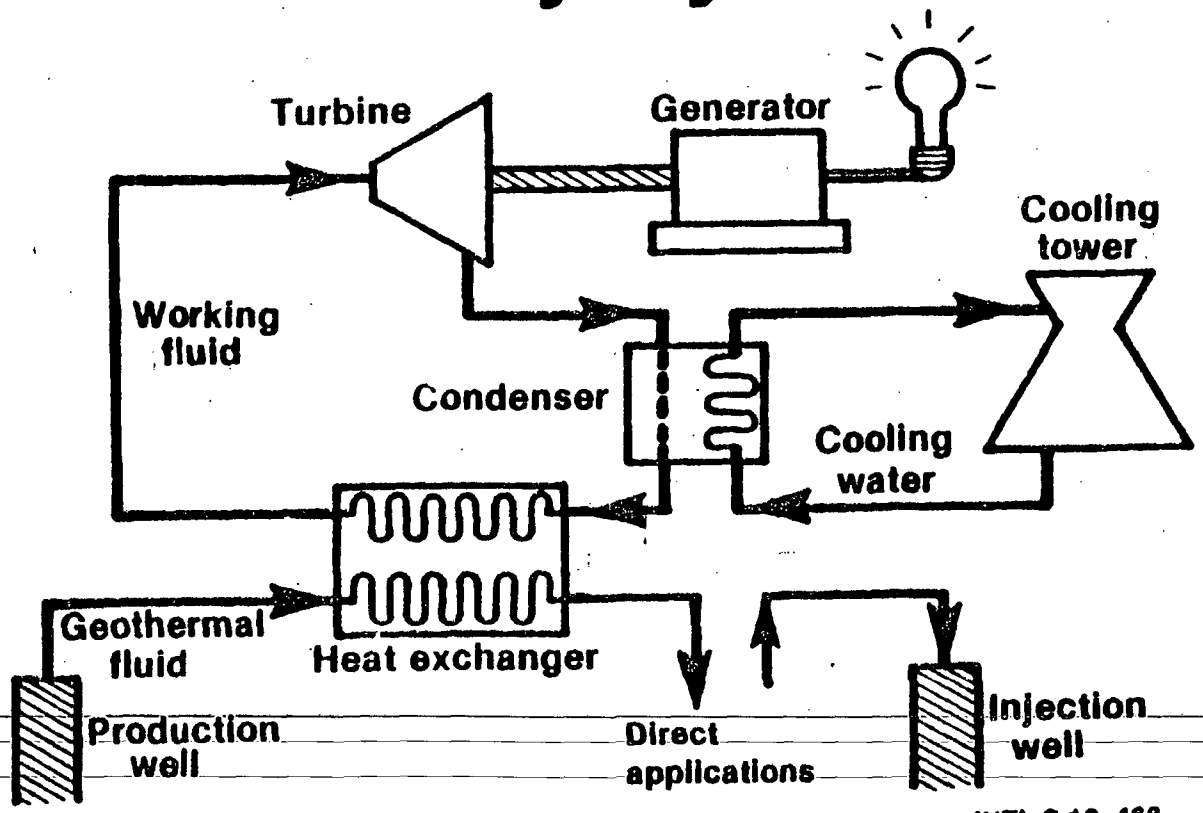
Plant expansion to 150 MWe is presently underway.



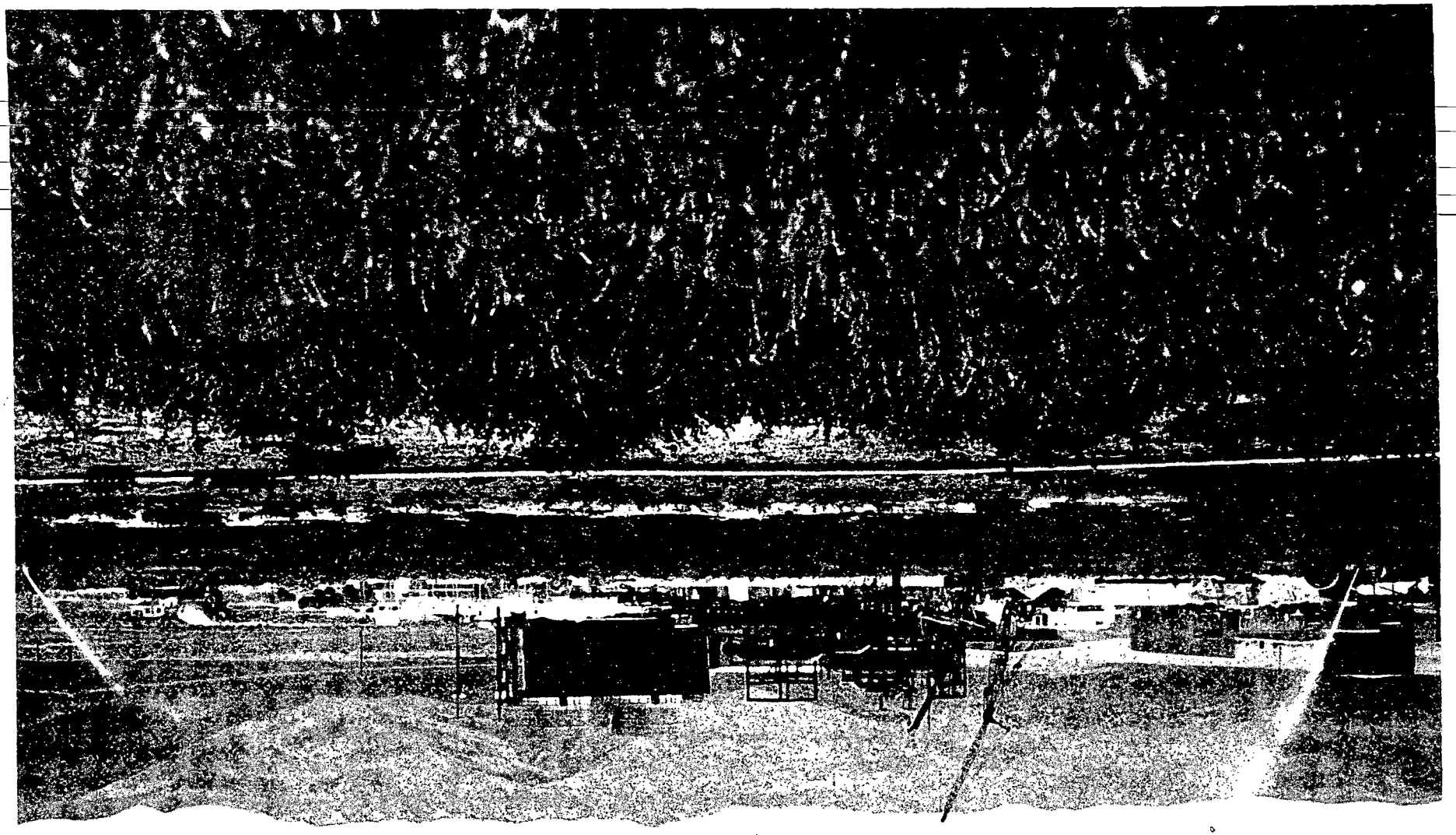
ELECTRICAL GENERATION BY A BINARY SYSTEM

Binary plants have the potential for a significant improvement over flash steam plants in efficiency or "utilization" of the geothermal fluid, especially at temperatures below 400°F. In the binary plant, a secondary or working fluid is heated and boiled by the geothermal fluid before entering a turbine. The working fluid is condensed as it exits the turbine and recirculated to the boiler. The potential for cascaded process heat exists as it does for the flashed steam plant. The superior performance of binary plants can significantly reduce the number of geothermal wells needed to supply the plant, resulting in a lower power generation cost than for flashed steam plants. A 10 MWe binary power plant constructed for Magma Power is undergoing startup operations in California's Imperial Valley, and a 5 MWe binary demonstration pilot plant constructed by DOE is near startup at Raft River, Idaho. Additionally, a 10 MWe binary plant in Nevada and a 50 MWe binary plant in California's Imperial Valley are proposed.

Binary System

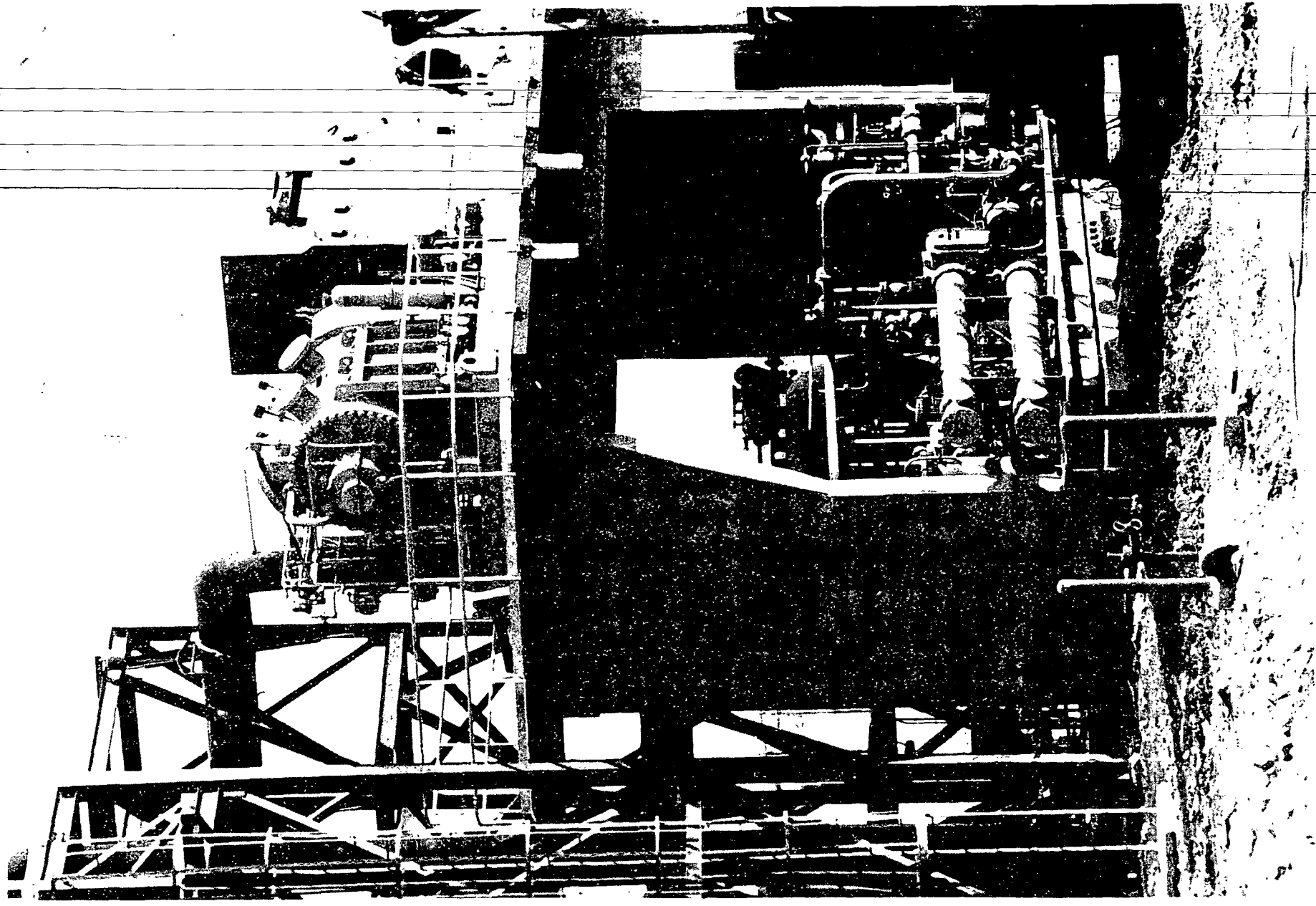


THE 5 MWe BINARY PILOT PLANT AT RAFT RIVER, IDAHO UNDER CONSTRUCTION IN SPRING, 1980.



A CLOSEUP OF THE TURBINE GENERATOR AT THE RAFT RIVER PILOT PLANT.

The turbine is a dual inlet radial inflow design.



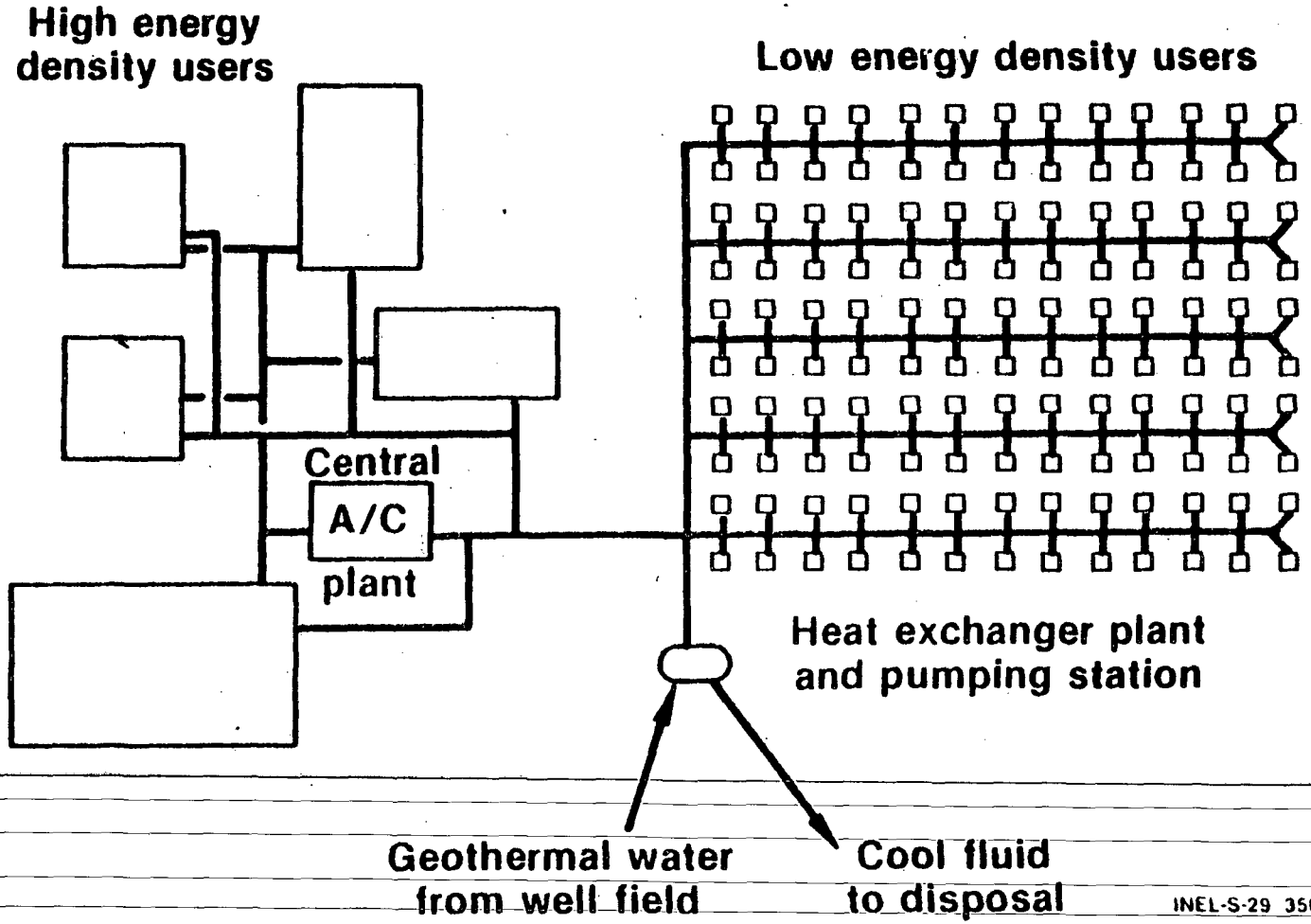
Space Conditioning

- Space heating
- Hot water heating
- Space cooling

CONCEPT FOR AN OVERALL GEOTHERMAL SPACE CONDITIONING/DOMESTIC HOT WATER SYSTEM FOR A TOWN SUCH AS AN M-X OPERATING BASE.

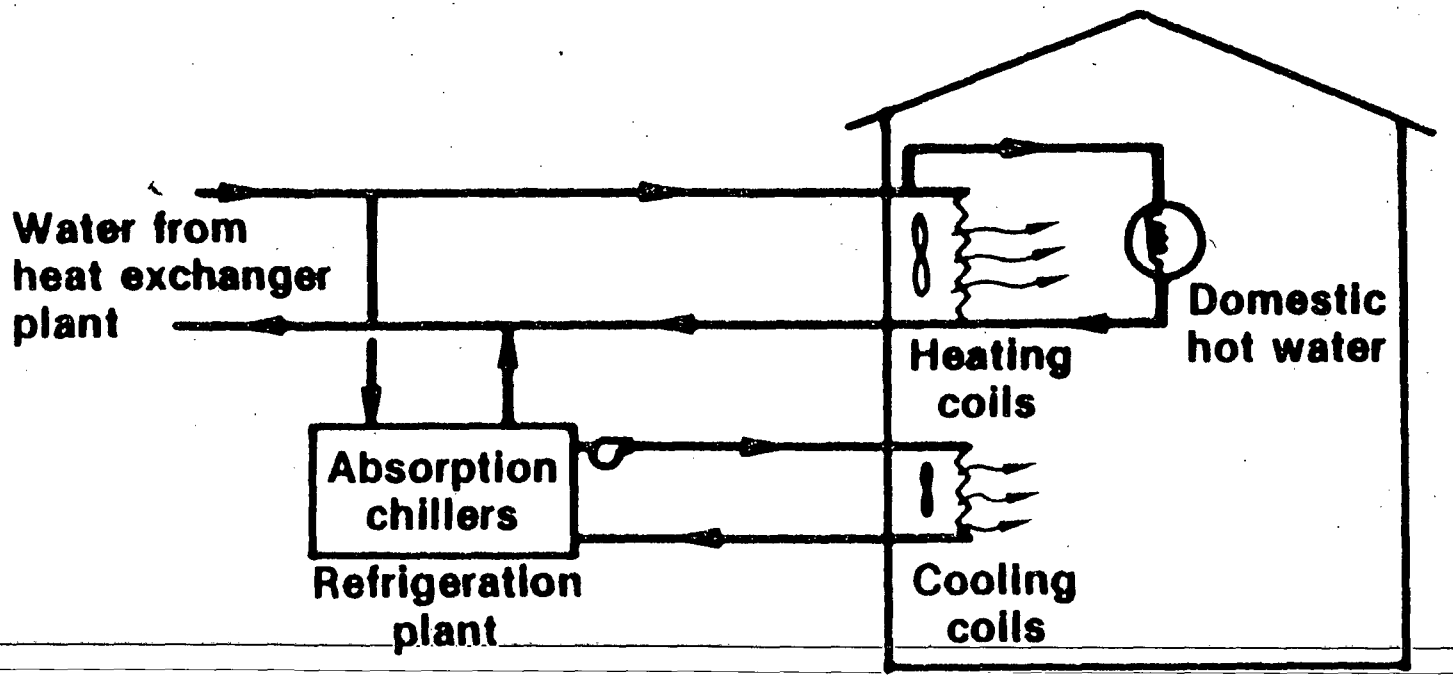
High density users such as maintenance facilities and offices would have a central absorption air-conditioning plant while low density users would obtain cooling from individual units.

Geothermal Space Conditioning/ Domestic Hot Water



DETAILS OF TYPICAL HIGH ENERGY DENSITY USERS

Geothermal
Space Conditioning and Domestic Hot Water
(High Energy Density Users)



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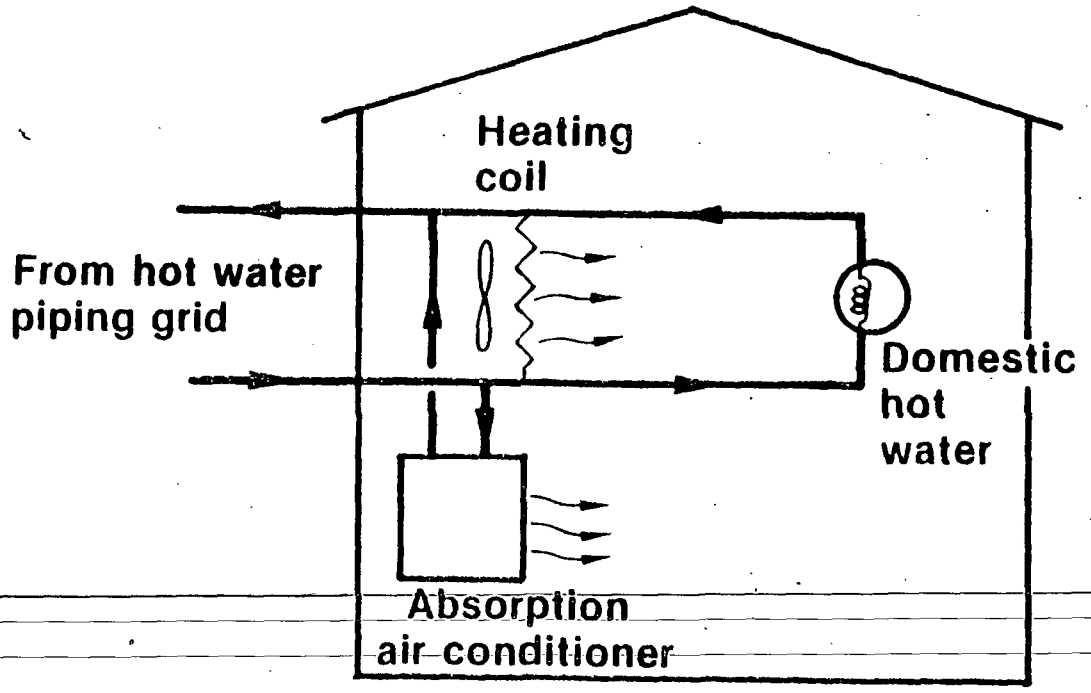
DETAILS OF TYPICAL LOW ENERGY DENSITY USERS.

Geothermal
Space Conditioning and Domestic Hot Water
(Low Energy Density Users)

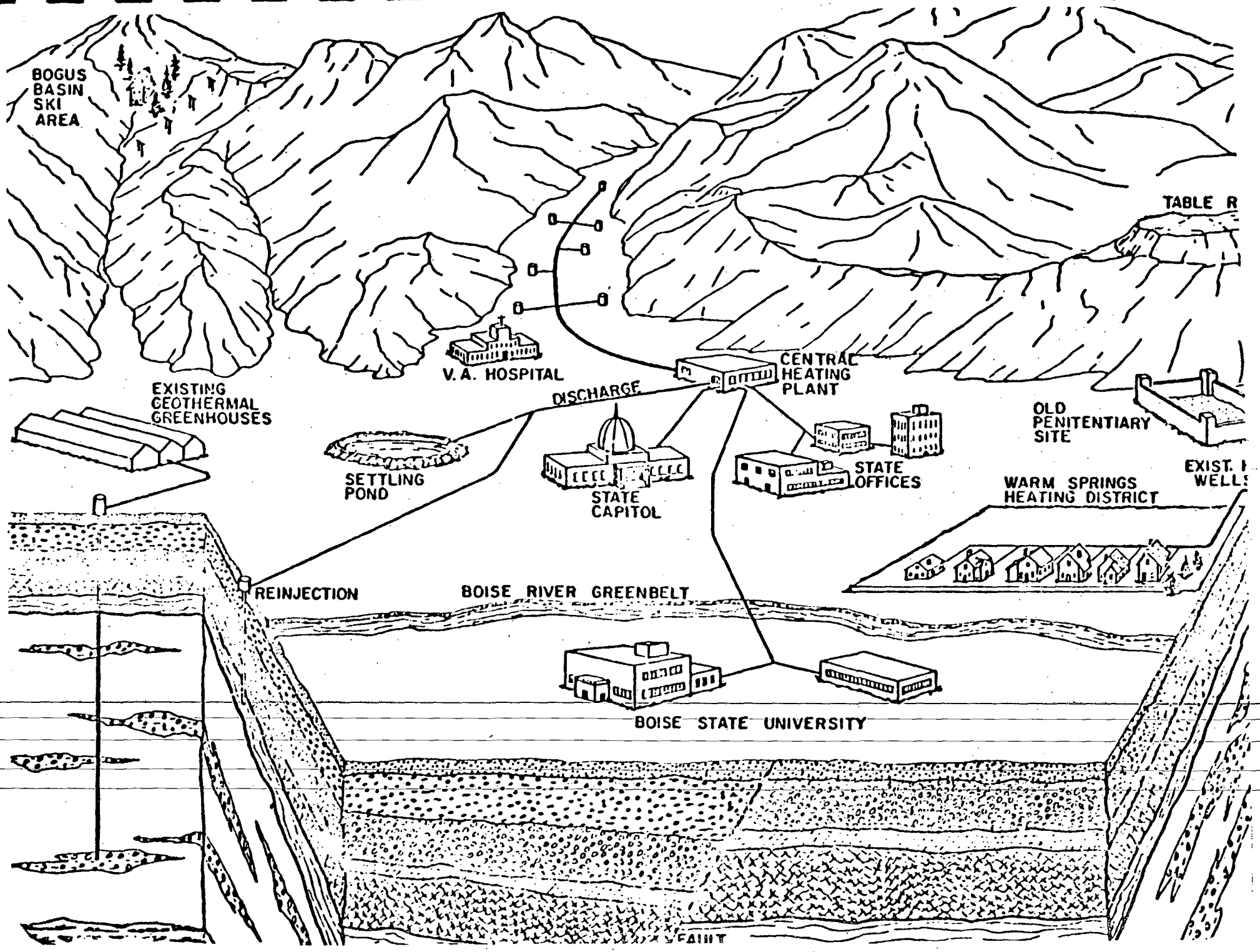


INEL-S-29 348

A 3-TON ABSORPTION AIR-CONTITIONER BY ARKLA MANUFACTURING USED FOR OFFICES AT RAFT RIVER, IDAHO.

AN ARTIST'S CONCEPTION OF THE BOISE, IDAHO DISTRICT SPACE HEATING SYSTEM.

This system is presently in the licensing and permitting stage.


BOGUS BASIN SKI AREA
TABLE R
V. A. HOSPITAL
CENTRAL HEATING PLANT
EXISTING GEOTHERMAL GREENHOUSES
DISCHARGE
OLD PENITENTIARY SITE
SETTLING POND
STATE CAPITOL
STATE OFFICES
EXIST. WELLS
WARM SPRINGS HEATING DISTRICT
REINJECTION
BOISE RIVER GREENBELT
BOISE STATE UNIVERSITY

Work Elements

3.1 Geothermal applications development

M-X/RES PROJECT GEOTHERMAL TASK

PHASE 1 OBJECTIVES HIERARCHY

DEFINE INTEGRATED RES OPTIONS THAT COULD
- **PROVIDE RELIABLE POWER FOR M-X**
- **ACCELERATE RES COMMERCIALIZATION**

DEVELOP DECISION PACKAGE BY MID '82 TO SUPPORT USAF DECISIONS ON
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- **RES ACQUISITION STRATEGIES**
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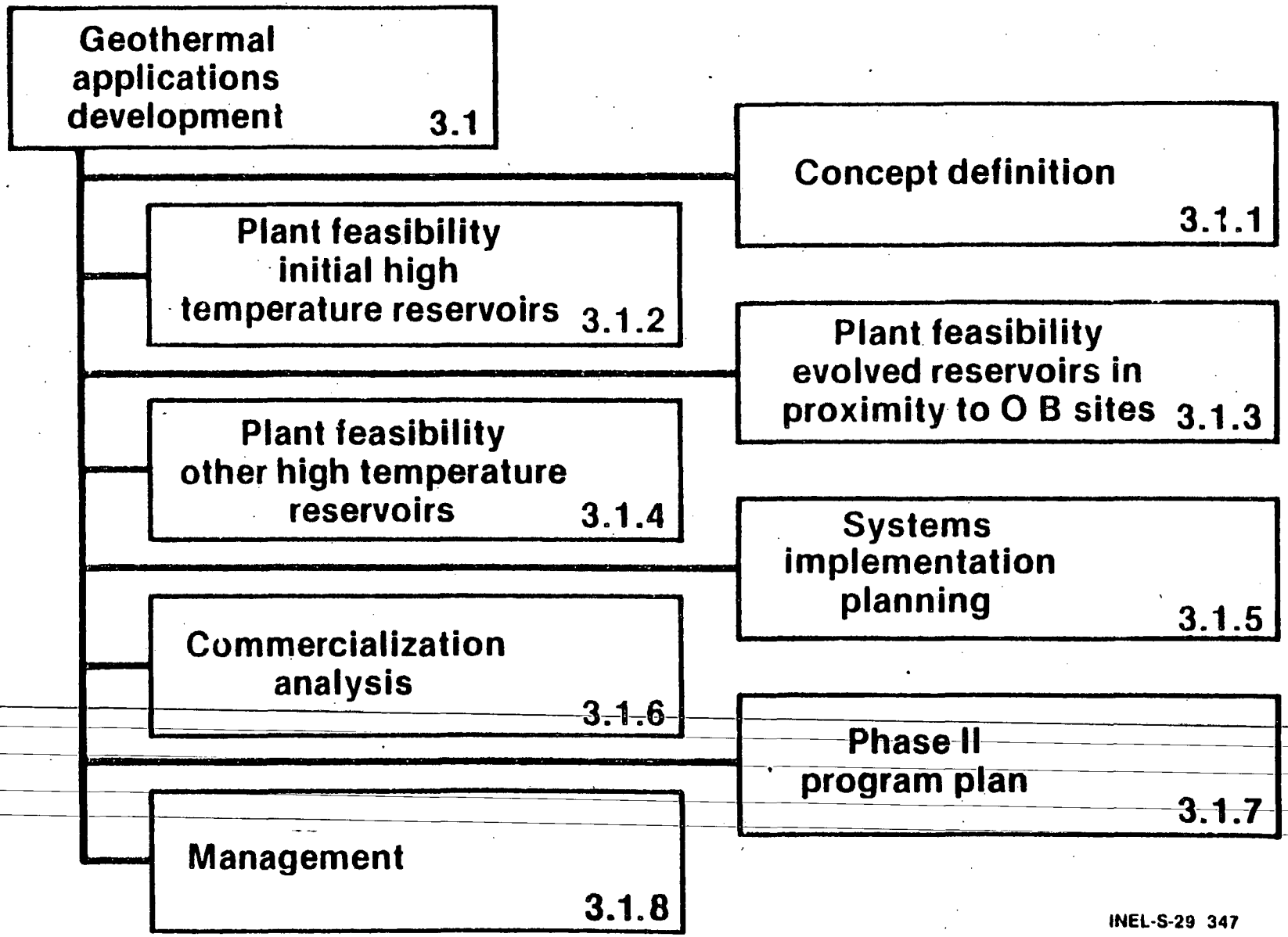
CHARACTERIZE GEOTHERMAL RESOURCE SITES IN OR ADJACENT TO THE M-X DEPLOYMENT AREA (2.3)
- **EXPLORE, CONFIRM, AND DEVELOP CASE STUDIES FOR GEOTHERMAL RESERVOIRS**
- **PLAN PHASE II ACTIVITIES**

DETERMINE PLANT FEASIBILITIES AND RESERVOIR SPECIFIC DESIGNS FOR ELECTRICAL AND DIRECT HEAT APPLICATIONS (3.1)
- **DEFINE CONCEPT, APPROACH**
- **DETERMINE PLANT FEASIBILITY FOR CONFIRMED RESERVOIRS**
- **PLAN SYSTEMS IMPLEMENTATION**
- **IDENTIFY COMMMERCIALIZATION IMPACTS**
- **PLAN PHASE II ACTIVITIES**

MX-028


Geothermal applications development 3.1
Concept definition 3.1.1
Plant feasibility initial high temperature reservoirs 3.1.2
Plant feasibility evolved reservoirs in proximity to O B sites 3.1.3
Plant feasibility other high temperature reservoirs 3.1.4
Systems implementation planning 3.1.5
Commercialization analysis 3.1.6
Phase II program plan 3.1.7
Management 3.1.8
INEL-S-29 347

PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WBS

Task 3.1.1 Concept Definition

3.1.1.1 Scenario/Technology Tradeoff and Strategies

Develop scenarios for the utilization of geothermal energy for electrical power for the overall system and for space conditioning of several OB sites, as well as a cascaded electrical power/space conditioning option for one OB site.

3.1.1.2 Generic Parameterization

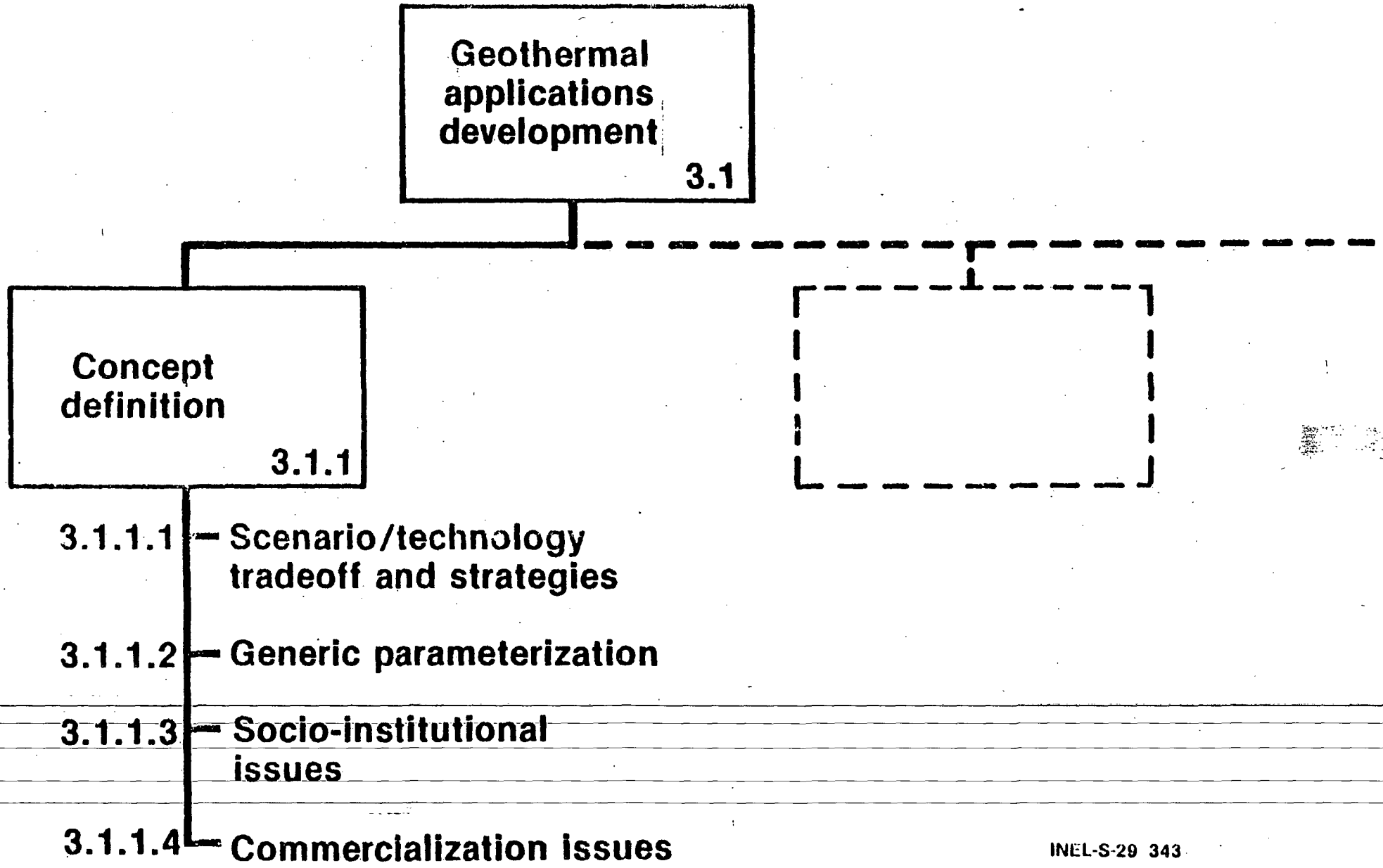
Develop generic performance and cost parameters for three types of electric power production and for space conditioning at typical OB sites, as functions of resource temperature, fluid chemistry and average well flow rates. Special consideration will be given to conceptual development of special binary and hybrid flash-steam-binary power plants to mitigate shortages of cooling water, and floating power concepts to mate with the generation characteristics of other renewable energy sources. Conceptual work on combination space-water heating and space cooling systems for the OBs will be carried through preliminary cost estimates and economics. This data is to be used for selection of the most promising electric generating and OB sites. Consideration of dry or hybrid cooling for electric power generation will also be evaluated.

3.1.1.3 Socio-Institutional Issues

Develop a generic list of the environmental concerns, permitting problems and political-legal ramifications appropriate for electric generating and space conditioning applications in the areas of interest. Evaluate each of the items and its potential impact on construction schedules.

3.1.1.4 Commercialization Issues

Scope the potential commercialization issues associated with development of large scale geothermal applications. Consider development of the infrastructure necessary for low- to intermediate-temperature geothermal applications, the market for geothermal components and the demonstration of large scale applications. Demonstration of ways to cut through the barriers to geothermal utilization will also be significant to commercialization. This task will be coordinated with DOE/DGE commercialization programs.


Geothermal applications development
3.1
Concept definition
3.1.1
3.1.1.1 Scenario/technology tradeoff and strategies
3.1.1.2 Generic parameterization
3.1.1.3 Socio-institutional issues
3.1.1.4 Commercialization issues

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PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WBS

Task 3.1.2 Plant Feasibility - Initial High Temperature Reservoirs

3.1.2.1 Reservoir Specific Parameterization

Contract with Northern Nevada Consortium and Utah Power and Light to buy reservoir and plant study data and transmission line studies (DOE/Nevada Operations Office).

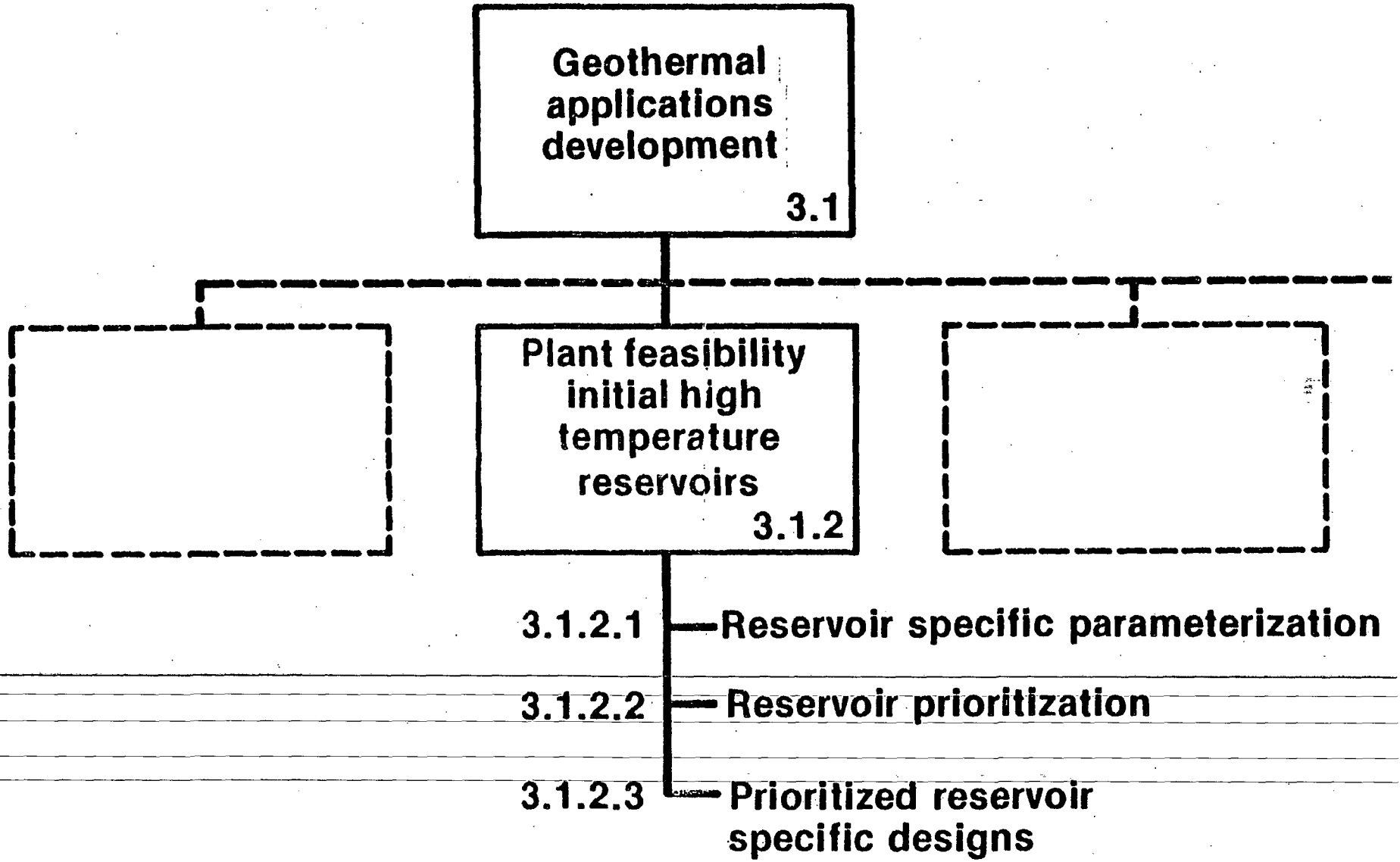
Review and evaluate the studies of 3.1.2.1

3.1.2.2 Prioritize Reservoirs

Prioritize the reservoirs on the basis of lowest power costs, technical feasibility, environmental and socio-institutional issues, commercialization aspects and strategic locations. Produce a final report.

3.1.2.3 Reservoir Specific Designs

Based upon Tasks 3.1.2.1 and 3.1.2.2 above, and Task 3.1.1.2, develop a plant conceptual design, if not produced in 3.1.2.1 above. Subcontract with an AE firm for a Title I design study. Review the Title I design and produce a final report package for M-X/RES consideration.


Geothermal applications development
3.1
Plant feasibility initial high temperature reservoirs
3.1.2
3.1.2.1
Reservoir specific parameterization
3.1.2.2
Reservoir prioritization
3.1.2.3
Prioritized reservoir specific designs

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PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WBS

Task 3.1.3 Plant Feasibility - Evolved Reservoirs in Proximity to Operating Bases

3.1.3.1 Analysis of Cascaded Systems

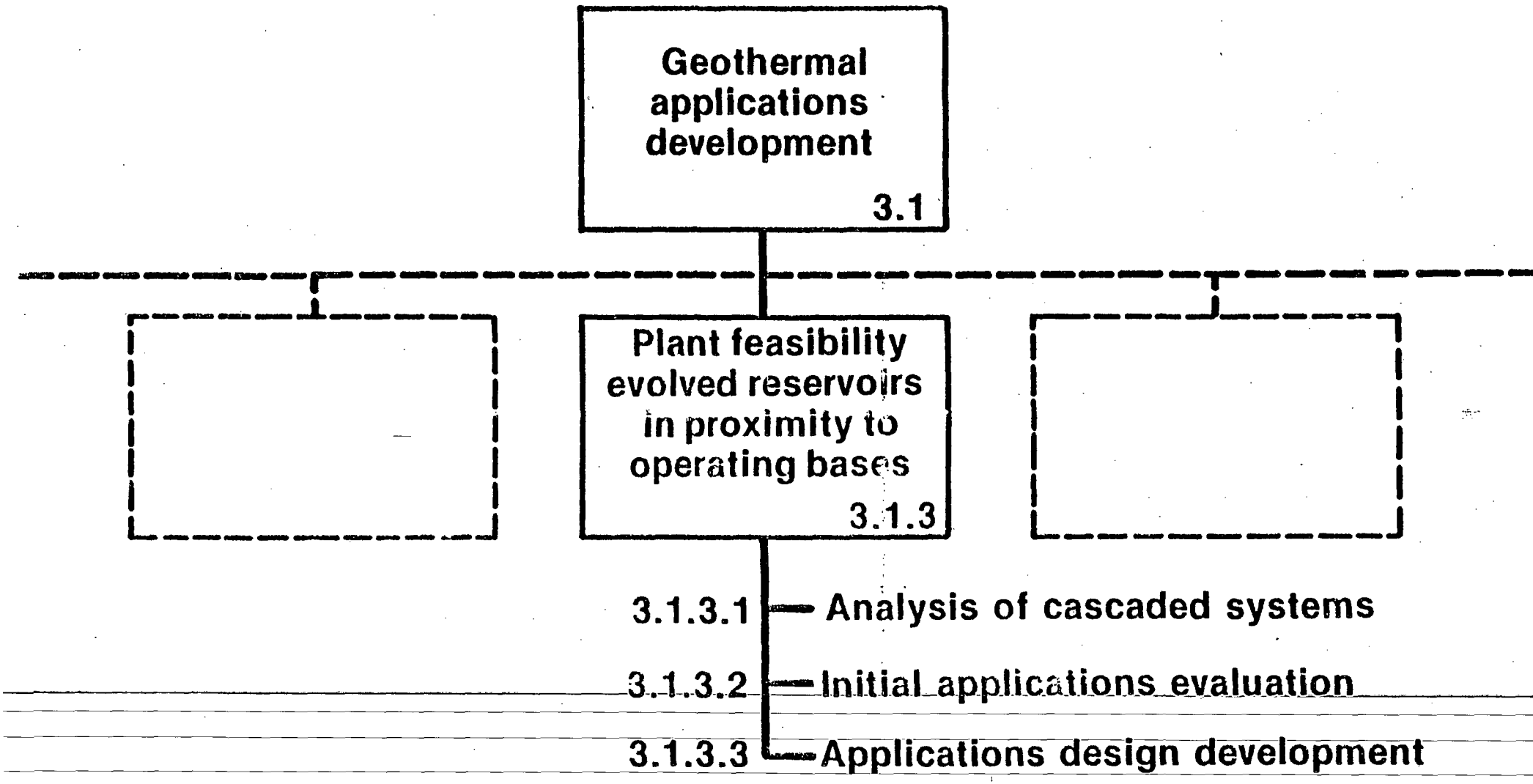
Working from the Generic Parameterizations of element 3.1.2, scope cascaded electric generation/space conditioning systems for the OB sites.

3.1.3.2 Initial Applications Evaluation

Using the generic data from tasks 3.1.2 and 3.1.3.1, and initial reservoir data, evaluate the potential systems appropriate for application at the OB sites.

3.1.3.3 Applications Design Development

Using updated reservoir data, the generic data, and the initial evaluations above select the appropriate system concepts. Perform a conceptual system design. Place a subcontract with an AE firm for a Title I design.


Geothermal applications development
3.1
Plant feasibility evolved reservoirs in proximity to operating bases
3.1.3
3.1.3.1 Analysis of cascaded systems
3.1.3.2 Initial applications evaluation
3.1.3.3 Applications design development

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Task 3.1.4 Plant Feasibility of Other High Temperature Reservoirs

Following the discovery and preliminary assessment of a new high-temperature reservoir, the initial estimate of fluid temperature, flow rate per well, and water quality will be used to determine the electrical generation capacity and economics of the site.

3.1.4.1 Reservoir Specific Parameterization

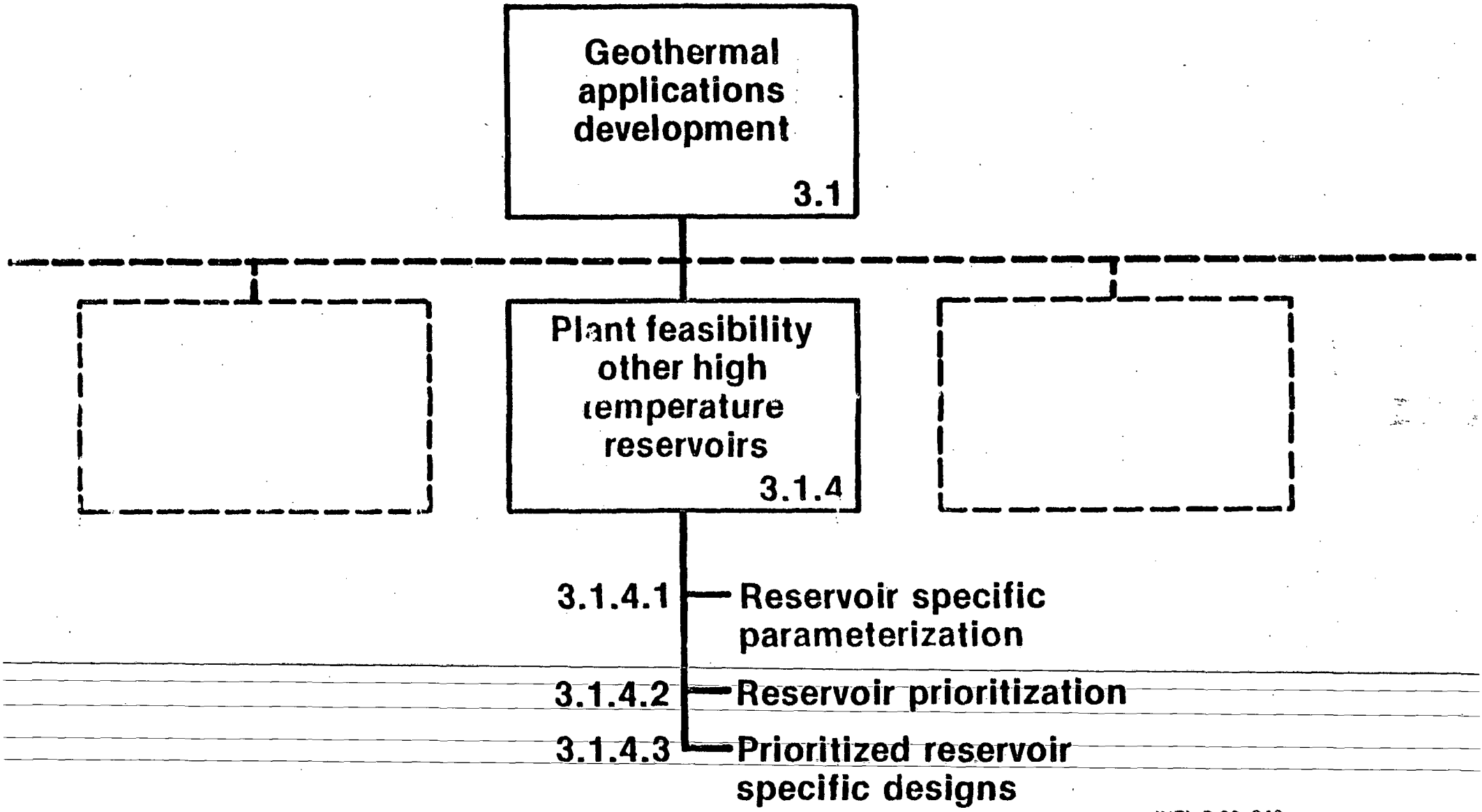
The electric generation generic parameterization developed in Task 3.1.1.2 will be adjusted to the characteristics of the specific reservoir.

3.1.4.2 Reservoir Specific Designs

As further reservoir definition becomes available, the parameterics of Task 3.1.4.1 will be refined and the economics of the site development will be evaluated. If the analysis proves favorable, an AE will be contracted to develop a reservoir-specific design. Given the site and resource characteristics, the AE will develop preliminary layouts and equipment sizes, and estimate the plant and equipment capital costs, O&M , and energy production.

3.1.4.3 Prioritize Reservoir Applications

After all of the preliminary designs have been completed and reviewed, the designs will be evaluated with respect to economics, energy impact, and commercialization impact. The designs will be prioritized with the initial resource sites (Tasks 3.1.2.3 & 3.1.3.3) to aid in the selection of the optimum electric generation configuration. This will consist of a combined effort of UURI and EG&G.


Geothermal applications development
3.1
Plant feasibility other high temperature reservoirs
3.1.4
3.1.4.1
Reservoir specific parameterization
3.1.4.2
Reservoir prioritization
3.1.4.3
Prioritized reservoir specific designs

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Task 3.1.5 Systems Implementation Planning

3.1.5.1 Operations Planning

Operating plans will be developed for the plant concepts that cover system operation, plant maintenance and SO testing. Support facilties, equipment, personnel requirements and training programs required for operation and maintenance of the plants will be identified.

3.1.5.2 Environmental and Safety Analysis

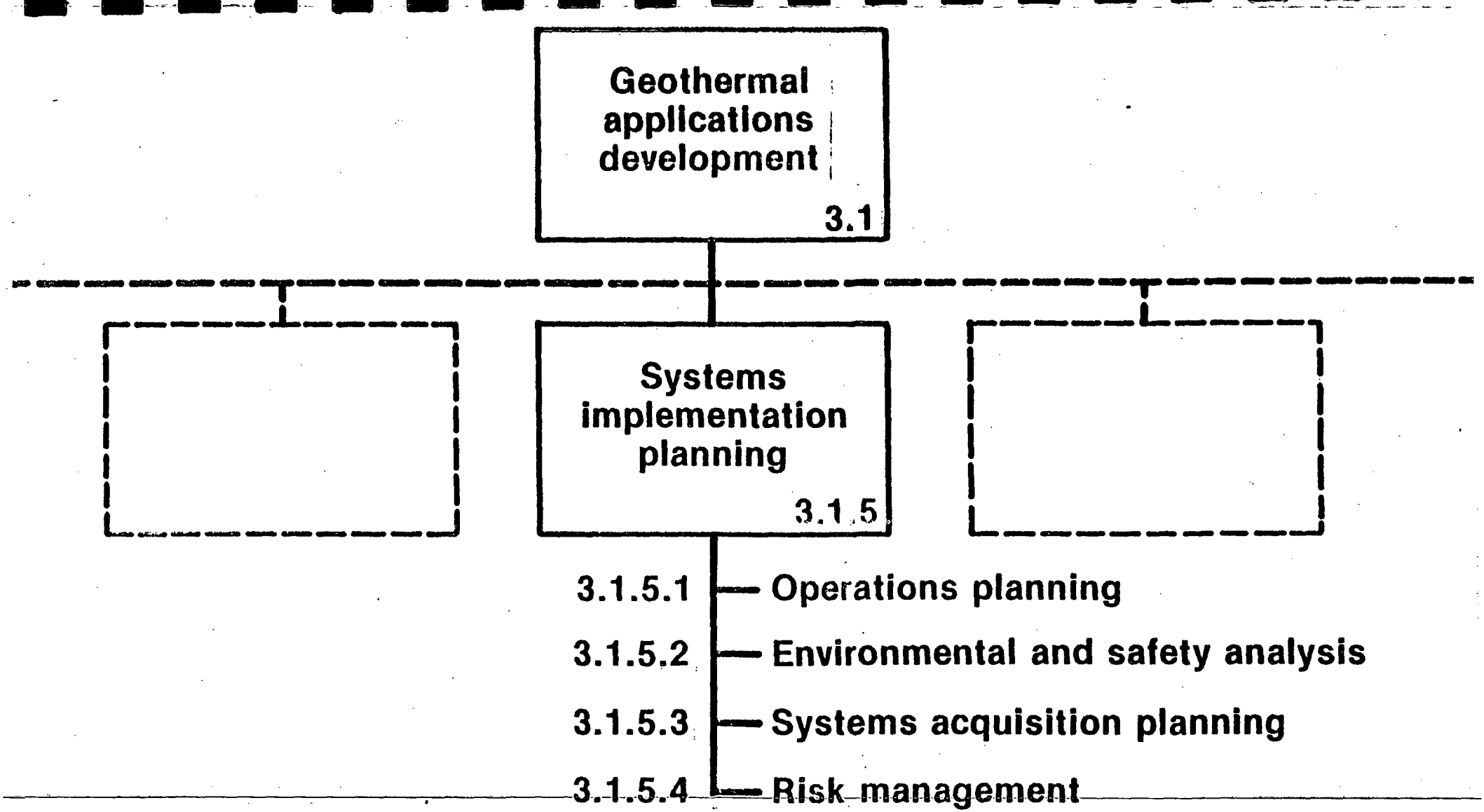
The potential environmental impacts and health and safety risks associated with the plant and concepts for installation, operation and maintenance of the plant will be identified and assessed. Special procedures required to comply with Federal, State, and local standards will be identified.

3.1.5.3 Systems Acquisition Planning

A plan that covers all items commencing with Phase II activities and culminating with the operational availability of the plant concepts will be prepared that reflects necessary design, development, prototype testing, CC tests, installation and checkout activities.

3.1.5.4 Risk Management

Finally, areas of possible risk will be identified that address performance, cost, and schedule for the various concepts that might commence with Phase II activities. Causative factors will be discussed, and plans developed for minimizing the risks.


Geothermal applications development
3.1
Systems implementation planning
3.1.5
3.1.5.1 Operations planning
3.1.5.2 Environmental and safety analysis
3.1.5.3 Systems acquisition planning
3.1.5.4 Risk management

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PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WBS

Task 3.1.6 Commercialization Analysis

3.1.6.1 Market Identification

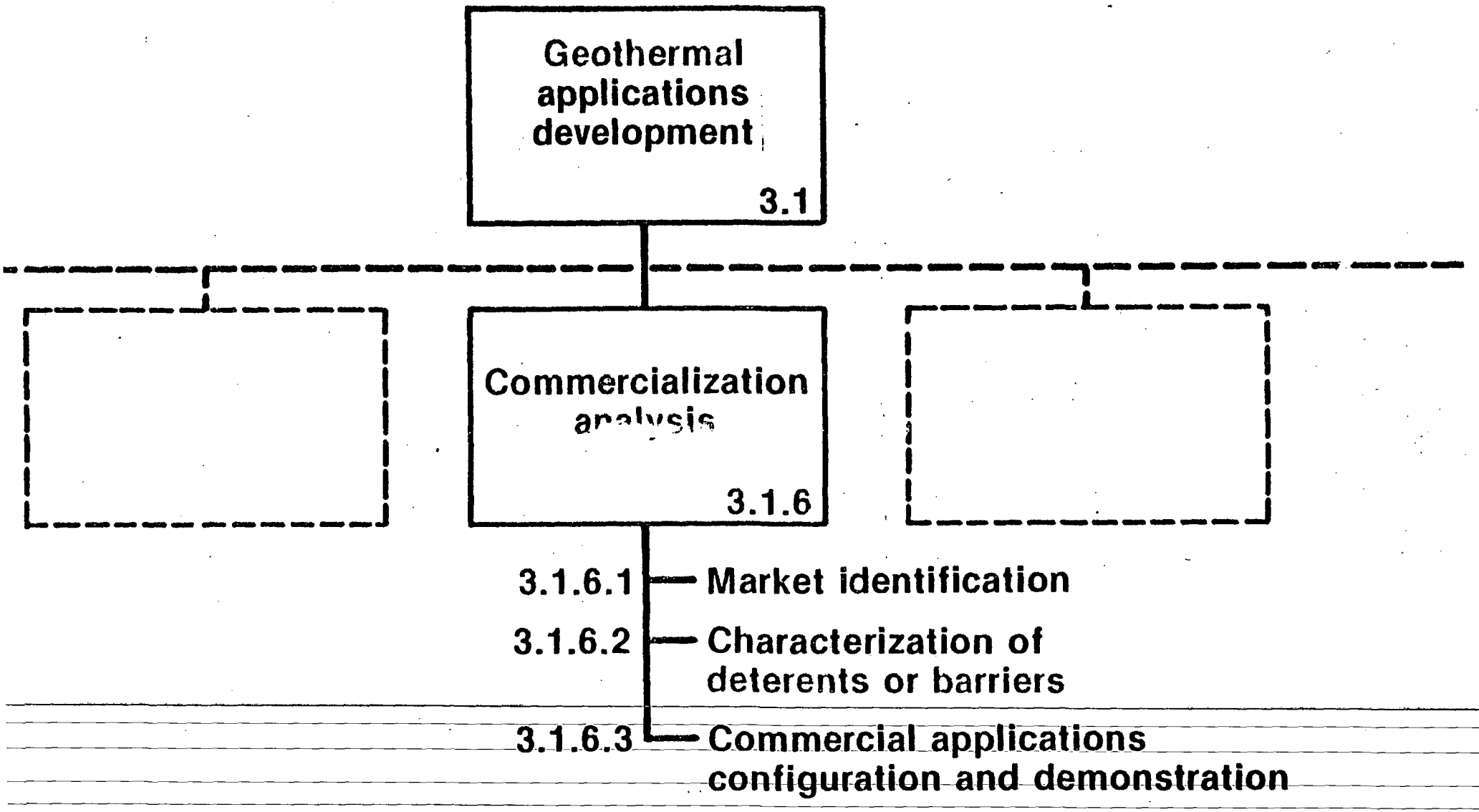
Existing and future markets for geothermal electric generation plants and district space conditioning systems will be identified, and used in the data dissemination phase of Task 3.1.8.

3.1.6.2 Characterization of Deterrents or Barriers

The deterrents and barriers to the development of geothermal utilization will be identified from past and projected geothermal projects. Issues such as permitting, licensing, rights of way, project infrastructure and capital formation will be covered. These issues will be cross-referenced to the quantity and scheduling of systems procured and demonstrated by M-X/RES applications.

Commerical Applications Configuration and Demonstration

The impact of the proposed M-X/RES project designs and demonstrations on the acceleration of geothermal commercialization wil be assessed.


Geothermal applications development
3.1
Commercialization analysis
3.1.6
3.1.6.1 Market identification
3.1.6.2 Characterization of deterents or barriers
3.1.6.3 Commercial applications configuration and demonstration

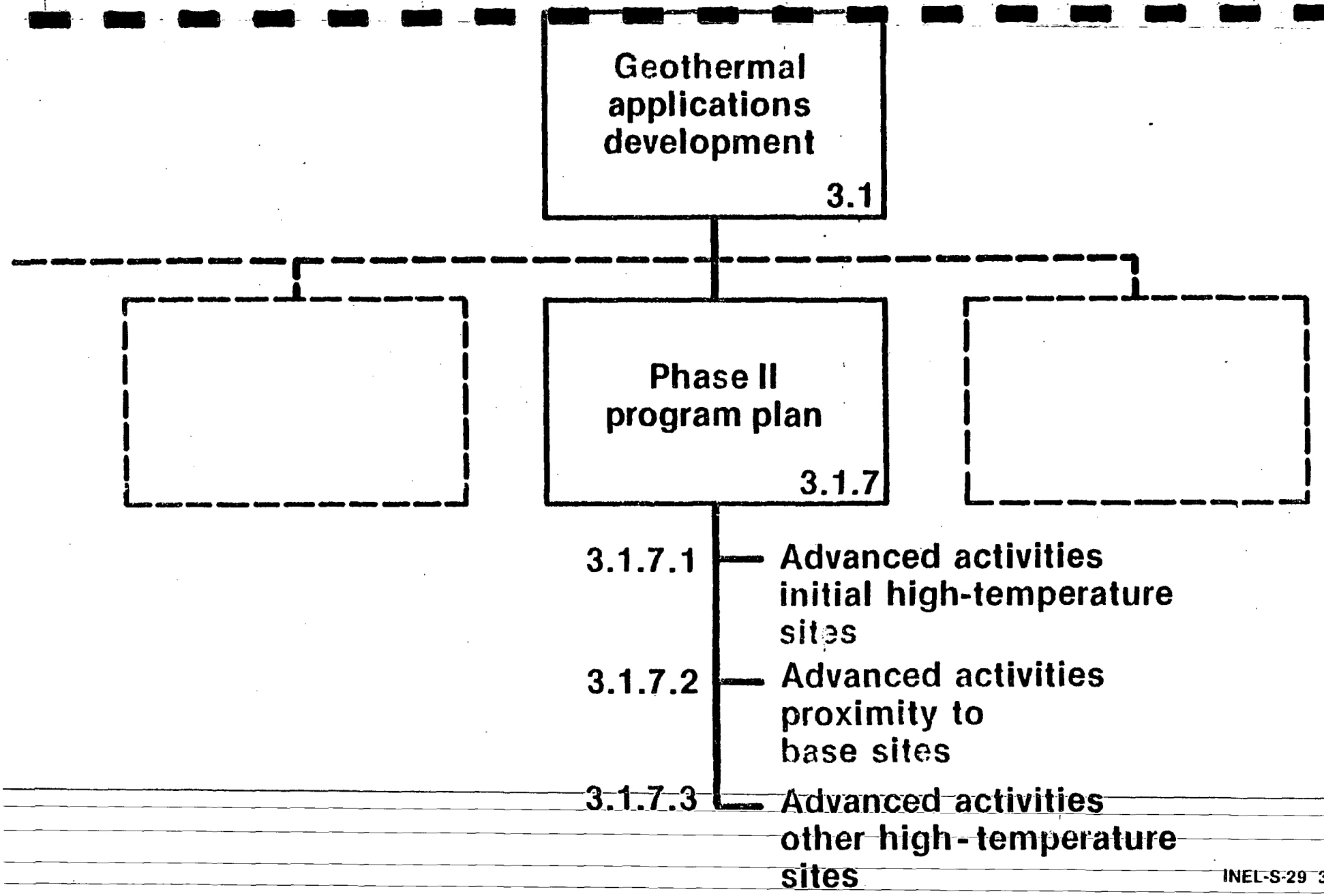
INEL-S-29 345

PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WBS

Task 3.1.7 Phase II Program Plan

The Phase II Program Plan contains work that will be performed after June 1982. On or about that date, decisions will be made regarding the contributions to be made by geothermal energy systems to the overall M-X/RES Project, and the ongoing work will be selected from work proposed in the Phase II Program Plan.

Subtasks that will be covered in the plan are: advanced activities at initial high temperature sites and in close proximity to base sites, and activities at other high temperature sites that are not colocated with Operating Bases.


Geothermal applications development
3.1
Phase II program plan
3.1.7
3.1.7.1
Advanced activities initial high-temperature sites
3.1.7.2
Advanced activities proximity to base sites
3.1.7.3
Advanced activities other high-temperature sites
INEL-S-29 342

PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WBS

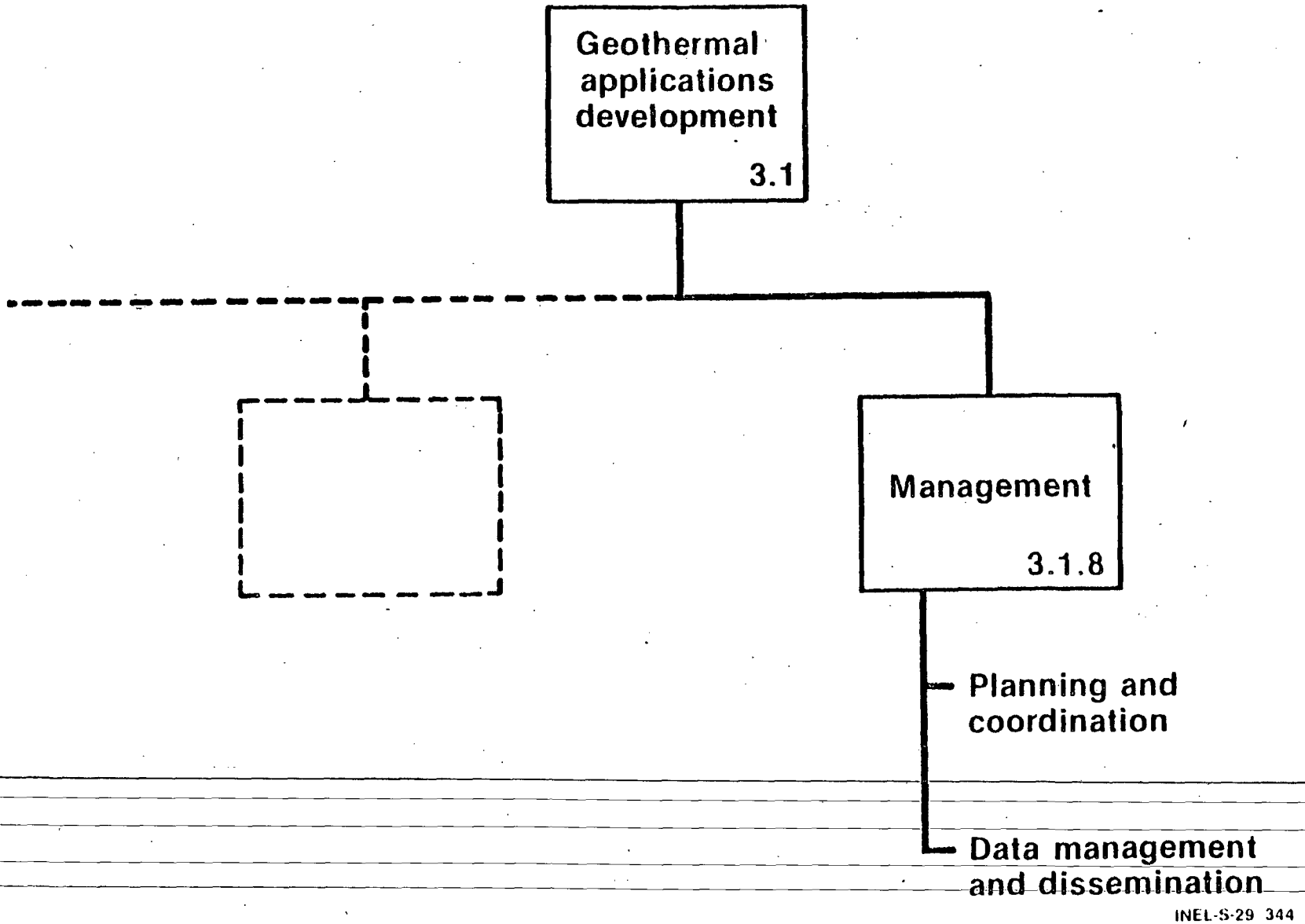
Task 3.1.8 Management

3.1.8.1 Planning and Coordination

This task will develop project objectives, finalize work breakdown structure, acquire necessary resources, schedule work and assure that schedules and fiscal constraints are met. The plan will be revised as necessary to keep it current.

3.1.8.2 Data Management and Dissemination

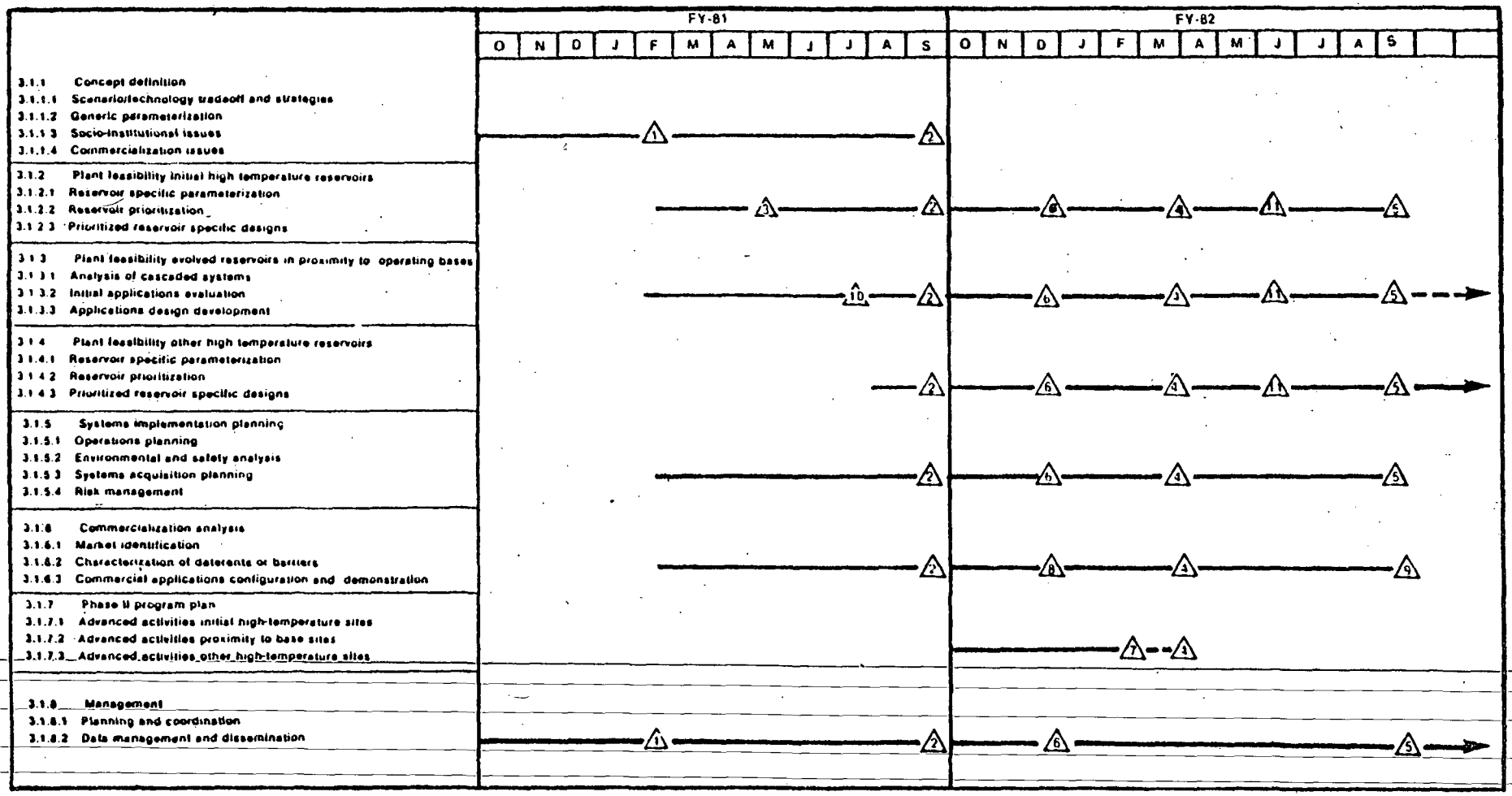
This task will assure that report and briefing schedules are met and that data is distributed to both other project teams and the commercial sector as appropriate.


Geothermal applications development
3.1
Management
3.1.8
Planning and coordination
Data management and dissemination
INEL-S-29 344

Phase II Activities

- Select plant site(s) and applications concepts
- Take conceptual designs for selected sites through final designs & equipment specifications
- Select construction contractor
- Purchase long lead equipment
- Construct plant(s)
- Perform plant testing and startup
- Power on line

Geothermal Applications Development Milestone Chart



Milestones

1. - Strategy presentation for integrated systems analysis to Aerospace, Inc.
2. - Preliminary task briefing to MX-RES project office
3. - Delivery of existing reservoir data
4. - Detailed task briefing
5. - Final report
6. - Preliminary assessment report
7. - Phase II task plan
8. - Interim commercialization report
9. - Final commercialization report
10. - Interim report on plant feasibility studies
11. - Reservoir specific specifications

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Summary

- Geothermal energy is appropriate for
  - Base load electric power generation
  - Space conditioning at OB sites
- Generic studies will provide basis for prioritization
  - Of exploration and selection of applications
- A-E firms will be contracted for design studies

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

ILLUSTRATIVE SCENARIO

50 MWe PLANT AND SPACE CONDITIONING AT MILFORD OB

OBJECTIVES

NATURE OF RESERVOIR

EXPLORATION

PLANT DESIGN

INSTALLATION AND OPERATION

SCENARIO OBJECTIVE

TO ILLUSTRATE A TYPICAL SEQUENCE OF EVENTS IN A REALISTIC SITUATION, NAMELY POWER GENERATION AND SPACE CONDITIONING AT THE MILFORD CANDIDATE OB SITE

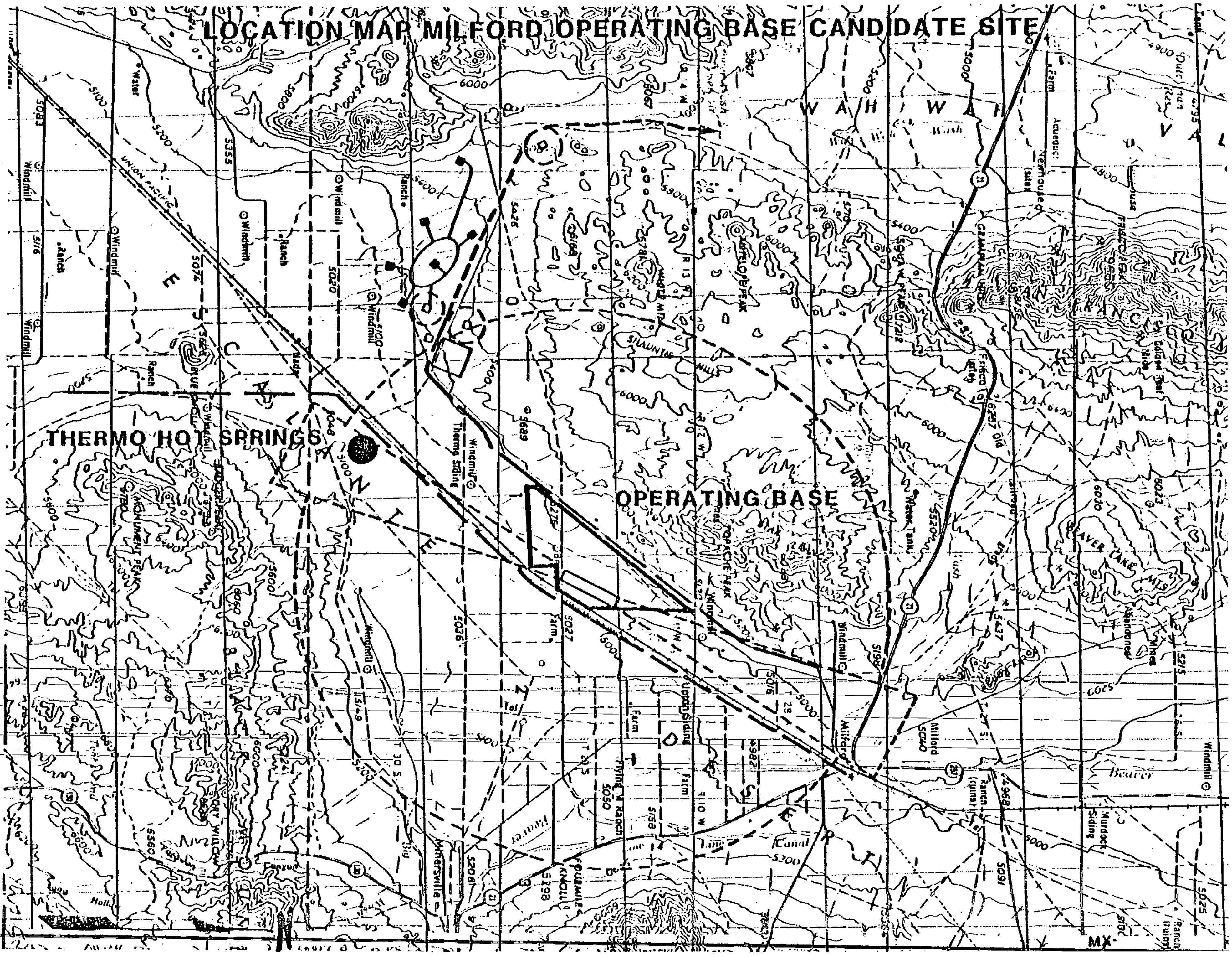
- TIMING, TOTAL TIME
- CRITICAL PATH ITEMS
- EXPENDITURES

LOCATION MAP

MILFORD OPERATING BASE--CANDIDATE SITE

This area south of Milford, Utah is under consideration for construction of one of the two operating bases for the M-X System. If constructed, this site would have a peak electrical power load of an estimated 35.8 MWe and a total maximum estimated thermal energy usage of 83 X 10^9BTU/mo, assuming equivalence to the proposed Beryl OB site.

The Thermo Hot Springs KGRA is located within about 6 miles of Operating Base. Republic Geothermal, Inc. holds leases on the land of interest. Only one deep exploration well has been drilled to date, and this well showed measured temperatures of 175^{o}C to 205^{o}C and low fluid production rates from a depth of about 7300 feet. These results are considered to be very encouraging, and to indicate high potential for discovery of either (or both) a reservoir capable of supplying a geothermal electric generating plant or a reservoir capable of supplying the heating and air conditioning needs of the Operating Base.

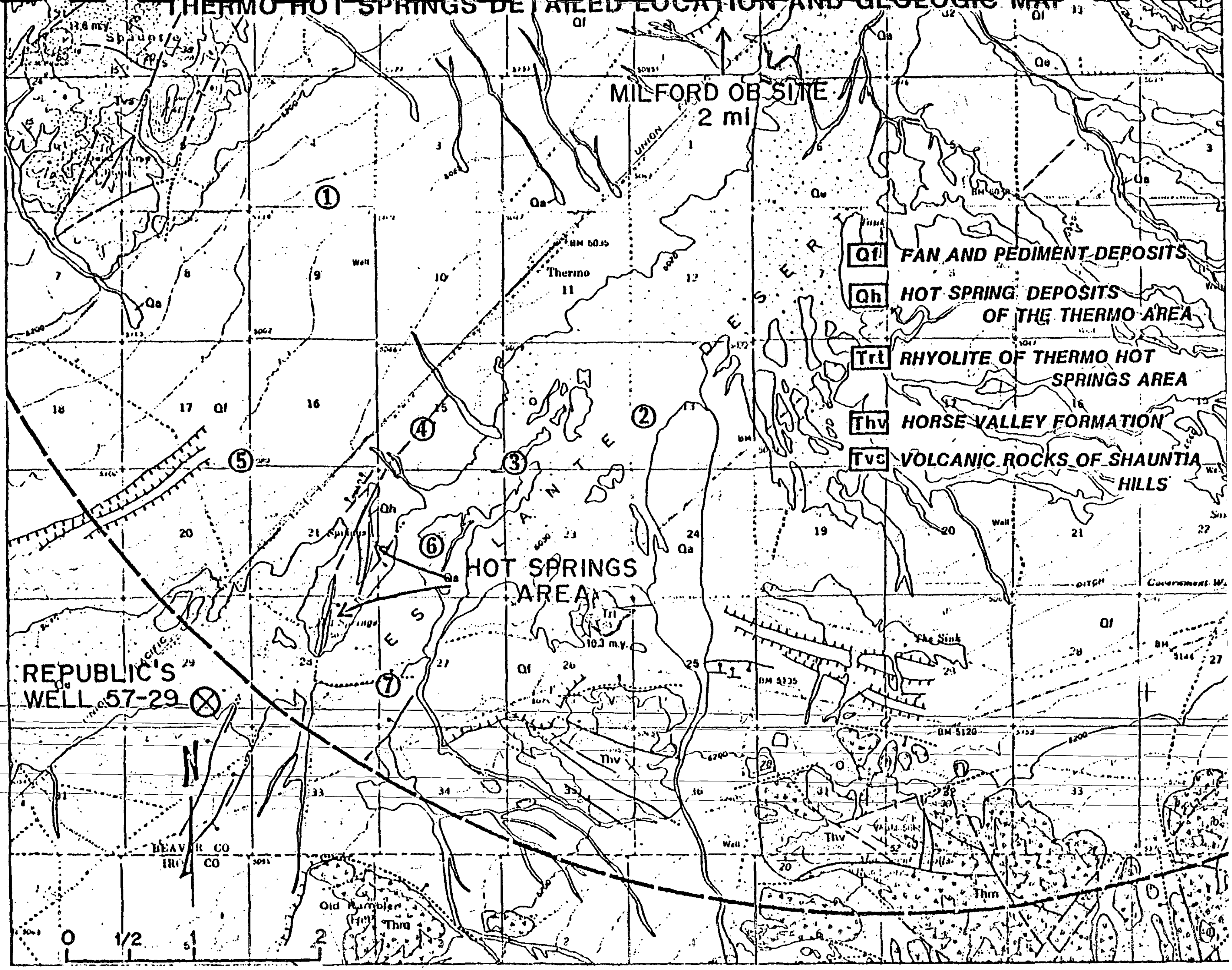

LOCATION MAP MILFORD OPERATING BASE CANDIDATE SITE
OPERATING BASE
THERMO HOT SPRINGS
WAH WAH
Milford
Minersville
Thermo Siding
Upton Siding
Murdock Siding
Fourmile Knoll
Beaver
Canal
Union Pacific
Frisco Peak
Beaver Lake Mts
Monument Peak
Blue Knoll
Antelope Peak
Shauntie Hills
Water Tank
Windmill
Ranch
Farm
MX

THERMO HOT SPRINGS--DETAILED LOCATION AND GEOLOGIC MAP

A search of literature for the Miford OB site area indicates the existence of data that bear on geothermal assessment. This map is a geologic map that also shows the circular outer boundary of the OB site as shown on the previous map. The hot springs themselves are called Thermo Hot Springs. The circled numbers are the locations of holes for which temperature gradient data are available. The mark in Section 29 in the lower left corner of the map shows the location of Escalante 57-29 drilled by Republic Geothermal due in late 1977.

The geologic map indicates that Thermo Hot Springs is located in an areas where the bedrock has been down faulted and the resulting depression has been filled with alluvial sands and gravels. The bedrock in the area is composed of volcanic rocks that were laid down between 7 and 30 million years ago. Geothermal reservoirs may be developed in permeable horizons within either the alluvium or volcanic sequences as well as along the faults which allow the transport of fluids to the surface.

THERMO HOT SPRINGS DETAILED LOCATION AND GEOLOGIC MAP



DATA FOR DRILL HOLE ESCALANTE #57-29

The information known for Escalante #57-29 is shown on the facing page. Based on a single, first analysis of known geologic data, it appears that Republic may not have drilled in the most favorable location. One of the initial action items under this scenario would be to contact Republic Geothermal to find out if they are willing to sell exploration data and to participate in cost-shared exploration with DOE. A favorable response would be anticipated because it is known that Republic is interested in further exploration in this area. Existing exploration data would be reviewed and perhaps purchased for the purpose of determining the need for any additional surface exploration work in order to site a second exploration test hole. At the same time a proposal for cost-shared exploration and confirmation drilling would be solicited from Republic. Upon completion of an agreement between republic and DOE, exploration to select a drill site would be initiated by a team of earth scientists from Republic, ESL and UGMS.

The following slides indicate some of the probable ingredients in such an exploration program. It would begin with a review and interpretation of data from the open literature and from the files of Republic. A conceptual model for the hypothesized geothermal system would be formulated, and then new exploration data would be collected to refine the model and to help site a drill test hole.

MILFORD OB SCENARIO

DATA PURCHASE
EXPLORATION BY REPUBLIC GEOTHERMAL

KNOWN: EXCALANTE #57-29 DRILLED LATE 1977

7288 FEET DEEP

TEMPERATURES 350°F - 400° F (175° C - 250° C)

LOW FLOW RATES

LOW TDS

ACTION: 1) CONTACT REPUBLIC ABOUT EXPLORATION DATA PURCHASE AND COST-SHARED EXPLORATION AND DRILLING

2) REVIEW AND PURCHASE EXISTING EXPLORATION DATA

3) NEGOTIATE COST-SHARED EXPLORATION AND DRILLING PROGRAM

THERMO HOT SPRINGS--WATER CHEMISTRY AND GEOTHERMOMETRY

Chemical data for Thermo Hot Springs are available in the literature, and geothermometry interpretations can be made of these data to predict temperatures in the geothermal reservoir. These interpretations are based on the assumption that water now issuing from the hot springs equilibrated chemically with the reservoir rocks at the reservoir temperature and still carries the signature of this chemical equilibrium. By applying such an analysis, the temperatures calculated using the concentrations of Na, K, and Ca, $T_{(Na\text{-}K\text{-}Ca)}$ = 199°C to 203°C, appear reasonable because measured temperatures of 175° to 205°C were reported for the 7288-feet deep Escalante #57-29. The temperatures calculated using the magnesium corrected Na-K-Ca geothermometer, $T_{(Na\text{-}K\text{-}Ca\text{-}Mg)}$ = 123°C to 130°C are lower because of a high Mg content of the spring water, which is possibly due to the presence of salt in the stratigraphic section.

The quartz geothermometers (Tqtz) are calculated using the measured SiO_2 concentrations and assuming either boiling or conduction to cool the thermal fluids from the reservoir temperature to the measured surface temperature. Both thermometers yield temperatures in the range 137°C to 148°C.

From the above analyses we would conclude that there is a very high likelihood of finding a productive geothermal reservoir whose temperature is in the range 130°C to 150°C, and that there is significant probability of finding portions of the reservoir having temperatures as high as 210°C.

THERMO HOT SPRINGS
WATER CHEMISTRY AND GEOTHERMOMETRY
Concentrations in milligrams/liter (mg/l)

Sample	1	2	3	4
Date	8/21/63	11/3/50	5/25/66	10/23/39
SiO_2	110	120	100	
Fe	0.13	0.05		
Ca	83	72	75	
Mg	9.7	9.8	9.7	
Na	360	360	360	
K	49	61	52	
HCO_3	384	360	359	370
CO_3	0	0	0	0
SO_4	480	470	460	460
Cl	210	220	210	220
F	14	6.7	6.7	
NO_3	1.0	0.1	0.1	0
TDS	1500	1490	1470	
T°C		82.5	78	
pH	8.1	7.8	7.7	
Yield (gpm)		19.3		10.8
$T°C_{(Na-K-Ca)}$	199	213	203	
$T°C_{(Na-K-Ca-Mg)}$	126	130	123	
$T\ qtz_{(boiling)}$	137	141	133	
$T\ qtz_{(cond.)}$	143	148	137	

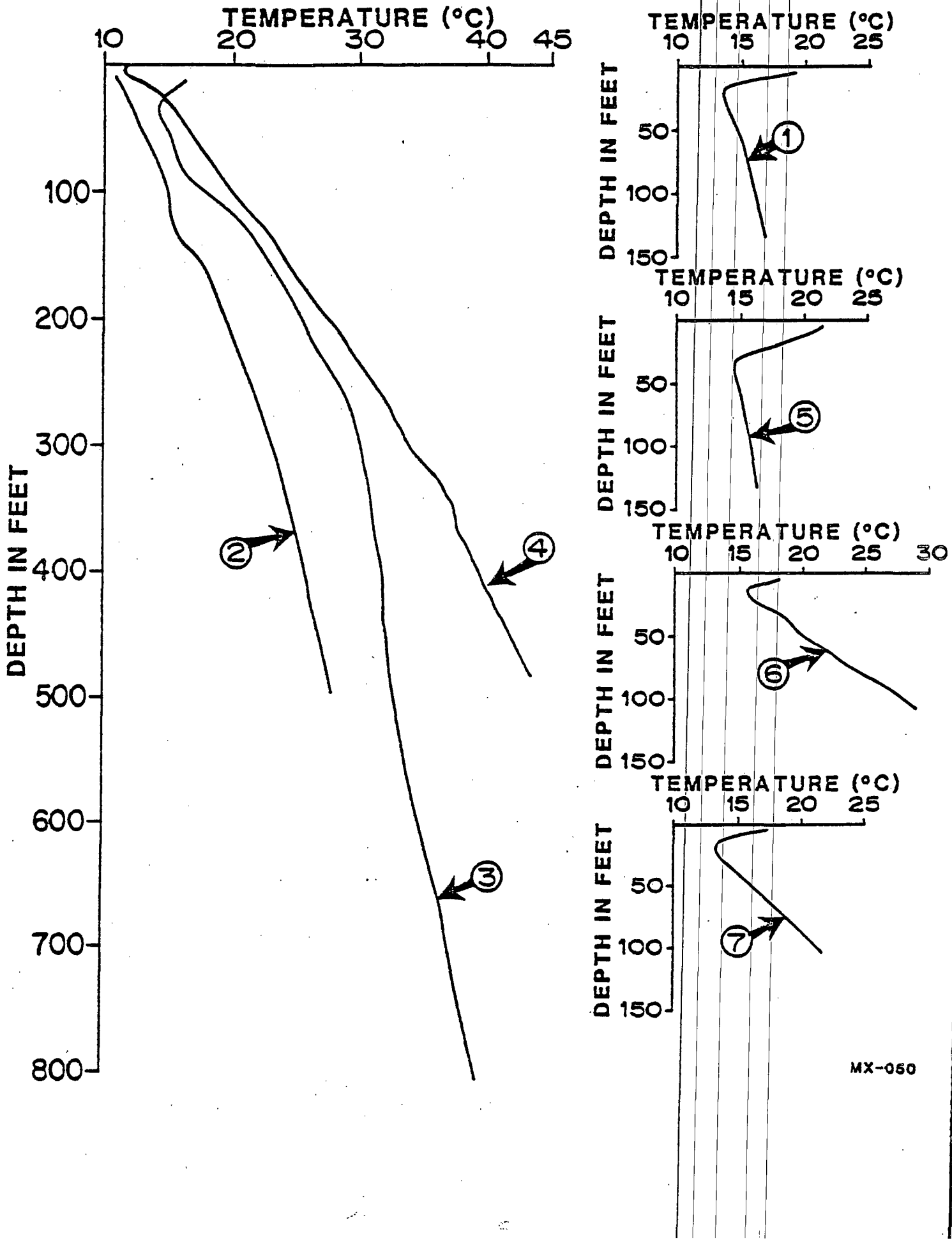
MX-036

TEMPERATURE PROFILES FOR WELLS NEAR THERMO HOT SPRINGS

The temperature profiles shown were compiled from the literature. They are based on measurements in available holes whose locations are on the geologic map on a previous page. This is the type of information that could be collected from the geotechnical borings being done by Fugro National as part of the overall M-X siting evaluation.

Note the range of gradients that can be found in a relatively small area, and particularly the high gradients in wells #4, #6, and #7, which are located either on or close to the faults that control the hot spring system. It is probable that further exploration of this area would include more gradient hole drilling to help pin down the locations of fractures that are in hydrologic communication with the reservoir at depth.

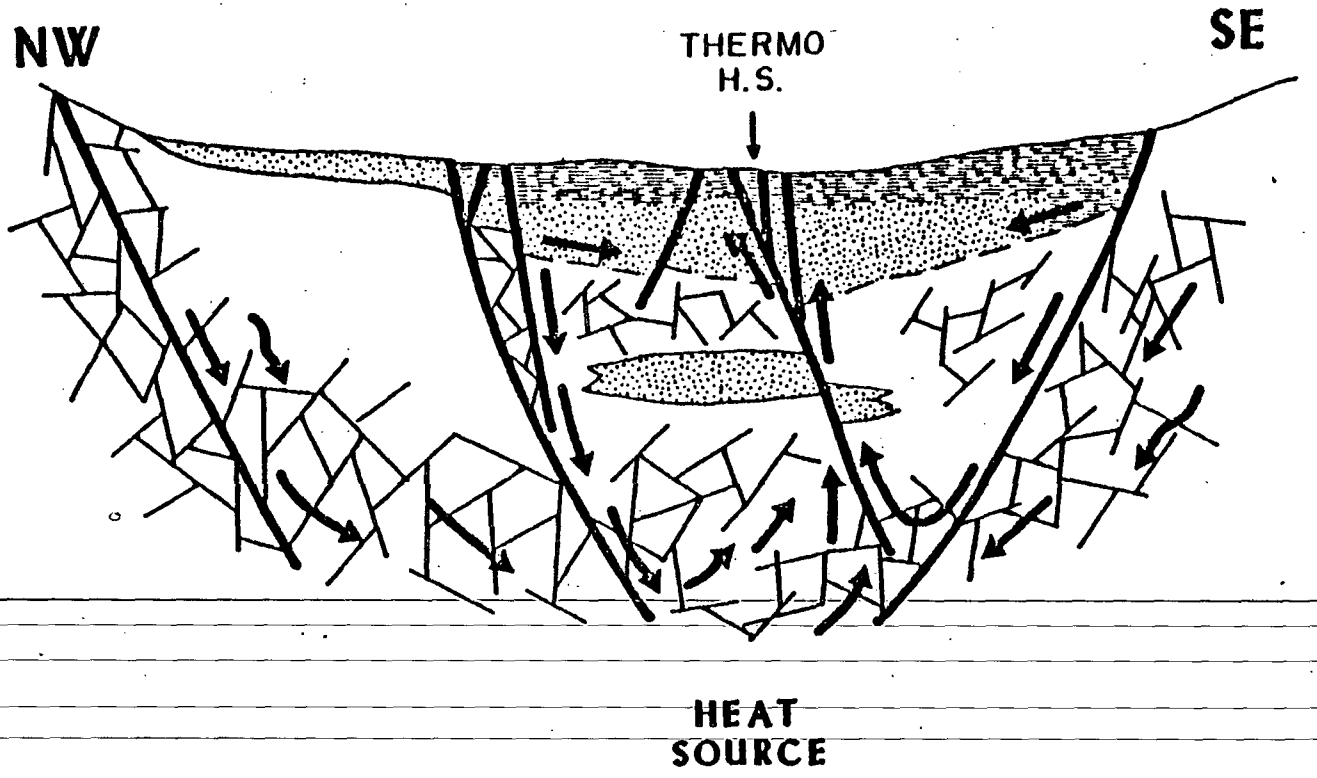
TEMPERATURE PROFILES FOR WELLS NEAR THERMO HOT SPRINGS, UTAH



CONCEPTUAL MODEL FOR THERMO HOT SPRINGS

From the data available, a conceptual model of the hydrothermal convection system at Thermo can be constructed. This model shows the importance of the fault zones that localize the hot spring system. It shows that these zones dip to the east and gives preliminary indication that holes should be drilled east of the hot springs to intersect the faults below zones of possible fresh water mixing in order to obtain higher temperatures.

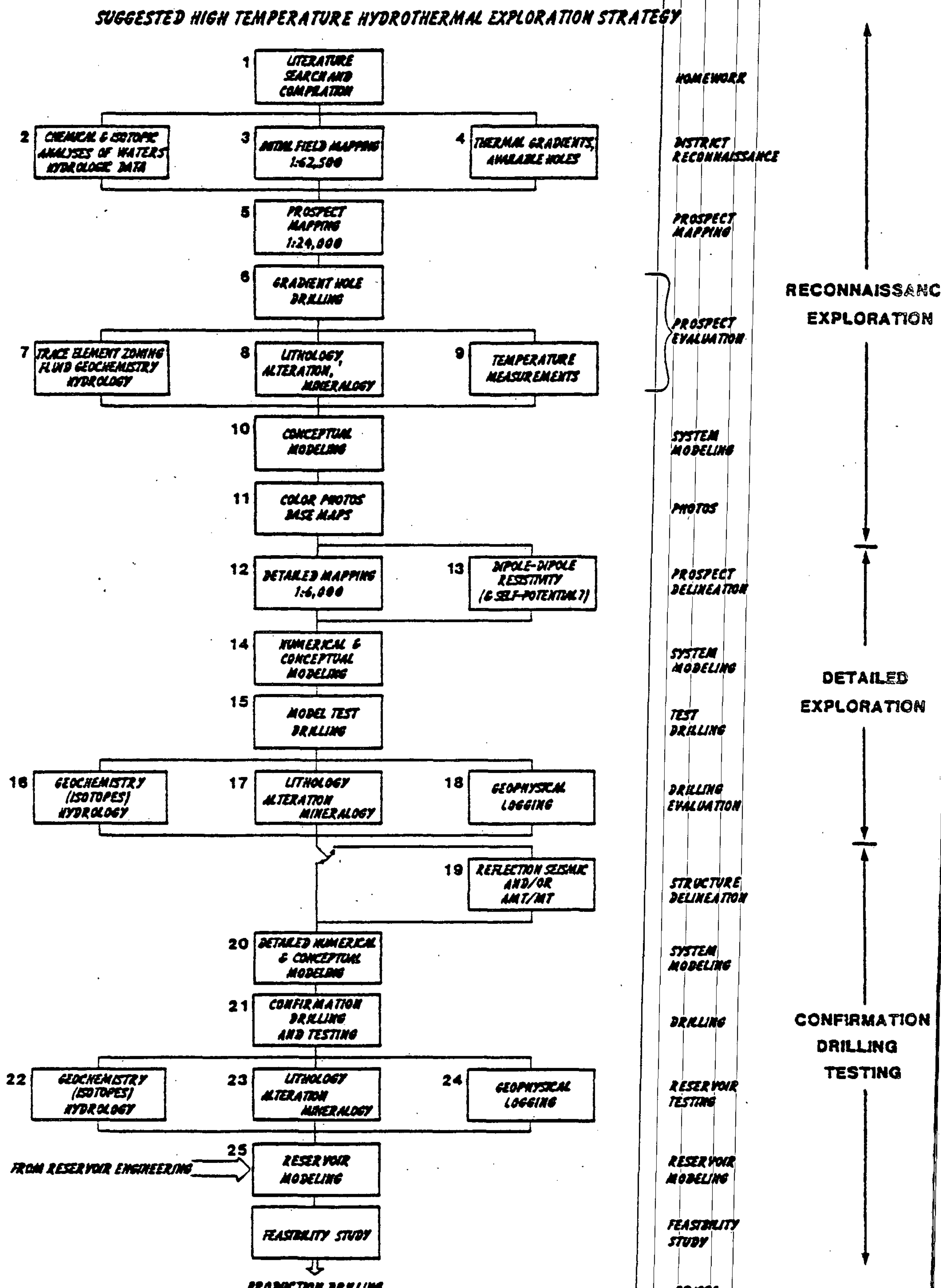
CONCEPTUAL MODEL FOR THERMO HOT SPRINGS



MX-063

SUGGESTED HIGH-TEMPERATURE EXPLORATION STRATEGY APPLIED TO THERMO

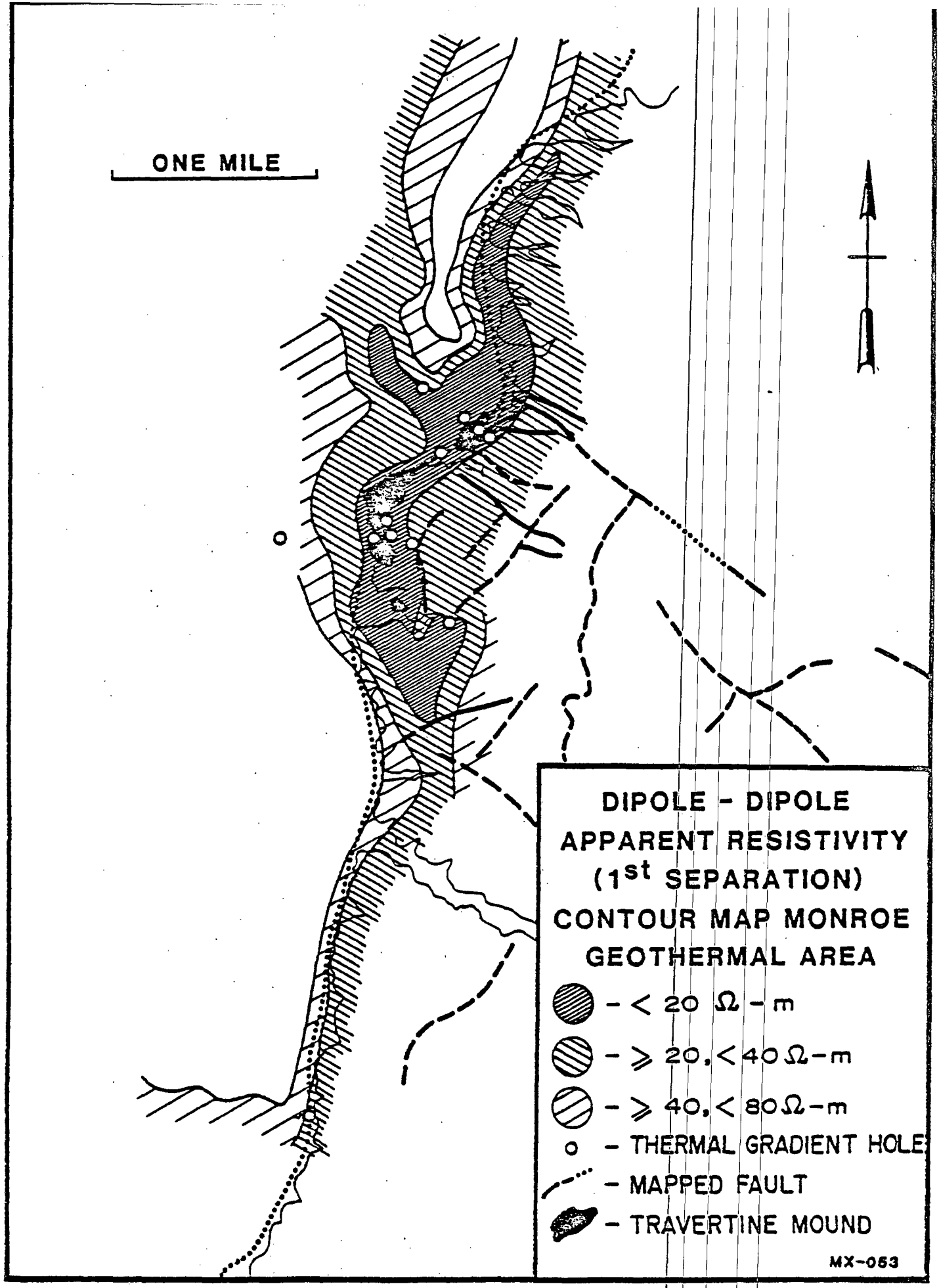
Having both a defined area of exploration and geoscience data compiled from the literature, places the exploration effort well down on the exploration strategy chart. An area is defined which is known to be favorable for the presence of a high-temperature hydrothermal resource and efforts can be concentrated on detailed exploration.


SUGGESTED HIGH TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY
1 LITERATURE SEARCH AND COMPILATION
HOMEWORK
2 CHEMICAL & ISOTOPIC ANALYSES OF WATERS HYDROLOGIC DATA
3 INITIAL FIELD MAPPING 1:62,500
4 THERMAL GRADIENTS, AVAILABLE HOLES
DISTRICT RECONNAISSANCE
5 PROSPECT MAPPING 1:24,000
PROSPECT MAPPING
6 GRADIENT HOLE DRILLING
7 TRACE ELEMENT ZONING FLUID GEOCHEMISTRY HYDROLOGY
8 LITHOLOGY, ALTERATION, MINERALOGY
9 TEMPERATURE MEASUREMENTS
PROSPECT EVALUATION
10 CONCEPTUAL MODELING
SYSTEM MODELING
11 COLOR PHOTOS BASE MAPS
PHOTOS
12 DETAILED MAPPING 1:6,000
13 DIPOLE-DIPOLE RESISTIVITY (& SELF-POTENTIAL?)
PROSPECT DELINEATION
14 NUMERICAL & CONCEPTUAL MODELING
SYSTEM MODELING
15 MODEL TEST DRILLING
TEST DRILLING
16 GEOCHEMISTRY (ISOTOPES) HYDROLOGY
17 LITHOLOGY ALTERATION MINERALOGY
18 GEOPHYSICAL LOGGING
DRILLING EVALUATION
19 REFLECTION SEISMIC AND/OR AMT/MT
STRUCTURE DELINEATION
20 DETAILED NUMERICAL & CONCEPTUAL MODELING
SYSTEM MODELING
21 CONFIRMATION DRILLING AND TESTING
DRILLING
22 GEOCHEMISTRY (ISOTOPES) HYDROLOGY
23 LITHOLOGY ALTERATION MINERALOGY
24 GEOPHYSICAL LOGGING
RESERVOIR TESTING
FROM RESERVOIR ENGINEERING
25 RESERVOIR MODELING
RESERVOIR MODELING
FEASIBILITY STUDY
FEASIBILITY STUDY
PRODUCTION DRILLING
RECONNAISSANCE EXPLORATION
DETAILED EXPLORATION
CONFIRMATION DRILLING TESTING
GG/681

DIPOLE-DIPOLE RESISTIVITY SURVEY

In this scenario, the next step in the exploration sequence may be to run a dipole-dipole electrical resistivity survey to detect the presence of hydrothermal alteration of rocks and of geothermal fluids to depths of 2000-4000 feet. This information would help to define the zone of exploration significance. We would expect to measure low electrical resistivity (high electrical conductivity) over the geothermal system due to the low resistivity of hot, briny fluids and of clay minerals often formed when hydrothermal fluids chemically alter rocks. The data collected would be similar to that shown in the accompanying figure. These data were taken from a resistivity survey of the hot spring area at Monroe, Utah, about 100 miles north-northeast of Thermo.

Other surface exploration work would also be undertaken. This work would include detailed geologic examination and mapping in the immediate area, fill-in gravity work to help delineate the structure of the valley better, and a soil mercury geochemical survey to help locate faults hidden beneath the valley fill material.


ONE MILE
DIPOLE - DIPOLE
APPARENT RESISTIVITY
(1st SEPARATION)
CONTOUR MAP MONROE
GEOTHERMAL AREA
- < 20 Ω - m
- ⩾ 20, < 40 Ω - m
- ⩾ 40, < 80 Ω - m
- THERMAL GRADIENT HOLE
- MAPPED FAULT
- TRAVERTINE MOUND
MX-053

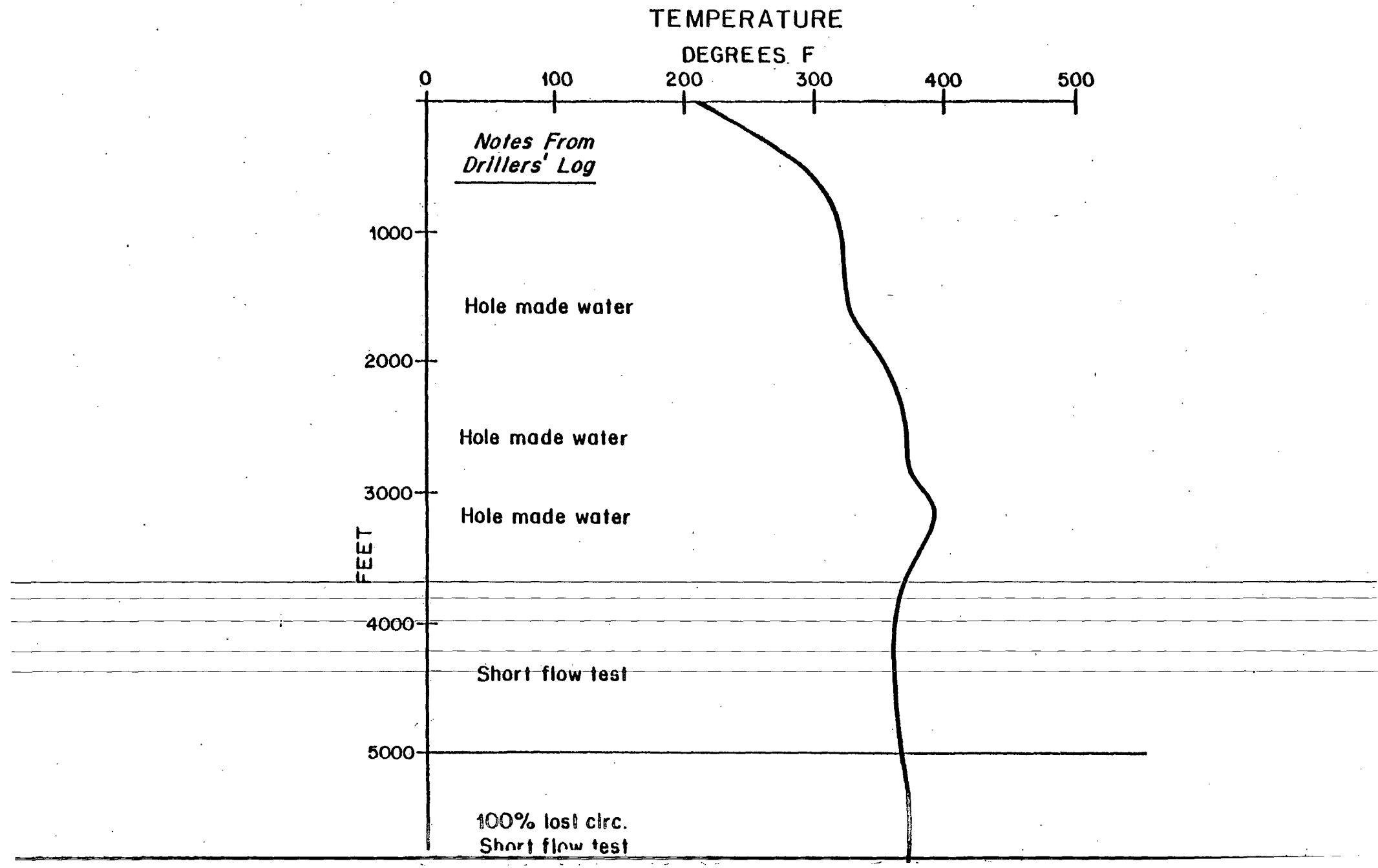
TEMPERATURE LOG OF CONFIRMATION DRILL TEST

On the basis of surface exploration surveys and further temperature gradient drilling it would be possible to site a confirmation drill test hole. The temperature profile shown is a hypothetical profile based on a confirmation well in the Roosevelt Hot Springs geothermal field. In this well the fluid production zones are shown by sharp increases in temperature on the thermal gradient log.

Following drilling the confirmation well would be completed in such a way that short-term and long-term flow tests could be performed. Such tests would be designed and carried out by the reservoir engineering staffs at Republic and EG&G. During flow tests, fluid temperature, pressure, enthalpy, chemistry and production rate would all be measured simultaneously as a function of time, and the flow rate would be controlled at one or more different values. After completion of the flow test, measurements of static fluid level, pressure and temperature profiles would be made as a function of time to determine recovery characteristics of the well. All of these data would be used to predict reservoir temperature, pressure, productivity, and lifetime.

MX/037

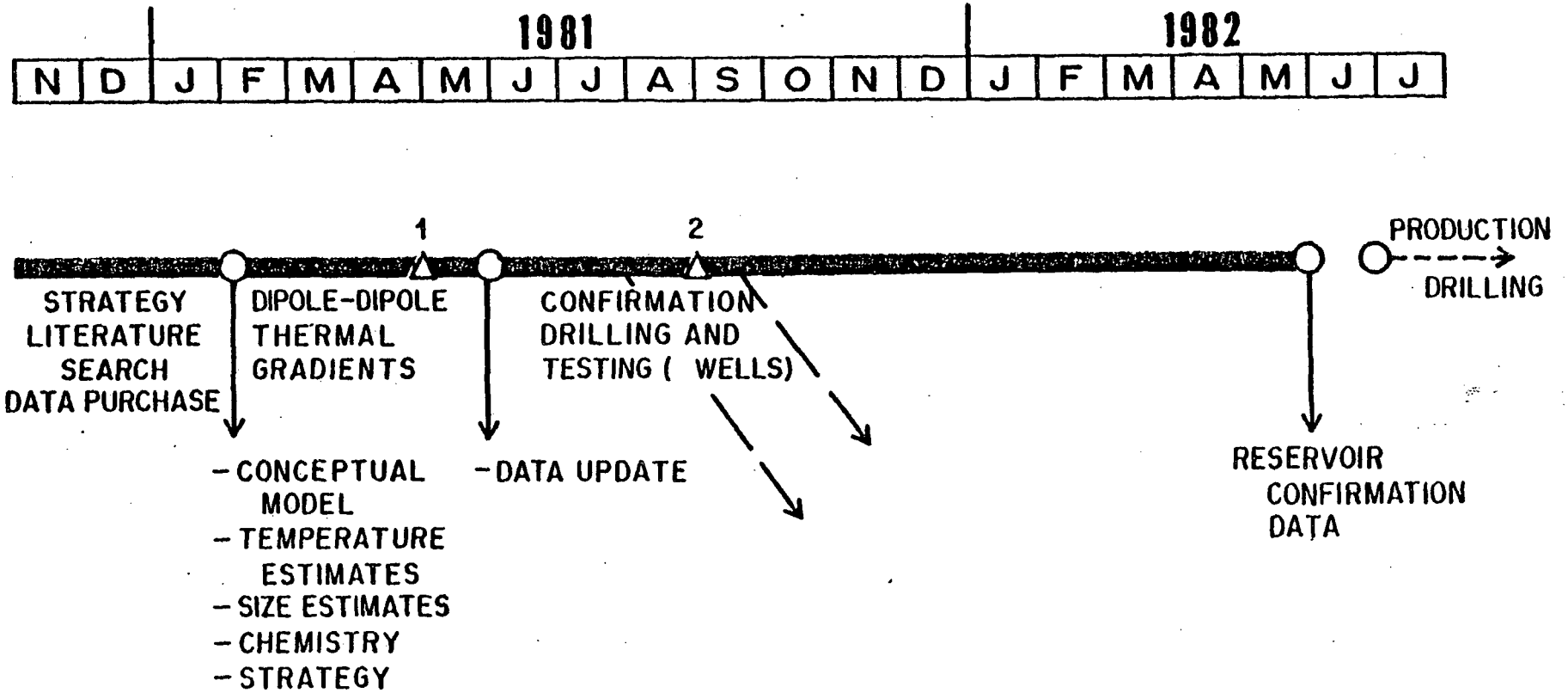
TEMPERATURE LOG OF CONFIRMATION DRILL TEST



MILFORD OB SCENARIO

Under this scenario it is assumed that three holes would be required to confirm the reservoir. During the exploration phases and the confirmation drilling and testing phases, data would be provided to EG&G and to Aerospace as available. For the purposes of this scenario it is assumed that of the three confirmation wells drilled, two would be found to be geothermal producers. The reservoir confirmation stage would be complete by the end of May, 1982. Expenditures to this date on reservoir confirmation would be about $5 million, approximately half of which would be funded by M-X/RES funds.

MILFORD OB SCENARIO



1. INTERIM ASSESSMENT AND DESIGN REPORT

2. PRELIMINARY TASK BRIEFING

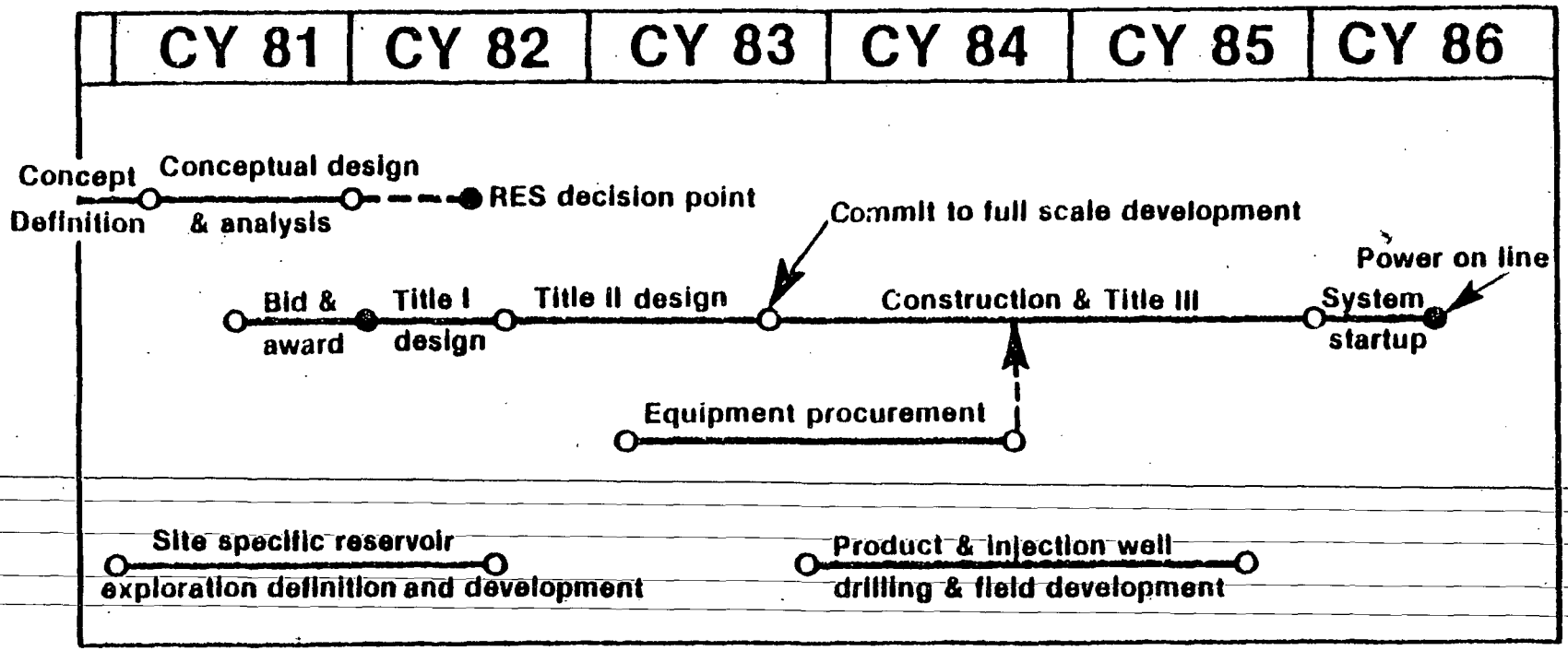
MX/061

MILFORD OB SCENARIO

The facing slide shows the overall plan for the Milford OB Scenario from concept definition to system startup with power on line. The scenario is based on the work necessary to provide a 50 MW(e) electric power plant and space conditioning for the operating base and includes site specific reservoir exploration, definition and development activities in addition to facility design and construction.

M-X/RES Geothermal Applications Development

Milford OB Scenario

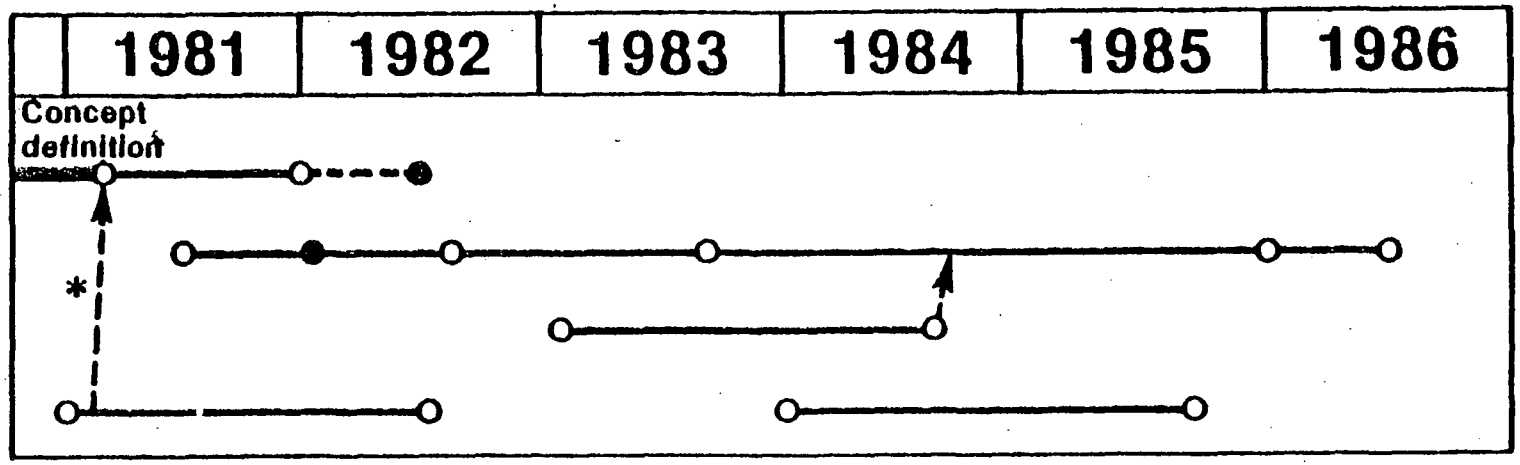


INEL-S-29 183

MILFORD OB SCENARIO

Prior to final confirmation and definition of the reservoir, the most likely geothermal M-X/RES concepts will be formulated. This involves determining which of the applicable technologies can be used to meet the task requirements. The electric generation technologies, for example, would include dry steam, dual flash and binary cycles, and the space conditioning technologies would include heat pumps, radiant heat, forced-air heat, and absorption air conditioning. Optimum methods of using these technologies will be developed for a range of possible conditions.

M-X/RES Milford OB Scenario



Concept definition

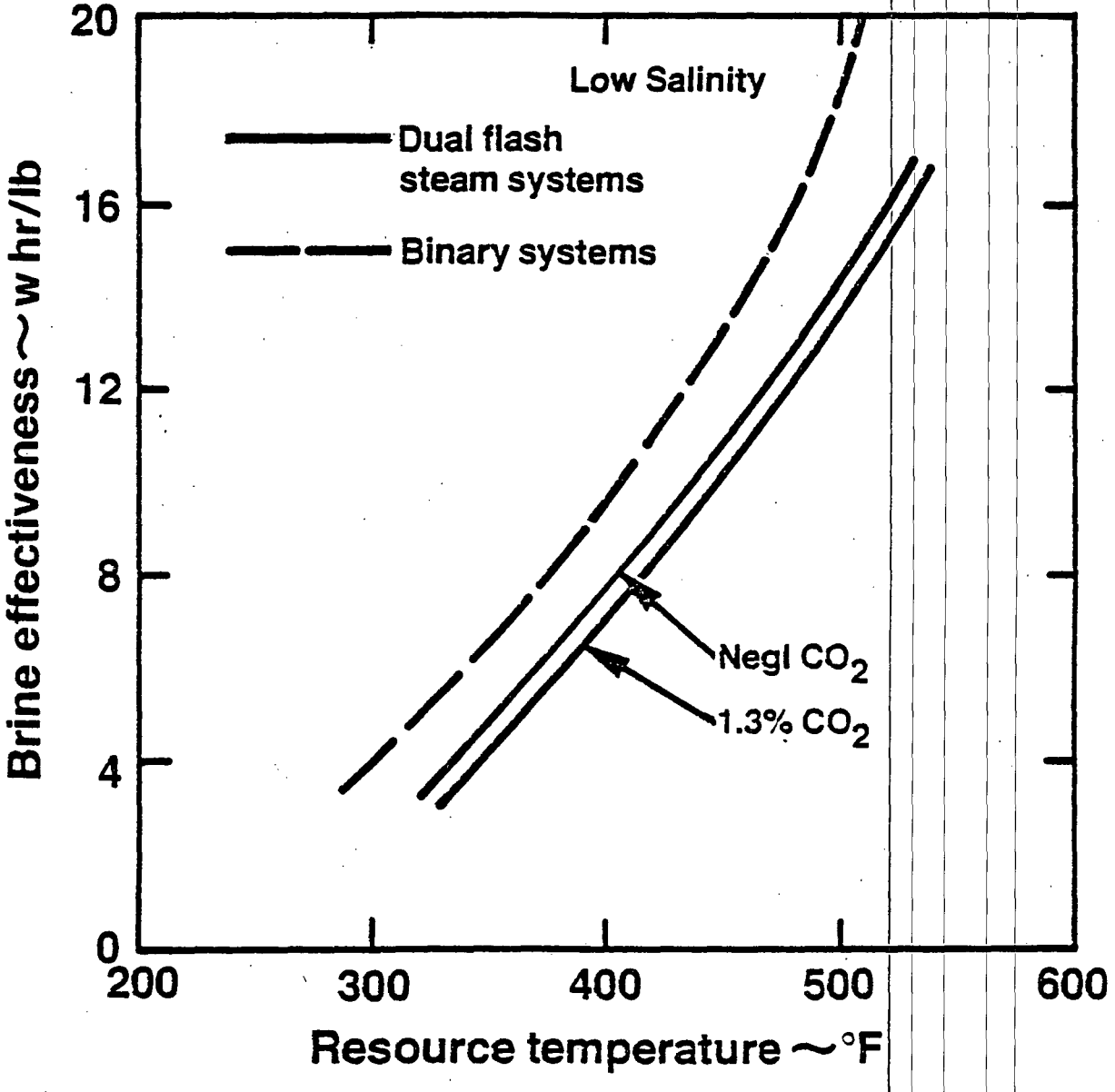
- Scenario/technology tradeoff and strategies
- Generic parameterization
- Socio-institutional issues
- Commercialization issues

* UURI transmits preliminary Milford site-specific reservoir temperature data

MILFORD OB SCENARIO

Generic parameterizations will be developed which will provide a quick means of estimating the economics of the various applications. These would include capital costs and O&M expenses for power plants and space conditioning equipment as a function of resource temperature and other applicable parameters.

Net Brine Effectiveness



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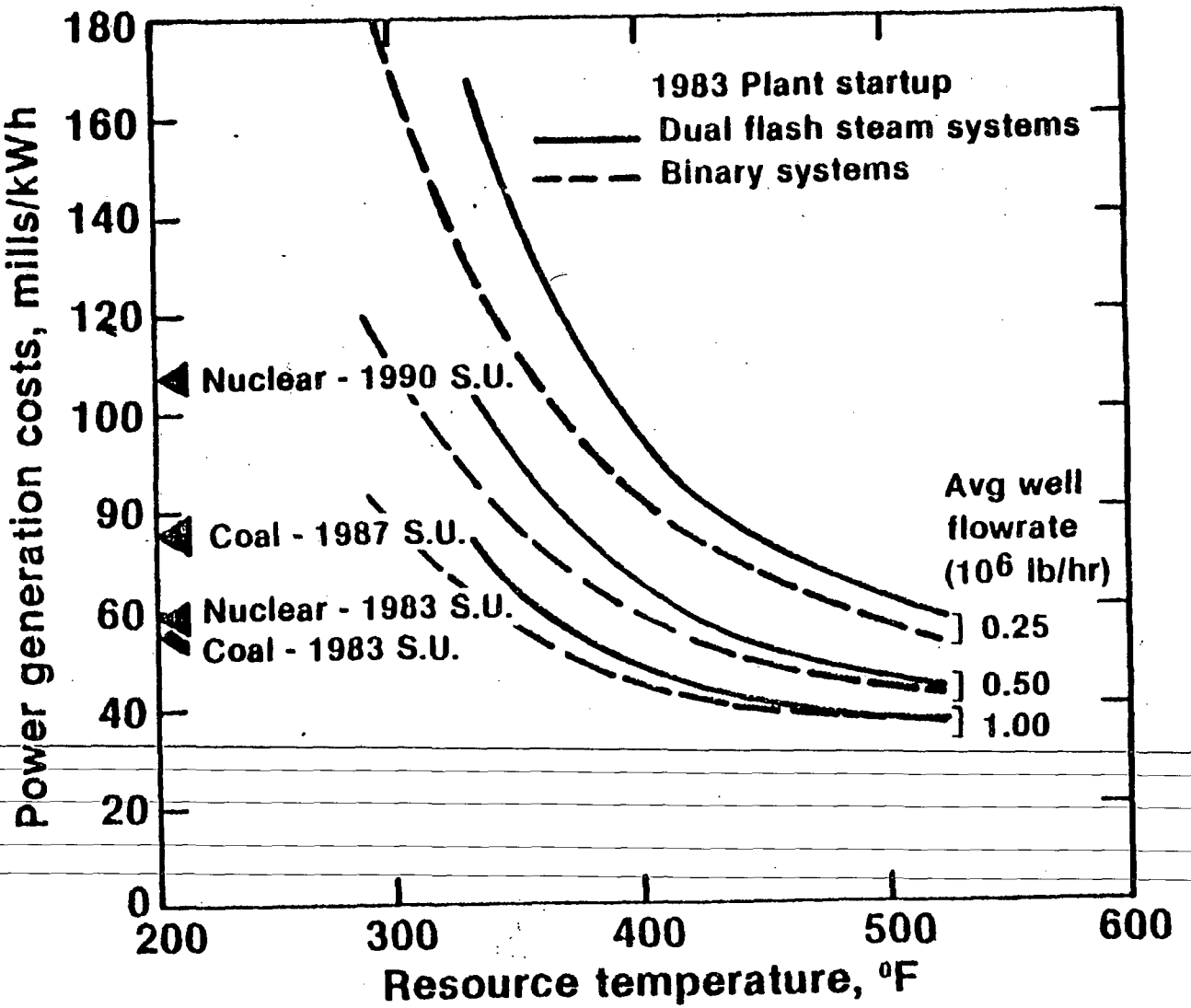
Geothermal Power Generation Costs



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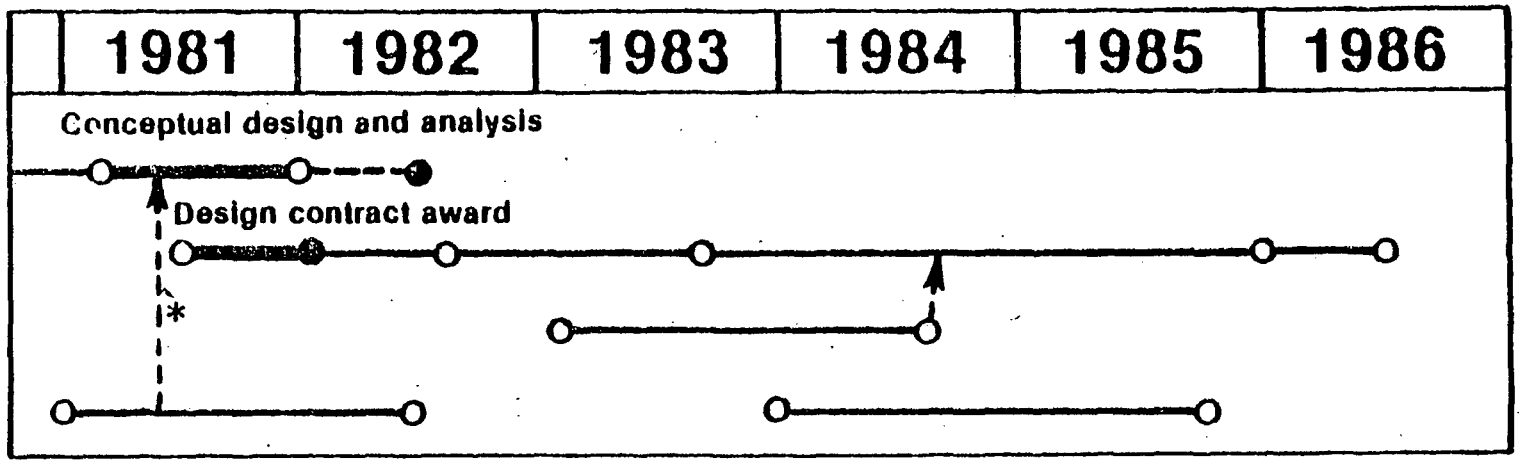
MILFORD OB SCENARIO

Upon receipt of preliminary site specific reservoir information, work will proceed as shown on the facing slide. The conceptual designs for both the 50 MW(e) power plant and space conditioning for the operating base will be developed. The generic parameterizations described previously will be used to estimate the performance characteristics and economics, and analysis necessary to back up the conceptual designs will be performed.

In addition, the work scope will be defined and bid packages will be prepared for transmittal to qualified architect/engineering firms that will cover the final design of the power plant and space conditioning for the operating base. Conclusion of the activity will result in the award of the necessary contracts.

M-X/RES Milford OB Scenario



Site-Specific conceptual design & analysis

- Generic parametrics are refined to reflect Milford data
- Preliminary economic analysis is performed
- Appropriate system concepts are selected
- Conceptual design of system is developed
- Conceptual design performance evaluated

Design contract awarded

- Work scope defined
- Bid package prepared and transmitted
- Bids are prepared by AE's
- AE submittals are reviewed
- Award package is prepared
- Approvals are obtained
- Contract is awarded

*UURI updates reservoir characteristics as more data becomes available

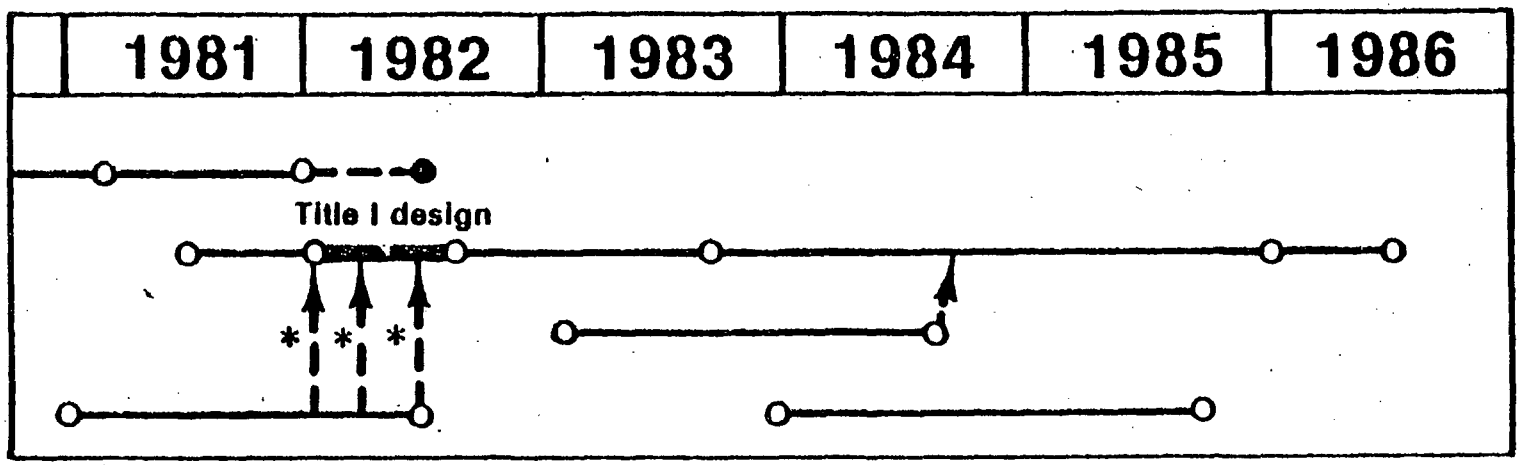
MILFORD OB SCENARIO

After award of the design contracts, the architect/engineers will proceed with Title I design of the 50 MW(e) power plant and space conditioning for the operating base. Conceptual designs will be refined, additional analysis performed, preliminary specifications prepared and other necessary work done to meet the design and performance requirements.

Additional site specific reservoir data resulting from well tests will be integrated into the Title I designs and analysis as it becomes available. The Title I effort will conclude after the necessary design reviews have been performed and approvals obtained to proceed with Title II.

It is during this time period that the decision point is reached regarding the contributions that will be made by the various energy systems to the overall M-X/RES project.

M-X/RES Milford OB Scenario



Preliminary title I design prepared

- Site plans and system layouts developed
- Preliminary specifications prepared
- System performance analyzed
- Implementation plan developed
- Commercialization analysis performed

Detailed task briefing and M-X/RES decision reached

* UURI transmitts reservoir data resulting from 3 well tests and reservoir engineering

MILFORD OB SCENARIO

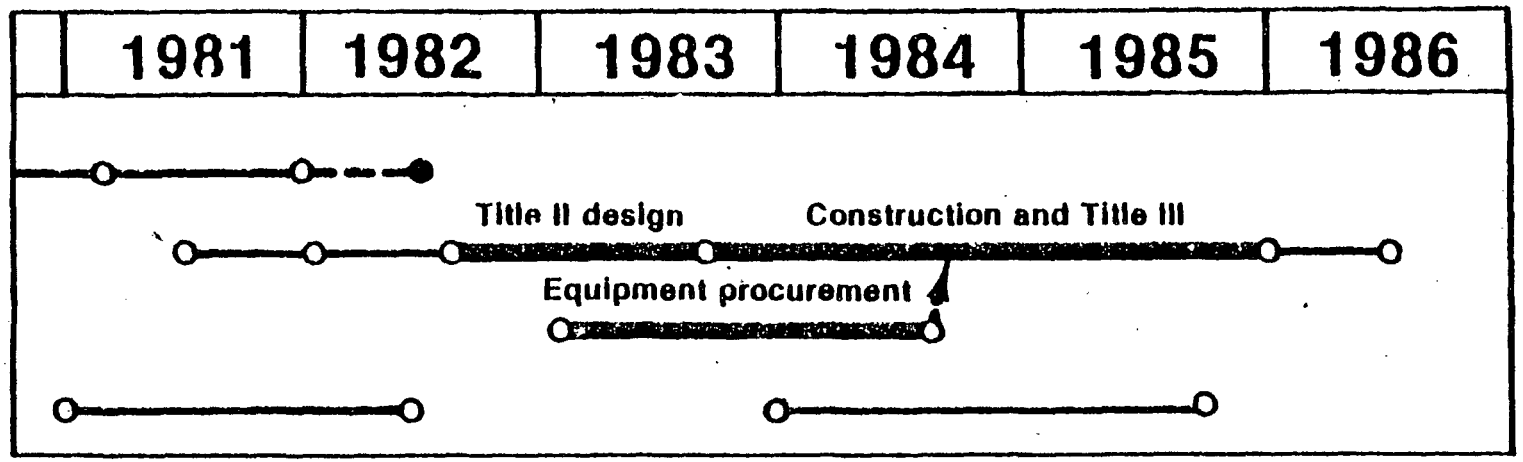
If the decision regarding contributions that will be made by the various energy systems to the overall M-X/RES project is to go ahead, work will be initiated on the Title II designs and analysis for the 50 MW(e) power plant and space conditioning for the operating base.

The architect/engineers will proceed to finalize the drawings, specifications and other Title II documentation. Long lead items will be identified, and some procurement actions initiated.

Initial contacts with construction contractors will be made prior to completion of the Title II design, but contracts will not be awarded for the main construction activities until the Title II design has been reviewed and the necessary approvals obtained to proceed with construction.

The balance of the equipment will be procured after approval of Title II, and this equipment will be installed by the construction contractor as they proceed with their construction activities. The architect/engineer will perform his Title III inspection and "as building" activities, and the facilities will be brought to an operation condition.

M-X/RES Milford OB Scenario

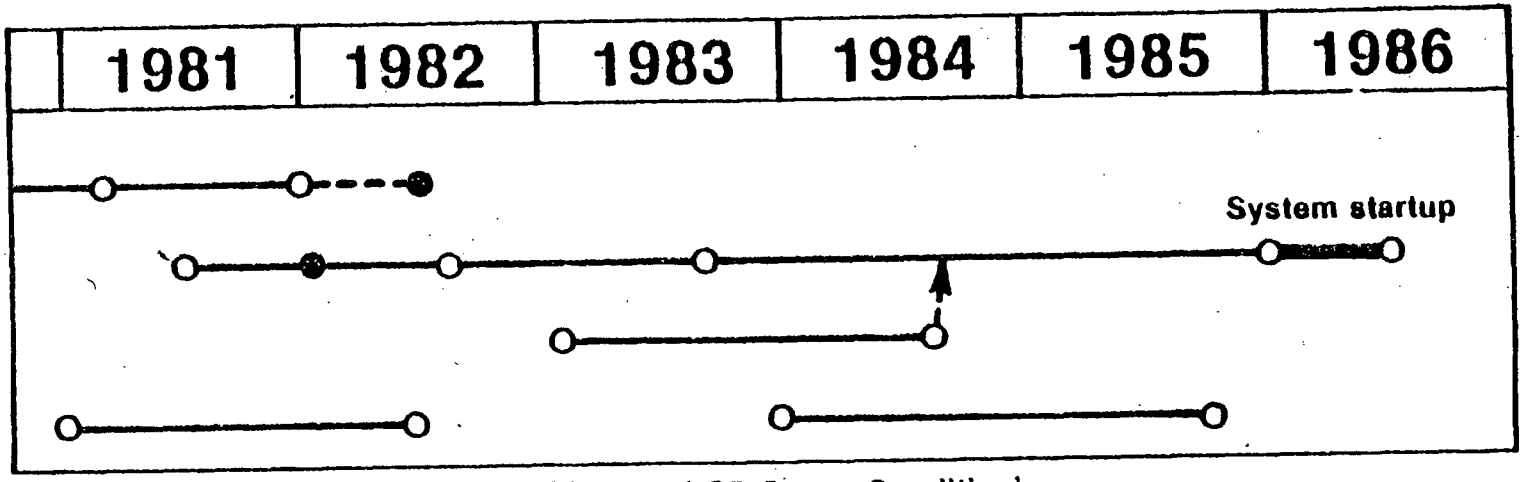


Title II design
- System design finalized
- Design specifications developed
- Engineering drawings produced

Equipment procurement
- Equipment specifications and tests developed
- Bid packages prepared and awarded
- Equipment received

Plant construction and Title III
- Equipment installed and tested
- Inspection activities performed
- Drawings as-built

M-X/RES Milford OB Scenario



System Startup for 50 MWe Power Plant and OB Space Conditioning

- Systems testing
- Personnel training
- Power on line

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M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

SCHEDULE AND EXPENDITURES

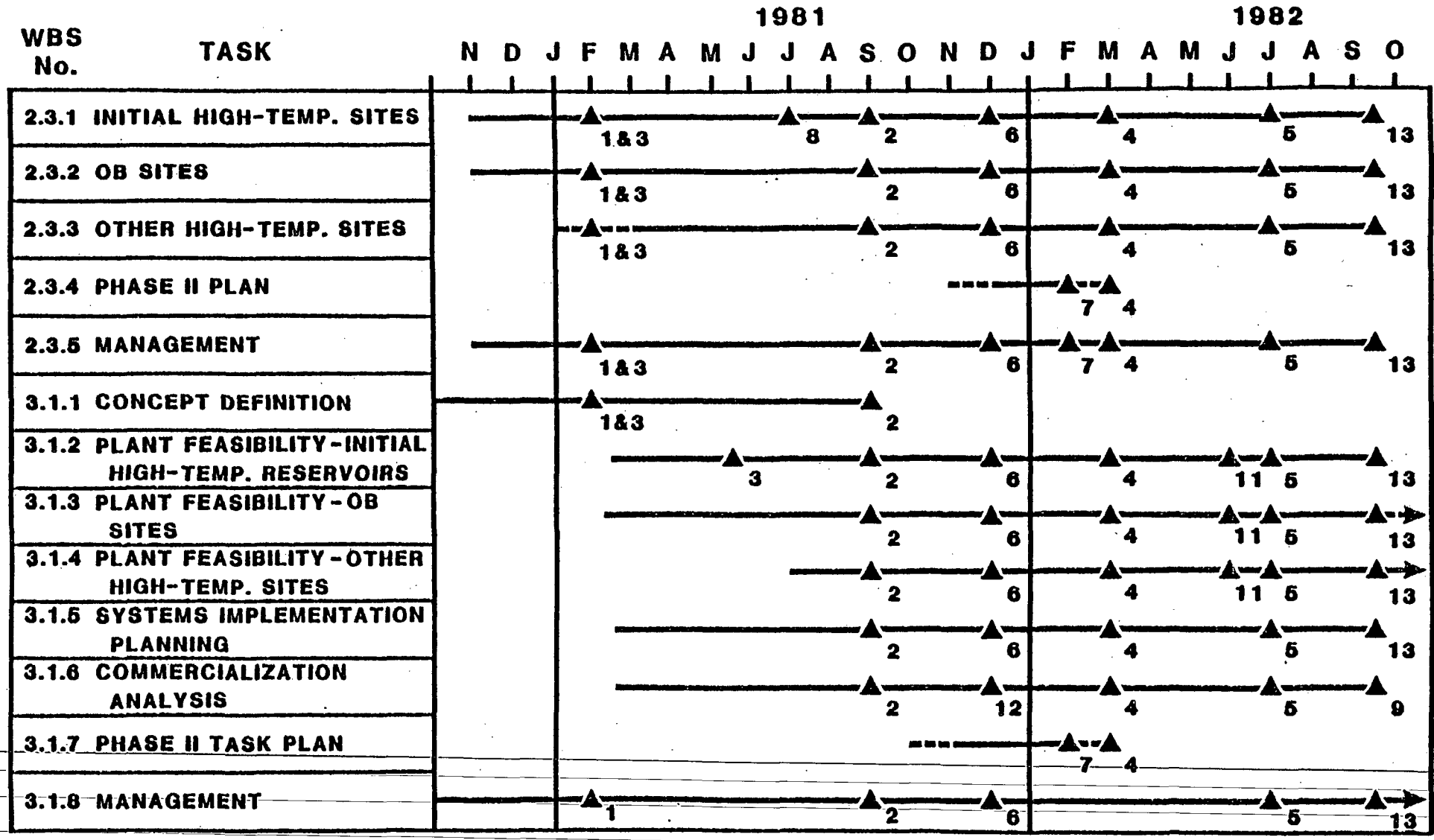
MASTER SCHEDULE

MAJOR MILESTONES AND DELIVERABLES

EXPENDITURE PLAN

MX/059

MASTER SCHEDULE



MILESTONES

1/ Strategy Presentation For Integrated Systems Analysis
2/ Preliminary Task Briefing
3/ Delivery Of Reservoir Data
4/ Detailed Task Briefing
5/ Final Report - Draft
6/ Preliminary Assessment Report
7/ Phase II Task Plan
8/ Interim Assessment and Design Report
9/ Final Commercialization Report
10/ Interim Report On Plant Feasibility Studies
11/ Reservoir Specific Specifications
12/ Interim Commercialization report
13/ Final Report

CONCENTRATED ACTIVITY

PHASING IN & OUT AS APPROPRIATE

MX-007

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK MAJOR MILESTONES AND DELIVERABLES

MILESTONES		DELIVERABLES	
FY1981 WORK INITIATION WITH ESL, EG&G, MMRI, AND UGMS	11/80	DRAFT PHASE I TASK PLAN	11/80
		PHASE I TASK PLAN	TBD
TASK PLAN APPROVAL	12/80		
RESERVOIR DATA AVAILABLE	2/81	STRATEGY PRESENTATION FOR INTEGRATED SYSTEMS ANALYSIS	2/81
INITIAL APPLICATION CONCEPT DEFINITION STUDIES AVAILABLE	2/81		
CONTRACTS IN PLACE FOR CONSORTIA FEASIBILITY STUDIES OF EXISTING HIGH -TEMPERATURE SITES	3/81		
		INTERIM ASSESSMENT AND DESIGN REPORT-INITIAL HIGH-TEMP SITES	7/81
PRELIMINARY TASK BRIEFING	9/81		
		PRELIMINARY REPORT ASSESSING RESOURCE AND APPLICATIONS POTENTIAL	12/81
		INTERIM COMMERCIALIZATION REPORT	12/81
		PHASE II TASK PLAN	2/82
DETAILED TASK BRIEFING	3/82	DETAILED TASK BRIEFING ANNOTATION	3/82
		RESERVOIR SPECIFIC HIGH-TEMPERATURE & LOW-TEMPERATURE SYSTEM SPECS	6/82
PHASE II TASK PLAN APPROVAL	TBD		
		FINAL PHASE I GEOTHERMAL RESOURCE AND APPLICATIONS DEVELOPMENT REPORT	9/82
		FINAL PHASE I COMMERCIALIZATION REPORT	9/82

FY 1981 EXPENDITURE PLAN

This chart identifies planned expenditure by contractor and WBS element during FY 1981. It assumes the initial availability of cost and obligational authority equal to or exceeding that requested by memorandum dated 27 October 1980 (A. J. Roberts to R. A. Gray - titled Near-Term Funding Requirement/MX Geothermal Assessment and Applications Task).

Contained within the estimates for UGMS and MMRI is funding to drill a combined total of forty 500-feet deep holes to assess the temperature gradients at sites in proximity to the candidate Operating Base locations and at several potential Other High-Temperature Sites. Additionally, allowance has been made for the initiation of several 1500-feet deep holes to analyze the stratigraphy of potential geothermal sites identified as a result of the gradient hole drilling.

As identified earlier, a major activity in resource verification is deep well drilling. Present estimates indicate that the drilling and testing of one 6,000-feet deep geothermal well results in the expenditure of from $1.25 million to $1.5 million. Past experience in sharing drilling and testing costs with industry indicates that they might be induced to incur as much as 40% to 50% of the cost. This experience implies that planned FY 1981 funding will provide for as few as one or two deep holes, a circumstance determined to be quite inadequate as discussed further below.

The parallel approach of investigation planned for the task provides for simultaneous concentration on three regions of potential geothermal resource as detailed previously. This multipath approach was chosen to increase the likelihood of successful identification by June 1982 of resources that would generate electrical power of significant proportions in relation to M-X System requirements. It would be quite reasonable to plan for the drilling of wells associated with each of the investigative paths.

Funding for drilling of one to two deep holes does not allow complete support of the multipath approach. An alternative solution to this problem could of course be the provision of additional funding in FY 1981.

Please note at the bottom of the chart that both the DOE field offices and DOE/DGE are planning the use of Task funding for travel and per diem expenditures.

FY 1981 EXPENDITURE PLAN

MX GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT PLAN

($000's)

WBS ELEMENT	DOE/ID CONTRACTORS ESL	EG&G	UGMS	DOE/NV CONTRACTORS MMRI	COST-SHARED DRILLING	INITIAL ELEC FEAS	FY 1981 TOTAL
2.3 GEOTHERMAL ASSESSMENT	660	75	1280	1270	1425		4760
2.3.1 INITIAL HI TEMP SITES	315	25	-	-	750	-	1090
2.3.2 OPERATING BASE SITES	135	25	715	636	250	-	1761
2.3.3 OTHER HI TEMP SITES	130	25	547	608	475	-	1785
2.3.4 PHASE II TASK PLAN	30	-	-	-	-	-	30
2.3.5 MANAGEMENT	50	-	18	26	-	-	94
3.1 APPLICATIONS DEVELOPMENT	200	665	-	-	-	350	1215
3.1.1 CONCEPT DEFINITION	-	225	-	-	-	-	225
3.1.2 PLANT FEAS - INIT HI TEMP SITES	-	60	-	-	-	350	410
3.1.3 PLANT FEAS - O/B SITES	-	38	-	-	-	-	38
3.1.4 PLANT FEAS - OTH HI TEMP SITES	-	22	-	-	-	-	22
3.1.5 SYST IMPLEMENT PLANNING	200	108	-	-	-	-	308
3.1.6 COMMERCIALIZATION ANALYSIS	-	86	-	-	-	-	86
3.1.7 PHASE II TASK PLAN	-	-	-	-	-	-	-
3.1.8 MANAGEMENT	-	126	-	-	-	-	126
SUBTOTAL	860	740	1280	1270	1500	350	5975
FIELD OFFICE TRAVEL & PER DIEM	-	-	8	-	-	8	16
DOE/DGE TRAVEL & PER DIEM	-	-	-	-	-	-	9
TOTAL							6,000

FY 1982 EXPENDITURE PLAN

Planned FY 1982 expenditures by contractor and WBS element are identified on this chart. The plan provides for continuity of the preceding year's exploration and confirmation and an escalation in drilling and applications development activities. Plans anticipate the performance of several site specific conceptual designs relating to electric power generation from identified reservoirs. Current estmates indicate that such efforts would require approximately $800K per site. EG&G's plan carries the funding for these activities in each of the three paths of approach. The division of this effort along each of the paths may not be supported by resource identification and therefore is at this time only representative of the possibility of provision of electricity from utility and/or DOD-owned generating plants located near an operating base as well as in the deployment area.

Estimates for cost-shared deep drilling allow from four to six holes to be completed in FY 1982. This would be an aggregate of five to eight deep wells, provided that all were performed on a cost-shared basis with industry. Difficulties in obtaining the participation of industry would result in a reduction in the number of holes that could be drilled and hence the number of sites for whch reservoir analysis could take place. Drilling estimates have been distributed among the three paths of approach for consistency with the applications developent funding.

FY 1982 EXPENDITURE PLAN

MX GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT PLAN

($000's)

WBS ELEMENT	DOE/ID CONTRACTORS ESL	DOE/ID CONTRACTORS EG&G	DOE/ID CONTRACTORS UGMS	DOE/NV CONTRACTORS MMRI	DOE/NV CONTRACTORS COST-SHARED DRILLING	DOE/NV CONTRACTORS INITIAL ELEC FEAS	FY 1982 TOTAL
2.3 GEOTHERMAL ASSESSMENT	850	0	1200	1200	4400		7650
2.3.1 INITIAL HI TEMP SITES	200	-	0	0	1600	-	1800
2.3.2 OPERATING BASE SITES	350	-	550	350	800	-	2050
2.3.3 OTHER HI TEMP SITES	200	-	580	775	2000	-	3555
2.3.4 PHASE II TASK PLAN	50	-	50	50	-	-	150
2.3.5 MANAGEMENT	50	-	20	25	-	-	95
3.1 APPLICATIONS DEVELOPMENT	200	3120	0	0	-	-	3320
3.1.1 CONCEPT DEFINITION	-	50	-	-	-	-	50
3.1.2 PLANT FEAS - INIT HI TEMP SITES	-	800	-	-	-	-	800
3.1.3 PLANT FEAS - O/B SITES	-	1000	-	-	-	-	1000
3.1.4 PLANT FEAS - OTH HI TEMP SITES	-	800	-	-	-	-	800
3.1.5 SYST IMPLEMENTATION PLANNING	100	170	-	-	-	-	270
3.1.6 COMMERCIALIZATION ANALYSIS	100	100	-	-	-	-	200
3.1.7 PHASE II TASK PLAN	-	50	-	-	-	-	50
3.1.8 MANGAGEMENT	-	150	-	-	-	-	150
SUBTOTAL	1050	3120	1200	1200	4400	-	10970
FIELD OFFICE TRAVEL & PER DIEM	-	-	-	-	-	-	20
DOE/DGE TRAVEL & PER DIEM	-	-	-	-	-	-	10
TOTAL							11,000

PROPOSED FUNDING REVISION

This chart proposes a revision in planned fiscal year funding for FY 198 and FY 1982. The inadequacy of FY 1981 funding for drilling has been previously indicated. While funding during the total three year period appears adequate as of this stage of planning, it would be desirable to shift approximately $2,000K in funding from FY 1982 to FY 1981 for use in deep well drilling.

Since completion of the drilling and testing of as many as four or five wells in FY 1981 is somewhat unlikely, the funding revision request is an over simplification of a requirement for more obligating authority (B/A). Sufficient B/A would be needed to enter into contracts for that drilling, but quite likely cost authority (B/O) of the same magnitude would not be needed.

PROPOSED FUNDING REVISION
M-X GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK
($000)

WBS ELEMENT	PLANNED FUNDING FY 1981	PLANNED FUNDING FY 1982	PLANNED FUNDING FY 1983	PROPOSED REVISED FUNDING FY 1981	PROPOSED REVISED FUNDING FY 1982	PROPOSED REVISED FUNDING FY 1983
2.3 GEOTHERMAL ASSESSMENT	4760	7650	4010	6760	5650	4010
3.1 APPLICATIONS DEVELOPMENT	1215	3320	4960	1215	3320	4960
DOE TRAVEL	25	30	30	25	30	30
TOTALS	6,000	11,000	9,000	8,000	9,000	9,000

MX-083

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

SUMMARY

OBJECTIVES

STRATEGY

DATA FLOW

STATUS

NEAR-TERM PLANS

OBJECTIVES HIERARCHY

This figure related the geothermal activities to the top-level M-X/RES Project objectives, and shows how the proposed M-X/RES Geothermal Assessment and Applications Development Task is designed to accomplish these top-level objectives.

M-X/RES PROJECT GEOTHERMAL TASK

PHASE 1 OBJECTIVES HIERARCHY

DEFINE INTEGRATED RES OPTIONS THAT COULD
- **PROVIDE RELIABLE POWER FOR M-X**
- **ACCELERATE RES COMMERCIALIZATION**

DEVELOP DECISION PACKAGE BY MID '82 TO SUPPORT USAF DECISIONS ON
- **RES MIX**
- **RES ACQUISITION STRATEGIES**
- **COMMERCIAL INCENTIVES**

IDENTIFY FEASIBLE CANDIDATE SYSTEMS FROM OTHER RES TECHNOLOGIES

IDENTIFY FEASIBLE GEOTHERMAL APPLICATIONS SYSTEMS: DETERMINE HOW, AT WHAT COST, AND ON WHAT SCHEDULE GEOTHERMAL ENERGY COULD BE DELIVERED TO M-X, WHILE BENEFITING THE COMMERCIAL COMMUNITY

CHARACTERIZE GEOTHERMAL RESOURCE SITES IN OR ADJACENT TO THE M-X DEPLOYMENT AREA (2.3)
- **EXPLORE, CONFIRM, AND DEVELOP CASE STUDIES FOR GEOTHERMAL RESERVOIRS**
- **PLAN PHASE II ACTIVITIES**

DETERMINE PLANT FEASIBILITIES AND RESERVOIR SPECIFIC DESIGNS FOR ELECTRICAL AND DIRECT HEAT APPLICATIONS (3.1)
- **DEFINE CONCEPT, APPROACH**
- **DETERMINE PLANT FEASIBILITY FOR CONFIRMED RESERVOIRS**
- **PLAN SYSTEMS IMPLEMENTATION**
- **IDENTIFY COMMMERCIALIZATION IMPACTS**
- **PLAN PHASE II ACTIVITIES**

MX-028

SUMMARY OF GEOTHERMAL STRATEGY

This chart summarizes the planned strategy for the M-X/RES Geothermal Task. Exploration and reservoir confirmation activities will be carried out at selected sites in these separate groups;

1) the presently known, Initial High-Temperature Sites that lie outside of the deployment area and are deemed to have high potential for supplying a substantial portion of the M-X System electrical requirements;
2) the near-vicinity (within 5 miles) of the candidate Operating Base sites. We expect that any resources found here would be lower in temperature, probably suitable for space conditioning loads. One known exception is at the Miford Candidate OB, where potential for electrical power generation exists from the Thermo KGRA;
3) within and immediately adjacent to the deployment area there is potential for discovery of now unknown high temperature sites suitable for electrical power generation.

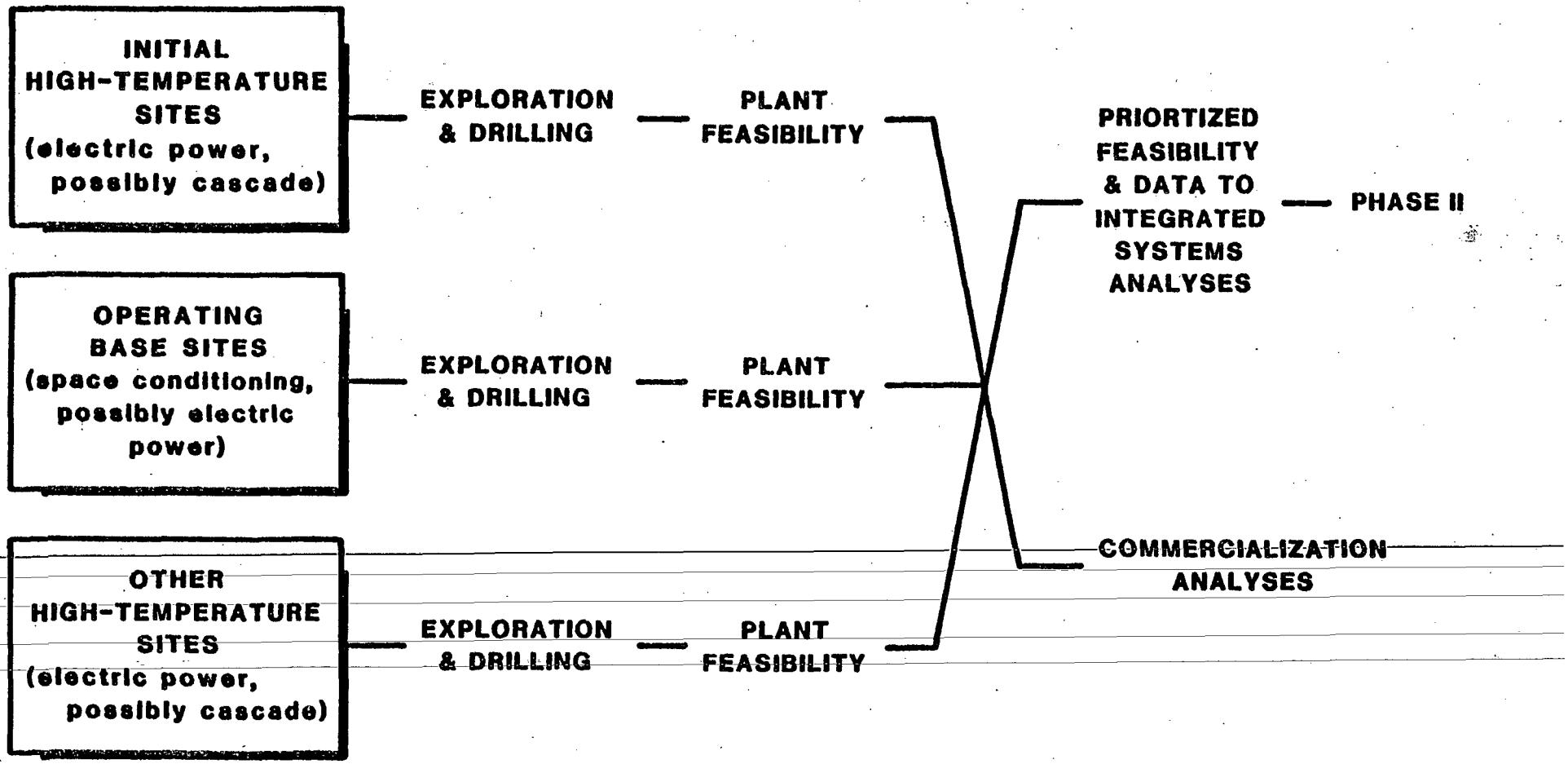
One resource information is in hand and the results of generic plant studies are understood, the highest priority sites and applications can be selected. Further drilling and reservoir specific plant feasibility studies will then be used to determine the candidate systems for submission to Integrated Systems Analysis. At the same time all resource and applications data will be analyzed for commercialization impact and impact on state-of-the-art.

MX/033

M-X/RES PROJECT

GEOTHERMAL TASK

SUMMARY OF GEOTHERMAL STRATEGY



MX/033

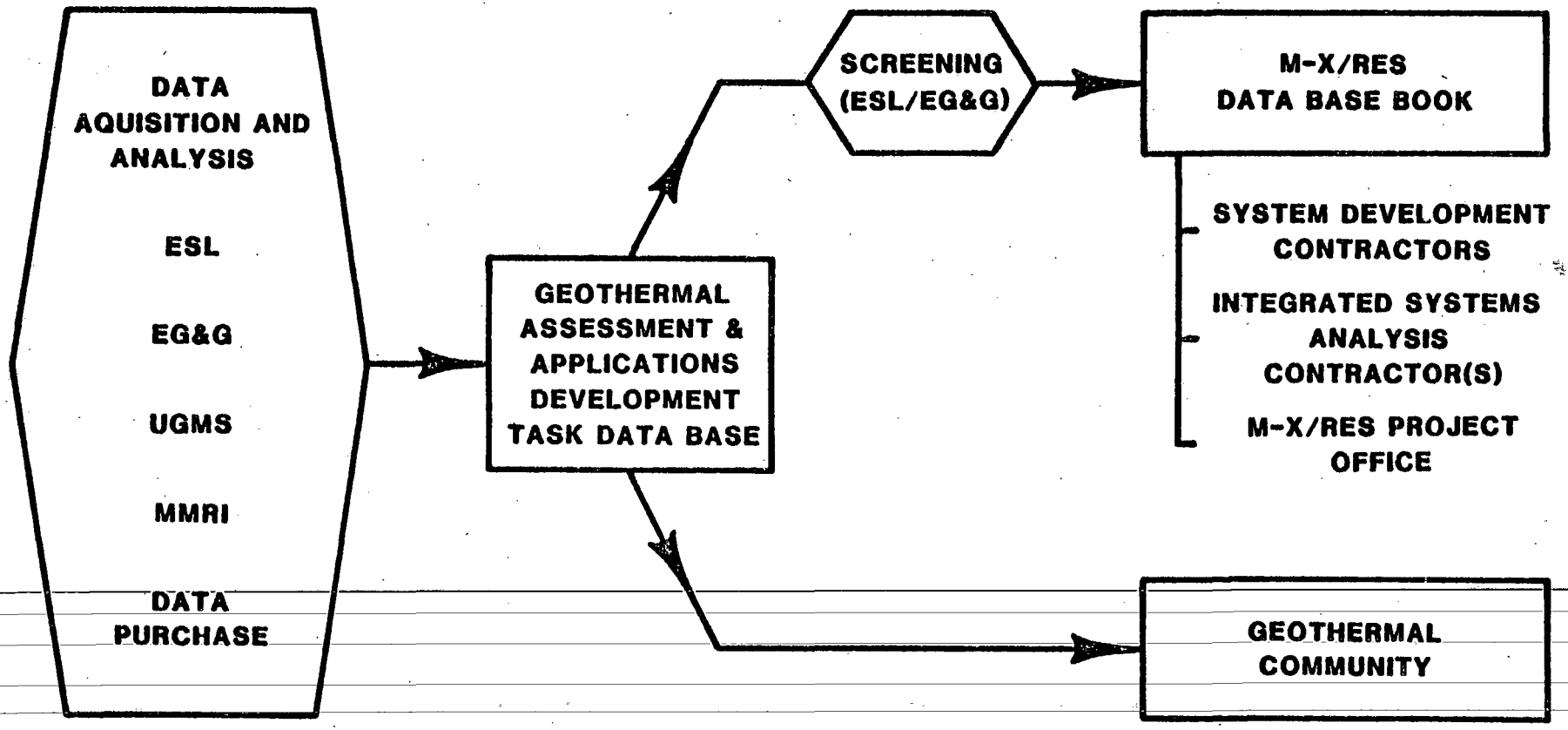
DATA FLOW

The flow of geothermal assessment and applications development data is depicted on this graph. All M-X/RES geothermal data will flow to a central Geothermal dAta Base at ESL. Slected and approved, nonproprietary, porions of these data will be released to the public in a timely manner to facilitate private exploration and commercialization. The resource and applications data bases will receive thorough analyses and screening by contractors, principally by ESL and EG&G, and selected data and complete analyses will be forwarded for inclusion in the M-X/RES Data Base Book and for analyses by the GSE/I contractor(s).

MX/030

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

DATA FLOW



MX/030

STATUS

The status of the M-X/RES Geothermal Assessment and Applications Deveopment Task is shown on this slide. A substantial amount of progress has been made in project planning and in identifying sources of data and technical assistance for successful accomplishment of the Task.

The next step is critical review with modifications, if needed, and approval of the Task plans as outlined in this briefing. DGE would then be ready to proceed with implementation as seen as funding is made available.

M-X/RES GEOTHERMAL TASK

STATUS

- DOE MANAGEMENT STRUCTURE ESTABLISHED
- EXPERIENCED CONTRACTORS IDENTIFIED, READY TO GO:ESL, EG&G, MMRI, UGMS
- WORKING RELATIONSHIP WITH AEROSPACE AND FUGRO ESTABLISHED
- STRATEGY & CONCEPT DEFINITION WORK IN PROGESS
- TASK MANAGEMENT PLAN IN PREPARATION
- SOURCES OF RELEVANT DATA IDENTIFIED
  - INDUSTRY COUPLED PROGRAM
  - STATE COUPLED PROGRAM
  - RAFT RIVER, ID, GEOTHERMAL DEMONSTRATION PLANT
  - DOE DIRECT HEAT DEMONSTRATION PROJECTS
  - FUGRO DATA
  - NEVADA ELECTRIC POWER CONSORTIUM DESIGN STUDIES
  - ROOSEVELT ELECTRIC POWER & CASCADE UTILIZATION STUDIES

→ FUNDING NEEDED TO PROCEED

NEAR-TERM PLANS

After approach and funding of the proposed plan contained herein, DGE and its contractors would begin immediately to work on the activities outlined in this figure.

M-X/RES PROJECT
GEOTHERMAL TASK

NEAR-TERM PLANS

- COMPLETE TASK MANAGEMENT PLAN
- BEGIN GENERIC FEASIBILITY STUDIES
- ACQUIRE AVAILABLE INDUSTRY RESOURCE DATA & STUDIES
- ACQUIRE AVAILABLE APPLICATIONS AND CONCEPTUAL DESIGN STUDIES
- IDENTIFY AND IMPLEMENT FUGRO SUPPORT
- REVIEW RESOURCE AND APPLICATIONS DATA ON INITIAL HIGH-TEMPERATURE SITES AND SELECT 1 OR 2 FOR DRILLING
- BEGIN GEOLOGIC RECONNAISSANCE OF DEPLOYMENT AREA
  - RECONNAISSANCE IN VICINITY OF OPERATING BASES
  - BROAD RECONNAISSANCE FOR OTHER HIGH-TEMPERATURE SITES

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

DISCUSSION AND RESPONSE

MX-055

DISCUSSION AND RESPONSE

- DOES THE PLAN MEET EXPECTATIONS ?
- IS THE CONTRACTING PLAN ACCEPTABLE ?
- WHAT FUNDING/SCHEDULE SHOULD BE EXPECTED ?
- CAN FUNDING BE SHIFTED FROM FY 81 TO FY 82 ?
- ARE THERE ANY FURTHER CONSTRAINTS THAT SHOULD BE CONSIDERED ?
  - a. HYBRID SYSTEMS HAVE NOT BEEN CONSIDERED
  - b. A DEDICATED DISTRIBUTION IS NECESSARY FOR CENTRALIZED GEOTHERMAL APPLICATIONS
- SHOULD WE PROCEED AS PRESENTED ?

GLOSSARY OF TERMS

BINARY PLANT - A plant in which the vapor of a secondary working fluid, such as an organic solvent is used to generate electricity and heat for vaporizing the secondary fluids provided by geothermal fluids.

CASCADING - Using the same geothermal fluid successively in more than one application.

CONFIRMATION DRILLING - Drilling in a geothermal resource area for purposes of establishing the occurrence of thermal fluids sufficient in temperature, quality and quantity for economic application.

CONFIRMED RESERVOIR - A discovery site at which drilling and flow testing have proven a sufficient resource to support economic use.

CONVECTIVE HYDROTHERMAL SYSTEM - A geothermal system in which there is heating and convection of naturally occurring fluids.

DISCOVERY - A site at which a successful well has been drilled and flow tested.

DISCOVERY HOLE - An exploration hole that intersects fluids of sufficient temperature and flow rate to suggest an economic resource.

EXPLORATION - Use of geology, geochemistry, geophysics, hydrology, and drilling for resource discovery (reconnaissance, detailed).

EXPLORATORY DRILLING - Drilling in a prospective geothermal resource area primarily for geologic information that bears on the nature of the resource.

FLASHED STEAM PLANT - Plant in which generators are powered by steam formed (flashed) directly from high temperature geothermal water.

GEOTHERMAL APPLICATIONS - Use of the energy in geothermal fluids produced from a geothermal reservoir.

GEOTHERMAL ASSSESSMENT - Exploration, drilling, flow testing and reservoir engineering activities designed to discover, confirm and obtain production from a geothermal reservoir.

GEOTHERMAL ENERGY - Natural heat from the earth.

GEOTHERMAL OCCURRENCE - A documented expression of the existance of a geothermal system such as a hot spring or a well containing warm water.

GEOTHERMAL PROSPECT - A site that has geothermal indications such as a thermal spring or well, favorable chemical geothermometers, anamolous geothermal graident or heat flow, or favorable geology.

GEOTHERMAL RESOURCES - Stored heat in the earth, both identified and undiscovered, that is recoverable using current or near-current technology, regardless of cost.

GEOTHERMAL RESOURCE TEMPERATURES -

LOW-TEMPERATURE GOETHERMAL RESOURCE - A geothermal resource whose temperature is in the range ($5^{o}C$ above mean ambient air temperature $\leq$ 90^{o}).

INTERMEDIATE-TEMPERATURE GOETHERMAL RESOURCE - A geothermal resource whose temperature is in the range ($90^{o}C \leq T \leq 150^{o}C$).

HIGH-TEMPERATURE GEOTHERMAL RESOURCE - A geothermal resource whose temperature is ($T > 150^{o}C$).

HYBRID SYSTEM - An application where part of the energy is geothermal and part is from another source such as coal or solar.

KNOWN GEOTHERMAL RESOURCE AREA (KGRA) - An area legally designated by the U.S. Geological Survey to be of interest and have high potential for development of geothermal resources, especially high temperature resources.

MWe - Megawatts of electrical energy.

MWt - Megawatts of thermal energy.

LIQUID DOMINATED - Geothermal reservoir which contains liquid as the dominant fluid. Temperatures may be in excess of $300^{o}C$.

PRODUCTION DRILLING - Drilling of geothermal wells in a confirmed reservoir for purposes of developing geothermal fluids in sufficient quantity for application. This usually requires large diameter wells (7-12") that have been fitted with appropriate well head equipment and liners.

REINJECTION - Returning of the geothermal fluids to the reservoir after their use in electrical power generation or beneficial heating.

RESOURCE ASSESSMENT - Geoscientific work including exploratory drilling done for the purpose of (1) determining the nature of a particular geothermal reservoir, (2) the best sites for drill testing, and (3) defining reservoir parameters.

RESERVOIR ASSESSMENT - Application of reservoir engineering techniques for analyzing flow test data and determining fluid temperature, producibility, fluid quality and reservoir life.

RESERVOIR ENGINEERING - Prediciton of reservoir temperature, production scenario and lifetime, based on analysis of temperature, pressure and flow rate data obtained during flow testing.

VAPOR DOMINATED - Geothermal reservoir which contains steam as the dominant fluid. Temperatures are typically around $240^{o}C$.