

The Geothermal Progress Monitor: Design and Implementation

MITRE

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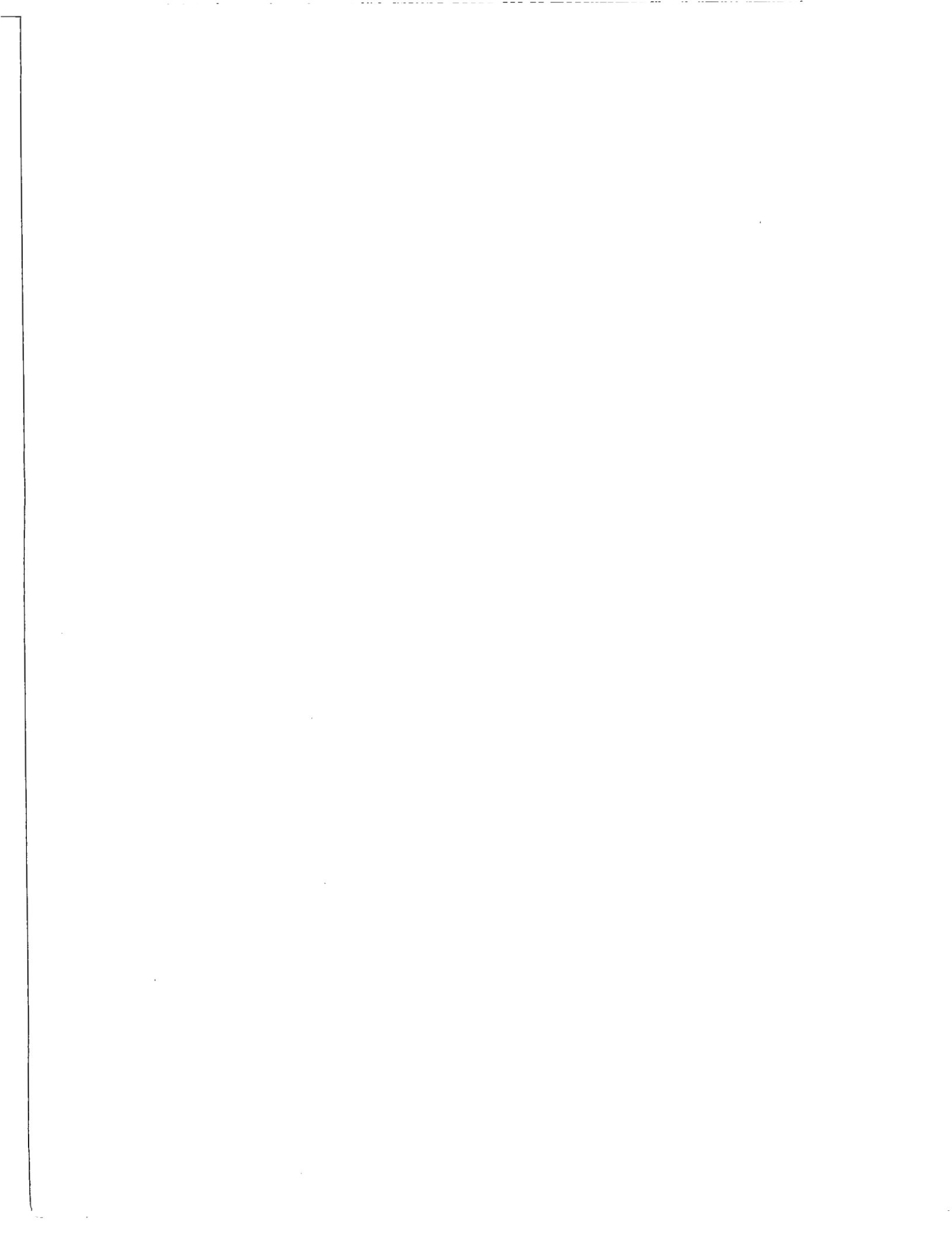
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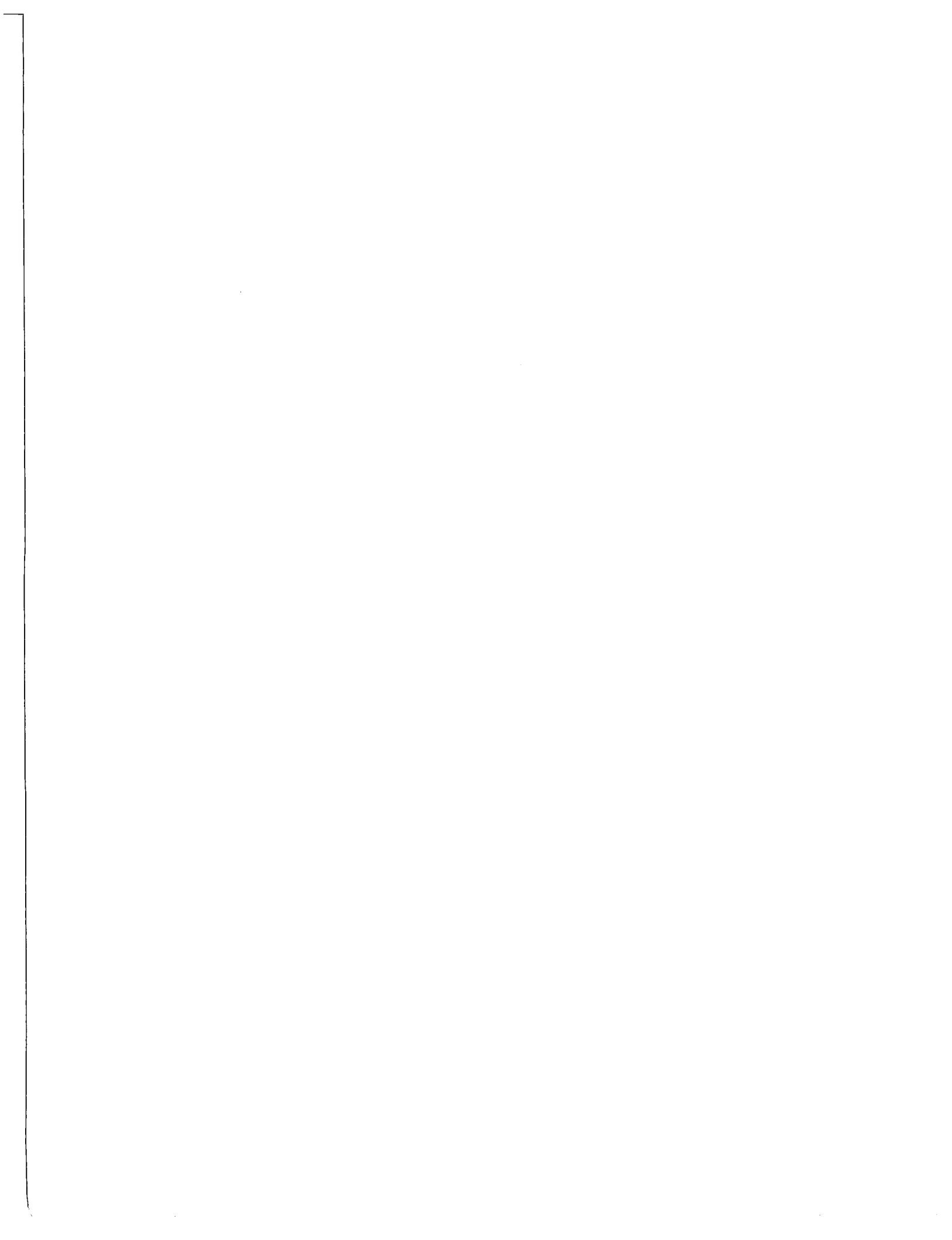
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ABSTRACT

The Geothermal Progress Monitor (GPM) is an information system that links the various elements of the public and private sectors of the geothermal industry. The monitoring effort emphasizes the identification and analysis of indicators of what the main participants in geothermal energy utilization - field developers, energy users and government agencies - are doing to foster the discovery, confirmation and use of this resource. The major indicators considered both important and measurable are leasing activities, drilling efforts, feasibility studies, construction plans and progress, costs of installations, levels of investment, environmental study and regulatory activities, legislative status and changes, and government monetary investments in projects and activities.

The GPM is unique in that it is a network, a process, a project staff and a product. As a process, the GPM identifies, acquires stores, tabulates, analyzes and reports on the information obtained through its network structure. The GPM project staff maintains the other aspects of the GPM and in particular produces pertinent analyses and responds to queries by providing information or directing the requestors to the appropriate sources. Finally, the GPM is a periodic report which summarizes activities, status and trends in the geothermal industry.



ACKNOWLEDGMENTS

The authors are indebted to a number of people who made special contributions to the design of the Geothermal Progress Monitor system. Major contributors from the Department of Energy DGRM/DGE Headquarters staff were Fred Abel (Project Manager), Rudy Black, David Allen, and Lou Werner. Members of DOE Regional Offices and Operations Offices who added a lot were William C. Gough, Tom Heenan, Marty Malloy, Bob Hackman, and John Griffith. Bruce Blakely and Jim Swanson of the U.S. Geological Survey provided valuable insights into the geothermal files of the Survey. Very significant contributions came from a number of investigators on DOE-sponsored technical and evaluation projects. These included Fletcher Paddison (Applied Physics Lab, Johns Hopkins University), Joe Hanny and Bob Schultz (EG&G, Idaho), Jack Howard, Dennis Lawrence, and Winifred Yen (Lawrence Berkeley Laboratory), Roy Cunniff and Paul McDevitt (New Mexico Energy Institute), Gordon Bloomquist (Oregon Institute of Technology), and Duncan Foley and Mike Wright (University of Utah Research Institute). The integration of earlier geothermal monitoring efforts into a useful system was aided greatly by insights and useful suggestions from everyone of these people.

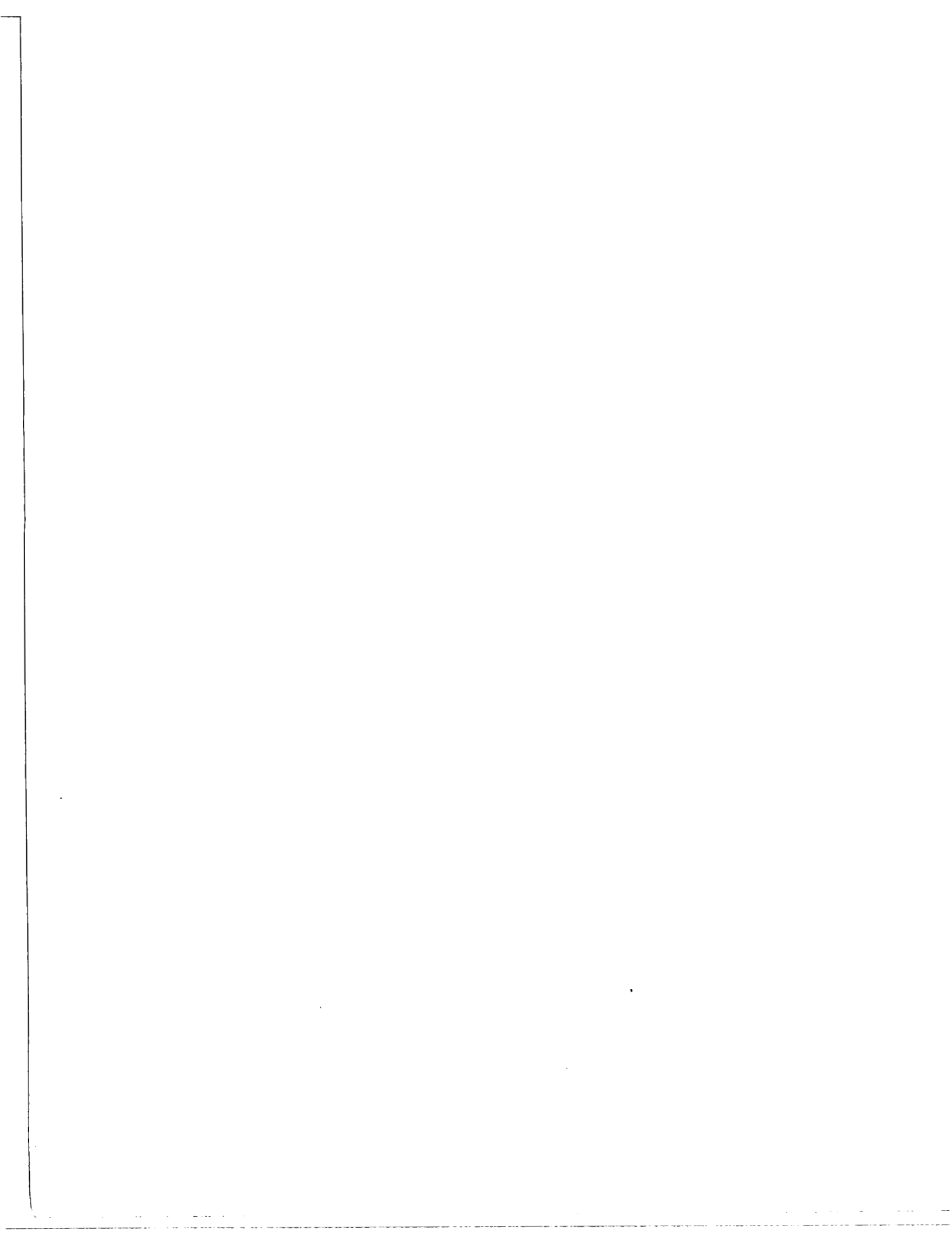


TABLE OF CONTENTS

	<u>Page</u>
LIST OF ILLUSTRATIONS	viii
LIST OF TABLES	viii
EXECUTIVE SUMMARY	ix
1.0 INTRODUCTION	1
1.1 Background	2
1.2 Purpose and Objectives	3
1.3 General Constraints on the GPM System	5
2.0 GENERAL DESIGN OF THE GPM	7
2.1 Information Types, Aggregation and Timing	9
2.2 Participants	11
3.0 REQUIRED OUTPUTS OF THE GPM	17
3.1 Activity Reports	17
3.2 Status Reports	17
3.3 Trend Analyses	20
4.0 INPUTS TO THE GPM	21
4.1 Information Sources	21
4.2 Field Structure	22
5.0 MECHANICS OF THE GPM	29
5.1 Activity Reports	29
5.2 Status Reports	29
5.3 Trend Analyses	30
5.4 Sources and Files	30
5.5 Implementation Responsibilities	30
5.6 Information Flows at MITRE	33
6.0 CURRENT EMPHASES AND ISSUES IN THE GPM	37
LIST OF REFERENCES	41
APPENDIX A: INFORMATION AVAILABLE FROM DOE GEOTHERMAL FIELD ACTIVITIES AND GEOLOGICAL SURVEY OFFICES	A-1
APPENDIX B: CONTRIBUTORS TO GPM DESIGN MEETINGS	B-1

LIST OF ILLUSTRATIONS

<u>Figure Number</u>		<u>Page</u>
1-1	Schematic of Information Flow in the Geothermal Progress Monitor	4
2-1	Geothermal Progress Monitor System	14
2-2	DOE Regions and Locations of the Regional Offices	15
4-1	Flow Chart of Existing Geothermal Information Networks	25
5-1	Geothermal Progress Information Treatment at MITRE	34

LIST OF TABLES

<u>Table Number</u>		<u>Page</u>
2-1	Geothermal Progress Monitor: Technical Areas Covered	8
2-2	Information Types and Timing	10
2-3	Levels of Information Aggregation	12
3-1	GPM Status Indicators	18
3-2	Typical Geothermal Progress Monitor Indicators, with Estimates of Reliability and Coverage	19
4-1	GPM Information Sources	23
5-1	GPM Input/Output Matrix	31
5-2	Current Implementation	32

EXECUTIVE SUMMARY

The Geothermal Progress Monitor (GPM) is an information system that links the various elements of the public and private sectors of the geothermal industry. The GPM is unique in that it is a network, a process, a project staff and a product.

As a process, the GPM identifies, acquires, stores, tabulates, analyzes and reports on the information obtained through its network structure. The GPM project staff maintains the other aspects of the GPM and in particular produces pertinent analyses and responds to queries by providing information or directing the requestors to the appropriate sources. Finally, the GPM is a periodic report which summarizes activities, status and trends in the geothermal industry.

The purpose of the GPM is to assemble the important facts about geothermal development activities in the United States as a basis for assessing the development of this alternative energy source. Its objectives are to:

- Monitor and report on geothermal development activities, status and trends in the government and private sector by locating, quantifying and analyzing public and private sector plans and actions.
- Serve the program management and information dissemination functions of the Division of Geothermal Energy and the Interagency Geothermal Coordinating Council.
- Serve as a national point of reference for reporting the pace of geothermal commercialization activities.

The initial emphasis for the monitoring effort is placed on the identification and analysis of important indicators of what the main participants in geothermal energy utilization - field developers, energy users and government agencies - are doing to foster the discovery, confirmation and use of this resource. The major indicators considered both important and measurable are leasing activities, drilling efforts, feasibility studies, construction plans and progress, costs of installations, levels of investment, environmental study and regulatory activities, legislative status and changes, and government monetary investments in projects and activities. Additional indicators may be pursued in the future, depending on specific needs or opportunities to acquire relevant data and facts.

During the initial 12 months of developing this monitoring effort, three primary procedural concerns were identified:

- (1) Establishing inexpensive mechanisms for acquiring and validating information.
- (2) Selecting the most useful geographical units for aggregating and analyzing information.
- (3) Deciding which indicators merit analysis and determining the degree of accuracy and confidence contained in the analyses, given a high probability of continuing gaps and errors in the acquired information.

INFORMATION ACQUISITION

The main sources of information to the GPM are information networks or services that already exist. Six major sources have been identified:

- (1) Department of Energy (DOE) Geothermal Program Field Structure. This consists of a number of DOE Regional Offices and Operations Offices; contractors who support reservoir confirmations, outreach, and technical assistance activities; the State Geothermal Resource Teams and the State Geothermal Commercialization Teams - who are usually agents of the resources and energy agencies of the various states. This network conducts various assessments of local conditions, and communicates news of important events to the DOE Division of Geothermal Energy (DGE) Headquarters in the form of Weekly Activity Summaries.
- (2) Field Structure of Other Agencies in the Interagency Geothermal Coordinating Council. Included here are the leasing programs of the Bureau of Land Management and the U.S. Forest Service, the leasing statistics program of the U.S. Geological Survey (USGS) and the Geothermal Resource Assessment Program of the USGS. Data from these agencies appear either in the form of monthly statistical tables, or in USGS File GEOTHERM, a database of the physical characteristics of geothermal sites. Many of the reports from these and other agencies are useful as progress indicators and require little further analysis.
- (3) Commercial Information Sources. These are principally the Petroleum Information Corporation's National Geothermal Service, the Munger Oilgram, Geothermal Energy Magazine, and the Geysers geothermal newsletter. These are key sources of information about drilling activities and events in the geothermal industry.
- (4) The International Business Services (IBS) Geothermal Newspaper Clipping Service. DGE has funded IBS to clip geothermal news items from most U.S. newspapers. These items contain information on site status, development activities, new ventures and legal/institutional problems.
- (5) Geothermal R&D Technical Reports. DOE has funded or stimulated the preparation of several thousand reports on all aspects of geothermal energy. These reports contain

information on site status, costs and plans for development.

- (6) Reports Originating from Federal and State Government Agencies. These reports are indicative of government activities and plans, and are often the original sources for new legislation and new or altered regulations.

Information from these sources is merged and analyzed in ways described in the body of the report.

GEOGRAPHICAL UNITS

Geothermal energy must be used or converted to electricity near where it is found because transport of geothermal fluids requires expensive insulated pipelines to prevent the loss of much of the contained heat. Therefore, effective utilization of this resource requires that reservoir characteristics and end use be carefully matched thermodynamically and geographically.

This consideration makes the specific geothermal resource site (a reservoir or prospect) the fundamental unit of any detailed analysis. There are on the order of 1500 known or suspected geothermal sites in the U.S. Many more will be identified in the next few years. This presents the possibility of an overwhelming amount of information to obtain and analyze, if all sites are to be monitored in detail.

In the initial approach to geothermal progress monitoring, the emphasis is on using states as the main unit for statistical aggregation. This has the advantage of producing useful statistics almost immediately, while allowing continued collection and the development

of cost-effective approaches to the aggregation and analysis of site-specific data.

Site-specific information is presently collected and tabulated at MITRE for the following cases where intense development activities are (or were) in progress:

- (1) Geothermal Electric Plants - operating, under construction or planned.
- (2) Geothermal Direct Heat Applications - operating, under construction or planned.
- (3) DOE Funded or Guaranteed Projects - particularly those funded under the Program Research and Development Announcement (PRDA), Program Opportunity Notice (PON) and Geothermal Loan Guaranty programs.*

MITRE is in the process of relating newly reported deep drilling activities to specific sites to monitor industrial production, step out and exploration activities. The University of Utah Research Institute is coordinating efforts of the State Geothermal Resource Teams to detect new deep wells and thermal gradient well drilling activities.

Much site-specific information has been collected for the Rocky Mountain Basin and Range States** by coordinated efforts of EG&G-Idaho, and the New Mexico Energy Institute. Lawrence Berkeley Laboratory is developing a geothermal data base management system and is

*PRDAs provide funding for feasibility studies and PONs provide funding for application demonstrations.

**Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah and Wyoming.

entering data for California and Hawaii into it. The Oregon Institute of Technology has site baseline data for Oregon, Washington, Idaho, Montana, Wyoming and Alaska. The Applied Physics Laboratory in Maryland has site and other data for 33 eastern states. The U.S. Geological Survey maintains file GEOTHERM which contains much data on physical characteristics of the major U.S. geothermal prospects.

All of these sources can be queried as needed, and preliminary efforts have been started to explore the possibility that some of the computerized data bases can be brought into compatible formats in order to facilitate information transfer between these various institutions.

ANALYSES AND THEIR ACCURACY

A number of target analyses were specified at the outset of the GPM effort in August 1979. These subject areas include: plans for and construction of electrical plants and direct heat installation, drilling of deep and thermal gradient wells, leasing of federal and private land for geothermal use, activities of governments to stimulate development and demonstrations at specific sites, environmental assessment activities, legal and regulatory changes, and cost and investment statistics.

It was recognized at the start that achievement of these analyses would depend on the ability to acquire data economically and accurately. Moreover, it was clear that certain baseline statistics and trends had to be compiled very quickly, since they were needed as inputs to the formulation of DGE policy.

The existence of the DGE State Geothermal Commercialization Teams and the network through which they report to DGE headquarters as well as a number of structured commercial and governmental data sources, made it possible to start the GPM effort based on two principles that allowed initial timeliness and later establishment of accuracy.

First, redundancy of sources allowed a rapid establishment of estimates for electric plants (installations and plans), direct heat installations, and deep geothermal wells. Second, feedback from a variety of sources has allowed establishment of a fair degree of confidence in the initial estimates. However, MITRE estimates that it will take about another year to achieve a comprehensive set of data in these areas.

Currently, sufficient data have been collected to establish status and trends for electric power plants, direct heat applications, deep geothermal wells and leases on federal lands. Other trends will be established as the data collection and analysis efforts mature. These data are maintained in a number of paper and computerized files which are accessible through the GPM network.

Details of the GPM system can be found in the body of the report. The interested reader is referred to the following major topics:

- Outputs from the GPM: Section 3.0.
- Inputs to the GPM: Section 4.0.

- Information flows between organizations: Section 4.2.
- Internal information processing: Section 5.0.
- Current emphases and issues in operating the GPM: Section 6.0.
- Description of data held at various organizations in the GPM system: Appendix A.

1.0 INTRODUCTION

To measure progress in geothermal development, a system for monitoring resource development was designed and implemented by The MITRE Corporation on behalf of the Division of Geothermal Energy (DGE) of the U.S. Department of Energy (DOE). The system, called the Geothermal Progress Monitor (GPM), tracks and reports significant events and trends in the U.S. geothermal industry and the federal geothermal program. The information resources of the GPM exist in the form of paper and computerized files maintained by a number of organizations throughout the U.S. Reports from the GPM consist mainly of manual and computerized analyses of the data contained in these information resources.

This capability is required by DGE and other members of the Interagency Geothermal Coordinating Council (IGCC) for two major purposes: to support effective management of the federal program for the industrialization of geothermal energy, and to provide information required for executive, legislative, statutory, and public needs.

This paper describes the design and implementation of the GPM. Included are the needs for and objectives of the system, the required information output, the information input needed to support this output, existing information bases and flow paths, and the system design that integrates these elements of the system.

1.1 Background

The DOE program for geothermal energy development was recognized in 1978 as one of the priority areas for rapid energy technology commercialization. In October of 1978, the Division of Geothermal Resource Management (DGRM) was established within DOE to promote geothermal energy technology and development throughout the nation. In February 1980, DGRM was merged back into DGE, which continues the mandate of DGRM with respect to the industrialization of geothermal resources in the United States.

The design of the GPM began in 1975, when MITRE was asked to develop system concepts for monitoring the development and utilization of geothermal energy in the U.S. The results of this study were published in February 1977.⁽¹⁾ No further action was taken until February 1979, when a panel of the DGRM Commercialization Workshop evaluated a number of concepts for a progress monitoring system. The panel further developed the rationale for such a system and described a preferred approach for its development. MITRE was tasked to develop and implement the GPM in July 1979. A review of the background, approaches and objectives was prepared by MITRE⁽²⁾ to provide a focus for discussion at a meeting of geothermal database managers convened by DGRM in August 1979. The results of this meeting served as a basis for developing an initial GPM design and a proposed first report of the GPM.⁽³⁾ These were reviewed at a

meeting of DGRM field elements in November 1979, and a consensus was reached to produce the GPM report on a trial basis for three issues. GPM Report No. 1 was issued in January 1980.⁽⁴⁾ A list of the contributors to the GPM design meetings is given in Appendix B.

1.2 Purpose and Objectives

The overall purpose of the GPM is to identify and quantify trends in the development and utilization of geothermal energy resources. Figure 1-1 illustrates the approach taken toward fulfilling this purpose. The top row of boxes shows the sources of information, the next row shows the conversion of this information into status indicators and trends, and the remainder shows users of the information.

The general objective of the GPM is to provide a quick-response centralized geothermal information collection, storage, analysis, and reporting system that tracks the development of geothermal energy in the U.S. and the world. This will assist the Director of DGE in reporting geothermal energy activities, status and trends to other officials in the government, field members of the DGE State Geothermal Commercialization Teams and other interested parties in the geothermal industry.

The intent is to collect and analyze a complex set of progress indicators from a wide variety of sources to produce a coherent, timely and usefully accurate picture of the status and rate of

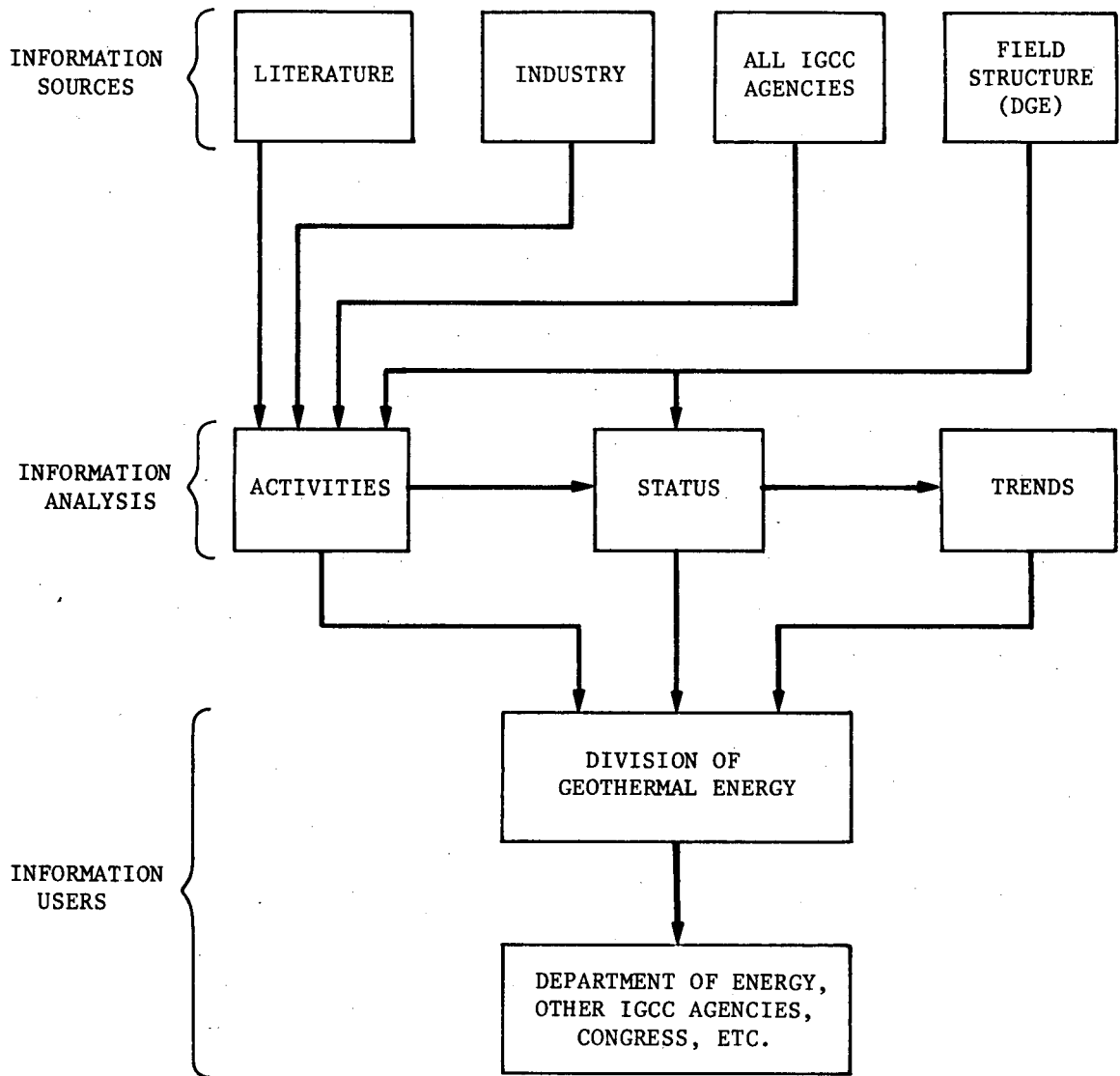


FIGURE 1-1
SCHEMATIC OF INFORMATION FLOW IN THE
GEOTHERMAL PROGRESS MONITOR

geothermal energy development. Principal emphasis is placed on developments of the geothermal resources and technological advances in the geothermal industry. The principal policy-oriented aim is to detect the degree to which the U.S. geothermal energy program is accelerating the growth of geothermal energy use and assure that federal programs and policies are designed to best meet the needs of actual geothermal development. The principal industrialization-oriented aim is to provide industry with information for their own geothermal development decision-making processes.

The specific objectives of the GPM are to:

- Monitor and report on geothermal development activities, status and trends in the government and private sector by locating, quantifying and analyzing public and private sector plans and actions.
- Serve the program management and information dissemination functions of DGE and the IGCC.
- Serve as a national point of reference for reporting the pace of geothermal commercialization activities.
- Provide site-specific development status information to the Geothermal Site Development Forecasting System.⁽⁵⁾

1.3 General Constraints on the GPM System

The following concerns and constraints have been identified as bounding the scope of GPM activities: The GPM is to:

- Be driven in the near term by DGE's needs for reporting to the member agencies of the IGCC, to upper levels in DOE, and to the DGE State Geothermal Commercialization Teams.
- Use existing information bases, rather than trying to build a new large information base.

- Develop immediately the most simple and important core parts of the system rather than trying to develop a very elaborate large system for implementation at some later date.
- Maximize the use of a number of different existing sources of information.
- Maximize access to the system by both people in the geothermal headquarters groups and people in the field.
- Minimize duplication of effort both with respect to the collection of information, the analysis of information, and storage of information at various places around the U.S.
- Use feedback from the DGE State Geothermal Commercialization and Resource Teams as the primary basis for validating the accuracy of the information in the GPM.

The reporting vehicle, the GPM Progress Report, will be published quarterly. The report will be prepared by MITRE, with DGE retaining editorial control over activity reports. MITRE will be responsible for and retain editorial control for estimates of the accuracy of the reported data, for the ranges of status indicators reported, and for trend analyses.

2.0 GENERAL DESIGN OF THE GPM

The design of the GPM resulted from consideration of the requirements and constraints described in the preceding section and from numerous discussions with DGE Headquarters and field personnel. Fifteen topical areas were identified that would comprehensively cover the geothermal energy field for the purposes of the GPM. For each of these topics, up to three types of information need to be developed: (1) events or activities, (2) status or the present situation, and (3) trends that can be identified from the first two types of information. To obtain the information to be reported, appropriate sources were identified and their participation solicited.

The 15 topics that the GPM is configured to report on are listed in Table 2-1. The first eight areas will each report status information, activity reports and trend analyses for those specific topics. The next five "activity" topics will carry activity reports of the indicated type. The General Activities section presently includes federal activities that are not reported in other sections and international activities. The Reports and Publications section includes brief announcements of recently published material that may be of interest to the GPM audience. The Directory lists the organizations and individuals in the GPM audience and others in the geothermal industry.

TABLE 2-1

GEOHERMAL PROGRESS MONITOR: TECHNICAL AREAS COVERED

-
- | | |
|---|---|
| ● Electrical Uses | ● General Activities |
| ● Direct Heat Uses | ● R&D Activities |
| ● Drilling Activities | ● Legal, Institutional
and Regulatory Activities |
| ● Exploration | ● Environmental Activities |
| ● Leases | ● State, Local and Private
Sector Activities |
| ● Outreach and Technical
Assistance | ● Reports and Publications |
| ● Feasibility Studies and
Application Demonstrations | ● Directory |
| ● Geothermal Loan
Guarantee Program (GLGP) | |
-

2.1 Information Types, Aggregation and Timing

The GPM will report three types of information: activities, status and trends. Activity reports are news items of general interest to the GPM audience which have been reported to DGE, but which may not have received the wider circulation that the information deserves. The GPM will not compete with commercial geothermal information services by attempting to report comprehensively, but rather, will provide its audience with announcements to stimulate further inquiry where appropriate.

Status reports provide a snapshot of information available on specific topics, including electric plants, direct heat sites, wells, R&D programs and others. These reports are presented in the form of lists that appear quarterly or semi-annually, updated as appropriate, but retaining the same format (for a given report) through each revision.

Trend reports will be issued on an ad hoc basis to highlight changes in the geothermal industry that may be deduced from analyzing status reports or from sequences of activity reports. These trends will signal both successes and shortfalls in the general geothermal energy development effort.

The timing of the issuance of the mentioned types of reports is summarized in Table 2-2. DGE activity reports are issued monthly or semi-monthly because they report on events where longer intervals would tend to make many items outdated. Initial experience suggests

TABLE 2-2

INFORMATION TYPES AND TIMING

INFORMATION TYPE	TIMING
● Activity Reports	Quarterly
● Status Reports	Semi-Annual
● Trend Analyses	Semi-Annual, or as Identified

that quarterly intervals provide a substantial number of events to report. Semi-annual intervals were selected for most status reports because relatively few changes occur in a six-month period for these items.

Table 2-3 shows the level of geographical aggregation needed for various types of information in the GPM files. The table answers the question, "What is the smallest geographic area for which separate data must be maintained?" for each type of information stored in GPM files. All files must be able to report down to the state level of aggregation, and at least four of the files are maintained down to individual sites. For example, the file on electric power plants is maintained at the site level of aggregation, because each potential plant represents a significant part of the total power-on-line picture. On the other hand, laws and regulations are only tracked down to the state level of aggregation, since states are the smallest jurisdiction for which significant laws and regulations are generally reported. The occasional local issue will be handled on an ad hoc basis.

2.2 Participants

The GPM is intended to be an operation of DGE Headquarters, managed by DGE while developed and implemented by MITRE. However, the Headquarters and MITRE operations of the GPM represent only a small part of the overall system, the point where information is assembled and processed. Most of the data collection will be done by DGE

TABLE 2-3

LEVELS OF INFORMATION AGGREGATION

TYPE OF INFORMATION	SITE	STATE	NATION
Deep Wells	X	X	X
Gradient Wells & Exploration Wells	X	X	X
Electric Power Plants	X	X	X
Direct Heat Projects	X ¹	X	X
Leasing	X	X	X
Program Research & Development Announcements (PRDAs), & Program Opportunity Notices (PONs)	X	X	X
Geothermal Loan Guaranty Programs	X	X	X
Laws & Regulations	-	X	X

¹Private homes within a heating district will not be tracked separately.

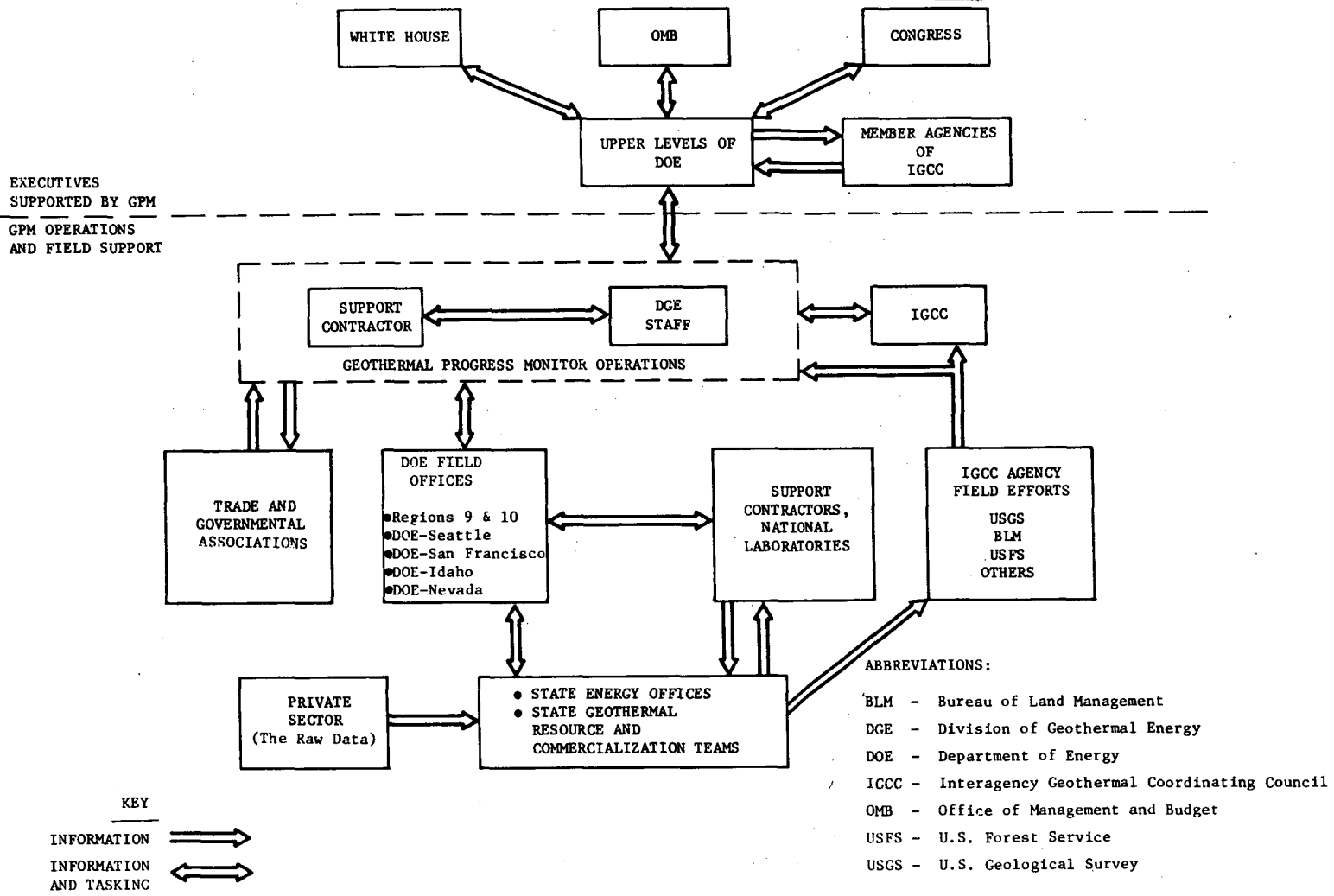
State Geothermal Commercialization and Resource Teams. Figure 2-1 illustrates the overall institutional scheme of the GPM System, including the executive levels served by the GPM and the field elements where the information originates. The actual configurations of the field elements are considerably more complex than depicted in Figure 2-1, with a lot of information flowing among the participants in more or less informal ways.

The primary formal source of information for the GPM is the DGE field organization. This organization is comprised of DOE Regional and Operations Offices and their designated contractors and State Teams. The principal Regional and Operations offices involved with the GPM are:

- DOE Region 9 Regional Office,
- DOE Region 10 Regional Office,
- DOE Seattle Operations Office
- DOE San Francisco Operations Office (Oakland)
- DOE Idaho Falls Operations Office
- DOE Nevada Operations Office (Reno)

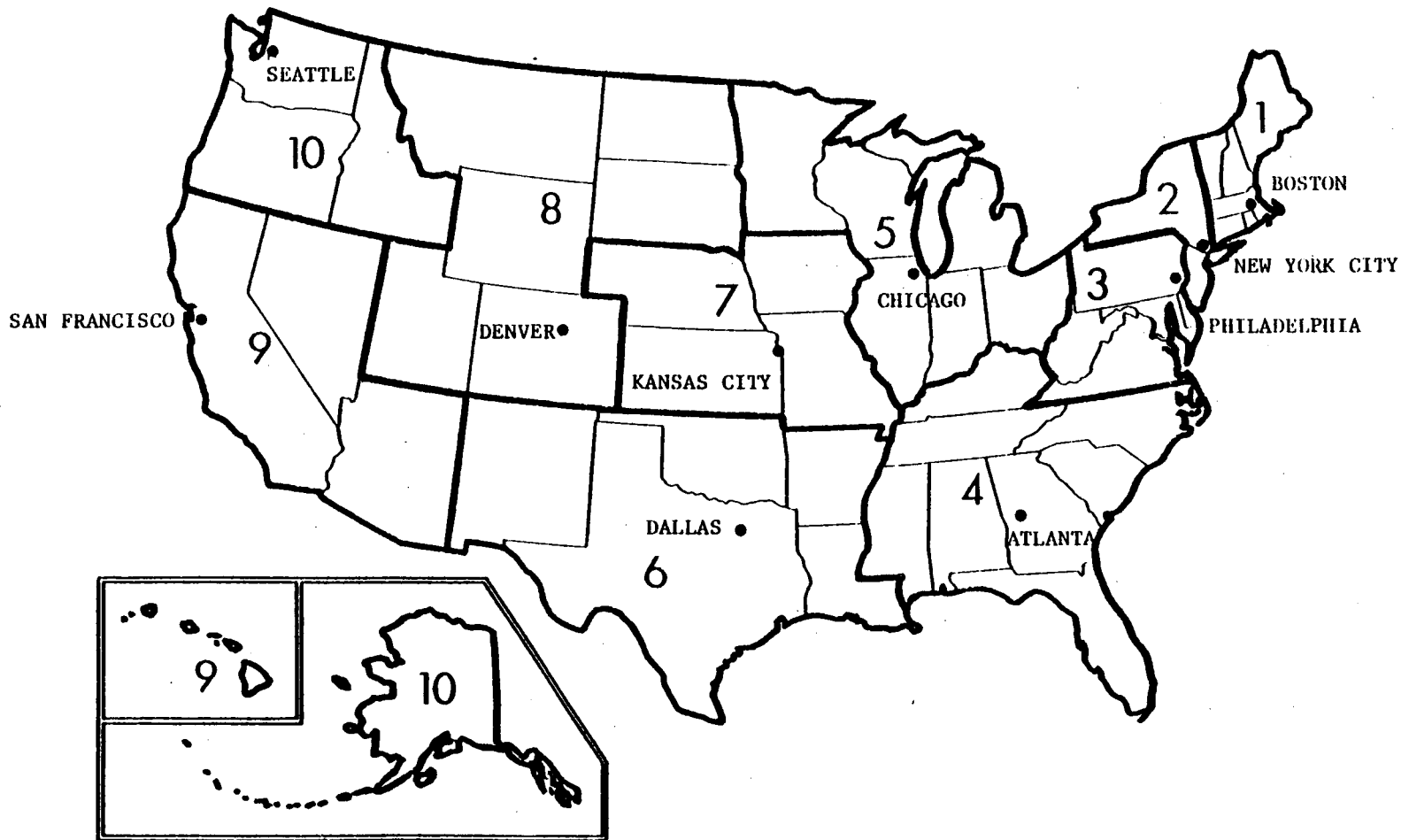
Each of these offices serves as a funnel to DGE Headquarters for information developed or collected by their contractors and State Geothermal Resource and Commercialization Teams. Figure 2-2 shows the states in each Region.

Other participants in the GPM include the member agencies of the IGCC. Of particular note is USGS, which maintains automated files on



14

FIGURE 2-1
GEOTHERMAL PROGRESS MONITOR SYSTEM



15

**FIGURE 2-2
DOE REGIONS AND LOCATIONS OF THE REGIONAL OFFICES**

the geothermal resources, the leasing activities on federal land (data are from the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS)), and on drilling activities on federal land. Periodic USGS reports based on these files provide a significant input to the GPM.

Appendix A describes some of the major organizations contributing information to the GPM. DGE is expected to continue to play its key role as coordinator and central point of contact for this information collection system.

3.0 REQUIRED OUTPUTS OF THE GPM

The GPM must provide three types of reports: (1) activity reports, (2) status reports, and (3) trend analyses. These are described in the following sections.

3.1 Activity Reports

Activity reports are event highlights to alert the GPM audience of events that may have significance for their own activities. These reports are taken chiefly from the DGE Weekly Activity Memorandum, and are supplemented by news reports gleaned from the various commercial information services. The 15 topic areas covered in the GPM have been given in Table 2-1 above.

3.2 Status Reports

Status reports are planned to be issued for the first eight topics listed in Table 2-1. These reports are in the form of tables which summarize available useful information about the given topic. Table 3-1 lists the status indicators used on several of the topics. Status reports will generally be issued semi-annually, and aggregated at the state level. One exception will be Electric Use summaries, which will show California broken out by the Geysers, Imperial Valley, and Other.

The accuracy of the reports is variable, depending upon the specific indicator. Future reports will clarify data limitations in terms of validity and completeness for each topic area. Table 3-2 shows some of the types of data reported in the GPM and MITRE's estimate of their reliability.

TABLE 3-1

GPM STATUS INDICATORS

DOMESTIC INDICATORS (AGGREGATED BY SITE OR STATE)

● General

- Wells Drilled
- Exploration Status
- Lands Leased
- U.S. Legislative Status
- State Legal Status and Plans
- Federal Project Status
- Geothermal Loan Guaranty Status

● Electric Sites

- Installed Plants
- Announced Utility Plans
- Detected Barriers to Investment/Construction
- Status of DOE Demonstrations
- Cost/Utilization Factor Data
- Market Penetration Forecast Results

● Direct Heat Sites

- Installed Systems
- Planned Systems
- Detected Barriers to Investment/Construction
- Status of DOE PRDA/PON Projects
- Cost/Reliability Data
- Market Penetration Forecast Results

FOREIGN INDICATORS (AGGREGATED BY COUNTRY)

- Electric Capacity On-Line or Projected
 - Direct Heat Use On-Line or Projected
-

TABLE 3-2

TYPICAL GEOTHERMAL PROGRESS MONITOR INDICATORS,
WITH ESTIMATES OF RELIABILITY AND COVERAGE

INFORMATION TYPE	DATA SOURCES	ESTIMATED RELIABILITY		ESTIMATED DATA COVERAGE	MITRE ANALYSIS	ESTIMATED OVERALL RELIABILITY
		STATE BASIS	SITE BASIS			
Number & Depth of Deep Wells at Site	<ul style="list-style-type: none"> • PIC National Geothermal Service • Munger Oilogram • USGS Reports on Federal Leaseholds • Miscellaneous Reports 	High	High	Medium	<ul style="list-style-type: none"> • Enter and sort in data base • Resolve inconsistencies • Report status and trends and site/state 	<ul style="list-style-type: none"> • By State - Very High • By Site - High
		High	High	Medium		
		Very High	Very High	Very High		
		High	High	Medium		
Deep Well Flow Rates	<ul style="list-style-type: none"> • Same as above 	--	Medium	Low	<ul style="list-style-type: none"> • Store by site, estimate average and variation 	Low-Medium
Number of Thermal Gradient Wells	<ul style="list-style-type: none"> • Same as above 	Medium	Low	Low	<ul style="list-style-type: none"> • Store by site, report annual count 	<ul style="list-style-type: none"> • By State - Medium • By Site - Low
Electric Plant Status	<ul style="list-style-type: none"> • DGE State Teams • Utility Company Announcements • Miscellaneous Sources 	High	High	Medium-High	<ul style="list-style-type: none"> • Store by site • Resolve inconsistencies • Report by site/state 	Very High
		High	High	Medium		
		Medium	High	Medium		
Direct Heat Use Status	<ul style="list-style-type: none"> • DGE State Teams • DGE PRDA & PON Descriptions • Miscellaneous Reports 	Medium	Medium-High	Medium	<ul style="list-style-type: none"> • Store by site • Resolve inconsistencies • Report by site/state 	Medium-High, but varying among states
		High	High	Only Fed. Projects		
		Medium	High	Very Low		

3.3 Trend Analyses

Trend analyses will be performed either at the request of DGE or on MITRE's own initiative. These analyses will identify any changes in the longer-term movement of the geothermal industry, and provide lead time for planning changes in the geothermal program where necessary. While no trend analyses have been initiated as yet, the following topics are under consideration:

- Deep well drilling - the impact of the 1978 National Energy Act
- Deep well drilling - Is significant activity appearing outside the Geysers and Imperial Valley?
- Trends in the rate of power plant commitments
- Growth rate of direct heat installations
- Analysis of growth rates in power plant capital costs
- Fluctuations in levels of planned power plants
- Rate of installation of power plants
- Variation in levels of leasing activity

4.0 INPUTS TO THE GPM

The inputs to the GPM are described below in terms of the source of the information and the organizational structure through which the information passes.

4.1 Information Sources

The sources of information for the GPM system fall into five broad categories:

- DOE, especially DGE
- Other federal government agencies
- State and local governments
- Commercial information services
- Private sector activities

DGE sources include the Headquarters activities as well as field activities of the Regional and Operations offices and their various contractors and the National Laboratories operating in their areas. Information obtained through DGE tends to be of a secondary nature, having been passed to Headquarters through a Field or Regional office from the point of origin. Work done at the National Laboratories is usually reported directly to Headquarters.

Other federal government geothermal activities include those undertaken by the USGS, the USFS, the BLM, and other member agencies of the IGCC. These activities are generally reported directly to DGE Headquarters, although there tends to be a time lag between field events and formal reporting due to normal administrative processes.

Also included here is the National Conference of State Legislatures (NCSL), which reports on state legislation throughout the nation.

State and local government activities include those of state energy offices as well as quasi-governmental organizations such as regional power authorities, land commissions, licensing boards and the State Geothermal Resource and Commercialization Teams supported by DGE.

The commercial information services include the Petroleum Information Corporation's National Geothermal Service, the Munger Oilogram, Geothermal Energy Magazine, the IBS Geothermal Daily Monitoring Summary and other periodicals and information services commercially offered to the geothermal industry.

Private sector activities range from major power plant developments to single home direct heat installations, and represent the largest number of sources of information and the most difficult group from which to systematically acquire information.

Table 4-1 lists these sources and indicates the type of information acquired from each.

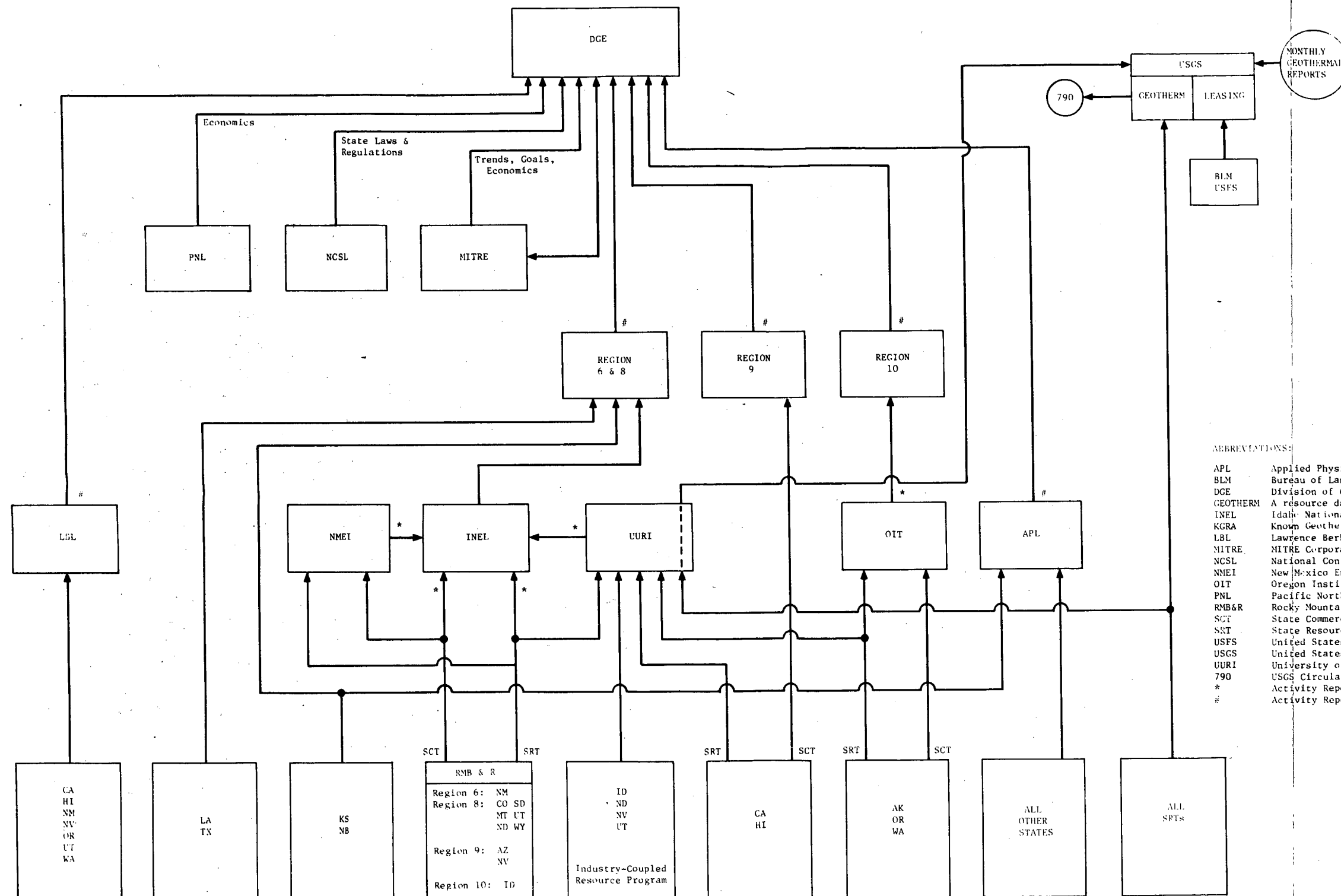
4.2 Field Structure

The principal way in which the sources of information are connected to the GPM is illustrated in Figure 4-1. From the bottom of the chart, information is seen as originating from a particular locality or activity. This information is acquired by the GPM via the State Geothermal Resource and Commercialization Teams, commercial

TABLE 4-1

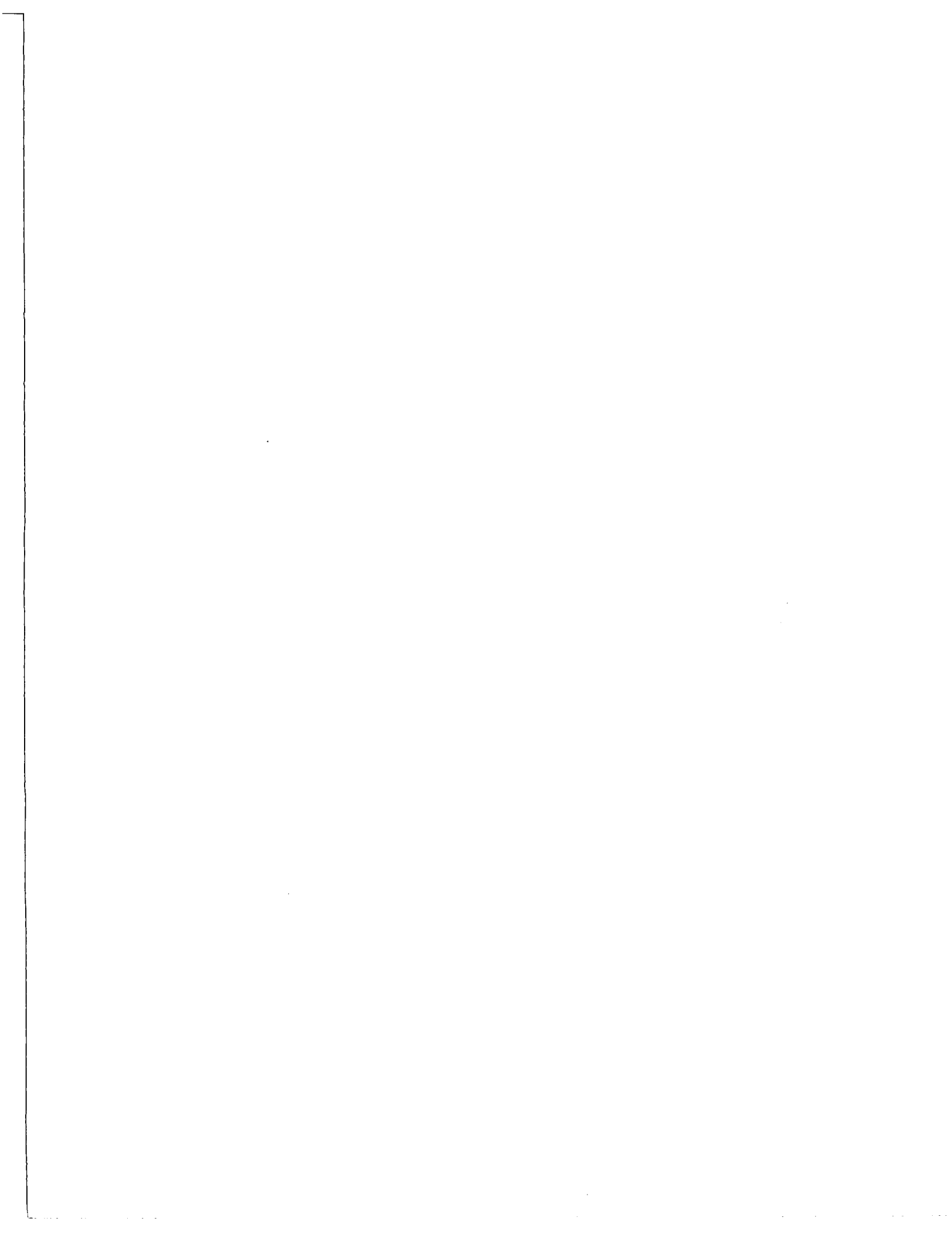
GPM INFORMATION SOURCES

SOURCE	TYPE OF INFORMATION	FREQUENCY
DGE State Geothermal Commercialization Teams	<ul style="list-style-type: none"> ● Activity Reports ● Status Reports 	<ul style="list-style-type: none"> ● Variable ● Semi-Annual (perhaps quarterly)
DOE Regional and Operations Offices	<ul style="list-style-type: none"> ● Status of Federal Projects ● Activity Reports 	<ul style="list-style-type: none"> ● Semi-Annual ● Variable
DGE Headquarters Staff	<ul style="list-style-type: none"> ● Activity Reports and "Washington news" 	<ul style="list-style-type: none"> ● Variable
DOE Contractors and National Laboratories	<ul style="list-style-type: none"> ● Technical Studies, Trend Analyses ● Status of Projects 	<ul style="list-style-type: none"> ● Occasional ● Monthly
USGS (including BLM & USFS)	<ul style="list-style-type: none"> ● Drilling Activities on Federal Land ● Leasing of Federal Land 	<ul style="list-style-type: none"> ● Monthly ● Monthly
IGCC Agencies	<ul style="list-style-type: none"> ● Agency Activities 	<ul style="list-style-type: none"> ● Variable to quarterly
National Conference of State Legislatures	<ul style="list-style-type: none"> ● Laws and Regulations 	<ul style="list-style-type: none"> ● Occasional
Commercial Information		
PIC National Geothermal Service	<ul style="list-style-type: none"> ● Drilling Reports 	<ul style="list-style-type: none"> ● Weekly
Munger Oilogram	<ul style="list-style-type: none"> ● Drilling Reports 	<ul style="list-style-type: none"> ● Weekly
Magazines (GEM, Geysers, etc.)	<ul style="list-style-type: none"> ● News 	<ul style="list-style-type: none"> ● Monthly
IBS	<ul style="list-style-type: none"> ● Clippings 	<ul style="list-style-type: none"> ● Weekly
Private Sector	<ul style="list-style-type: none"> ● Site Specific Information 	<ul style="list-style-type: none"> ● When queried



- ABBREVIATIONS:
- APL Applied Physics Laboratory
 - BLM Bureau of Land Management
 - DGE Division of Geothermal Energy
 - GEO THERM A resource data base (USGS)
 - INEL Idaho National Engineering Laboratory
 - KGRA Known Geothermal Resource Area
 - LBL Lawrence Berkeley Laboratory
 - MITRE MITRE Corporation
 - NCSL National Conference of State Legislatures
 - NMEI New Mexico Energy Institute
 - OIT Oregon Institute of Technology
 - PNL Pacific Northwest Laboratories (Battelle)
 - RMB&R Rocky Mountain Basin and Range
 - SCT State Commercialization Teams
 - SRT State Resource Teams
 - USFS United States Forest Service
 - USGS United States Geological Survey
 - UURI University of Utah Research Institute
 - 790 USGS Circular 790
 - * Activity Reports, Status Reports, Inputs to State Fact Summaries
 - # Activity Reports, State Fact Summaries

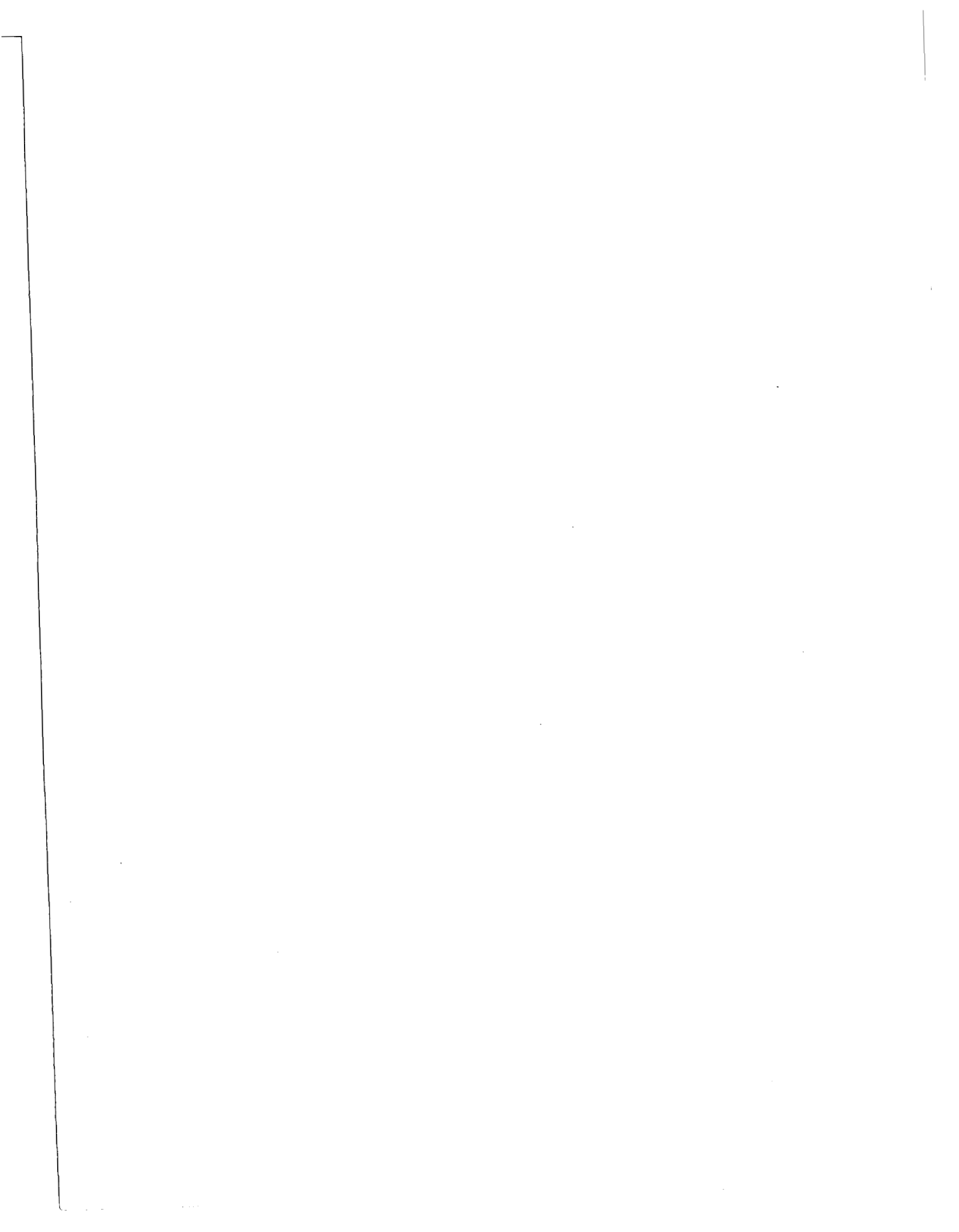
**FIGURE 4-1
FLOWCHART OF EXISTING GEOTHERMAL
INFORMATION NETWORKS**



information services, or a DGE contractor or laboratory. From these sources the information passes to a DOE Regional or Operations office, where it is collected and forwarded to DGE in Weekly Activity Summary reports. Non-DOE government geothermal activities are generally reported to DGE, either directly or through the IGCC.

The present network contains redundant paths for information concerning geothermal activities arising from DOE or other government programs or initiatives, and also for deep drilling activities in the private sector. Information on other private sector activities, and some local initiatives, cannot yet be reliably assumed to be acquired by this network until more direct means can be implemented. This gap is presently being filled by the commercial information services.

The reader is referred to Appendix A for descriptions of contributions to the GPM from many of the organizations described in Figure 4-1.



5.0 MECHANICS OF THE GPM

Operation of the GPM is an interactive effort of MITRE and DGE. Responsibilities for the various aspects of the system are allocated between DGE and MITRE, with DGE having overall responsibility for the system and MITRE being responsible for operating and maintaining the system. The following sections describe more specifically the particular responsibilities within the GPM system.

5.1 Activity Reports

These reports will arise from several sources:

- Activity summaries prepared by DGE from reports received from its field teams and from the upper levels of DOE.
- Reports from IGCC members forwarded to the GPM by the chairman of the Budget and Planning Working Group.
- Activity reports suggested to DGE by MITRE, culled from geothermal literature and news reports.

DGE exercises editorial control over all activity reports.

5.2 Status Reports

Status information is maintained in site-specific soft (paper) files in order to handle the large amounts of information that must be maintained on particular sites or installations. The following soft files have been established:

- Electric power sites
- Direct heat sites
- International activities
- Lease sales
- Drilling data

From these files the information is abstracted to form hard (computer) files. The hard files are maintained on a computer text editing system for rapid editing and production of reports in tabular form.

Computer generated reports are used to circulate information to field teams for updating and validation. These are "frozen" every six months to be issued as status reports in the GPM. The hard files will also serve to provide quick totals of information and rapid accession to sources of the data. Tape copies of the six-month frozen files will be made for later use in analysis of trends.

5.3 Trend Analyses

The trend analyses will arise from periodic review of status indicators. These reviews will highlight changes in time intervals, quantities, and costs, and provide the basis for more detailed investigation and analysis. Other trend analyses might be suggested by DGE or other interested parties, and performed by MITRE as resources permit.

5.4 Sources and Files

Table 5-1 lists the various sources of information for the GPM files with the time intervals and file types for each. This table also indicates the GPM outputs each information source supports.

5.5 Implementation Responsibilities

Table 5-2 lists the responsibilities of the participants in the GPM for implementing the system. Briefly, MITRE is responsible for

TABLE 5-1
GPM INPUT/OUTPUT MATRIX

INPUTS	OUTPUTS														
	MONTHLY ACTIVITY REPORTS	LEASE STATUS	ELECTRIC SITES STATUS	DIRECT HEAT SITES STATUS	WELLS DRILLED	FEDERAL PRDA, PON STATUS	RESOURCE BASE UPDATES	LEGAL STATUS; FEDERAL OR STATE	DOE LOAN GUARANTY STATUS	R&D ACTIV- TIES	EXPLORA- TION	ENVIRON- MENTAL ACTIV- TIES	OUTREACH AND TECHNICAL ASSIST- ANCE	STATE- LOCAL- PRIVATE SECTOR	FOREIGN INSTALLA- TIONS AND PLANS
Reports from DGE State Teams	A	B	B,C	B,C	B,C	B,C	B,C	B	-	B	B	B	B	B	-
Reports from DGE Headquarters Staff	A	-	-	-	-	B,C	-	B	B,C	B	-	B	B	-	B
Reports from USGS	A	B	B,C	B,C	B,C	-	B,C	-	-	-	B	-	-	-	-
Reports from Other IGCC Agencies	A	B	B,C	B,C	-	-	-	B	B,C	B	-	B	B	-	B
National Conference of State Legislatures	A	-	-	-	-	-	-	B	-	-	-	-	-	B	-
Industry Drilling Reports	-	-	B,C	B,C	B,C	-	B	-	-	-	B	-	-	-	-
Private Sector Magazines	A	B	B,C	B,C	B,C	B	B	B	-	-	B	B	B	B	B
Solicited Reports	A	B	B,C	B,C	-	-	B	-	-	B	B	B	-	B	B
Unsolicited Reports	A	B	B,C	B,C	B,C	-	B	B	-	B	-	B	-	B	-
IBS Clipping Service	A	B	B,C	B,C	B,C	-	-	B	-	-	-	-	B	B	B

KEY: A - Reported monthly, not stored.
B - Stored in soft (paper) files.
C - Stored in hard (computer) files.

TABLE 5-2

CURRENT IMPLEMENTATION

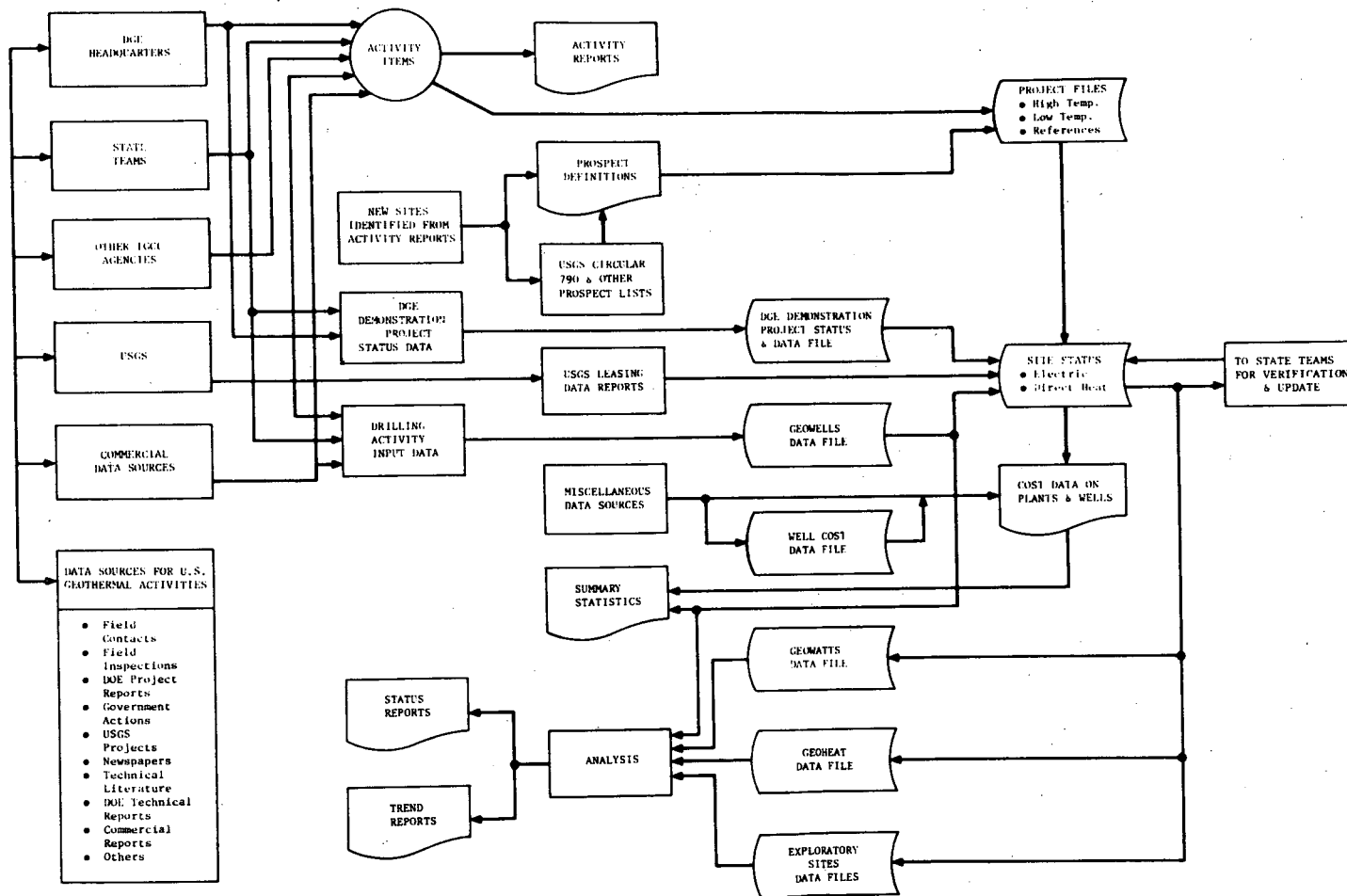
<u>DGE HEADQUARTERS</u>	<u>MITRE</u>
<ul style="list-style-type: none"> ● System Requirements ● Supply Information ● Validate Information ● Official Channel for Acquiring Information ● Review and Publish Reports ● Request and Use Trend Analyses 	<ul style="list-style-type: none"> ● System Design and Documentation ● Collect Information ● Validate Information ● Establish Manual and Automated Files ● Organize and Prepare Reports ● Suggest and Perform Trend Analyses
<u>DOE REGIONAL OFFICES AND STATE TEAMS</u>	<u>OTHER AGENCIES</u>
<ul style="list-style-type: none"> ● Monitor the Field ● Maintain Deep/Detailed Knowledge of Field Activities ● Report Activities ● Update Status Information ● Help Analyze Significance of Trends 	<ul style="list-style-type: none"> ● USGS - Report Site Physical Data - Report Leasing Events and Status (BLM, USGS) ● EPA - Report Environmental Assessment Results ● NCSL - Report State Legislative Status and Events ● DOD - Progress at Coso, CA Site

system design and implementation, collecting and validating information, maintaining the hard and soft files, organizing and preparing reports, and performing trend analyses. DGE is responsible for system requirements, providing information and assisting in its validation, being the official channel for acquiring information, reviewing and publishing the reports, and requesting and using trend analyses. The field teams monitor the field, maintain close contact with field activities, report events, update status information, and assist in analyzing the significance of trends. Other IGCC agencies will provide site physical data, leasing activity information, environmental assessments, and state legislative and regulatory activity reports.

5.6 Information Flows at MITRE

Information of many types comes to MITRE through the five main source categories shown in the upper left of Figure 5-1. Reports of significant or exceptional events (activity items) are detected either by DGE Headquarters or MITRE and reported in the next GPM Progress Report.

Activity items are examined to determine if they represent actions at a previously unreported site, and are filed with respect to the site at which they occur. Special attention is devoted to activities related to DGE demonstration projects, geothermal drilling activities, geothermal electric plant sites and geothermal direct heat sites. Well costs and plant (electric and direct) costs are recorded when detected.



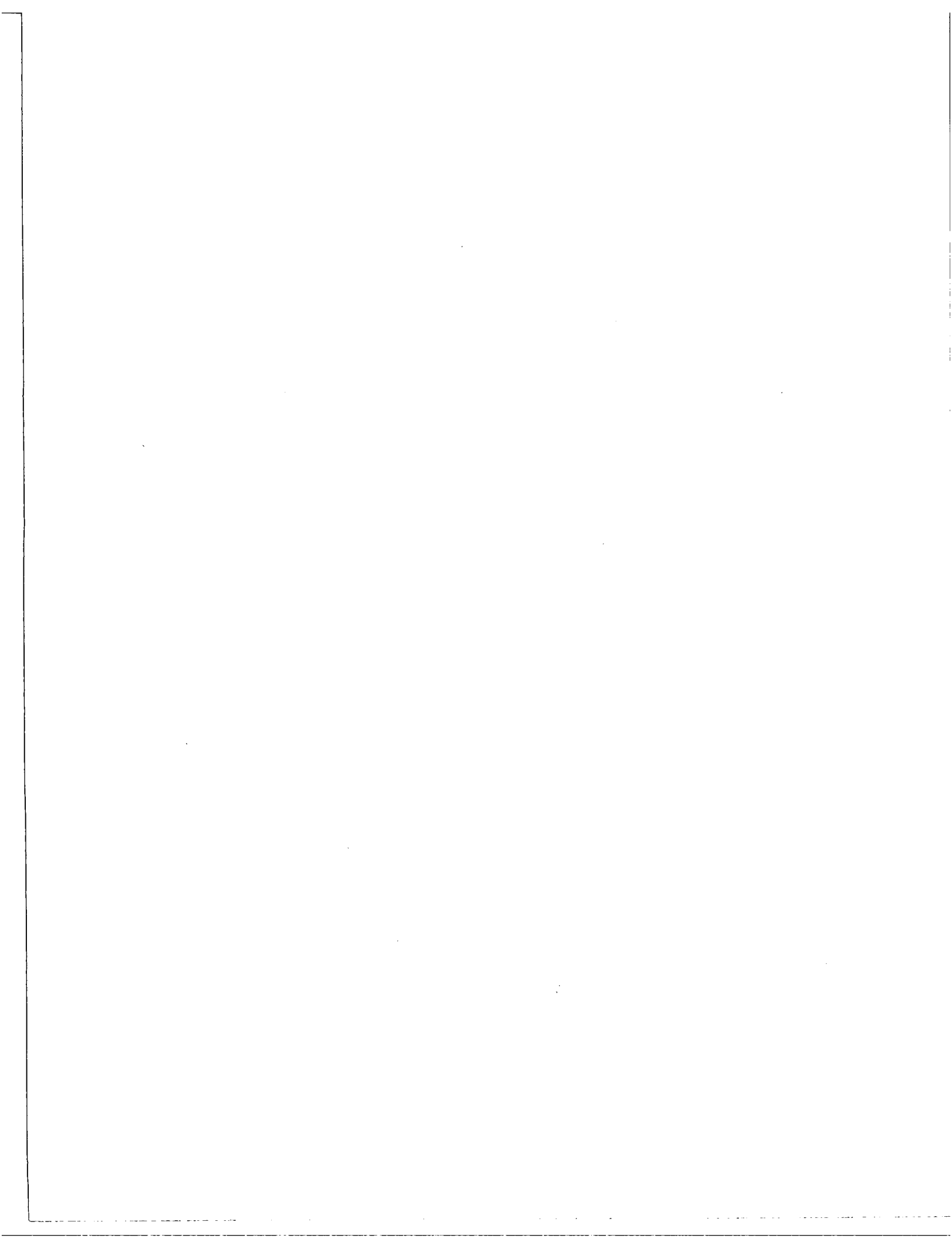
**FIGURE 5-1
GEOTHERMAL PROGRESS INFORMATION TREATMENT AT MITRE**

Activity items that alter site status are recorded on a status form, on which sequential entries reflect an increasing commitment of the industry or DGE to either explore a site or develop it. This recording process is well underway for electric plant (high temperature) sites, but not begun for direct heat (lower temperature) sites.

Computerized databases have been established for electric plants (GEOWATTS), direct heat installations (GEOHEAT) and geothermal wells (GEOWELLS). The initial (November 1979) contents of GEOWATTS and GEOHEAT, compiled from a variety of sources, were sent out to the DGE State Geothermal Resource and Commercialization Teams. Significant improvements were made to these files based upon the information returned from the State Teams.

From these files summary statistics, status and trends are analyzed and reported. The immediate need continues to be acquiring baseline status data for a multiplicity of sites. When this is accomplished, trends will be established by comparing changes in status over six-month intervals.

Verification of trends will require storing collected status information quarterly, since industry tends to assess trends over calendar years while the federal government tends to assess trends over fiscal years.



6.0 CURRENT EMPHASES AND ISSUES IN THE GPM

A number of emphases and concerns may be inferred from Figure 5-1. First, information must be collected from a broad variety of sources. Items range from formal reports to direct contacts with people in private industry. The timeliness and reliability of the received items will vary greatly.

Verification of the accuracy of the information reported by the GPM is an important issue. The reports will have high visibility and will ultimately be the factual basis upon which some aspects of government policy will be formulated.

The present mode for validating the GPM information consists of cross checking redundant sources and resolving differences by telephone contacts. As the implementation of the GPM progresses, field checks of selected sites and activities should be performed to ensure that the information reported is comprehensive as well as accurate.

Second, a simple basis for aggregating and interpreting this information must be established. At the moment, the effort at MITRE emphasizes:

- (1) Electric plants.
- (2) Direct heat applications.
- (3) Status of development at individual geothermal locations.
- (4) Federal industrialization efforts (loan guaranties, industry and state-coupled drilling programs, etc.).

The current level of effort has not allowed timely tracking of a number of important categories of information, including:

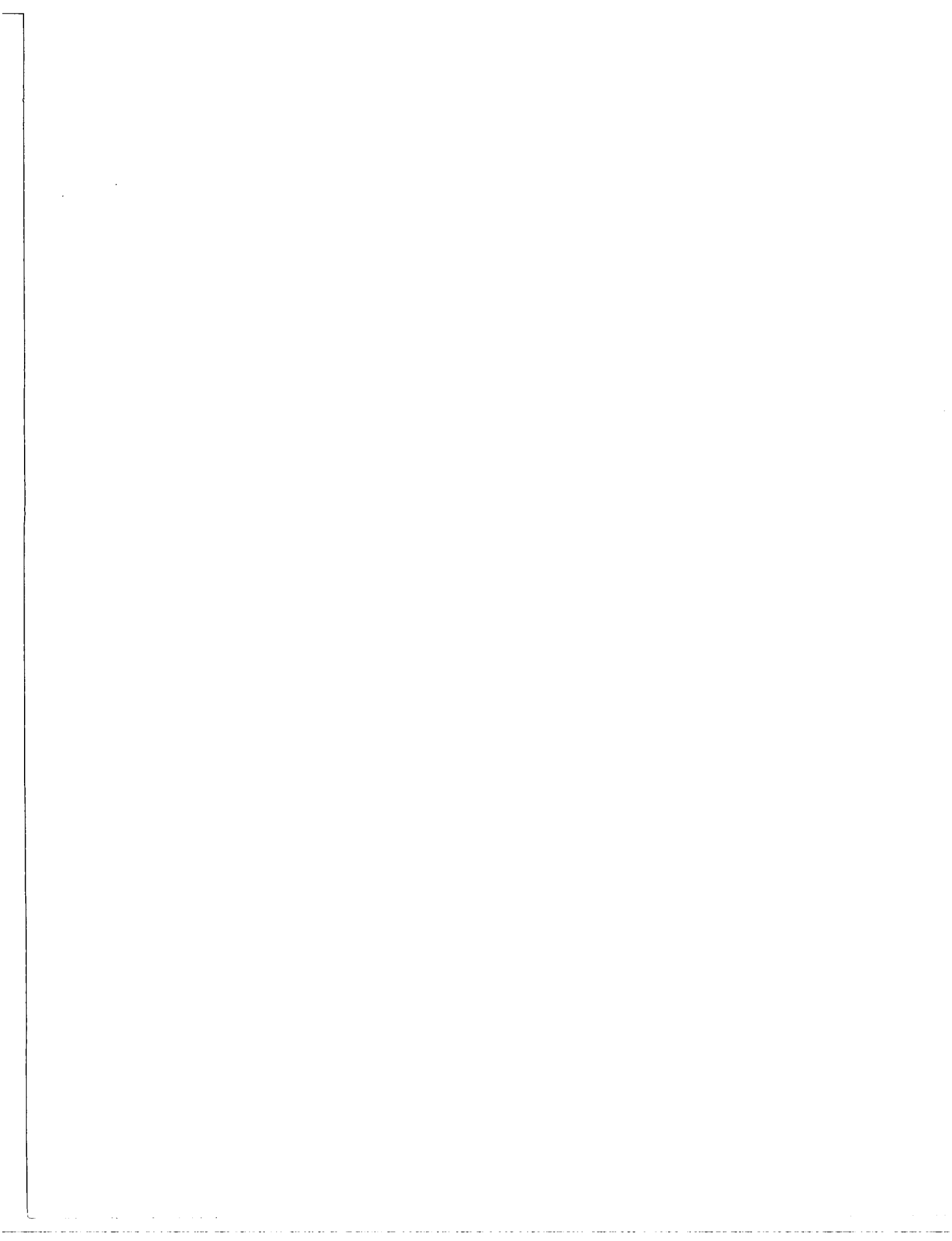
- Status of state laws and regulations
- Status of site- and region-oriented environmental assessment activities
- Status of technology-development efforts
- Tracking of early exploration and development activities on non-federal lands.

Third, the most complex undertaking in this effort is the establishment and tracking of accurate information about the status of development at specific geothermal sites. Site status is most easily determined when inputs on activities at or concerning a site come from many sources. In most cases where many sources report frequently, the site is either well into development - i.e., construction will begin within one to two years; or the site is the focus of a government-funded project - i.e., frequent reports flow directly to DGE Headquarters or the DGE State Geothermal Resource and Commercialization Teams. This will leave many sites where the owner/developer must be queried directly by a DGE State Team to assess site status. Thus, achieving accurate site status assessments will require increasingly closer coordination between MITRE and the DGE State Teams.

Fourth, by the time information reaches the levels indicated by "Status Reports," "Trend Reports," and "Analysis" in Figure 2-4, the information has become highly abstracted. Much of the initial anecdotal material that might have been coupled to the countable and

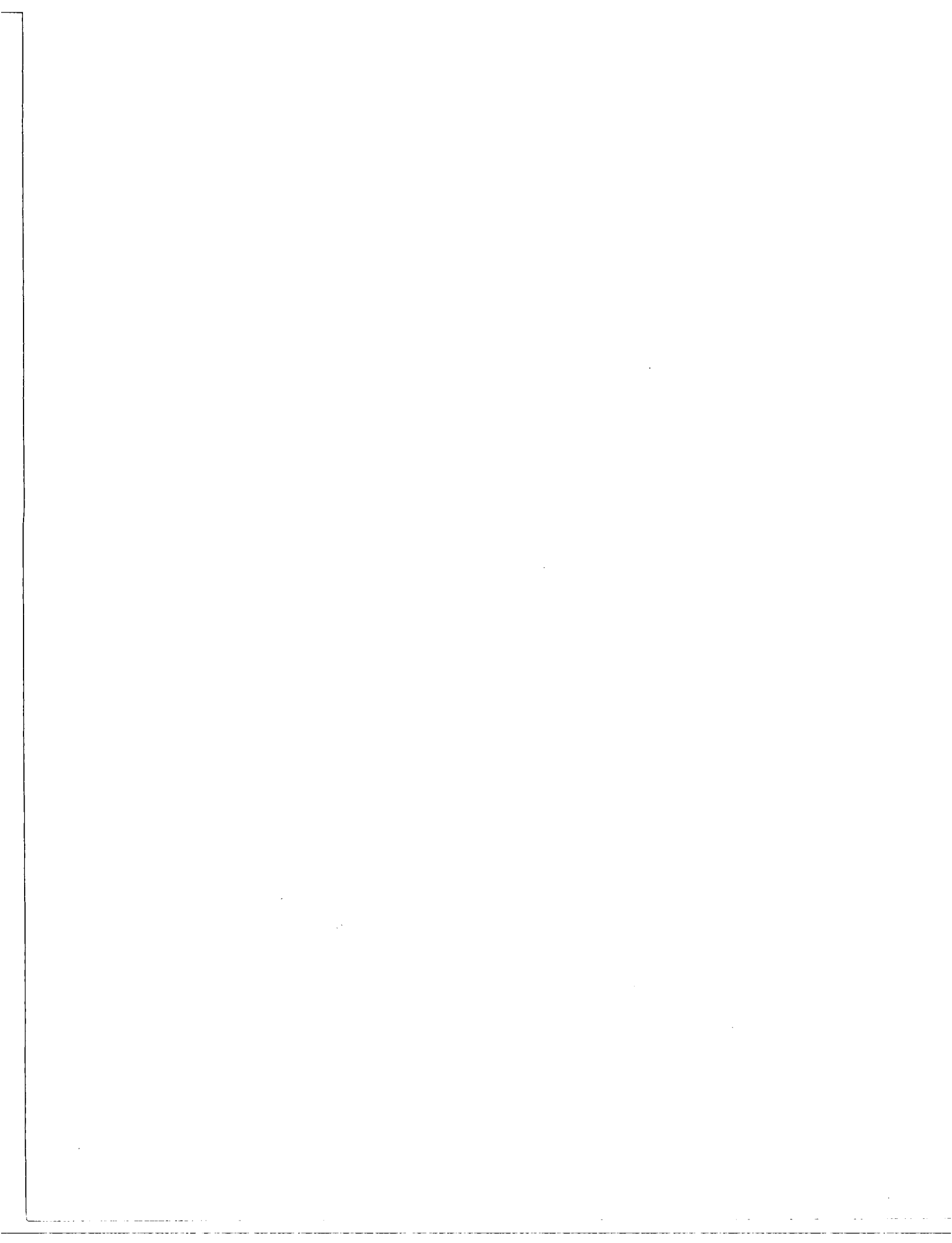
quantifiable facts will have been removed from the major quantitative reports to be retained only in the "Prospect Information Soft Files."

If the conditions that underlie detected trends are to be analyzed, considerable interpretive expertise will have to be developed either at specific locations in the DGE field structure, or at MITRE.



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APPENDIX A

**INFORMATION AVAILABLE FROM
DOE GEOTHERMAL FIELD ACTIVITIES
AND GEOLOGICAL SURVEY OFFICES**

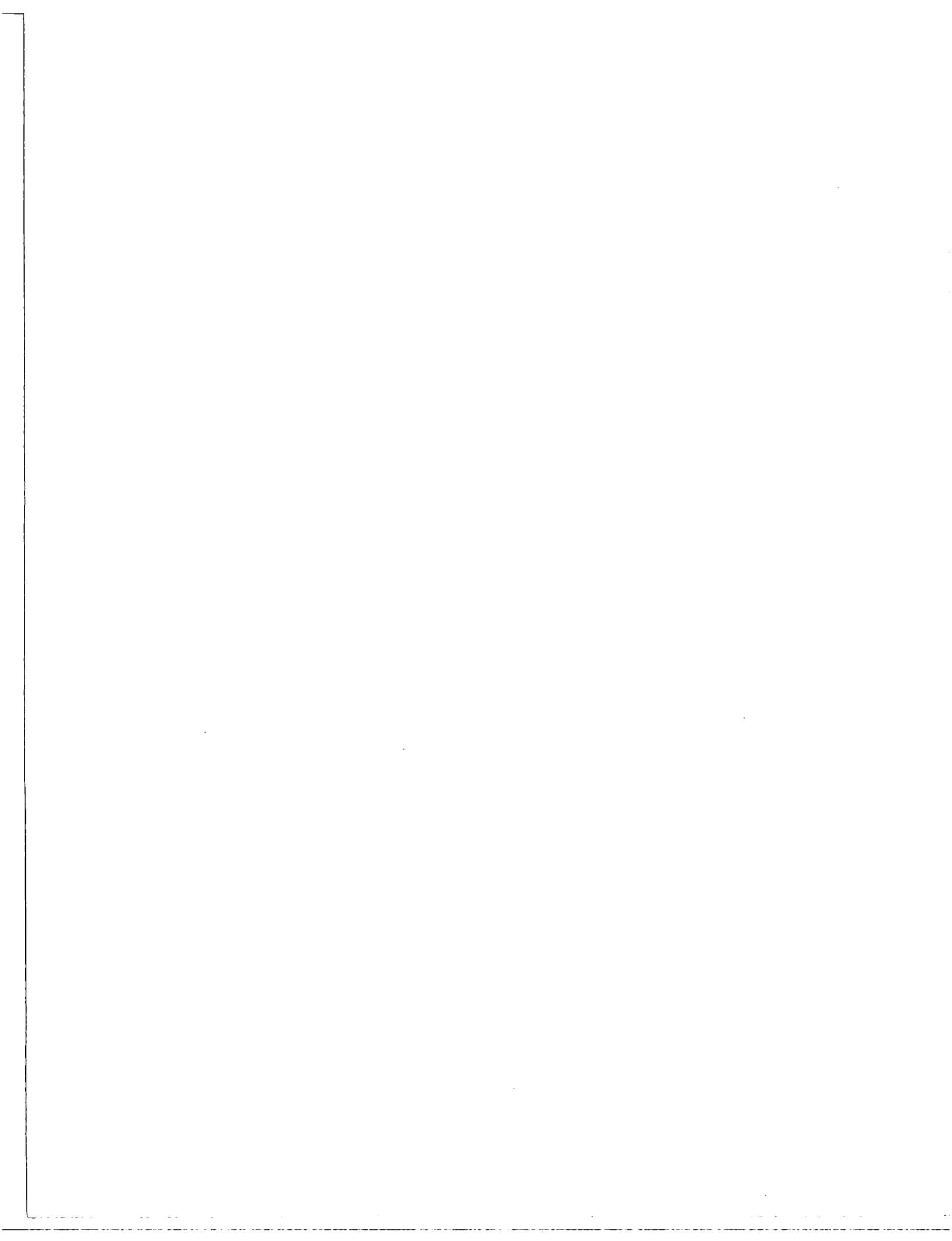
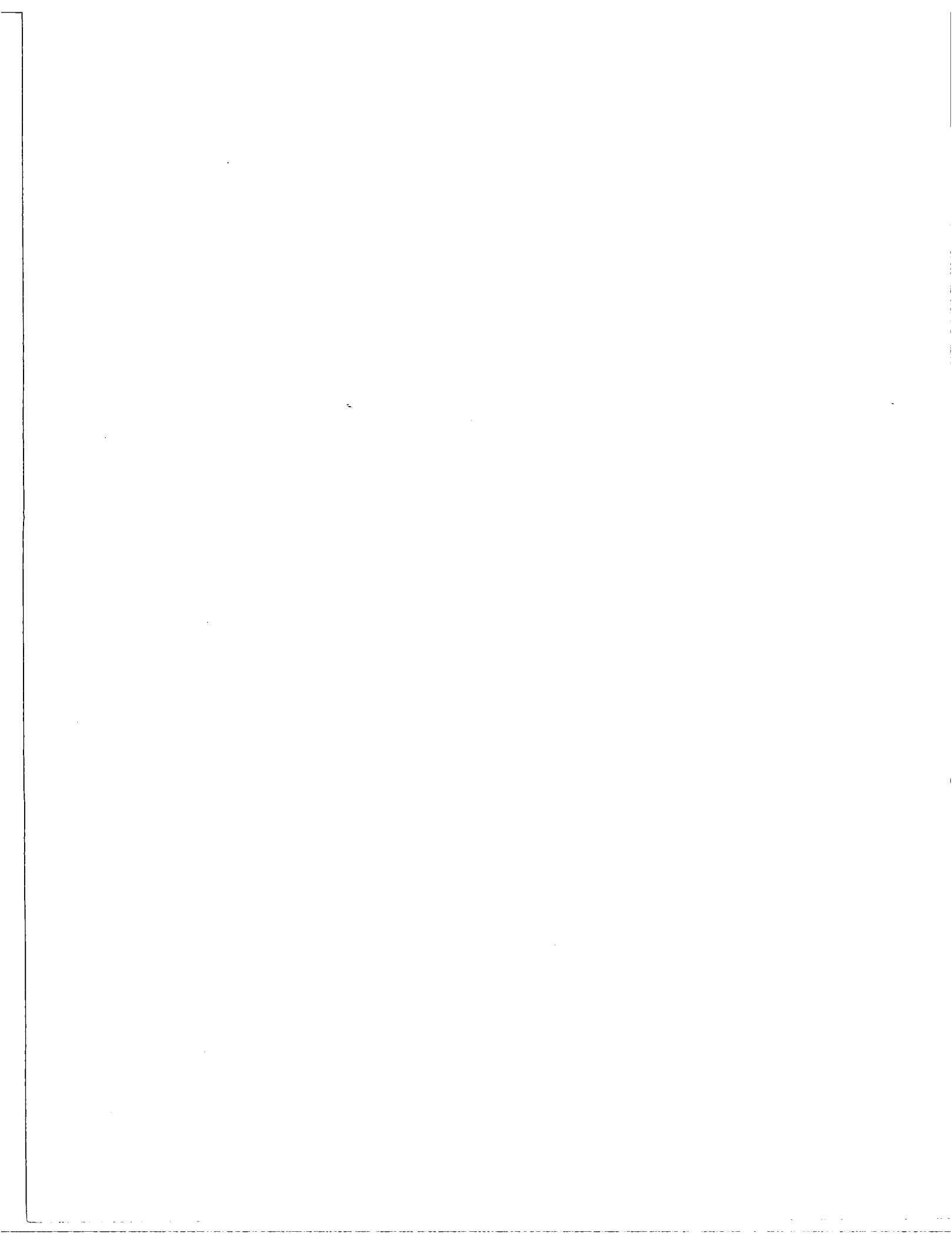


TABLE OF CONTENTS

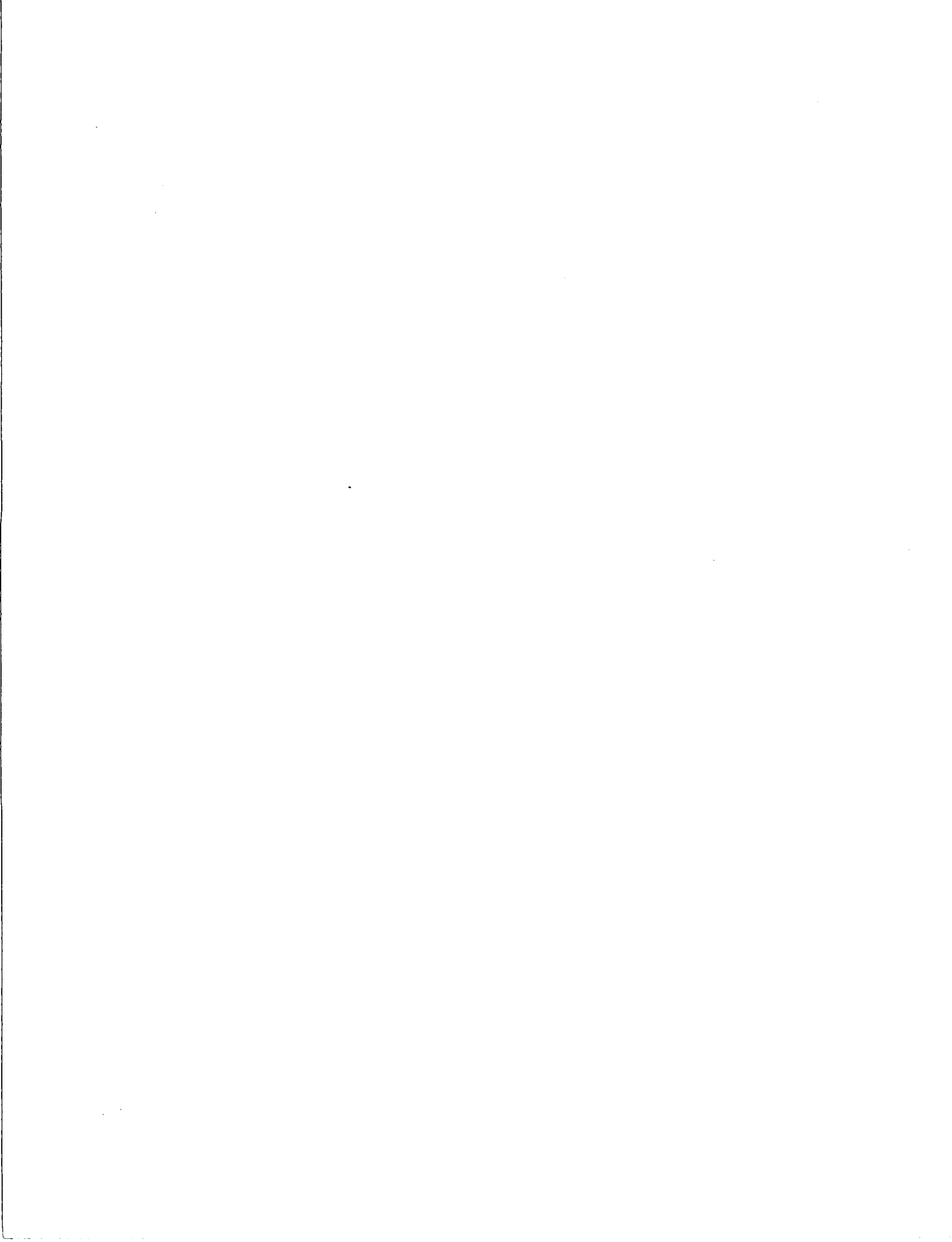
	<u>Page</u>
1.0 INTRODUCTION	A-5
2.0 APPLIED PHYSICS LABORATORY (APL) OF JOHN HOPKINS UNIVERSITY INFORMATION BASES	A-7
3.0 IDAHO NATIONAL ENGINEERING LABORATORY (INEL) INFORMATION BASES	A-9
4.0 LAWRENCE BERKELEY LABORATORY (LBL) GRAD DATABASE	A-11
5.0 NEW MEXICO ENERGY INSTITUTE (NMEI) ROCKY MOUNTAIN BASIN AND RANGE DATABASE AND ECONOMICS STUDIES	A-13
6.0 OREGON INSTITUTE OF TECHNOLOGY (OIT) INFORMATION DATABASE	A-17
7.0 UNIVERSITY OF UTAH RESEARCH INSTITUTE (UURI)	A-19
8.0 U. S. GEOLOGICAL SURVEY (USGS) GEOTHERM DATABASE	A-23
9.0 U. S. GEOLOGICAL SURVEY (USGS) FEDERAL GEOTHERMAL LEASING ACTIVITIES	A-29



1.0 INTRODUCTION

A number of the important information collection and evaluation efforts of the Geothermal Progress Monitor (GPM) system, and the development of databases that support those efforts, are conducted by contractors to the Division of Geothermal Energy (DGE), and by other federal agencies, particularly the U.S. Geological Survey (USGS). This appendix describes some of the larger of these efforts, and some of the DGE program activities that these efforts were designed to support.

In most cases, the GPM effort draws from previously established information gathering and analysis activities at these institutions. As development of the GPM progresses through cooperative interaction of the organizations that comprise it, some standardization of data reporting can be expected to develop. Where such standards develop, they in turn can be expected to alter internal aspects of some of the activities described in following sections.



2.0 APPLIED PHYSICS LABORATORY (APL) OF JOHNS HOPKINS UNIVERSITY INFORMATION BASES

APL maintains a summary for each of the 33 eastern states that it tracks. These summaries include the following categories:

- (1) Assessment of Geothermal Potential by State. This assessment, which provides a comparative understanding since each state is different, develops a general scenario or site prospectus based on a brief initial survey. Aggregated assessments of area potential will be developed from inputs from DOE, the states, military and other sources.
- (2) Assessment of User Market Co-Located with Resources.
- (3) Preparation for Development of Resources. This includes information on state-level legal status, technical preparation (demonstration of resource and availability of technical assistance), identification of informed state and local officials, and identification of steps for site prospectus development.
- (4) Precursors to Possible Development. These include leasing of public land, expressions of interest and requests for technical aid, proposals to states and others, and preparation and distribution of definite site prospectuses by states (sales brochures).
- (5) Applications. These are indications of possible development, e.g., appropriation of water, wasting or reinjection of water, and tracking abandonment of wells.
- (6) Environmental Impact or Assessment.
- (7) Clean Water Act, and Monitoring of EPA data.
- (8) DOE Demonstration Projects. These offer a generalized approach to progress monitoring but require additional data.

Some data developed by APL include State Fact Sheets, identification of potential resource/market areas, market studies, and predictions of regional (aggregated) potential. State Fact Sheets have been completed for each of the 33 eastern states. They contain

summary data of energy uses and resources, geothermal activities, a list of pertinent contacts for geothermal development and a list of reference documents. State Fact Sheets are derived from many sources of information including DOE, Bureau of Census, and USGS maps.

Potential resource/market areas have been identified at the county level on the basis of potential population, residential, commercial or industrial energy use. Detailed market studies are generated within a county, state or town and are adapted to the concerned market. Aggregations of regional geothermal potential include data abstracted from the state fact sheets and market identifications and studies, as well as scenarios and site prospectuses.

3.0 IDAHO NATIONAL ENGINEERING LABORATORY (INEL) INFORMATION BASES

INEL prepares weekly and monthly activity reports based on information collected from the State Geothermal Commercialization Teams through telephone calls. This information is edited and forwarded to the DOE Idaho Falls Office, which reviews it and sends it to DGE Headquarters. These reports cover the ten states of the Rocky Mountain Basin and Range Region.* The contents of these reports include commercial activities, state programs, changes in state geothermal regulations, and information about the status and progress on federal government programs and projects.

INEL also is responsible for the preparation of the State Fact Books. Eleven of these have been published to date, and a few more are in the final stages of preparation. The contents of these state data books include:

- Basic information about the state such as population, major cities, etc.
- Leasing, drilling, and known geothermal resources
- The status of commercialization efforts
- The locations of wells and hot springs, as derived from information provided by the University of Utah Research Institute (UURI)

The input to the State Fact Books comes from the State Geothermal Commercialization Teams, UURI and other government contractors.

*Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah and Wyoming.

The contents of the books have been reviewed by UURI and the State Geothermal Commercialization and Resource Teams.

APL is abstracting brief statements of information from the INEL State Fact Books to be added to APL's three page State Fact Sheets for each of the 33 eastern states. As a result, DGE will receive a book of State Fact Sheets that includes all 50 states.

4.0 LAWRENCE BERKELEY LABORATORY (LBL) GRAD DATABASE

The Lawrence Berkeley Laboratory at the University of California in Berkeley maintains the GRAD database. GRAD (Geothermal Resource Applications Database) is an interactive database which contains site-specific information about scenarios and schedules used or anticipated for a particular geothermal development. It is based on the Stanford University SPIRES database management system. Some of the sources of information used by LBL for GRAD are the Munger Oilgram, the Geothermal Hot Line (a California state newsletter), and a number of other commercial sources. Other publications used as information sources are obtained from the DOE Technical Information Center in Oak Ridge, TN, the Journal of Geophysical Research, and reports from LBL, UURI, INEL, and DOE.

GRAD was begun as an interactive effort with the University of Pisa for creating a database that contained both United States and international information. The University of Pisa was to cover Europe, Africa, and Asia. LBL was to cover North America, South America, and the Pacific. The interactive effort with the University of Pisa is currently limited to the interchange of technical information. This effort could contribute a valuable source of information to tracking world-wide geothermal activities, developments and trends.

The GRAD system covers only DOE regions 9 and 10. Within those regions, 331 sites have been selected for tracking. These include

both electric and direct heat application sites. The data entry forms to the GRAD system allows for referencing the sources of the information that are placed in the database.

The list of topics covered in GRAD is development-sequence oriented. The classification system for these topics and development sequences follows the conventions of the USGS/U.S. Bureau of Mines. It is based on geological understandings of the geothermal resources and on estimates or measures of the economics of the specific sites for electric or direct heat development purposes.

5.0 NEW MEXICO ENERGY INSTITUTE (NMEI) ROCKY MOUNTAIN BASIN AND RANGE DATABASE AND ECONOMICS STUDIES

The key to the New Mexico Energy Institute effort in database handling and information collection has been to emphasize both flexibility and simplicity. The states covered by the system are Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah and Wyoming.

Five large files are maintained for computer use: a Site file, a City and Town file, an Energy file, an Industrial file, and a Cash file.

The Site file contains information on both electric and direct heat application sites. Each of the records in this file includes:

- Site Identification Number
- Site Name
- County
- Latitude
- Longitude
- Township
- Range
- Section
- Reservoir Volume, with source of information
- Subsurface Temperature, with source of information

The latitude and longitude information is used for calculating distances to particular cities, for which similar information is maintained in the City and Town file.

The City and Town file contains data on 1800 cities and towns in the States. The major items consists of:

- Identification Number
- Town Name
- County
- Latitude
- Longitude
- Population Size
- Heating Degree Days
- Lowest Temperature Recorded

NMEI also maintains much data on various government and private projects in the states. The information on these projects is kept in soft files, which are large enough to fill a medium size conference room. The size of these files on projects, sites, and cities underscores the need for careful specification of what information should be sent forward to the GPM.

The economic studies at NMEI depend heavily on three special automated files; the Energy file, the Industrial file, and the Cash file. Regional energy consumption is based on information on fuels and information on the consuming sector of the energy use economy. Although estimating energy demand is relatively easy, price data and consumption by sector are difficult to obtain for specific cities.

The economic studies rely on a city file which is similar to that discussed above, except that it includes additional information

consisting of an industrial data file and an energy file for each city. Some of this information is drawn from consumption records, from public utility commission reports, and any other sources that are available.

Resource information is drawn from USGS Circular 726, as updated by USGS Circular 790, and by information currently in the GEOTHERM database as updated by the State Geothermal Resource Teams.

NMEI has analyzed the price growth rate as a function of the energy demand and identified 350 cities for which geothermal direct heating appears to be economical under certain conditions. This analysis results from what is called the "Computer Assisted Scenario, Hydrothermal" (CASH), which tabulates by city the amount of resource that is going to be economical by what year, given the price growth rate for alternative energy sources.

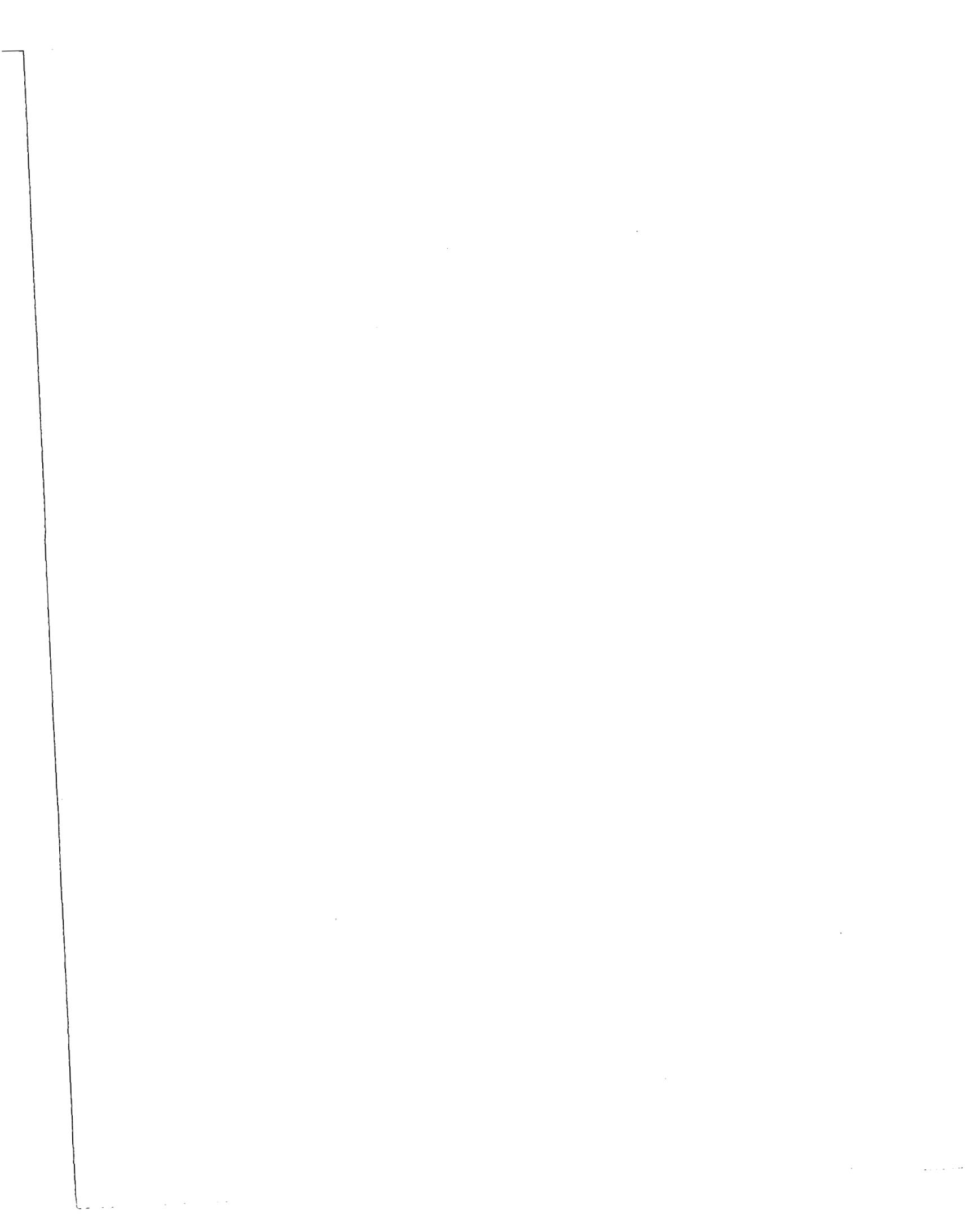
It has been suggested that the GPM should include some system for rank ordering both electric and direct heat sites with respect to the most and the least promising. NMEI's experience indicates that one problem is that such a rank ordering implies a system of value judgements, which could result in an undesirable exclusion of promising sites and inclusion of less promising sites. The major problem is that the initial categorization can and will change over time, as the various geophysical, economic, and institutional factors change. In addition, major exogenous variables to the geothermal scene can

greatly influence potential geothermal development. An example is that the possible disruption of nuclear-based electricity could quickly result in increased public and investor interest in geothermal energy as a feasible alternative.

6.0 OREGON INSTITUTE OF TECHNOLOGY (OIT) INFORMATION DATABASE

OIT has collected data on a site-by-site basis for approximately 200 sites in a six-state region, including Alaska, Idaho, Montana, Oregon, Washington and Wyoming. These data contain state energy overviews, site data summaries on legal and institutional analysis of geothermal energy development, and a geothermal use inventory. It is thoroughly referenced and documented with respect to sources.

The site data summaries include various geoscience reservoir data, geographic data, location data, ownership data, and environmental and climatic data. For certain states there are specific lease data including federal, state and in certain cases, private lease data. In addition, OIT has acquired the developmental status on each site, and for a few select sites, a cost-benefit analyses. The OIT database keeps track of competitive local fuels as does the NMEI database. Natural gas appears to be the primary target fuel to be replaced in these western states, but much oil is used in some locations and user sectors.



7.0 UNIVERSITY OF UTAH RESEARCH INSTITUTE (UURI)

The University of Utah Research Institute geothermal work does not maintain computer databases, but does generate much information in connection with its activities in the DOE/DGE Industry-Coupled Drilling Program and to the State-Coupled Direct Heat Geothermal Program. The overall emphasis in much of this work is in resource characterization with the purpose of assisting geothermal developers and potential geothermal users in characterizing the geothermal sites in which they are interested.

The Industry-Coupled Drilling Program has shared the cost of wells with industrial companies. Wells were drilled at Roosevelt Hot Springs and Cove Fort-Sulfurdale in 1978. Cost-shared wells were drilled in 1979 at twelve sites by eight different companies with two companies drilling at one of the sites. The 1979 contract dollar cost was \$9.9 million.

This information is disseminated to the industry through "open file data releases". These are meetings, held within six months after the data has been collected, at which industry representatives can go through these files and buy portions of them if they desire.

Data collection and sales provides a high degree of contact between UURI and the major geothermal developers, especially those involved in the search for high quality resources for electric use. These companies are frequent users of the geothermal samples library/laboratory where UURI maintains both samples and equipment

for analyzing samples of materials from geothermal drilling well holes.

The State-Coupled Direct Heat Geothermal Program covers 18 western states. The responsible parties are state agencies who receive assistance from USGS, UURI, the National Oceanographic and Atmospheric Survey and the Los Alamos Scientific Laboratory. Output reports from the direct heat studies are sent directly to USGS for input into their GEOTHERM database, and to UURI where they are evaluated and refined, with the refined reports being forwarded to GEOTHERM.

One of the most important forms of information that comes out of these studies is a detailed scientific map of the geothermal resources in specific states. Much of the information that goes on such a map is not easily put into a computer. The information contained in the map includes heat flow values, geothermal gradient, oil well data, and areas of present use. UURI maintains a hard copy file of this database, but does not plan to convert this into a computer database at the present time.

One result of this work has been the identification of a number of high quality direct heat drilling targets. These represent the best development prospects in ten western states. There are about 152 good sites that deserve further exploration. Of these sites, 21 have temperatures greater than 150°C, 63 are in the 90°-150°C range, and 68 have temperatures below 90°C. The criteria used to select

these high quality target sites included quality of the resource, proximity to potential users, and the district concept, i.e., identified geographical clusters of favorable sites.

UURI receives many user assistance requests especially from people that are interested in direct heat applications and interacts closely with INEL and OIT to service these requests.

The geothermal work in progress at UURI and the University of Utah supports DGE in a number of areas:

Regional Planning. This effort supports the formulation of regional geothermal industrialization and market penetration plans. UURI has participated with EG&G-Idaho in the formulation of such plans for the Rocky Mountain Basin and Range Region.

User Assistance. A cooperative effort with EG&G-Idaho offers up to 100 hours of professional assistance to potential developers of geothermal energy, with UURI being responsible for the geoscience aspects.

Geothermal Database. UURI is putting together a database which will incorporate, but not duplicate USGS file GEOTHERM, as well as data and information which can best be stored as paper copies (soft files) rather than on the computer. This database will be vital to better regional planning and to user assistance.

Energy Technology Programs. UURI performs management assistance on behalf of DOE for the Industry-Coupled and State-Coupled Programs. In the Industry-Coupled Program, UURI interprets data and publishes

technical reports and case studies on the information which DOE purchases from the industry. A geothermal sample library has been established to store and distribute samples from geothermal wells drilled for this program and for other programs.

State-Coupled Program. UURI assists in the coordination among DOE, USGS, and the 13 State Teams now operating under DOE contract. The objective of this program is to assist USGS in the compilation and publication of data and maps on the nation's low- and moderate-temperature resources.

Technology Development Program. This supports both of the above programs with the objective of increasing the cost effectiveness of exploration for and assessment of geothermal resources. The induced seismicity effort provides funds for installing a seismic network in the Roosevelt-Cove Fort-Thermo area for the purpose of obtaining baseline data and monitoring seismic activity associated with well tests. This network will operate before and after Roosevelt goes into production in 1983.

Support for Commercialization. The UURI professional staff covers a broad range of talent in the earth sciences with emphasis on exploration and assessment problems related to geothermal resources. UURI has a growing resource data base and are actively working with State Teams in the western U. S. who are continuing to assemble and upgrade that database. The current projects bridge the gap between technology development and commercialization of geothermal resources, with emphasis on resource assessment.

8.0 U.S. GEOLOGICAL SURVEY (USGS) GEOTHERM DATABASE

GEOTHERM is a computerized file created and presently operated by the U. S. Geological Survey as part of its Geothermal Research Program. It was initiated as part of the International Geothermal Information Exchange Program at the First Geothermal Implementation Conference in New Zealand in 1974. Its objective is to provide for the prompt exchange and dissemination of new geothermal information and data. GEOTHERM contains information concerning the physical characteristics, geology, geochemistry, and hydrology of national and some international geothermal resources. The data include published information and data from other computer files, personal communications, and compilations by various government and private organizations.

GEOTHERM is not a software package but a file which uses the GIPSY (General Information Processing System) data storage and retrieval system. GIPSY was developed at the University of Oklahoma which provided utilities for the input, retrieval, manipulation, presentation, and maintenance of information composed of numeric, codified, or natural language data. GIPSY is operational on the USGS IBM 370/155 computer in Reston, Virginia.

Since its inception, GEOTHERM has existed as a public file. With this in mind, the philosophy of the file has been to provide standardized, well-documented data. Each data item in the present format is designed both for further manipulation and for visual presentation.

Therefore, GEOTHERM data can be used for subsequent computer processing or for printed output.

GEOTHERM was created for use in the characterization and assessment of geothermal resources and to provide a central location for a potentially large volume and variety of data. Recent interest in geothermal energy has caused a vast proliferation of geothermal resource data. Using the GIPSY retrieval program, GEOTHERM can make highly selective and rapid data retrievals in an assortment of output modes that would be difficult to accomplish using conventional techniques.

USGS has been active in geothermal assessment and has published assessments of these resources in the United States (USGC Circulars 726 and 790). GEOTHERM played an active role in this study in the areas of data acquisition, editing, manipulation and display. GEOTHERM is also being used by DOE for a state-cooperative project to produce state maps illustrating low-temperature geothermal resources.

GEOTHERM is currently composed of three subfiles: Geothermal Fields/Areas, Sample Data/Chemical Analyses, and Geothermal Wells/Drill Holes.

Geothermal Fields/Areas. This subfile includes data on locality, surface manifestations, industrial developments, subsurface temperatures and dimensions, basic chemistry, thermal energy, general geophysics, geology, and other related information of a geothermal field or area. This subfile contains approximately 510 records of

which 290 cover geothermal fields from the 1975 USGS Geothermal Assessment (USG Circular 726), and 220 from the 1978 USGS Geothermal Assessment (USGS Circular 790), some of which are updated versions of the 1975 data.

Sample Data/Chemical Analyses. This subfile includes chemical analysis data from thermal springs and wells. Space is provided for three types of analyses: water, condensate and gas. Data items include source identification, locality, sample description, collection conditions, and physical and chemical characteristics of the fluids. This subfile contains 4600 records on wells and springs in the United States, New Zealand, and Mexico.

Geothermal Wells/Drill Holes. This subfile contains physical data from wells drilled for geothermal production or development. Information includes depth, casing, flow rates, and other physical data. The 436 records currently in this subfile were provided by the USGS Conservation Division, and are an inventory of geothermal wells and drill holes in the United States.

The scope of the file is obviously concentrated on data related to hydrothermal convection systems. However, GEOTHERM has the flexibility to include other subfiles as deemed necessary. The information in GEOTHERM is public and no proprietary data can be stored.

Each basic record on GEOTHERM consists of information furnished on a single reporting form. Some of the file specifications are as follows:

- o Numeric data are all converted to metric units
- o All numeric fields in the file are formatted alike so they can be retrieved and manipulated as an array
- o The file allows a variable amount of significant figures
- o Qualification codes exist for numeric data (e.g., L = less than, E = estimate, and T = trace)
- o Locality information is required (latitude and longitude preferred)
- o Documentation is provided in the form of a reference to the sources of information and the name and affiliation of the person who compiled the record.

In 1978, USGS completed the second assessment of U.S. geothermal resources (USGS Circular 790). GEOTHERM's contribution to this assessment can be considered a model for the application of a resource data file. The file was used for two aspects of the assessment, the intermediate- to high-temperature convective resources, and a first-time comprehensive assessment of the low-temperature resources of the United States. GEOTHERM's role in the assessment was in the following areas:

- (1) Data Acquisition and Filing. Over 2000 records of warm springs and wells were entered into the file for use in the assessment of low-temperature areas, and 220 records from intermediate- to high-temperature geothermal areas were added to the file.
- (2) Data Editing and Maintenance. Changes or additions to records were easily made with the GIPSY update program.
- (3) Map Plots. Over 60 maps with various scales and projections were produced using coordinates stored in GEOTHERM.
- (4) Data Calculations and Manipulations. The data in GEOTHERM were used in many operations including geothermometric

calculations, gradient calculations, statistics, determinations of volume and contained heat, point graphs, and regressions. In addition, estimates of recoverable heat and work available were calculated for the intermediate- and high-temperature systems.

- (5) Data Display. GEOTHERM was important for rapid retrieval, sorting and display of data. An open-file report of the intermediate- and high-temperature systems was published using a printout from GEOTHERM.

Other agencies are also involved in geothermal resource assessment. DOE is currently involved in a program to produce state maps depicting low-temperature geothermal resources and has made cooperative agreements with the concerned states to produce these maps. The first phase of this state-coupled program is to compile information on thermal wells and springs from the various sources and to enter the data into the GEOTHERM file. Much of the information currently on the sample file has been entered by these state agencies. The GEOTHERM staff also works closely with the National Oceanographic and Atmospheric Administration, which will produce some of the maps.

A number of comments about the status of GEOTHERM surfaced at the Geothermal Progress Monitor databases meeting held at The MITRE Corporation in McLean, Virginia in August, 1979. GEOTHERM is not entirely cleaned up yet. Much of the data came from the WATSTORE water well information file. One pass was made to clean that information in 1977 or 1978. The information was sent out to the State Geothermal Resource Teams for review in preparation for publishing USGS Circular 790.

GEO THERM contains all sites that are listed in USGS Circular 790. The information is much less complete with respect to lower-temperature sites than it is for high-temperature sites. It is not generally expected that GEO THERM will be totally up to date until perhaps three to four years from now.

GEO THERM has the number of wells and data on individual wells for the electric sites only. GEO THERM can not make map printouts directly, but it does contain latitude and longitude information in decimal degrees.

The data that goes into GEO THERM comes from two different major sources. The data for the high-temperature sites, that is sites with electrical generating potential, is collected and prepared by the USGS staff. The data for the lower-temperature, direct heat application sites comes from the State Geothermal Resource Teams, UURI, and APL.

9.0 U.S. GEOLOGICAL SURVEY (USGS) FEDERAL GEOTHERMAL LEASING ACTIVITIES

This system currently is tracking the status of many thousands of lease applications and active leases. The system is highly computerized and is capable of generating reports in many formats.

This system provides a lease and prelease history of all geothermal activity by the USGS, Bureau of Land Management (BLM), and U.S. Forest Service (USFS), as well as providing the monthly reports to the Under Secretary of Energy and Minerals, Department of Interior, on noncompetitive geothermal leasing and application activity. In addition to the programs necessary to update the data files, programs designed to produce the following output products are operational:

- Format A-1: Summary of the status of noncompetitive applications
- Format A-2: Summary of noncompetitive leases and acreage
- Format A-3: Pre- and post-lease history of applications for leases
- Format A-4: Pre- and post-lease history of applications of USFS lands
- Format A-5: Noncompetitive applications sequenced by applicant
- Format A-6: Noncompetitive applications sequenced by township and range
- Format A-7: All active lease sequenced by leasee

- Format A-8: Summary of all geothermal leases and acreage
- Format A-9: All active leases and corresponding BLM district offices
- Format A-10: All terminated and all relinquished leases
- Format A-11: All applications located within a specified township and range
- Format A-12: All leases, sequenced by new actions for the month
- Format A-13: New partial assignments and segregations
- Format A-14: Applications sequenced by county

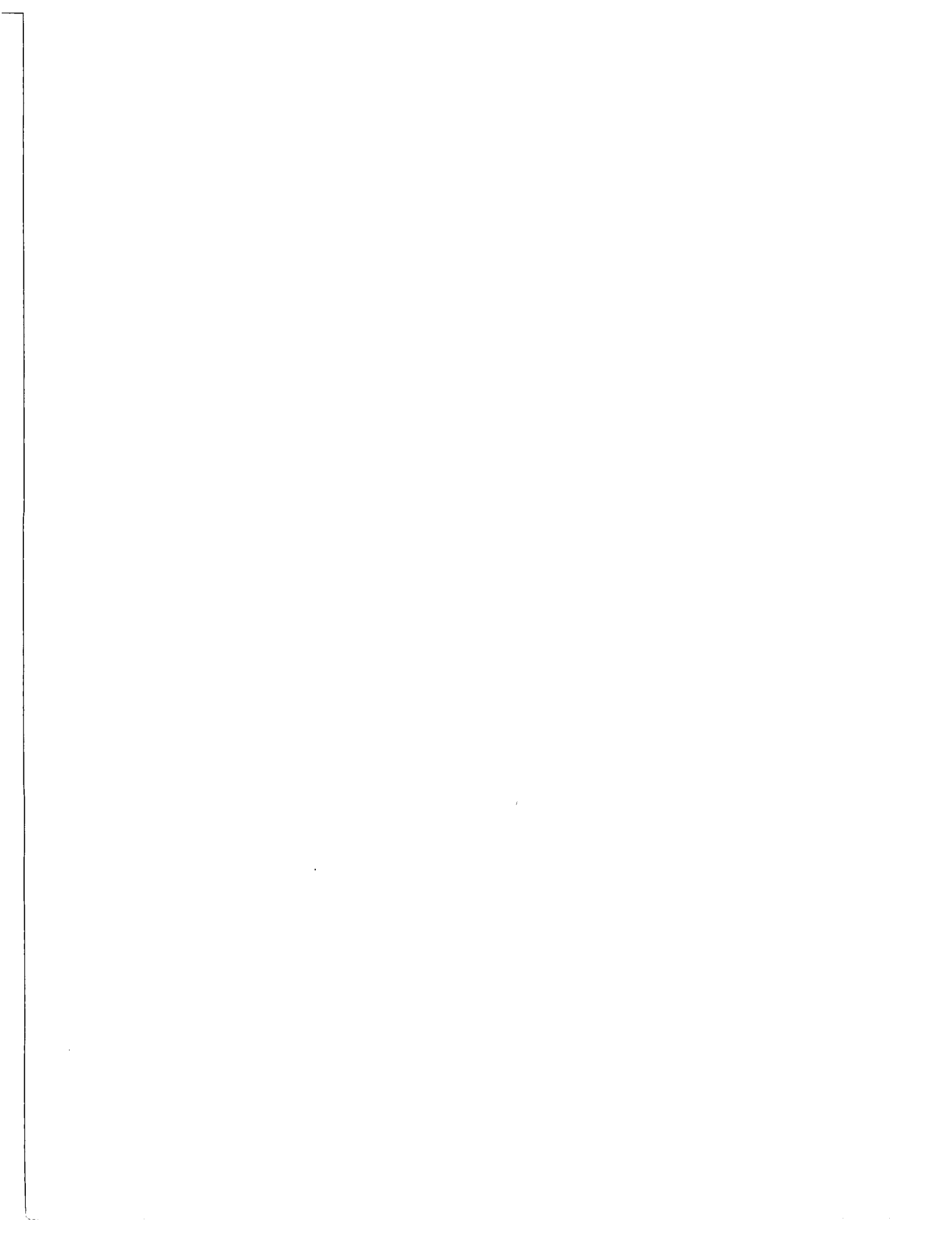
There are other data files unique to internal USGS administrative and operational practices which serve as management tools to meet internal and external deadlines, provide historical records of competitive lease sale activity, and provide a history of bidding at all geothermal lease sales. Proprietary information does become a factor in handling these data bases.

The data held in this USGS information system is about federal lands only, except in cases where state and private lands are near or adjacent to federal leaseholds. The developer may pay lower federal lease fees if he reports his expenditures to improve his holding in the nearby non-federal locations. It appears that the only way to get non-proprietary information on private leases is to go out to the county seat offices and to do exhaustive title searches on lease transactions.

The data from the BLM and USFS comes to USGS strictly as a computer printout. Some analyses of program and improvement on these

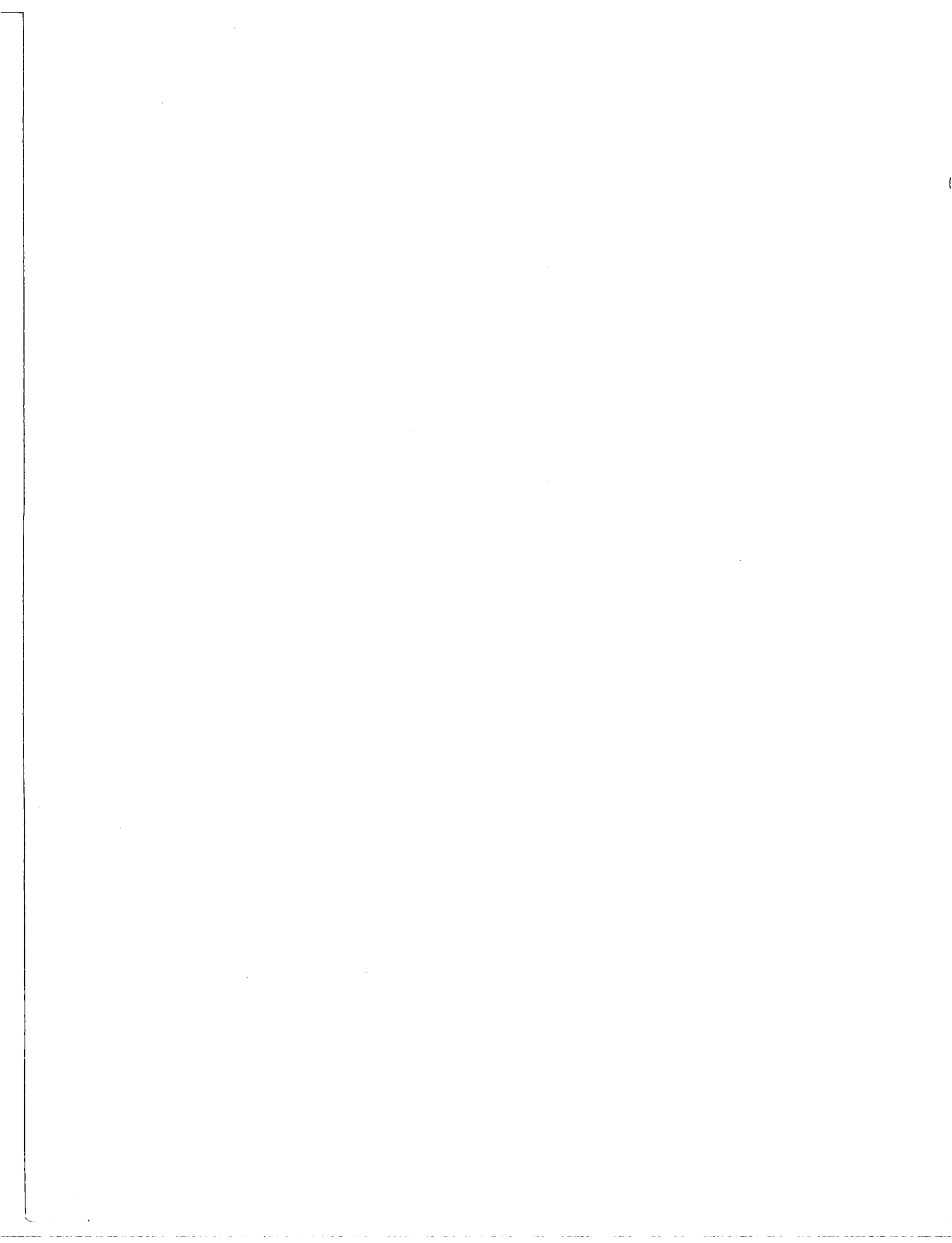
leaseholds is made by BLM, USFS and USGS, but these analyses have not been published.

The new geothermal omnibus legislation may cut off most of the competitive lease sales, because they will apply only to sites with known electric potential.



APPENDIX B

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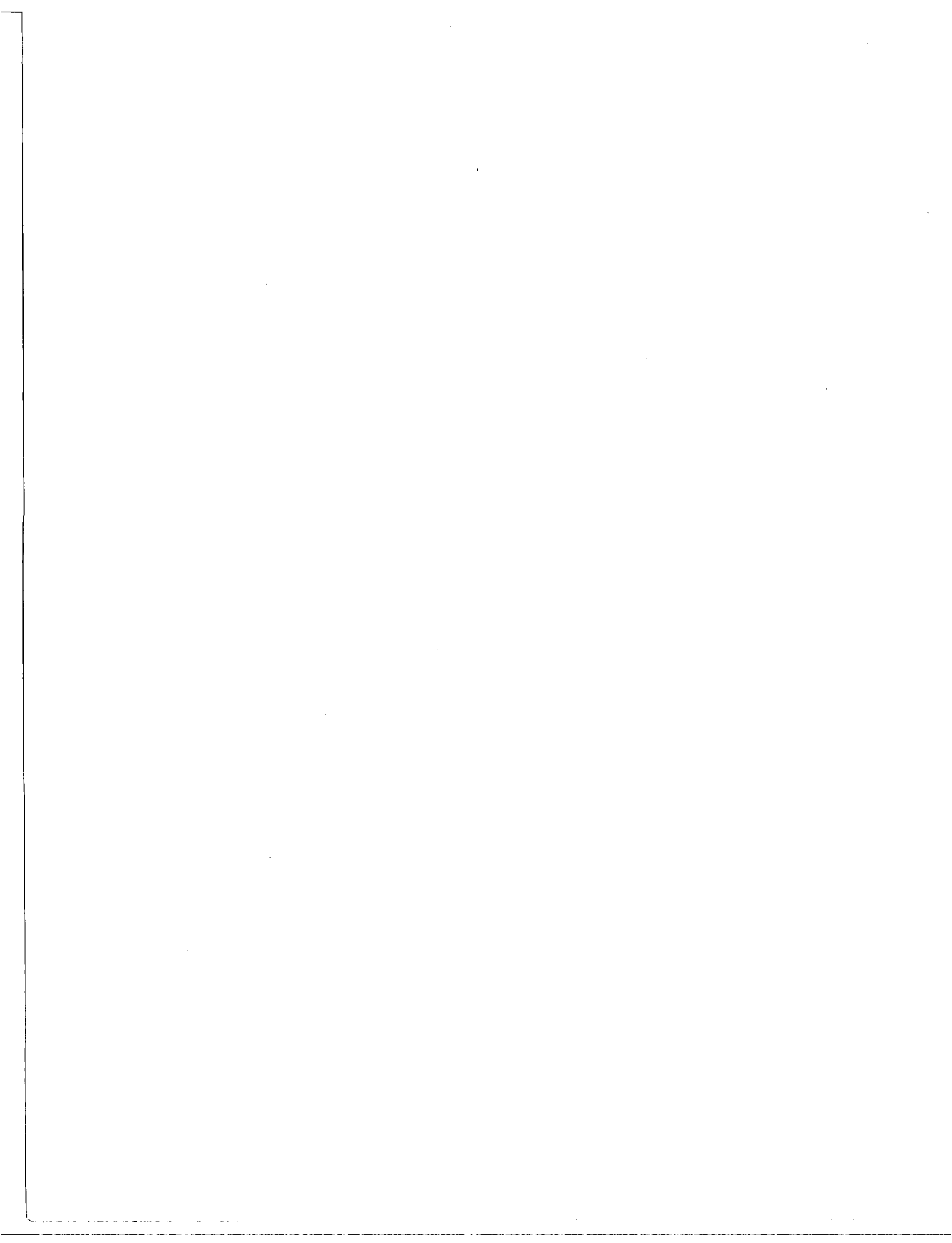
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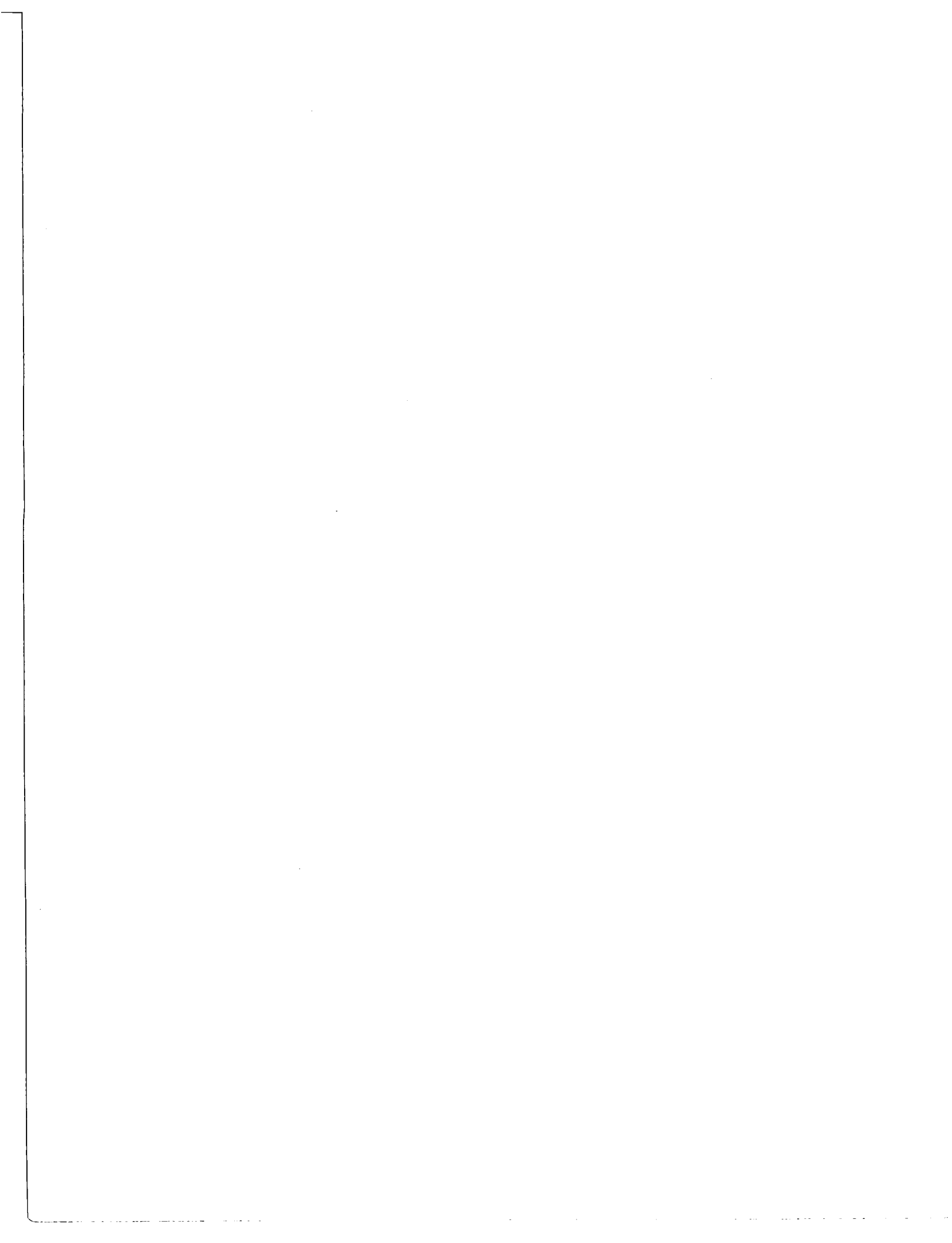
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MITRE Project Approval: 



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