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AQUACULTURE FACILITY POTENTIAL
AT BOULDER HOT SPRINGS,
BOULDER, MONTANA
GT A REPORT NO. 1

J. G. Keller

U.S. Department of Energy

Idaho Operations Office • Idaho National Engineering Laboratory

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TRANSITION

AQUACULTURE FACILITY POTENTIAL

AT BOULDER HOT SPRINGS,
BOULDER, MONTANA
(GTA REPORT NO. 1)

J. G. Keller

Published November 1981

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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ABSTRACT

This report examines the potential of using geothermal water to develop a commercial aquaculture facility to raise channel catfish at Boulder Hot Springs, Montana.

Maximum catfish growth occurs in water with a temperature from 80°F to 85°F. This temperature can be maintained when the 175°F geothermal water is mixed with the available 55°F water.

The only economically viable culture considered was the raceway culture. The 4000 gpm supply of 55°F water could supply 7 to 8 raceways with a total production of 269,000 to 307,000 pounds of catsfish per year. This operation, discounting the purchase of land, would cost about \$150,000 (1980).

The Geothermal Technical Assistance Program was developed under the premise that the majority of groups or individuals with available geothermal resources do not have the experience or manpower necessary to do a preliminary engineering and economic feasibility evaluation for geothermal energy projects. In order to disseminate technical information and to facilitate expanded use of geothermal energy resources, assistance was provided through FY-1981 in a consulting format on a first-come, staff-and-funds-available basis. Technical assistance can relate to conceptualization; engineering; economics; water chemistry implications for environmental, disposal, and material selection considerations; and planning and development strategies. This report is one of a series adapted from consultation provided to requestors either through in-house efforts or through limited efforts subcontracted to local engineering firms. The Geothermal Technical Assistance (GTA) reports in this series, which are listed below, will be available early in 1982 to those with interest in specific geothermal applications.

<u>GTA Report Number</u>	<u>EG&G Report Number</u>	<u>Title</u>
1.	EGG-GTH-5512	<u>Aquaculture Facility Potential at Boulder Hot Springs, Boulder, Montana</u>
2.	EGG-GTH-5521	<u>Preliminary Geothermal Disposal Considerations, State Health Laboratory, Boise, Idaho</u>
3.	EGG-GTH-5573	<u>Geothermal Conversion of Veterans Hospital, Boise, Idaho</u>
4.	EGG-GTH-5574	<u>Geothermal Applications for Highway Rest Areas</u>
5.	EGG-GTH-5575	<u>Geothermal Applications for a Tannery</u>
6.	EGG-GTH-5599	<u>Preliminary Conceptual Design for Geothermal Space Heating Conversion of School District 50 Joint Facilities at Pagosa Springs, Colorado</u>
7.	EGG-GTH-5617	<u>Selected Geothermal Technical Assistance Efforts (comprising short descriptions of ten space heating projects, five district heating projects, and three heat exchanger projects)</u>
8.	EGG-2137	<u>Geothermal Source Potential and Utilization for Methane Generation and Alcohol Production (subcontractor report)</u>
9.	EGG-2138	<u>Geothermal Source Potential and Utilization for Alcohol Production (subcontractor report)</u>
10.	EGG-2139	<u>Potential Geothermal Energy Applications for Idaho Elks Rehabilitation Hospital (subcontractor report)</u>
11.	EGG-2144	<u>Technical Assistance Report on a Geothermal Heating Utility for Lemmon, South Dakota (subcontractor report)</u>
12.	EGG-2145	<u>Economic Analysis for Utilization of Geothermal Energy by North Dakota Concrete Products Company (subcontractor report)</u>
13.	EGG-2146	<u>Geothermal Feasibility Analysis for Polo School District No. 29-2, South Dakota (subcontractor report)</u>

<u>GTA Report Number</u>	<u>EG&G Report Number</u>	<u>Title</u>
14.	EGG-2147	<u>Preliminary Feasibility Study of Heating and Cooling Alternatives for Nebraska Western College, Scottsbluff, Nebraska (contractor report)</u>
15.	EGG-2148	<u>Inventory of Thermal Springs and Wells Within a One-Mile Radius of Yucca Lodge, Truth or Consequences, New Mexico (subcontractor report)</u>
16.	EGG-2149	<u>Space Heating for Spa Facilities at Ojo Caliente, New Mexico (subcontractor report)</u>
17.	EGG-2150	<u>Space Heating for Office Building at Glenwood Springs, Colorado (subcontractor report)</u>
18.	EGG-2151	<u>District Heating for Subdivision in Dickinson, North Dakota (subcontractor report)</u>
19.	EGG-2152	<u>Space Heating for Subdivision in Truth or Consequences, New Mexico (subcontractor report)</u>
20.	EGG-2153	<u>Space Heating for Veterans Administration Medical Center, Marlin, Texas (subcontractor report)</u>
21.	EGG-2154	<u>District Heating for Subdivision in Castle Rock, Colorado (subcontractor report)</u>
22.	EGG-2155	<u>Space Heating for Twin Lakes School Near Gallup, New Mexico (subcontractor report)</u>
23.	EGG-2156	<u>Reservoir Data for Electrical Generation at Gila Hot Springs, New Mexico (subcontractor report)</u>

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AQUACULTURE FACILITY POTENTIAL AT BOULDER HOT SPRINGS,

BOULDER, MONTANA

The Boulder Hot Springs resource was examined to determine the potential for the development of a commercial aquaculture facility. This examination included a technical feasibility study and an estimate of the installed cost for a commercial-sized operation. It must be noted that commercial aquaculture facilities are complex and require intense management for a successful operation. No two fish farms are alike from the standpoint of design, water use, feeding practices, fish density per unit volume, and fish husbandry methods.

After a lengthy literature review, it was concluded that there were no technical impediments to a successful aquaculture operation; there were, however, numerous management, planning, and economic factors that could have a profound impact on the overall success.

The Boulder Hot Springs chemical analysis reveals a fairly clean resource. The critical variables would be hardness in terms of CaCO_3 , dissolved CO_2 , fluoride, boron, and dissolved oxygen. Channel catfish require a minimum of "salty" water; however, the hot water resource is cleaner than the cold water supply in this case. This discrepancy will be rectified when appropriately mixed to produce the 80°F water. Similarly, the fluoride level is relatively high but will be brought down to acceptable limits when mixed with the cold water supply. The boron level is within acceptable limits. The main concern will probably be with the dissolved oxygen content. Mechanical aerators may be required prior to use in the raceways. This can be done relatively cheaply with homemade aerators (like meshed screens), or appropriate equipment can be purchased from a variety of sources. A list of people knowledgeable in the field and vendors is given in Appendix A. A list of short courses provided to people either in business or who are contemplating going into a fish farming operation is given in Appendix B. A list of references that may be worth purchasing for the proposed activity is in Appendix C.

To begin the analysis, it was assumed that one acre of water surface would be most viable economically. Other assumptions included:

- o That adequate supplies of cold water ($\sim 55^{\circ}\text{F}$) were available up to nearly 4000 gpm
- o That adequate land area was available with a 5 to 10% slope
- o That channel catfish and tilapia would be the harvested crop
- o That an adequate market was available
- o That processing was not included.

Catfish production has long been centered in the southern states where warmer climates made it relatively easy to maintain warm static ponds throughout the growing season. Northern climates, however, are not adaptable to pond cultures of channel catfish. Established growing conditions for channel catfish are as follows:

- o Temperature $>70^{\circ}\text{F}$ with a range of 55 to 90°F
- o Optimum culture temperature 80 to 85°F
- o pH 6.5 to 8.5
- o Dissolved oxygen >3 ppm for survival, ≥ 5 ppm for optimum growth
- o CO_2 <2 ppm
- o Alkalinity >40 ppm

The criteria for pH, temperature and alkalinity could all be satisfied by the Boulder Hot Springs resource. There were no data on dissolved oxygen and carbon dioxide, but it was assumed that CO₂ was within acceptable limits and that aeration would raise the dissolved oxygen to 90 to 95% of saturation. Oxygenation equipment needed to achieve these conditions is inexpensive.

The commercial production of catfish is a rapidly developing industry; books and reports written more than 5 years ago are already outdated. Less than 25% of the operators who have entered the catfish business to date have made a profit. This is a result of underestimating the efficiency and dedication required and the need for superior farm management. Maximizing efficiency is only one reason behind a recommendation for raceway culture rather than ponds; others include:

- o Raceways replenish the oxygen concentration for better growth, with 90 to 95% of saturation preferred.
- o Metabolic byproducts are continually flushed through the system, resulting in better disease control.
- o Raceways allow more pounds per volume capacity, which increases production per unit volume of water.
- o Fish that swim constantly in a mild current produce superior quality meat.

Therefore, only a raceway culture was considered an economically viable choice for the resource. Dirt raceways may be less expensive to construct and are entirely acceptable, but they are more labor intensive and they contribute to problems in disease control, fish containment, and handling activities. Concrete raceways are preferred, and costs can be kept within limits if no outside labor is required.

Contact with fishfarm operators indicated that: (a) raceway culture is the most desirable, and (b) the market is not now nor is it likely to become saturated with increases in the number of fish farming operations.

The production of channel catfish requires temperatures ranging from 70 to 85°F, although they can survive temperatures close to freezing. Maximum growth occurs in the 80 to 85°F range. Temperature fluctuation is critical; changes of $\pm 1^\circ\text{F}$ can have a 5% effect on the catfish growth. It was assumed that 80°F water would be used in the raceways. This water temperature was to be obtained by mixing appropriate quantities of 55°F water with the 175°F geothermal water. Hot and cold springs on the site produce sufficient quantities of these waters. Three cases were considered: Case 1, if all the 1000 gpm of geothermal water were used; Case 2, if 500 gpm were used; and Case 3, if only 250 gpm were used:

- o Case 1 1000 gpm of 175°F water mixed with 3800 gpm of 55°F water would produce 4800 gpm of 80°F water
- o Case 2 500 gpm hot water mixed with 1900 gpm cold water would produce 2400 gpm of 80°F water
- o Case 3 250 gpm hot water mixed with 950 gpm cold water would produce 1200 gpm of 80°F.

As an average, 0.05 to 0.08 fps velocity should be maintained in the raceway. The lower velocity would require 673 gpm in a raceway with dimensions 10 x 4 x 100 ft. This flow would effectively change the raceway water about twice per hour. The optimum water replacement time is 20 to 30 minutes. The loading of catfish should not exceed 0.8 lb/ft^3 of water for each inch of fish. For example, for 12-inch channel catfish, the maximum density should be 9.6 lb of fish per ft^3 of water. A raceway whose dimensions are 10 x 4 x 100 feet (see Figure 1), therefore, could hold approximately 28,800 lb (see Figure 1).

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Figure 1. Catfish facility raceway.

Eight raceways like the one shown in Figure 1 at approximately 670 gpm/raceway gives the following:

Face velocity	=	0.05 ft/s
Density index	=	0.8 lb catfish/ft ³ of water for each inch of fish
	=	9.6 lb/ft ³ for 12-inch catfish
Pounds of catfish	=	38,400 lb/raceway
Total pounds	=	307,200 lb
Total square footage	=	8,000 ft ² (0.18 acre)

For the Case 1 analysis, 4800 gpm of 80°F water could supply 7 to 8 of these raceways producing 268,800 to 307,200 lb of catfish/year. One operator stated that the raceways could be cascaded into another section, doubling the production rate. It should be noted that appropriate oxygenation equipment would be required before entering the second set of raceways. Other operators claimed that the flow rate could be reduced to 250 to 300 gpm for each 10 x 4 x 100 ft raceway, and therefore a total of about

16 raceways could be supplied by the 4800 gpm of 80°F water. This flow rate reduction increases the turnover time and, therefore, increases risks of bacteria problems and oxygen deprivation. For Case 2 and 3, the pounds of fish produced are decreased proportionately.

Approximately one laborer is required per 100,000 to 150,000 lb/yr production capacity. Therefore, approximately two people would be required for a facility to handle 270,000 to 300,000 lb/yr. The cost of a fish farming operation is dependent to a large extent on existing resources (labor and material) available to construct the operation. The cost estimate given below includes material and labor in 1980 dollars.

o Raceways (material cost @ \$15,000)	\$52,000
o Raceway screens	6,000
o Pumps (cold water) from existing spring-fed cold water pond	12,000
o 16-in. piping @ \$50/ft	10,000
o Supplemental liquid oxygen system	5,000
o Miscellaneous--alarm system, emergency equipment	<u>4,500</u>
	\$89,500

These costs do not include buildings for handling and storage, costs of disposal piping or ditch to discharge area, settling ponds that may be required to reduce the suspended solids load into the receiving water, or costs of product transportation. These costs also neglect installation costs except for the raceways and piping. A representative of the Idaho Water Resource Research Institute estimated a cost of \$1,000,000 for a 1-acre facility, including the price of land and processing equipment. For an 8,000 ft² facility like the one outlined above, and discounting the purchase of land, the cost is estimated at \$150,000 (1980).

APPENDIX A

1919

APPENDIX A

Bill Klontz

Idaho Water Resources Research Institute

University of Idaho

Moscow, Idaho (208) 885-6336

Leo Ray

Route, 3 Box 193

Buhl, Idaho 83316 (208) 543-6645

(Would be interested in selling the fingerlings and buying the harvested fish.)

Bob Erkins

Bliss, Idaho (208) 352-4460

B. R. Jenkins

Box 43

Hooper Hot Springs

Hooper, Colorado 81136 (303) 378-2424

Kramer, Chin & Mago, Inc.

1917 First Avenue

Seattle, Washington 98101 (206) 447-5300

(Consultants and design feasibility company with years of raceway experience.)

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APPENDIX B

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APPENDIX B

Hatch Biologist Laboratory

Box 252

Genoa, Wisconsin 54632

Jim Warren (608) 689-2121

4 days duration, annually in February

Federal Short Course

Cooperative Extension Service

Box 5405

Mississippi State University

Mississippi 39762

Dr. Tom Wellborn (601) 325-3174

2 weeks duration, annually in May

1944

1944-1945

1945-1946

1946-1947

1947-1948

1948-1949

1949-1950

1950-1951

1951-1952

1952-1953

1953-1954

1954-1955

1955-1956

APPENDIX C

APPENDIX C

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