GL00524

Department of Energy
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December 23, 1977

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IDAHO DEPARTMENT OF WATER RESOURCES, CONTRACT EG-77-S-07-1663
(PHASE 0 STUDY)

Please find attached a final copy of report of the Phase 0 planning performed in Idaho. The Idaho Department of Water Resources is now engaged in Phase I of the geothermal assessment program.

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Program Geologist
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Attachment:
As stated

FINAL REPORT
STATE OF IDAHO GEOTHERMAL RESOURCE
LOW TEMPERATURE ASSESSMENT
IDWR STUDY PLAN
PHASE 0

by

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PRESENTED TO

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

by

IDAHO DEPARTMENT OF WATER RESOURCES

December, 1977

INTRODUCTION

Past efforts aimed at furthering the understanding and development of geothermal resources in Idaho have concerned numerous local, state, and federal agencies. These include the Idaho Bureau of Mines and Geology (IBM&G), Boise State University (BSU), Idaho State University (ISU), Boise City, Idaho Department of Water Resources (IDWR), U.S. Department of Energy (DOE), U.S. Forest Service, and U.S. Geological Survey (USGS). The last four agencies have legislative or congressional mandates to fulfill and, therefore, will continue to be involved in regulation, development and data collection activities. It is therefore necessary to coordinate and plan future geothermal activities in Idaho among these agencies to derive the greatest benefit from each participant. A four party agreement has been signed for this purpose.

Under the above mentioned agreement, IDWR will work with DOE, the USGS and the U.S. Forest Service in a multi-phase, three-year program. Preliminary assessments of low, intermediate, and high temperature geothermal sources will be made first, followed by confirmation drilling.

The preliminary phase (phase 0) consisted of planning the study, particularly phase I. Phase I will consist of a regional investigation of the resource. Phase II will be an expanded study of selected high-potential areas. Conduct of phase II will depend on results of phase I. This report outlines the results of phase 0. Its objectives are to (1) develop a plan for the compilation and systhesis of data relevant to direct heat application of the low to moderate temperature geothermal resources and (2) develop a technical plan for the involvement of the State of Idaho in the reservoir assessment and confirmation programs being planned for southern Idaho by the U.S. Geological Survey and Department of Energy.

USGS will have lead responsibilities for the support and conduct of regional geological, geophysical and geochemical studies of phase one and two and serve as overall coordinator. IDWR will have lead responsibility for a survey of the state's low to moderate temperature resources suitable for direct heat applications. IDWR will also cooperate with USGS and DOE in the hydrologic studies, geochemical surveys and local resource evaluation, as well as for environmental studies during phase one leading to preparation of environmental reports for sites to be drilled in phase two. The Forest Service will coordinate activities on its lands. DOE will support state activities through its Idaho Operation office and have lead responsibility for management and support of intermediate and deep drilling operations. Reservoir engineering studies during phase two will be accomplished by DOE at the Idaho National Engineering Laboratory.

The project outlined under these agreements may be expanded later to include direct participation by the Bureau of Land Management or others, depending on the location or status of sites selected for phase one.

Don Mabey, Office of Geochemistry and Geophysics, USGS, Denver is currently responsible for inter-agency coordination. Past and present investigation efforts by these agencies are summarized below. Future investigations and projects aimed at further progress in characterizing and developing Idaho's geothermal resource potential and IDWR's involvement in these programs are also outlined.

PRESENT STATUS OF AVAILABLE DATA (DATA BASE, PHASE-0)

Much data bearing on Idaho's geothermal potential has been collected by previous investigations. A data file has been assembled at IDWR containing information on Idaho's geothermal resource and includes the following. Ross (1970) published locations of 380 thermal springs and wells and chemical analyses on 112 of them. Nichols and others (1972), investigated geothermal water and power resource development in Idaho. Young and Mitchell (1973) published geologic and geochemical data on 125 springs and wells in Idaho and located 25 areas, based on the existing methods, where aquifer temperature of 140°C or higher were thought to exist. Young and Whitehead (1975a, 1975b) published geochemical and well log information on 20 wells and springs in the Weiser area of West-Central Idaho, and 96 wells and springs in the Grandview-Bruneau area of southwest Idaho. Warner (1975) wrote on special aspects of Cenezoic history of southern Idaho and their geothermal implications. DOE, through its Idaho Operations Office has published numerous reports related to the Raft River and Boise geothermal development projects in southern and western Idaho. These reports are listed as ANCR and TREE Reports in the bibliography. Mitchell (1976a, 1976b, 1976c) evaluated the geochemistry and geologic setting of thermal and mineral waters in northern Cache Valley, and Blackfoot Reservoir area of southeastern Idaho and Camas Prairie area of south-central Idaho and included chemical analysis on 33 sampled springs and wells. Cater and others (1973), included analysis on 12 thermal springs in Idaho Primitive area. Brott, and others (1976a, 1977), published 99 heat flow values obtained from 134 measured bore holes throughout central and southern Idaho and produced a heat flow model of the Snake River Plain based on 1976 data. White and Williams (1975) presented geochemical and geologic data on 57 springs and wells in Idaho. Jim Swanson (USGS) has compiled in the geotherm data file, chemical analyses on 333 thermal water sample sites.

Numerous other geologic, hydrologic and geophysical studies have been published or are available through open file, which, although not bearing on geothermal directly, contain much useful information concerning it.

The above data file is available for public use.

PRESENT STATUS OF STUDY EFFORTS

IDWR has received funds from DOE to survey the state's geothermal potential from the standpoint of direct heat application. The planned program is two phased.

PHASE I - A Survey Of Direct Heat Applications Of Geothermal Resources in Idaho

Phase I will include among other things, surveys of thermal springs and wells, including compilation and synthesis of existing and newly acquired data, to select promising areas where geothermal water could readily be put to direct heat use in low to moderate temperature applications. This phase of the study will seek to identify areas in Idaho where water from areas of existing thermal springs or wells could be applied as a direct energy source, sole or augmented, in agriculture, forest products, mining, food processing industries or in space heating, refrigeration or air conditioning or other applications. This phase will require one year to complete which will run from August 1, 1977 to August 1, 1978.

Objectives: The general objectives are as follows: (1) describe, in a single reference, the thermal water chemistry and quality from existing and newly acquired data on thermal springs and wells in Idaho; (2) evaluate the geothermal potential of Idaho from the standpoint of direct heat application; (3) pinpoint specific areas and general uses for direct heat application of known geothermal water in Idaho; and (4) provide basic data on low temperature resources in Idaho for potential users.

Procedure: Phase I will be conducted on eight separate Tasks identified hereafter as Tasks I-A through I-H.

Task I-A Provide Geotherm Data

The U.S. Geological Survey (USGS) has developed a computer information system for geothermal data called GEOTHERM. This data bank is useful for development of the resource as well as basic research for state and federal agencies and private interests.

Objectives: The objectives of this task are (1) to compare existing GEOTHERM data to geothermal data available to Idaho Department of Water Resources and (2) to provide the U.S. Geological Survey with any geothermal data not currently in GEOTHERM.

Procedure: Geothermal data available to IDWR will be evaluated with respect to data in the geothermal system as provided by USGS. Available data, above 35°C, not currently in GEOTHERM will be provided to the USGS in the format compatible with GEOTHERM.

Deliverables: The above mentioned geothermal data will be provided to USGS in a GEOTHERM compatible form.

TASK I-B Statewide Compilation and Synthesis of Geothermal Data

This task is concerned with obtaining and synthesizing all available geochemical information on thermal springs and wells in Idaho.

Objectives: The objectives are (1) to determine what geothermal data is available in the State of Idaho and (2) to determine where additional data will be collected within data tasks of Phase I.

Procedure: All published data on geochemistry, geology and water quality from existing thermal springs and wells and relevant geophysical data for important geothermal sites in Idaho will be obtained and studied to determine where additional data collection will be necessary within this study. In addition, the USGS GEOTHERM data bank will be utilized to obtain data not available to IDWR. This data will be synthesized with computer programs currently available at IDWR.

Deliverables: Information gained from this task will be used to guide work throughout the remainder of this project. Data will be included in final report.

TASK I-C Field Data Collection

This task will include the gathering of additional major element chemical analyses, trace metal analyses, and other water quality parameters.

Objectives: The objectives of this task are to gain needed water quality data on existing thermal springs and wells from areas in Idaho where it is lacking or limited.

Procedure: There are over 380 thermal water occurrences listed by Ross (1971). Only about 240 good quality major element chemical analyses exist from an estimated 180 sampled locations. For purposes of this study it is vital that 130 of the 240 samples sites be resampled to obtain data on possible contaminants (As, B. Hg, Li). These data exist for the remaining 110 sampled locations. Thirty to forty additional samples in selected areas will be obtained for major element analyses including contaminants. These will be taken in potential use areas such as Burley, Blackfoot, and Pocatello.

It is desirable to obtain trace metal analyses on as many springs and wells as possible for which chemical analyses on major constituents are available. Trace metals give insight into the likelihood of mineral extraction from thermal waters as valuable metals are known to be associated with geothermal brines in certain parts of the world. Knowledge of trace metal constituents is also valuable in engineering design for hot water use, and certain elements could represent potential pollution hazards if present in sufficient quantities. Trace element samples will be taken in conjunction with contaminants. Trace element sampling costs will involve only containers, preservation, and analyses.

The 30-40 total analyses samples would be analyzed by standard wet chemical or atomic obsorption techniques for the following elements and dissolved constituents: Si, Na, K, Ca, Mg, SO_4, Cl, F, NO_3+NO_2, P, NH_3, As, B, Li, Hg. Collection and preservation techniques of Presser and Barnes (1974) will be followed on the samples to be run by standard analyses. The 50-60 trace metals include: Al, Sb, Ba, Bi, Cd, Cs, Cr, Co, Cu, Au, Fe, Se, Mn, Mo, Ni, Pl, Pu, Rb, Sc, Ag, Sr, V, W, Zn, Zr as well as others and would be run by neutron activation analyses at the Idaho National Engineering Laboratory near Arco, Idaho.

Field data to be collected on major element samples would include CO_3, HCO_3 determinations, pH, surface temperatures, specific conductance and discharge measurements where these are not available. Idaho Department of Water Resources has available for field data collection a modern, well-equipped mobile laboratory capable of the above mentioned determinations as well as others.

Deliverables: The results of the sample collection will provide the most complete chemical analyses on about 200 thermal water occurrences in Idaho. Data will be included in the final report.

TASK I-D Computerization, Reduction and Interpretation of Geochemical Data

The data from Tasks I-B and I-C, will be computerized, synthesized and reduced using existing programs and computer facilities available to IDWR.

Objectives: The objectives of this task are to tabulate surface temperatures at each site and summarize thermal water discharges, water quality characteristics, and possible uses for geothermal water.

Procedure: Aquifer temperatures have been estimated for some of the known geothermal water occurrences. The data available represent the springs and wells in Idaho with the highest known surface temperatures and silica concentrations and, in many instances, may preclude the possibility of mixing the hot geothermal and cold groundwater. In addition, previous data on subsurface or aquifer temperature might be in error, in some cases, due to lack of knowledge of mineral constituents responsible for controlling certain dissolved chemical constituents found in thermal waters. Ways have recently been devised to overcome, in large measure, many of these difficulties. Therefore, a reinterpretation of previously acquired data on approximately 200 lower temperature springs and wells must be accomplished to complete the data necessary for a statewide assessment of direct heat application of geothermal resources.

The synthesis of the data will include calculation of subsurface, aquifer or reservoir temperatures using the following methods: Silica (Si) assuming equilibrium with quartz, chalcedony and amorphous phases; mixing models assuming equilibrium with quartz and chalcedony phases; Na-K-Ca and Na/K methods and determining atomic and molar ratios of elements. Dissolved solids, sodium adsorption ratios, salinity hazards and other water quality parameters will also be calculated. These data, along with measured surface temperatures and discharges, will be interpreted to determine potential uses for geothermal water at a specific site.

Deliverables: The results of the data synthesis and analysis will include the following information in the final report:

(1) Map of Idaho showing all known thermal water occurrences at 1:1,000,000 scale. Such a map is not available at present.

(2) A table giving chemical analyses for approximately 280 thermal water analyses in Idaho.

(3) A table giving trace metal chemical analyses for approximately 125 thermal water analyses in Idaho.

(4) A table of calculated aquifer temperatures at each sample site using six different geochemical thermometers and two mixing models. In addition, the table will contain calculated atomic ratios of selected chemical constituents which are useful in interpreting the geochemical thermometers.

(5) A table of selected geothermal sample sites, discharges, surface and aquifer temperatures and uses that could be made for these particular waters.

(6) A map or maps showing chemical quality parameters: i.e., areas of high fluoride concentrations, areas of high total dissolved solids and areas of high sodium adsorption ratios and/or salinity hazards.

TASK I-E Lineament Data

LANDSAT satellite imagery and high altitude U-2 photography (currently available for most spring and well areas in Idaho) will be studied. These have proven useful in the discovery of geologic structures previously unrecognized by conventional surface and photogeologic mapping techniques, Mitchell (1975a, 1975b, 1975c) and Day (1974).

Objectives: The objective of this study is to utilize remote sensing data for linear and curvilinear geologic features in the analysis of the individual sites being examined in the overall study.

Procedure: Existing lineament data will be obtained from Idaho Bureau of Mines and Geology. False color LANDSAT satellite imagery will also be studied with the help of a zoom transfer scope. This device enables super-position of various scale photos upon different types of base maps and photos. High altitude U-2 photos and regular air mapping photos will also be employed. These have never been employed in Idaho in a study of this type and will help refine existing lineament data. Spring and well location maps will also be viewed in order to determine lineament-thermal water discharge relationships. For example, do thermal water discharges have preferred locations with respect to lineaments? Do they occur on lineaments of preferred length, where lineaments cross, die out or intersect other types of structures which may be visible on the photo? These studies, integrated with the data from available geologic publications and geophysical data from Task F-K, should enable the gross lithology and structural control of many springs and wells to be determined. Good quality lineament maps will be necessary to target drillholes in follow-on work, it any.

Deliverables: Area-by-area maps showing linear features and thermal water occurrences will be included in the final report. A discussion will also be included of structural controls of thermal water discharges, area by area, based on lineaments, geological and geophysical data.

TASK I-F Contracted Geophysical Data Interpretation

Studies of existing unpublished geophysical data will be made on a basin-by-basin basis in selected areas of geothermal water occurrences.

Objectives: The objective of this task is to interpret geologic and geophysical data from existing maps and reports to further define structural controls for geothermal water in Idaho.

Procedure: Existing unpublished geophysical data will be studied by consultants to interpret geologic and other data. The geophysicists who contract to perform this task will furnish IDWR an open-file report. Its conclusions, area by area, would be incorporated into the data interpretation to help define gross structural control of thermal spring and well areas.

Deliverables: The results will be utilized with the lineaments data to further define the structural control for thermal water occurrences in Idaho. This information will be extremely valuable to help locate possible drill sites for follow-on work, if any.

TASK I-G Land Ownership and Lease Status of Known Geothermal Occurrences

D E L E T E D

TASK I-H Recommendation Of Sites For Detailed Future Evaluations, If Any

Objectives: The objectives of this task are (1) to recommend those sites in Idaho which show definite promise of early implementation of geothermal energy as an energy source for existing and potential facilities and (2) recommend those methods of site-specific resource inventory evaluation and conformation tasks which will be best suited to each selected site.

Procedure: Site selection and a general outline of target areas will be determined from an evaluation of the data gathered in the preceding tasks. Site selection will be made by evaluating the following parameters: (1) water quality and quantity, (2) surface temperature, (3) estimated subsurface or reservoir temperature, (4) location of potential use sites with respect to discharge area and potential discovery areas, (5) type of use best suited to a particular area, and (6) potential of a site for large-scale geothermal development.

The methods to be employed for further site-specific evaluation in follow-on work, if any, will probably vary from site to site depending on geological and hydrological conditions in each area. Evaluation methods will be chosen from those which have been proven to be effective in other geothermal areas. These methods will include in many instances, but not limited to, any or all of the following: (1) geophysical, including gravity, magnetics, resistivity, seismic, heat flow, infrared, earth temperature, remote sensing; (2) geological, including surface mapping, rock type identification, struc-

tural identification, delineation of areas or zones of rock alteration, etc. (3) geochemical, including more water quality isotope (H/D and $O^{16}/10^{18}$ and other isotope ratios); (4) hydrologic, including pump tests, water level measurements, aquifer characteristics such as storage coefficients, porosity, permeability and other hydrologic parameters, and (5) economic evaluation of the feasibility of direct heat use at specific sites.

Deliverables: Sites recommended for further reservoir conformation and site-specific studies will be listed in table form and shown on a map. This will be included in the final report. Site-specific recommendations as to the evaluation techniques to be employed at each site will be tabulated or included in a discussion of each area.

TASK I-I Preliminary Environmental Assessments

The objective of this study is to provide a preliminary assessment of environmental considerations at sites being considered for selection as future reservoir confirmation sites.

Deliverables: A report summarizing preliminary environmental assessments based on an examination of existing data will be prepared for areas being considered as candidates for selection as future reservoir confirmation sites, in accordance with ERDA-DGE environment reporting guidelines.

TASK I-J Report Writing and Illustrations Preparation

The final Phase I task will include report writing, preparation of illustrations, tables, maps, and editing for publication.

Objectives: Prepare the final report.

Procedure: The final report, including maps and tables, will be prepared as specified under Article A-V(b), Deliverables and Reports.

PHASE I BUDGET

The budget for the project is outlined as below:

1. Personnel Costs:

Salaries and Wages	$ 42,000	
Division Administration and Support (16%)	6,720	
	$ 48,720	
Fringe Benefits (22%)	10,720	
TOTAL PERSONNEL COSTS		$59,440

2.	Operating Expenses		
	Disposable supplies for sample collection	$ 1,100	
	Travel	5,000	
	Computer time 4 hrs. at $330/hr.	1,320	
	Vehicle costs (10,000 miles at 20 cents/mile)	2,000	
	Report publication (approx. 700 copies at $6.50/copy)	4,600	
	TOTAL OPERATING COSTS		$ 14,020
	TOTAL DIRECT COSTS		$ 73,460
3.	Indirect Costs (15% of Direct Costs)		11,019
4.	Subcontractors		
	Geophysical Interpretation of Unpublished Data	$ 5,000	
	Environmental Assessment	11,500	$ 16,500
5.	Permanent Equipment		
	Zoom transfer scope	$ 5,600	
	Digitizer	15,500	
	Temperature Gradient Well measuring equipment	3,000	
	Recording Water Quality Monitor System	2,500	26,600
6.	Neutron Activation Analyses (to be provided by EG&G Idaho, Inc.)		$ 18,750
	TOTAL ESTIMATED COST		$146,329

PHASE II - Geothermal Resource Assessment and Reservoir Confirmation Through State Participation in Federal Activities in Idaho

Phase II will investigate the selected areas in greater detail in order to locate possible drill sites to augment existing thermal water information and to further assess and confirm reservoir potential. The IDWR expects to be directly involved in many parts of this future work. Preliminary data review already indicates several areas where future work may be warranted. Work has already begun by others in some of these areas. However, more work is necessary to confirm the resource.

Areas Where Site Specific Work Has Started:

(1) The Bruneau-Grandview area is located south of the Snake River in Northern Owhyee County. Over one hundred, high yield, artesian, hot water irrigation wells have been drilled in a 1,200 square mile area between Murphy

and Bruneau, Idaho. Hot water produced by these wells ranges in temperature from 20 to 83°C at land surface. Young and Whitehead (1975) evaluated these thermal waters and concluded that subsurface temperatures probably do not exceed 150°C in the area unless substantial mixing of thermal with non-thermal water is occurring at depth. Renner and others (1975) calculated 263 X 10^{18} calories of heat to exist in the area based on estimated volume and heat capacity of the rocks in the area and a temperature above 15°C. Brott and others (1975) obtained heat flows ranging from 1.5 to 4.1 heat flow units in the area. It is generally accepted that the Bruneau-Grandview area has a potential for large-scale direct-heat application in food processing, industrial, space heating, or other low temperature uses. The types of uses best suited to the area needs to be researched. A good approach to delineate and evaluate this area's total and useable potential will be a product of IDWR's Phase I study. Investigations oriented toward obtaining information needed to adequately manage the geothermal resource in this area will be recommended. The Geologic Division, USGS has already begun the first step in such a program, by developing an adequate geologic map. The Water Resources Division, USGS is determining the feasibility of isotope sampling to answer several pertinent questions pertaining to the Bruneau-Grandview area. IDWR will coordinate its efforts with the Water Resource Division, USGS, to assess the aquifer characteristics, recharge areas, basin yield, and other parameters necessary to model the system. These detailed investigations are oriented toward obtaining sufficient information to adequately understand and utilize geothermal resources in this area without adversly affecting present development. IDWR's funding for the project would be provided by contract from DOE, and state money as well.

(2) Another area being considered for development is the Rexburg-Sugar City-St. Anthony area. Since the destruction of Sugar City by the Teton Dam flood, consideration has been given to rebuild Sugar City utilizing geothermal energy for space heating. A thermal well has been drilled near Newdale, approximately 12 miles northeast of Sugar City. This well has a surface temperature of 105°F, is 385 feet deep, and produces about 300 gpm. This well is now the domestic water supply for the town of Newdale. Brott and others (1976) determined heat flow values in this area to range between 1.1 and 8.1 HFU and to average 4.6 HFU. This may indicate a high temperature heat source in the area. Brott and others (1977) also proposed a theoretical model of the Snake River Plain region and gave evidence that the eastern portion is probably much hotter than the western portion. ERDA - Idaho Falls is collecting temperature gradient data and chemical analyses of groundwater in the Sugar City area oriented toward selecting possible drill sites to obtain thermal water to heat Sugar City. The Geological Division, USGS is planning a series of deep resitivity soundings in this area as well as more detailed geologic mapping and gravity measurements. The Water Resources Division, USGS will investigate water quality and isotope chemistry of the intermediate and deep regional aquifer systems to determine recharge areas and provide needed data for the geophysical interpretation. These studies should help indicate the magnitude, depth, and size of the geothermal reservoir or heat source which may exist in the area.

(3) D. D. Blackwell and C. A. Brott, Southern Methodist University (SMU) have been funded for a heat flow study aimed at testing the eastward migrating heat source theory (Brott and others, 1977) for the origin of the Snake River Plain, and its geothermal implications. This proposal funded

from USGS is to drill a series of heat-flow test holes along Highway 51 from Duck Valley Indian Reservation north to connect with the similar holes already drilled across the western Snake River Plain near Mountain Home-Bruneau. This line would determine if the Nevada Battle Mountain high heat flow anomaly extends northward into Idaho. Another line of holes along the northern margin of the Snake River Plain would be drilled to determine heat flow in the area and trends associated with the northern border of the plain. Holes will also be drilled in the younger rhyolitic rocks near the center of the Plain and perhaps in the rim of the Island Park Caldera.

(4) Studies of the Boise Front geothermal system have been made by the BSU Geology Department primarily to determine where to locate exploratory holes. These studies will be continued with DOE participation. These further investigations are to test wells this summer. Drilling and testing of bore holes in other areas along the Boise Front to assess the reservoir limits and characteristics and the long term availability and amount of the resource are recommended. BSU is conducting chemical studies related to fluoride determination by standard methods on hot and cold waters along the Boise Front and Boise River from Arrowrock Dam to Boise River-Snake River confluence.

(5) Boise City has received a grant from DOE for a space heating project in the Boise Area for heating of large buildings in the downtown area. Their project is oriented toward legal aspects including land and resource ownership in the Boise area and the KGRA problem as it relates to space heating. The testing of production and resource assessment wells has been tested by DOE. Many questions still need to be answered along the Boise Front with regards to resource extent and management.

(6) The Idaho Bureau of Mines and Geology is presently investigating linear features in the Boise River drainage of the southern Idaho Batholith. The study is in conjunction with the geology of the area. This information, if available in time, will be valuable in the lineaments study portion of IDWR's Phase I study. Other lineament maps and reports that are available including the South Mountain-Juniper Mountain area of west-central Owyhee County and the AMS scale lineaments data for much of the state.

(7) Environmental impact statements on areas where federal monies are involved, will have to be made before development begins. USFS is presently conducting environmental assessment studies in the Island Park Caldera Area of eastern Idaho adjacent to Yellowstone National Park. Ideally, these would be conducted after reservoir analysis has been completed. However, some basic background data could be collected in these areas during assessment. IDWR will be involved in this activity.

Summary of USGS Involvement in Idaho

I. Regional Geophysics

A. Gravity (Mabey - Denver)

1. Complete reconnaissance coverage of the southwestern corner of Idaho.

2. Complete reconnaissance coverage of area adjacent to southeastern margin of Snake River Plain.

3. Obtain additional detail in areas of special geothermal interest.

B. Aeromagnetic (Mabey - Denver)

May fly local surveys relating to special geothermal problems.

C. Heat flow (Blackwell - SMU)

Support of Blackwell's regional heat flow studies.

C. Magneto-telluric (Stanley - Denver, U of Texas)

1. Complete reconnaissance of Snake River Plain.

2. Sounding in areas of special geothermal interest.

E. P-wave delay (Iyer - Menlo Park)

Extend P-wave detail study from Yellowstone over eastern Snake River Plain.

F. Magnetic-array (Fitterman - Denver)

Start a magnetic-array study in eastern Snake River Plain.

G. Seismic refraction (U of Utah)

Cooperate with University of Utah proposed seismic refraction study of Yellowstone and eastern Snake River Plain.

II. Regional geology (Oriel - Denver)

A. Southwest (Ekren - Denver)

Start a new mapping program in Owyhee County.

B. Eastern Snake River Plain (Prostka and others - Denver)

Continue mapping program in and adjacent to eastern Snake River Plain.

III. Local geology

A. Bruneau - Grandview

1. Mountain Home Air Force Base (Crosthwaite - Boise, Mabey - Denver) (Possible new program to investigate geothermal resources available to the Air Force.

2. Regional geology and geophysics interpretation of this part of the Snake River Plain (Ekren and Mabey - Denver)

3. Attempt to develop a new study of geothermal system.

B. Sugar City - proposed (Prostka - Denver)

1. Cooperate with INEL hydrologic study (Crosthwaite - Boise)

2. Geologic mapping (Prostka - Denver)

3. Gravity and magnetic interpretation (Mabey - Denver)

4. Resistivity survey (Zohdy - Denver)

C. Raft River (Mabey - Denver)

1. Prepare new proposal for resource assessment (Mabey - Denver)

2. Hydrology - Consultation with INEL (Crosthwaite - Boise)

3. Subsurface geology (Crosthwaite - Boise, Covington - Denver)

4. Heat flow study (Nathenson - Menlo Park)

D. Geophysical Support for IDWR (Mabey - Denver)

1. Analysis of existing USGS data.

2. Minor new surveys.

Summary of DOE Involvement in Idaho

DOE will continue to support the Raft River Project.

1. A thermal loop is planned as part of Raft River demonstration project.

2. DOE is expected to participate in the following activities:

a) Support Boise project in the form of funding of Boise City's effort.
b) Analyze further results of DOE and USGS ground water investigations in the Sugar City area with the intent of siting a drill hole there.
c) Fund IDWR's effort.
d) Fund other site specific work.
e) Supply management and support for drilling for reservoir elevation.
f) Handle environmental reviews for Federal requirements.

Other Federal Studies

USFS and BLM will be involved in land use and environmental studies. The Forest Service is currently conducting an environmental assessment on Island Park.

Areas Where Site Specific Work Has Not Started

(1) From the standpoint of population vs. known thermal water occurrences in Idaho, five or six other areas standout as possessing potential for

large scale uses. These are (Idaho Falls, Blackfoot, Pocatello, Burley, Twin Falls, Mountain Home including the Air Base, Caldwell and Nampa). The Idaho State University Geology Department is interested in investigating the utilization of thermal water near Tyhee just north of Pocatello, but have not been funded. They could participate in this project on the recommendations made in Phase I proposal if the area proves favorable. This would probably be done under subcontract to IDWR.

(2) Several large areal or regional studies should be pursued. IDWR has prepared for submittal in late 1977, or 1978 a proposal for a heat flow study of the Basin and Range-Northern Rocky Mountain Provinces in Southeast Idaho by contracting with Dr. David Blackwell of Southern Methodist University (SMU). This investigation would be run similar to the Snake River Plain Heat Flow Study, Brott and others (1976, 1977) conducted by IDWR and SMU. The products of this research will be a report containing data obtained and a general interpretation in layman's language, and a report discussing the tectonic implications of heat flow values found in the region. Some preliminary data in support of this part of the project has been obtained this summer (1977) by personnel of SMU. IDWR has on file a preliminary project proposal to submit to USGS or DOE, for funding in late 1978 for this project.

(3) Warner (1975) maintains that left-lateral displacement or rotation of the northern Idaho crustal block relative to southern Idaho has taken place along a zone roughly coincident with the present course of the Snake River. He postulates that a relative displacement of up to 50 miles has taken place sometime after deposition of the Chalk Hills formation of mid-Pliocene age. If this theory is correct, the Bruneau-Grandview thermal anomaly zone has been rifted also, and what may have been a large portion has been transported northwestward relative to the southern half, to a position presently lying between Boise and Weiser, Idaho. IDWR suggests some investigation of this area, between Boise and Weiser, north of the Snake River and south of the Boise Front to determine if in fact, the other "half" of the Bruneau-Grandview aquifer system (Banbury basalt and silicic volcanics) may exist at depth in this area. Provided the aquifer contains hot water, a deep resitivity profile or two across this zone may delineate the aquifer. Several slim intermediate depth drill holes to confirm geophysical and geologic findings in the area would also be in order should the other data prove positive. IDWR could run the drilling program. This areas contains a large concentration of Idaho's population and as such consumes much of the State's energy. A discovery of a major energy source in this area could be a giant step toward Idaho's energy self sufficiency.

(4) Publication by USGS of its regional gravity and magnetic map with regional interpretations of the data would be a valuable contribution toward public and private exploration for geothermal resources in Idaho.

(5) Other areas which have received attention in the past with regard to high temperature geothermal resources are the Weiser, Little Camas Prairie, Blackfoot Reservoir, and Northern Cache Valley areas. Although subsurface temperatures in the Blackfoot Reservoir area appear to be low, based on geochemical thermometry, the geology of the area appears so favorable to deep (> 2km) geothermal reservoirs that this area as well as the others which have received attention should receive further work. These studies could include heat flow, seismic, deep resistivity, and deep test drilling to verify and detail the geophysical evidence.

(6) A deep exploratory hole should be drilled in the eastern Snake River Plain to determine if high temperatures exist within the Snake Plain aquifer as postulated by Brott and others (1977). The location of this hole should be based on available geologic and geophysical and additional geophysical and geochemical data collected in the eastern Snake River Plain. Geochemical data from existing irrigation wells could be obtained by IDWR, and patterns interpreted to determine possible hot water leakage zones into the Snake Plain aquifer. This information would be useful to help site the deep well. The deep hole should be a cooperative venture between the State of Idaho, DOE and USGS and other agencies should be consulted on its location and drilling plan. This should insure an optimum location and adequate data collection.

(7) Heat flow studies of the Snake River Plain Region suggest that temperatures hot enough for space heating may be found nearly everywhere beneath this region at a depth of from 1 to 2 km. Temperatures hot enough for power generation may be found nearly everywhere at a depth of 3 to 4 kilometers (Brott and others 1976). Oil and gas wells drilled in the western Snake Plain Region which have penetrated to 3 km depth are reported to have bottom hole temperatures of 200°C or higher, and confirm, to some extent, the above hypothesis: several intermediate depth (1 km) slim holes (6"-8" diameter randomly selected) should be drilled in areas of large populations to actually confirm these findings. IDWR could supervise this program.

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APPENDIX C

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

STATEMENT OF COSTS

1. Name and address of Contractor: Idaho Department of Water Resources

2. Contract number: EG-77-S-07-1663 Phase 0

3. Beginning and ending date of pertinent contract period: January 28, 1977 through October 30, 1977 as extended by letter of July 27, 1977

4. Costs incurred during the pertinent contract period. (List only those costs which are to be reimbursed by ERDA or proportionately shared by the parties in accordance with Article A-II(a) and Article A-III.)

Cost Categories (The listing of categories should be consistent with the itemization in Appendix A)	Amount
a. Salaries and wages	$ None
b. Equipment	None
(List separately the cost of each piece of equipment separately listed in Appendix A to the contract or for which separate approval was obtained from ERDA)	
c. Travel (show amounts for both foreign and domestic. If none, state none)	----
Domestic includes travel for data collection as per contract extension	$5,000
Foreign	None
d. Other Direct Costs	None
e. Total Direct Expenditures	$5,000
f. Indirect Charges overhead (telephone, typing, etc.)	$1,000
(Indicate percent and expenditures to which percent is applied)	

5.	Total Costs for items under Article A-II(a) for pertinent contract period	$6,000
6.	Support Cost for the pertinent contract period set forth in Appendix A, as defined in Article B-XXVIII of the contract, chargeable to ERDA, for the pertinent contract period (percent of Total Costs using percent shown in Article A-III of Appendix A for pertinent period of contract)	$6,000
7.	Cumulative Support Cost (Support Cost under this statement plus Support Cost for previous periods of the contract) ..	$6,000
8.	Accumulated Support Ceiling in Article III of the contract	$6,000
9.	The difference between lines 7. and 8.	None
10.	Provide information regarding contributions by the Contractor of items listed in Article A-II(b) of Appendix A during pertinent contract period. State the extent of the Contractor's actual contribution, the measure of such contributions should be in the same terms as the Contractor's commitment under Article A-II(b), e.g., time, dollar, etc. A-II(b) (see note) January 28, 1977 to June 30, 1977	$13,532.69
11.	Actual outstanding commitments for property at the end of the period covered by this statement	None

I hereby certify that this report is true and correct to the best of my knowledge and belief and that the costs listed herein were incurred in connection with the performance of the research provided for under this contract and in accordance with the terms and conditions set forth therein.

C. Stephen Allred, Director Idaho Department of Water Resources
(Name and Title of an authorized representative)

(Signature) (Date)

Note: Includes fringe benefits at 15% and administrative support costs at 17% of total employee costs.