1148 SRES HB 779 1996

In the Lower 48, however, the lower costs would surely have to be offered before much enthusiasm would be engendered.

However, a single well such as the one discussed above would supply from 1000 to 3000 people, depending on the exact conditions, and requires that kind of load to be economic. Installations for smaller groups of people would only be economic if the source costs were small, as might be obtained if springs or shallow wells could be used. Obviously, the proposed use of hot water for purposes other than household space heating could reduce the population base required to support a geothermal well. Greenhouse heating and municipal building heating are examples.

Proposal: A three step program is thus envisaged to demonstrate the economic use of geothermal hot water for space heating in Alaska.

The first step, using presently available data where feasible, would be to survey the towns of Alaska with populations in the region of a few thousand people to determine the heating energy demand, geology, present fuel costs, and local emotion concerning energy. On the basis of this survey, some half dozen towns would be picked for further work. The basis for picking the towns would be the leverage apparently available with respect to fuel costs, general geology, etc.

The second step would be to choose drilling sites in or near the towns, after preliminary geology and geophysics studies, on the basis of property ownership, engineering feasibility, town planning, etc. Some six exploratory holes would then be drilled to depth to determine the geothermal characteristics.

The third step would be to then choose the town offering the best economic and social advantage, and install a municipal heating system, which would then be operated for several years to determine economic and engineering data.

Hopefully, the latter installation would prove sufficiently economic that other municipalities would then move in this direction on their own.

More detailed work would have to be done during step one to estimate the funding required for steps two and three. However, it would appear that step one could be accomplished for about $150,000. Present estimates are $3,000,000 to $4,000,000 for step two and $2,000,000 to $4,000,000 for step three. These numbers include engineering and planning costs, in addition to the construction costs. It is assumed that step one would be jointly supported by the state and ERDA, but that steps two and three might also attract municipal funding.

Step one could be accomplished within six months after approval. Step two could be accomplished during calendar year 197[illegible]. Step three would probably take two years.

It is envisaged that the state energy office would be the sponsor of this project, and that the work would be done by contract to the University of Alaska and private contractors.

APPENDICES E-3 to E-5 (INCL.)

PROPOSED TOTAL ENERGY STUDIES OF SELECTED ALASKAN THERMAL SPRINGS

by

R. B. Forbes, D. Dinkel, L. Leonard
University of Alaska
Fairbanks, Alaska 99701

ABSTRACT

There are 95 or more thermal springs in Alaska. Based on geologic and geochemical data, we do not know of any Alaskan thermal springs that are related to vapor-dominated or large hot water reservoirs which have the potential for generating large amounts of electricity.

Heat is a precious commodity in the arctic and subarctic, and thermal springs are promising energy sources for rural Alaskan communities. Although small amounts of electricity could be generated from springs with higher flow rates and temperatures, utilizing Rankine Cycle-organic working fluid systems, non-electric applications show the greatest promise.

An optimum total energy system designed for a small, isolated Alaskan village would generate a small amount of electricity (40-60 kw) with the subsequent extraction of energy for space heating, controlled environment agriculture, fish farming and hatchery operations, and sewage processing and disposal.

Phased experiments and pilot studies are recommended for Manley, Clear Creek, and Pilgrim Springs in 1975-77 to test the engineering feasibility of this concept.

Selection of Demonstration and Study Sites

Proposed Sites: Three sites have been selected for proposed geothermal demonstrations and experiments to evaluate the feasibility of the total energy extraction concept, as applied to thermal springs in the rural Alaskan environment. The recommended sites (shown on the following page) are:

(1) Manley Hot Springs (90 miles northwest of Fairbanks)

(2) Pilgrim Springs (40 miles north of Nome)

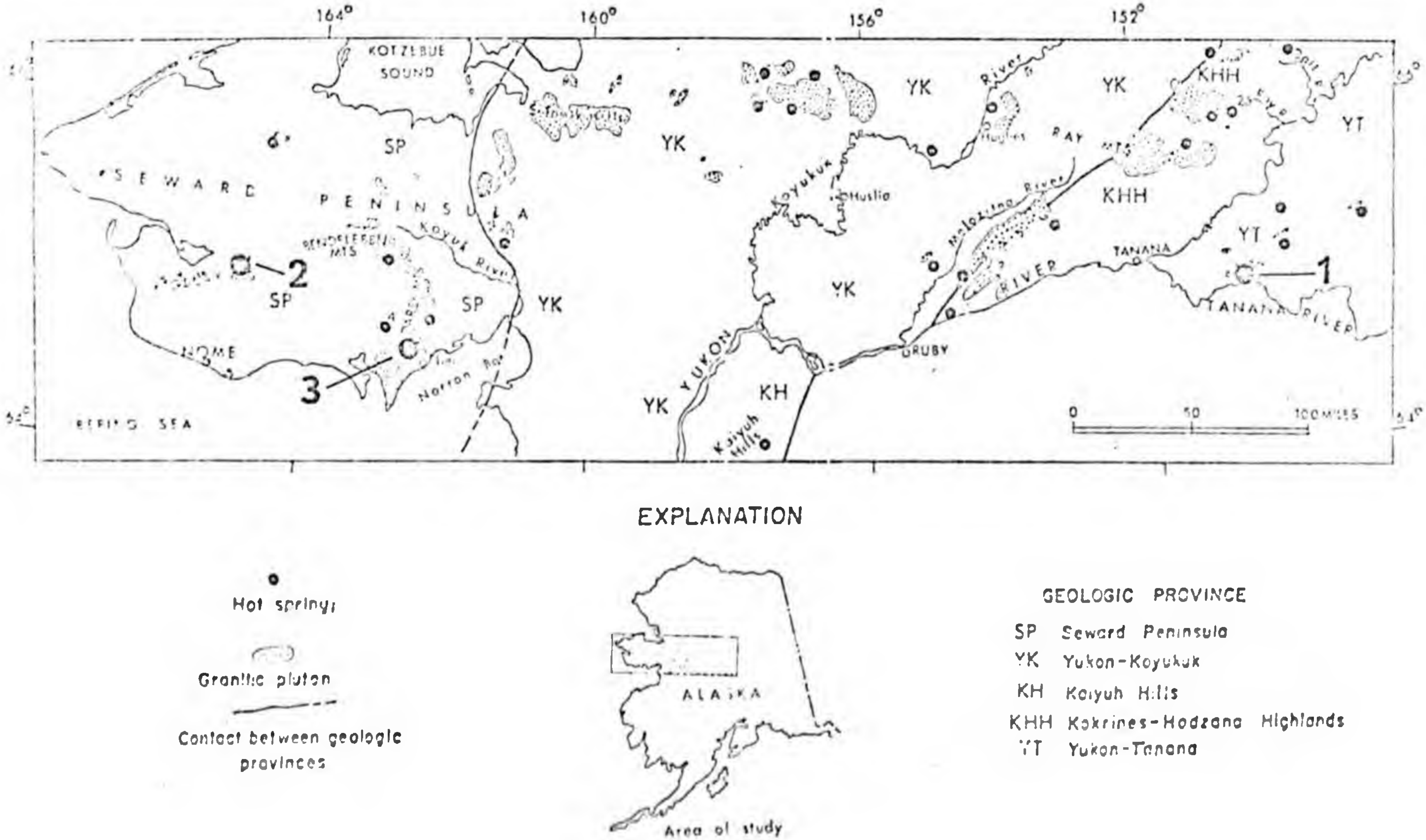
(3) Clear Creek Springs (15 miles north of Elim, on the south-eastern coast of the Seward Peninsula)

Manley Hot Springs: The thermal springs at Manley are privately owned and operated by Mr. Charles Dart. There are three major springs at the Manley site: One has a temperature of 64°C and an estimated flow rate of 20-25 gal/min; the second spring has a temperature of 51°C and an estimated flow rate of 200 plus gal/min; and the third has a temperature of 55°C and an estimated flow rate of 30 gal/min.

Manley is accessible from Fairbanks, via an all-weather road and by commercial air transportation. The Manley Springs are presently utilized for greenhouse operations, space heating and bathing. Mr. Dart has offered his facilities and support for the proposed project.

Pilgrim Springs: Pilgrim Springs are owned by the Catholic church, and under lease to Mr. C. J. Phillips of Nome. Based on temperature measurements by earlier workers, maximum spring water temperatures were thought to be about 68°C. Shallow subsurface thermal probes (8 ft.) recorded temperatures up to 80°C during field work conducted in summer 1974.

Although the site was formerly occupied by a Catholic Mission school until 1942, it is now abandoned. A small airstrip is accessible to light aircraft, via a short flight from Nome.



Geologic sketch map showing location and geological setting of thermal springs in central and westcentral Alaska (taken from Miller et al., 1973). Manley, Pilgrim, and Clear Creek Springs are shown as locality numbers 1, 2, and 3, respectively.

Mr. Phillips enthusiastically endorses the proposed program, and has given his permission for on-site demonstrations and experiments.

Clear Creek Hot Springs: The Clear Creek Thermal Springs are about 15 miles north of the village of Elim, on the southeastern coast of the Seward Peninsula. There are three springs, and one of these flows at an estimated rate of 450 gal/minute at a temperature of 68°C -- one of the largest estimated flow rates of known Alaskan thermal springs.

Although there are no residents near the Clear Creek Springs, the village of Elim is located on the coastline about 15 miles due south of the springs. Moses Point, another community, is located about 5 miles east of Elim.

Elim is a native village with an estimated population of 150-200 residents. Local industries include fishing, hunting, reindeer herding, and a potential lumber industry. Elim is currently served by an AVEC 100 kw diesel power system. Diesel oil must be lightered ashore from offshore anchorages. The peak power consumption during winter 1972-73 was 63 kw.

Plan of Research

Scope of Research

We propose a three-year investigative program including a one-year engineering evaluation of a Rankine-cycle generating system; a three-year agricultural application-space heating study; and a geochemical program to monitor the temperatures and chemistry of the thermal spring waters and ground temperature variation during the experiments.

Rankine-Cycle Turbine Evaluation

(L. Leonard)

Ormat Turbines Ltd. has agreed to collaborate with the University of Alaska in a project to evaluate the feasibility of producing electric power at Manley, using thermal spring water as an energy source. Ormat has agreed to supply a 2.5 kw organic Rankine-cycle turbine for field tests at Manley. This unit is to be equipped with a newly designed spring water-working fluid heat exchanger to extract heat from the thermal spring water. University of Alaska personnel would prepare the site, install the unit, and monitor the performance and output efficiency after installation.

The lead time prior to delivery and installation is estimated to be from 6 to 9 months. During the site construction phase, several shallow holes will be drilled to evaluate the possibility of obtaining hotter water in the shallow subsurface. If hotter water cannot be obtained, however, water from the hottest spring (64°C) will be used. If this temperature proves too low, the input water temperature can be raised by supplemental heating to the minimum temperature which is required by the system, and the value of the demonstration can be maintained. A one-year evaluation period is planned to monitor sustained performance characteristics and the effect of possible variations in water temperature and flow rate.

Present estimates indicate that a 20 gpm flow rate would be required for the evaluation. Outflow temperatures from the generator would be approximately 47°C. The outflow water will be returned to the agricultural and space heating systems for the extraction of additional energy.

The electricity produced by the experiment will be consumed by other Manley experiments, including lighting for the instrument hut and water pumps required by the gardening experiments. These applications will also aid in evaluating the generator performance under varying loads.

If this small scale power demonstration proves successful, Ormat Turbines Ltd. will collaborate with the University of Alaska in the construction and installation of a larger pilot plant at another thermal spring (Clear Creek Springs).

Space Heating Studies
(L. Leonard)

Space heating experiments will constitute a significant part of the Manley engineering studies. Two structures are to be built at the site. A laboratory hut with accommodations for two investigators, which will also serve as a test enclosure for space heating experiments. The agricultural experiments will also require a building which will include a greenhouse and a controlled environment module which will need continuous heat.

Water delivery, regulation, and convector systems will be designed and tested. Whenever possible, commercially available equipment will be used. This work will concentrate on the optimization of existing equipment and systems, rather than attempts to develop new and radical techniques. Applications engineering studies will document the effects of fluctuations in flow rate and temperature of input water on heating systems.

Agricultural Applications and Experiments
(D. Dinkel)

Building on the past and present Manley agricultural successes, we propose a series of experiments and engineering application studies to determine the optimum methodology and economic feasibility of utilizing energy from thermal springs for the production of large-scale vegetable crops in controlled environment modules, greenhouses, and heated garden plots.

Controlled Environment Experiments

(D. Dinkel)

The major objective in this study is to determine economically optimum environmental controls and methods which could lead to large-scale vegetable farming at Alaskan hot springs. These experiments will require a specially designed and constructed agricultural laboratory. This structure would be composed of three modules, including a greenhouse unit, a hydroponic section, and a controlled total environment module.

The greenhouse would be operated during extended summer growing seasons and heated by thermal spring water and radiant heat from the warm ground. The intermediate section will function as a greenhouse or hydroponic unit, as controlled by detachable insulated panels which would overlie the basic glass frame enclosure.

The controlled total environment unit is to be a completely enclosed insulated module, heated by radiant heat from the warm ground, thermal spring water, and radiant heat from solar lamps powered by electricity generated by the 2.5 kw Ormat energy converter. Environmental controls will include solar radiation, ambient air and substrate temperature, CO_2 content (in air), and nutrient supply and chemistry.

Heated Garden Plot Experiments

(D. Dinkel)

There are extensive areas of warm ground adjacent to Manley Hot Springs. The average root depth soil temperatures in Interior Alaska are about 13°C during most of the growing season. In June 1974, soil temperatures up to 45°C were measured at root depths near the hottest of the Manley Springs as compared to soil temperatures of 11°C, 300 meters distant. Soil temperatures averaged 25°C within the thermally disturbed zone, which included a surface area of about 6.7 acres. Based on recent studies by Dinkel (1974) and others, the potential yield of such acreage, when farmed with the new techniques, is such greater than that of arable land with the usual Interior Alaskan soil temperatures.

Planned experiments include preliminary soil temperature grid surveys and the compilation of detailed isothermal contour maps. Garden plots would then be located in planned temperature zones, and crops would be planted according to optimum root temperature requirements. Additional garden plots would be heated by networks of subsurface pipe (PVC, copper, steel) carrying thermal spring water, and surface irrigation with warm spring water would also be evaluated. Early planting and transplant techniques are to be explored, including the use of temporary plastic shelters. The yields per unit area, growth time, and quality versus cost would be compared to those of control garden plots farmed with standard agricultural methods.

Geochemical and Geophysical Studies

(R. B. Forbes)

Very little is known about the annual and/or seasonal variation in chemistry, temperature, and flow rate of thermal springs in general, and Alaskan springs in particular. Such variations, if large, could be very troublesome. A drop of a few degrees in water temperature could seriously reduce the performance and efficiency of binary type generating systems, and changes in flow rate would pose additional regulation problems. Variation in water chemistry, including relative increases in the concentration of alkalies, silica, calcium, and fluorine could be hazardous to agriculture, if the spring water is used for irrigation and/or for nutrient solutions.

As mentioned in an earlier section, it is now known that thermal spring waters are composed of at least 95% recirculated meteoric water. We do not know, however, what the turn-around time is in such systems;

and the problem is complicated by mixing with water from the local water tables, before emergence. Continuing geochemical data should be acquired during the program, to be applied to several problems and studies including:

(1) Short and long-term variation in the chemistry, temperature, and flow rate of spring water.

(2) Correlation of the above variations with local precipitation, break-up chronology, water table level, and barometric pressure.

(3) Turn-around time (surface-reservoir-surface) of water in the thermal spring system, with the aid of tritium and oxygen isotope analyses.

(4) Identification of the factors which control the mixing of ground and spring water in the subsurface, and the affect on the chemistry of the spring water.

The chemical monitoring system would be centralized in the laboratory module to be constructed on the site. Continuous temperature and flow rate data would be registered on recorders in the laboratory, and daily water samples would be analyzed with the aid of flame photometric and atomic absorption analytical equipment in the same laboratory.

Tritium and oxygen isotope analyses of spring water will be done at outside laboratores by separate contract, on weekly samples.

Appendix E-3

MANLEY HOT SPRINGS PROJECT

MANLEY HOT SPRINGS

Scheduled Work

Objectives:

The Manley experiments are designed to -

A. Determine the soil heating potential of hot spring water using several distribution methods.

B. Determine the yields and quality of high income type crops when grown with extended seasons and optimum soil temperature.

C. Test the efficiency of geothermal water to heat greenhouses and produce electricity for lighting and year-round crop production.

D. Gather data that will be useful in designing systems for the use of waste thermal energy that results from the conversion of fuel sources to electrical energy, thus promoting energy conservation and reducing thermal pollution from these waste energy sources.

E. Determine costs of production using these geothermal energy sources.

Agricultural Studies: (D. Dinkel)

Outdoor Studies: Crops will be grown in areas adjacent to Manley Hot Springs in soils that vary in soil temperature and length of cropping season.

Variables: A factorial de n is planned using three or four replicates.

A. Soil Heating Treatments (3)

1) Unheated normal cultivated soil (the soil temperatures in Interior Alaska average about 13°C at the 5cm soil depth).

2) Geothermally disturbed soil selected to be as near 20-24°C as possible.

3) Soil heated to 24°C using geothermal water run through pipes placed beneath the soil surface.

B. Plastic mulch treatments (3)

1) No plastic mulch

2) Black plastic mulch soil covering

3) Clear plastic mulch soil covering

C. Plastic row coverings or cloches (2)

1) No row covering

2) Clear polyethylene row covering

D. Crops (8)

<u>Warm season</u>

1) Cucumbers

2) Sweetcorn

3) Snapbeans

4) Tomatoes or Peppers

<u>Cool season</u>

5) Peas

6) Broccoli

7) Carrots

8) Lettuce

Data will be gathered as follows:

A. Soil temperature at 4, 8 and 12cm on all plots on a daily basis using thermocouples.

B. Air temperature at 1, 5, 10 and 20cm above the plots on a daily basis.

C. Soil reaction (pH) on a weekly basis.

D. Soil nutritional status on a weekly basis.

1) Nitrogen

2) Phosphorous

3) Potassium

E. Crop data

1) Number of days to emergency

2) Number of days to crop maturity (measured by market quality)

3) Quality evaluations

4) Yields (total and marketable)

5) Significant morphological data for a specific crop (example - number of days to anthesis for peppers)

Greenhouse:

In addition to the use of the greenhouse to start plants for the field studies, there will be studies conducted with the objective of determining varieties and techniques for the continuous year-round production of high value crops. These studies are designed to determine the proper crops, varieties, scheduling for plantings and techniques for culture using the supplementary lighted greenhouse and the total controlled environment system for production.

Variables:

A. Crops (6)

1) Cucumbers

2) Tomatoes

3) Lettuce

a) leaf

b) head (crisp)

4) Radishes

5) Green onions

6) Turnips

B. Lighting (2)

1) Supplemental light with HID lamps to 300 micro-einsteins (PAR)

2) No supplemental lighting

C. Seasonal scheduling (in order to determine if proper scheduling will allow a grower to schedule the main vegetative growth prior to the dark part of the year and thereby improve year-round production even without supplemental lighting)

1) Summer season growth initiatic

2) Fall season growth initiation

3) Spring season growth initiation

Data will be gathered as follows:

A. Crop data

1) Number of days to emergence

2) Number of days to crop maturity

3) Quality evaluations

4) Yields (total and marketable)

5) Significant morphological data for a specific crop (example - number of days to anthesis for tomatoes)

B. Temperatures

1) Air, daily and nightly

2) Soil, daily and nightly

C. CO_2 (daily)

D. Light measurements (micro-einsteins PAR)

In addition to the other more elaborate statistically designed studies, preliminary research will be accomplished to determine if irrigation with hot water will be practicable. Small areas will be watered with hot water using (1) trickle irrigation, (2) sprinkler irrigation, and (3) fog irrigation. Data will be gathered on soil and air temperature and on soil moisture content.

Studies will be conducted for three years in order to achieve adequate replication.

Appendix E-4

PILGRIM HOT SPRINGS PROJECT

Pilgrim Hot Springs Project

(R. B. Forbes)

Background: Pilgrim Springs is located approximately 40 miles north of Nome, in the southwest corner of the Bendeleben (A-6) Quadrangle.

Before the arrival of the white man, the Eskimo name for Pilgrim Springs was Kruzgamepa. During the height of early gold mining activity, the Springs served as a resort for residents of Nome, Solomon, Council, and other mining communities, and vegetables were also raised at the springs for local markets.

Subsequently, the Catholic Church established a mission school for native children at Pilgrim Springs which was closed in 1942. At present, the springs are leased from the Catholic Church by C.J. Phillips of Nome.

Geologic and Geochemical Setting: The Pilgrim River Valley is mantled by alluvial fill. Precambrian gneisses and biotite schists are exposed on Hen and Chickens Mountain, four miles north of the springs, and Cretaceous granitic intrusives cut Precambrian gneisses and schists in the hills to the south and east (Sainsbury, 1974). Miller et al. (1972) have suggested that an extension of the Bendeleben Range front fault may underlie the alluvium of the Pilgrim River Valley, and that Pilgrim Springs may be related to this fault system.

Serpentine Hot Springs is located approximately 50 miles north of Pilgrim Springs waters, and is characterized by high salinity of the NaCl type (see table on next page). The saline character of the Pilgrim Spring water has aroused speculation on a possible marine origin.

To the northeast, a large lowland area centered on Imuruk Lake is covered by a very young basaltic volcanic field which ranges in age from

Chemical Analyses of Pilgrim and Serpentine Spring Water (taken from Miller et al., 1973)

Component	Pilgrim	Serpentine	
SiO_2	100.0	100.0	*ppm
Al	0.044	0.083	
Fe	----	----	
Ca	530.0	47.0	
Mg	1.4	0.48	
Na	1450.0	730.0	
K	61.0	40.0	
Li	4.0	4.7	
NH_3	----	----	
HCO_3	30.1	64.5	
CO_3	----	----	
SO_3	24.0	29.0	
Cl	3346.0	1480.0	
F	4.7	6.4	
Br	----	----	
pH	6.75	7.91	

* parts per million

3.5 million year old basal volcanics to very young flows which may have been erupted as recently as a few hundred years ago (D.M. Hopkins, unpublished data).

The larger springs and associated seeps emerge from channel sands and silts in an abandoned meander loop of the Pilgrim River. However, other seeps and patches of warm ground occur in the adjacent area as shown by snow-free ground and bright green vegetation in winter versus summer aerial photographs (see "A Geophysical Reconnaissance of Pilgrim Springs").

Based on the apparent lack of subsidence and tilting of the mission buildings (with the exception of damage of uncertain origin to the green-house) and the absence of thermokarst pits in the cleared fields, the Pilgrim Springs area appears to be free of permafrost. The three dimensional geometry and areal extent of the thawed zone are not known.

Pilgrim Springs as a Potential Geothermal Resource

Although Pilgrim Springs has a previous agricultural and resort history, it has excited more recent interest as an indicator of a possible subsurface geothermal stream or hot-water reservoir.

Based on the silica, potassium-sodium and sodium-potassium-calcium thermometers (White, 1970), (Fournier and Truesdell, 1970), (Fournier and Truesdell, 1973), estimates of the sub-subsurface reservoir temperature of Pilgrim Springs have ranged from 120° to 137°C (Miller et al., 1973). Previous estimates of spring water flow rates have ranged from 6 to 20 gal/min. However, data reported in this study show that earlier temperature and flow measurements must be treated with caution due to the high permeability of the surrounding channel sands, and the mixing of spring and ground water.

Geophysical Survey

In an attempt to refine previous estimates of the geothermal potential of Pilgrim Springs, we applied several geophysical survey techniques including:

(1) Seismic refraction profiling

(2) Geomagnetic profiling

(3) Microseismic background recordings

(4) Surface and subsurface water temperature measurements in springs and seeps

The results of the survey and recommendations for further work are summarized below.

(1) Shallow subsurface water temperatures in zones of maximum upwelling reach 80°C a few inches below the bottom sediment.

(2) Pilgrim Springs waters are diluted by mixing and convection with local ground water, and water temperatures and salinities will increase in the subsurface.

(3) A 9060/5540 ft/sec discontinuity is located approximately 208 feet below the springs, which is believed to be Tertiary sediments or hydrothermally-cemented glacio-fluvial gravels. The sedimentary section, if present, may be up to 400 feet thick.

(4) Tertiary sediments, such as those which occur to the northeast, contain permeable rock units which could make good geothermal reservoirs; and a hydrothermally-cemented conglomerate cap would offer an interesting target, if it does indeed exist.

(5) The negative magnetic anomaly over the springs is most satisfactorily explained by a zone of hydrothermal leaching along the conduit system, which has a lower magnetic susceptibility.

(6) Subsurface spring waters will be more saline at depth, and with increasing temperature will constitute a serious corrosion problem in respect to drilling and application engineering.

(7) Although the observation period was dangerously short, the absence of microseismic activity during the two recording periods minimizes the probability of vapor phase reservoirs.

Plan of Research:

(1) An extended seismic refraction profile should be completed which includes deeper penetration and north-south step-outs. Objectives include the definition of Tertiary rocks versus hydrothermally-cemented gravels, and the Nome Group basement discontinuity.

(2) Based on a refined seismic profile, a shallow drilling program should be initiated which will accomplish the following objectives:

(a) A drill hole which penetrates the 208-foot discontinuity under Pilgrim Springs. The upper part of the hole will be in water-saturated sand, and effective drilling techniques will require driving casing ahead of the bit, and up-hole circulation to remove the unconsolidated and water-saturated sediment.

(b) The drilling program should include several halts in drilling activity to allow the development of a reasonably good thermocline in the water column in the cased hole, to allow meaningful gradient measurements.

(c) The casing should contain a corrosion resistant plastic liner.

(d) If shallow (100 feet) subsurface temperatures approach 100°C, drilling should be suspended until blow-out prevention equipment is installed at the well head.

(e) Draw-down and pumping tests should be conducted after each cycle of down-hole temperature measurements. This is the only method which will supply meaningful flow rate and capacity data in terms of large-scale geothermal applications.

(3) An agricultural experimental program should be activated at Pilgrim Springs which would evaluate the feasibility of the following:

(a) Shallow subsurface heating of agricultural plots by thermal spring water circulated through networks of plastic pipe.

(b) Heating of hydroponic and greenhouse facility by thermal waters from Pilgrim Springs.

(c) Heating of local residences by thermal spring waters.

(d) Desalinization of spring waters to provide potable water.

PILGRIM SPRINGS PROJECT

Scheduled Work

Summer 1976:

(1) Seismic refraction and surface geomagnetic survey of area (Stone, Gedney, Forbes)

(2) Aeromagnetic survey of area (subcontract)

(3) Shallow holes (100 ft.) drilling and thermal gradient measurements (subcontract)

(4) Exploratory drilling of seismic target, with downhole temperature, flow rate and related measurements (subcontract)

(5) Data evaluation and analysis (Forbes, Stone, Gedney)

Appendix E-5

CLEAR CREEK SPRINGS PROJECT

Clear Creek Springs Project

(R. B. Forbes)

Socio-Economic Framework of Elim

Background: The village of Elim, which is located about 15 miles from Clear Creek Springs, had a population of 170 people in 1970 when it became a fourth-class city. The population is Eskimo, with the exception of resident Bureau of Indian Affairs school teachers.

Elim was apparently an ancestral Eskimo village prior to the coming of the white man. A Covenant Church Mission was established in the village in 1914 by L.E. Ost. Elim received a post office in 1943.

Apparently the Elim people and adjacent villages paid little attention to Clear Creek Spring, although remnants of hunting camps can be found in the area.

There is no major industry in the village of Elim at present. The residents make their living from subsistence hunting and fishing, commercial fishing, trapping, reindeer herding, and a locally-owned cooperative store. Other sources of employment are mainly government related.

In recent years, the State Rural Development Agency has awarded several small grants to the village to perform public works projects, which have totaled about $2000 per year in resident wages.

The 1970 census showed the average individual income in Elim to be between $500 and $1000 per annum. At that time, skills possessed by unemployed villagers included:

a) grocery clerks
b) diesel mechanics
c) carpenters
d) dredge winchmen
e) heavy equipment oilers
f) truck and jitney drivers
g) reindeer herders
h) dozer operators
i) fishermen

Elim has a council which governs village affairs including law enforcement. There are two health aids in the village, but there is no sanitation aid, and no mechanized fire department.

Elim residences are mostly old log structures of one or two rooms. There are a few frame houses. Generally, the condition of the houses is poor, and most are in need of repair.

The only utility system in Elim is the Alaska Village Electric Cooperative power system. This system consists of two 50 kw diesel generators. The peak load in the winter of 1972-73 was 25 kw with an expected peak for 1974-75 estimated at 44 kw. There are no sewer or water systems.

Organized activities in Elim consist of:

a) Boy Scouts
b) 4-H Club
c) weekly movies
d) Sewing Circle
e) Covenant Church activities
f) Dog Race Committee

There are no community indoor or outdoor recreation facilities.

The geothermal potential of Clear Creek Springs offers interesting opportunities for the village of Elim. However, careful planning is necessary to insure that proposed developments and applications are compatible with the wishes and lifestyle of the Elim people. Preliminary discussions should be held with the villagers to determine what electric and/or non-electric applications are best suited to the needs and desires of the community.

Geologic and Geochemical Setting: The geologic setting of Clear Creek Springs has been described by Mil   et al. as follows:

> "Hot springs on either side of east-flowing tributary of Clear Creek. Spring south of tributary has large flow estimated at several hundred gal/m and is about 400 ft above Clear Creek valley floor. A temperature of 63°C. was measured in 1970. Two hot spring areas occur north of tributary. The upper spring is inaccessible by helicopter; the lower one has a smaller flow than the spring to the south and a temperature of 67°C. . Chemical analysis available.
>
> "Springs are in quartz monzonite of Darby pluton less than 1/4 mi from contact with Devonian limestone. Pluton-limestone contact is inferred to be major fault (Miller and others, 1972) trending N.18°E."

A partial chemical analysis of water from Clear Creek Hot Springs has been reported by Miller et al. (1973) (see table on next page).

According to the Na-K-Ca geothermometer, the reservoir temperature for this spring water is estimated to be 111°C. The springs emerge from fractures in quartz monzonite, and this setting, along with the probable low reservoir temperature, argues against the presence of large subsurface geothermal steam reservoirs. However, Clear Creek Springs have excellent resource potential due to the large (400 gal/min or greater) flow rate of one of the springs, and a location which is 400 vertical feet above the valley floor.

Plan of Research: The high cost of food, heat and power in Elim, and the proximity of the village to Clear Creek Springs, constitute an optimum setting for a village demonstration project, involving the total energy concept as applied to the most acute energy needs of an isolated arctic community.

Socio-Economic Assessment

At the outset, the needs and wishes of the Elim people must be det   ined, and a program should be developed which has a reasonable

Partial Chemical Analysis of Water from
Clear Creek Hot Springs (Miller et al., 1973)

SiO_2	--
Al	--
Fe	--
Ca	5.6
Mg	0.06
Na	54.
K	1.4
Li	--
NH_3	--
HCO_3	34.
CO_3	34.
SO_4	25.
Cl	4.9
F	--
Br	--
B	.02

PH = 9.43
T = 67°C

probability of answering these needs without disrupting village life, as idealized and desired by the residents.

We suggest that a small group of villagers, selected by the Village Council, be brought to Manley in the early stages of the project, to observe the pilot studies and experiments, and that the details of the Elim-Clear Creek program be finalized at an Elim-University of Alaska workshop, following the Manley visit.

Clear Creek Experiment

Calculations show that a 50 kw binary generating system could be driven by the 400 plus gal/min inflow of Clear Creek Springs water. The outflow temperature would be about 55°C. Considering the flow rate, the residual energy potential of the water is impressive. A 400-foot fall to the valley floor offers an additional hydroelectric inducement.

The Clear Creek experiment, subject to conferal with the Elim Council, would include the following:

(1) Installation of a 50 kw binary generating system.

(2) Construction of an electric transmission line to Elim.

(3) Possible development of a new community at the Clear Creek Springs site, utilizing the total energy of the springs, for:

- (a) Generation of electricity
- (b) Space heating
- (c) Controlled agriculture environment
- (d) Salmon hatchery operations

CLEAR CREEK PROJECT

Scheduled Work

Sandia Laboratories (ERDA) and the Geophysical Institute have agreed to conduct joint investigations at Clear Creek Hot Springs. Sandia is currently developing a thermodynamic working fluid generating system which could be evaluated at Clear Creek Springs in 1976 and/or 1977.

The experiment would also include the generation of additional electricity via a 400 ft. fall of outflow water to the valley floor, and the possible transmission of power to the village of Elim.

Although equipment readiness dates are not yet firm, site evaluation and selection must proceed during summer 1976, if applications engineering studies are to proceed at the desired rate. Funding is requested for one month's field work, including helicopter support, to conduct the necessary reconnaissance. The field evaluation will include:

(1) Water temperature and flow rate measurements.

(2) Geologic and geophysical investigations of the site.

(3) Route surveys for possible power transmission and/or hot water pipelines.

(4) Site selection for generating equipment.

(5) Mixing potential with Clear Creek, in respect to possible fish farming and hatchery operations.

Prior to the field work, a land status search will be conducted, to answer questions relating to the stewardship of Clear Creek Springs; and clearance will be sought for the planned experiments.

Preliminary Proposal

For

Wind Power Demonstrations at Selected Alaskan Sites (Umnak Island, Cold Bay, and Kotzebue)

October 1975

Submitted to

Director
Alaska State Energy Office
Anchorage, Alaska 99501

by

Geophysical Institute*
University of Alaska
Fairbanks, Alaska 99701

*Contact: Prof. Tunis Wentink, Jr., 479-7607 or 479-7558

Early solution of the well known energy problems that beset rural Alaskans now, and probably for at least several years if no actions are taken, requires positive efforts. Further problem definition and exploratory experiments will only prolong the difficulties. Problem solutions using existing technology should be started soon. However, especially where new, unconventional, or unfamiliar technology is involved, natural caution calls for limited but meaningful demonstrations prior to large and costly plant installations. In brief, FIELD DEMONSTRATIONS OF USEFUL ENERGY-PRODUCING HARDWARE SHOULD BE STARTED AS QUICKLY AS POSSIBLE.

This is a proposal for necessary (for installation) planning studies and actual demonstrations of wind power at three different Alaskan locations. These are included in one project because of cost savings through best use of personnel and similarity of equipment. The locations are the former Cape Air Force Base (and also formerly Fort Glenn) on Umnak Island in the Aleutians (referred to below as Umnak), Cold Bay and Kotzebue.

In view of several discussions regarding Alaskan wind power projects with the Director of the Alaska State Energy Office (ASEO) and the interest expressed by Governor Hammond, we do not dwell on the motivation for these tasks. Briefly, the sites were selected because:

1. Umnak is a prime site for an important aquaculture (salmon hatchery) demonstration facility, where the abundant resources of wind and warm water can be exploited.
2. Cold Bay is an outstanding location for windmill evaluation and use of the wind-derived energy. It has a large state-owned airport, using a considerable amount of expensive power. It presents an opportunity to use an existing distribution grid for wind work,

an important feature for possible future ERDA support. Also the local utility (Northern Power and Engineering Corp.) will cooperate in the project, including significant manpower contributions. Cold Bay is one of the best locations in Alaska for windmill exploitation. The Geophysical Institute has considerable experience in the area, including a close and continuing cooperative relationship with the U.S. National Weather Service (First Class Station) at Cold Bay.

C. Kotzebue offers a high visibility location for wind power demonstrations, since it is a major way-station for much travel between bush communities, or between the bush and Fairbanks, Anchorage, etc. A demonstration at the state-owned U of A Community College at Kotzebue (CCK) would also permit energy economies at the CCK and also real-life training in wind machine utilization, and thus a propagation among the villages of windmill use information.

Project Special Features

A major feature of this proposal is the expectation that a private foundation (The Kresge Foundation) will supply at least $50,000 as a gift to the Geophysical Institute for capital equipment (mostly the windmills*).

*These windmills would remain the property of the University of Alaska; the grant would be specifically to a regular 4-year college or university. These would be installed in the locations selected, on an indefinite long-term no-cost loan basis. They would not be removed, except by mutual consent of the Geophysical Institute and the actual user at the selected locations. This proviso is only to insure proper use for the grantor's intended purpose.

This gift requires the guaranteed support by others to insure satisfactory completion of the project, and we intend not to re-apply for this gift until such support (detailed in the budget) is assured in writing. However, there are problems in making even parts of the entire project dependent on Kresge support. These are:

1. The amount Kresge might grant will not cover enough capital equipment for all three sites.
2. Kresge probably will not respond to our new grant application until 1 July 1976, too late for field implementation until early 1977.
3. Umnak, and perhaps Cold Bay, will not qualify under Kresge's conditions.

These problems are elaborated on below.

There are not enough funds in the expected Kresge grant to supply windmills and necessary auxiliary equipment for all three sites. At least two machines will be needed for Kotzebue, and one twice the size (and cost) for Cold Bay. Also the electric power requirement for the Umnak hatchery needs to be defined. In any case, one windmill for Umnak is the minimum.

Also the ground rules on which our earlier successful application to Kresge was based were that the capital equipment was for native village electrification demonstration and energy use by the villagers. Cold Bay thus does not qualify, and Umnak Island (excluding Nikolski) has no native settlement now. Nelson Lagoon would qualify, but for the purposes of the State (and ERDA funding) Cold Bay is a better candidate for a demonstration.

Another problem exists in basing this proposal on Kresge support. While the probability of the grant is very high (approved once, but then reluctantly relinquished by us), we must formally reapply for such a grant (telcon to me from Kresge, October 1975). The probability will be increased if we show in writing the endorsement of the Governor and guaranteed State fiscal support. Kresge will not entertain an application before 1 January 1976, or notify us of the result until 1 July 1976. Unless we can order windmills by about March 1976, their delivery at the field locations will be too late for installation before spring 1977. We propose that the State of Alaska's initial funding be such as to cover the entire project, with the understanding that the State contribution would probably be decreased eventually by the amount of the Kresge grant.

Another feature is the combination of the Umnak and Cold Bay activities initially at Cold Bay. Much planning and preliminary work for an Umnak wind system can be accomplished at Cold Bay, and money could be saved by doing this. There is no merit in installing windmills at Umnak until the actual hatchery site selection there is well defined; possible topographic shielding must be evaluated before wind machines are installed. There is no question that windmills will work on Umnak, but the maximum energy production can vary considerably with the specific location. Also, the wind machines should not be operated until personnel (Aleuts or others) are resident, and so can learn about and monitor machine behavior. However, wind speed surveys should be started at Umnak as soon as other activity, like geothermal measurements (temperature, flow rates, etc.), are begun. Soil surveys to insure satisfactory tower footings should also be made as early as possible.

Activity for Umnak

Depends on project details (exact location and energy requirements as defined by Bill McNeil or others).

1. Survey trip* to establish tower location and footing requirements, and shelter† facilities.
2. Supervise tower erection and start wind checks (tower to be used for windmill later). Local labor required.
3. Plan and order wind power system (includes auxiliary equipment).
   (a) Machine selection (December 1975?) depends on project needs and also best kind available; actual choice may indicate that first erection and testing should be done at Cold Bay, then moved to Umnak.
4. Supervise and instruct on windmill erection, checking and routine operation. Local labor required.
5. Write evaluation reports, for project use and for best educational and useful publicity effects in and out of state government.

Activity for Cold Bay

Depends on availability of wind machines, determined in connection with other site tasks. Geophysical Institute personnel will work in close cooperation with Northern Power and Engineering Company (NPEC) of Anchorage, the Cold Bay utility.

1. With NPEC advice, design wind power system (with minimal energy storage capacity) for tie in with the existing electric grid.
2. Order appropriate wind power system (estimated 13 KW rated).

*All Umnak activity coordinated with Cold Bay task, to save time and money
†For staging and use in wind and power facilities.

3. In conjunction with NPEC install tower and wind power system. Local labor used. NPEC will contribute significant manpower in installation and operation.

4. Continue present U of A cooperative wind behavior program with National Weather Service facility at Cold Bay, as these relate to the actual windmill operation.

5. Investigate specific wind power uses as these may apply to the State-owned Cold Bay Airport electrical needs, and for extrapolation to other Alaskan airports.

6. Write evaluation reports, for project use, and for best educational and useful publicity efforts in and out of State government. Stress economics of the wind-produced power.

Activity for Kotzebue

This project has been detailed elsewhere for use as a significant electricity source for the U of A Kotzebue Community College (KCC). Considerable planning has been done already. The Kotzebue effort combines the attractive features of cost-savings to the State, high visibility to native transients through this way-point, and teaching opportunities through "real-life" operating equipments and short courses at a facility that is directed to education of the rural people.

Initial cost savings for this project may stem from cooperation with the U of A effort for the actual construction of the KCC in early 1976. Equipment such as for tower footings and erection will be available and combined logistics also may effect savings.

We would do at Kotzebue:

1. Wind measurements at site selected (KCC?) to establish vertical effects, and determine the validity of extrapolation of wind data

from Kotzebue Airport. (Use a tower intended for a windmill later.)

2. Based on results of (1) above, supervise installation of 2 or 3 windmill systems for demonstration; also use for electric lighting of KCC facility.
3. Write evaluation reports, etc., as in item (5) of Umnak activity.
4. Organize and give short course in windmill technology and use at KCC, if interest exists.

APPENDIX G

The Alaska Geothermal Resources Act of 1971 higher cash offerings than plaintiffs' bids, the defendants acted properly in determining that the high cash bids on those 33 tracts were th apparent high bids, not plaintiffs' bids. Kelly v. Zamarello, Sup. Ct. Op. No. 705 (File Nos. 1255, 1256), 486 P.2d 906 (1971).

Royalty legislation on state oil and gas leases is a matter within the paramount jurisdiction of the state. The conservation of oil and gas is a matter within the authority of the states. 1969 Op. Att'y Gen., No. 6.

The royalty provisions of a mineral leasing act are related to conservation of natural resources. 1969 Op. Att'y Gen., No. 6.

The United States, under the 10th amendment to the Constitution of the United States, has no authority to legislate on state royalty provisions and state oil and gas leases. 1969 Op. Att'y Gen., No. 6.

An overriding gross royalty of 2% of all proceeds from any state and federal lands conflicts with the Statehood Act and the province of the Alaska state legislature. 1969 Op. Att'y Gen., No. 6.

A 2% overriding gross royalty cannot apply to a federal lease on public lands within the State of Alaska. 1969 Op. Att'y Gen., No. 6.

A 2% overriding gross royalty cannot apply to a State of Alaska oil and gas lease issued pursuant to AS 38.05.180. 1969 Op. Att'y Gen., No. 6.

Cited in Shell Oil Co. v. Pan American Petroleum Corp., 5 Alas. L.J. No. 11, p. 230 (Nov., 1967).

ALR reference.—Validity of compulsory pooling or unitization statute or ordinance requiring owners or lessees of oil and gas lands to develop their holdings as a single drilling unit and the like, 37 ALR2d 434.

Sec. 38.05.181. Geothermal resources. (a) *Purpose.* The legislature finds and declares that

(1) the people of Alaska have an interest in the development of the state's geothermal resources potential for

(A) use in the generation of electrical power that may reduce the state's dependence on fossil fuel power plants that seriously pollute the atmosphere in a number of areas;

(B) the production of geothermal steam that may provide central heat for urban areas close to geothermal areas;

(C) the production of valuable minerals and other byproducts associated with geothermal steam and accompanying brines; and

(D) the distillation of fresh water;

(2) the state, through the Department of Natural Resources and its division of lands, should exercise its authority to encourage the exploration for, discovery and production of, geothermal resources in the public interest to

(A) encourage maximum economic recovery of this potentially important natural resource and prevent its waste;

(B) ensure that the exploration for, and production of, geothermal resources, and the disposal of wastes from them, are carried on in a way that will safeguard life, health, property, public welfare and the environment; and

(C) preserve the state's natural, scenic values especially in those areas where geothermal resources are or may be found; although the need to develop new sources of energy rapidly is becoming urgent, every effort also must be made to protect those hot springs and geysers that are among nature's scenic wonders.

(b) *Land survey and classification.* (1) Because of the absence of detailed geothermal mapping and the limited geochemical, geological or geophysical knowledge of the state's geothermal resources that is available, a survey of geothermal resources shall be included in the complete geological survey of the state authorized by AS 41.07.020, and a statement of the progress of the geothermal resources survey shall be contained in the annual report required by that section.

(2) The classification of known geothermal resources areas, each of which shall contain at least one well capable of producing geothermal resources in commercial quantities, shall be made by the commissioner upon recommendations of the director, the state geologist or the United States Geological Survey under AS 41.07.040.

(3) Within 125 days after August 15, 1971, the commissioner shall publish a statement of all lands which were included within any known geothermal resources areas on August 15, 1971. He shall also publish from time to time his determination of other known geothermal resources areas specifying in each case the date the lands were included in the area.

Revisor's note (1973). — The provisions of AS 41.07, referred to in (b)(1) and (2) of this section, have been repealed. See AS 41.08.

(c) *Authority.* (1) Under the provisions of this section and subject to §§ 135—145 of this chapter, where applicable and not in conflict with this section, the commissioner may issue prospecting permits and leases for the exploration, discovery, development, utilization, extraction and removal of geothermal resources in or from state lands administered by him.

(2) Rights to develop and utilize geothermal resources underlying lands owned by the State of Alaska may be acquired solely in accordance with the provisions of this section.

(3) The commissioner shall prescribe those regulations he considers appropriate to carry out the provisions of this section. The regulations may include, without limitation, provisions for

(A) the prevention of waste,

(B) development and conservation of geothermal and other natural resources,

(C) the protection of the public interest,

(D) assignment, segregation, extension of terms, relinquishment of leases, development contracts, unitization, pooling, and drilling agreements,

(E) compensatory royalty agreements, suspension of operations or production, and suspension or reduction of rentals or royalties,

(F) the filing of surety bonds to assure compliance with the terms of the lease and to protect surface use and resources,

(G) use of the surface by a lessee or permittee of the lands embraced in his lease or permit,

(H) the maintenance by the lessee of an active development program, and

(I) protection of water quality and other environmental qualities.

(d) *Eligibility.* (1) Prospecting permits and leases under this section may be issued only to or held by

(A) persons or associations of persons who are citizens of the United States or who have declared their intention of becoming citizens, or who are citizens of any country, dependency, colony, or province, the laws, customs, and regulations of which permit the grant of similar or like privileges to citizens of the United States;

(B) any corporation or corporations organized and existing under and by virtue of the laws of the United States or of any state, territory or the District of Columbia; or governmental units, including, without limitation, municipalities or boroughs;

(C) any alien person entitled to a prospecting permit or lease by virtue of a treaty between the United States and the nation or county of which the alien person is a citizen or subject.

(2) In every case of joint bidding, the names of all persons, firms, or corporations interested in a particular joint bid shall be specified.

(e) *Land administration.* (1) Administration of this section shall be under the principle of multiple use of public lands and resources, and, insofar as feasible, shall allow coexistence of other permits or leases of the same lands for deposits of other minerals under this chapter, and the existence of permits or leases issued under this section does not preclude other uses of the areas covered by them. However, operations under other permits or leases or other uses may not unreasonably interfere with or endanger operations under a permit or lease issued under this section, nor may operations under permits or leases issued under this section unreasonably interfere with or endanger operations under a permit or lease issued under any other law. This section does not supersede the authority which the head of a state department or agency has with respect to the management, protection, and utilization of the state lands and resources under his jurisdiction. The commissioner may prescribe by regulation those conditions he considers necessary for the protection of other resources.

(2) If the commissioner determines independently or on advice of the director, the state geologist or the United States Geological Survey that the production, use, or conversion of geothermal steam is susceptible of producing a valuable byproduct, including commercially demineralized water for beneficial uses in accordance with applicable state water laws the commissioner shall require substantial beneficial production or use of these byproducts unless, in individual circumstances he modifies or waives this requirement in the interest of conservation of natural resource or for other reasons satisfactory to him. However, the production or use of those byproducts is subject to the rights of the holders of preexisting leases, claims, or permits covering the same land or the same minerals, if any.

(3) For the purpose of properly conserving the natural resources of any geothermal resources areas, or any part of them, the lessees may unite with each other or with others in collectively adopting and operating under a cooperative or unit plan of development or operation of the geothermal resources lands. The commissioner may, with the consent of the holders of leases involved, establish, alter, change, and revoke any drilling and production requirements of these leases, permit apportionment of production, and may make those regulations with reference to these leases, with like consent on the part of the lessees, in connection with the institution and operation of any cooperative or unit plan, as the commissioner considers necessary or proper to secure the proper protection of the interests of the state.

(4) Any person engaged in the production of geothermal resources under a lease issued by the commissioner may commingle geothermal resources from any two or more wells without regard to whether the wells are located on the lands for which the lease was issued or elsewhere. However, the lessee shall install and maintain meters or other measuring devices satisfactory to the commissioner to measure the amount of geothermal resources produced from lands for which leases were issued by the commissioner.

(f) *State land; limitations, exclusions.* Leases or permits for lands withdrawn or acquired in aid of the functions of the Department of Natural Resources may be issued only under those reasonable terms and conditions that the commissioner may prescribe by regulation to insure adequate utilization of the land or its waters for the purposes for which they were withdrawn or acquired. However, leases or permits under this section may not be issued for

(1) lands administered as state parks, recreation or wilderness areas, or

(2) lands in a fish hatchery, wildlife refuge, wildlife range, game range, wildlife management area, waterfowl production area, or for land acquired or reserved for the protection and conservation of fish and wildlife that are threatened with extinction.

(g) *Unknown land; prospecting permits.* (1) Subject to the provisions of (c) of this section, the commissioner shall issue a prospecting permit to the first qualified applicant under this section and those regulations he may prescribe for lands which have not been classified as known geothermal resources areas, upon the payment to the commissioner of not less than $1 an acre for each acre of land included in the permit, in accordance with (k) (1) (C) of this section. An application for a permit shall be denied if, before the issuance of the permit, the land is classified or reclassified as known geothermal resources land under (b) (2) of this section.

(2) A permit gives the permittee the exclusive right for a period of three years to prospect for geothermal resources upon land included within the permit. The commissioner may, in his discretion, extend the primary term of a permit for a period not exceeding two years, except that the combination of the primary term and extension of a permit may not exceed a total of five years. The commissioner may amend or terminate a permit issued by him within the primary term period or within the extension, if any, with the consent of the permittee.

(3) Upon the classification of any of the land included within a permit issued under this section as known geothermal resources land areas, the permittee is entitled to a lease for this land. The classification of this land shall be made in accordance with (b) (2) of this section. The terms of the lease shall include the royalties and other terms contained in (j), (k) and (l) of this section on the effective date of the lease.

(h) *Known areas; leases.* (1) If the land to be leased under this section is within a known geothermal resources area and no prospecting permit on it has been issued, this land shall be leased to the highest responsible qualified bidder under this section and those regulations the commissioner may prescribe for notice to the public of terms and conditions of the sale, conduct of the sale, receipt of bid, and awarding of the lease, and bidding shall be by competitive bid, oral or sealed at the discretion of the commissioner, under regulations he promulgates, and on the basis of a cash bonus, net profit, or other single biddable factor.

(2) In leasing land under this section, the commissioner may prescribe a development program. In prescribing the program, the commissioner shall consider all applicable economic factors, in-

cluding market conditions and the cost of drilling for, producing, processing and utilizing of geothermal resources.

(i) *Conversion of leases and permits.* (1) Notwithstanding any other provisions of this section, at any time within 180 days following August 15, 1971,

(A) with respect to all land which was subject to valid leases or permits issued under §§ 135—180 of this chapter or to existing mining claims located on or before August 15, 1971, the lessees or permittees or claimants or their successors in interest who are qualified to hold geothermal leases may convert their leases or permits or claims to geothermal leases covering the same land;

(B) where there are conflicting claims, leases, or permits embracing the same land, the person who first was issued a lease or permit, or who first recorded the mining claim is entitled to first consideration;

(C) with respect to all land which was, on August 15, 1971, the subject of applications for leases or permits under §§ 135—180 of this chapter, the applicants may convert their applications to applications for geothermal leases having priorities dating from the time of filing of applications under this chapter.

(2) No person may convert mineral leases or permits, or applications for them, or mining claims for more than 10,240 acres.

(3) The conversion of leases, permits, and mining claims and applications for leases and permits shall be accomplished in accordance with regulations promulgated by the commissioner; no right to conversion to a geothermal lease accrues to a person under this section unless the person shows to the reasonable satisfaction of the commissioner that substantial expenditures for the exploration, development, or production of geothermal steam or other resources have been made by the applicant who is seeking conversion, on the land for which a lease is sought or on adjoining, adjacent, or nearby federal or state land.

(4) With respect to land within a known geothermal resources area and which is subject to a right to conversion to a geothermal lease, the land shall be leased by competitive bidding, except that the competitive geothermal lease shall be issued to the person owning the right to conversion to a geothermal lease if he makes payment of an amount equal to the highest bona fide bid for the competitive geothermal lease, plus the rental for the first year, within 30 days after he receives written notice from the commissioner of the amount of the highest bid.

(j) *Acreage.* (1) An application for a prospecting permit or lease may not be made for less than 640 acres nor more than 2,560 acres and shall embrace a reasonably compact area. However, a permit or lease may be issued for a parcel less than 640 acres if that parcel is isolated from or not contiguous with other parcels of land available for permit or lease under this section, or if the land is irregularly subdivided.

(2) Prospecting permits or leases for land beneath lakes and rivers, and below the mean high tide level of tide and submerged land, may be issued for not less than 640 acres nor more than 5,760 acres and shall embrace a reasonably compact area, except that a permit or lease may be issued for a parcel less than 640 acres if the parcel is isolated from or not contiguous with other parcels of land available for permit or lease under this section.

(3) Except as otherwise provided in this section, no person, association or corporation may take, hold, own, or control at one time, whether acquired directly from the commissioner under this section or otherwise, any direct or indirect interest in state geothermal leases exceeding 25,600 acres, including leases acquired under the provisions of (i) of this section.

(4) At any time after 15 years from August 15, 1971 the commissioner, after public hearings, may increase this maximum holding by regulations, not to exceed 51,200 acres.

(5) Subject to the other provisions of this section, the permittee or lessee is entitled to use as much of the surface of the land covered by his geothermal lease or permit as may be found by the commissioner to be reasonably necessary for the exploration, production, utilization, and conservation of geothermal resources. However, any well drilled for the discovery and production of geothermal resources, which is located within 300 feet of an outer boundary of the parcel of land on which the well is situated or within 300 feet of a public road, street or highway dedicated before the commencement of drilling of the well, is a public nuisance. Where several contiguous parcels of land in one or different ownerships are operated as a single geothermal resources lease or operating unit, the term "outer boundary" means the outer boundary line of the land included in the lease or unit. In determining the contiguity of any of these parcels of land, no street, road or alley lying within the lease or unit is considered to interrupt that contiguity.

(k) *Royalties and rentals.* (1) Each permit or lease issued under this section shall provide for

(A) a royalty of not less than 10 per cent nor more than 15 per cent of the gross revenue, exclusive of charges, approved by the commissioner made or incurred with respect to transmission or other services or processes, received from the sale of steam, brines, from which no minerals have been extracted, and associated gases at the point of delivery to the purchaser of them;

(B) a royalty of not less than two per cent nor more than 10 per cent of the gross revenue received from the sale of mineral products or chemical compounds recovered from geothermal fluids in the first marketable form as to each mineral product or chemical compound for the primary term of the lease;

(C) an annual rental payable in advance of not less than $1 an acre or fraction of an acre for each year of a permit or lease.

(2) The royalties specified in this section are subject to renegotiation under (m) of this section based upon recommendations of the director and the renegotiations are not limited by the maximum royalties specified in (1)(A) and (B) of this subsection.

(3) Royalty payments shall be made for all geothermal resources used by the lessee, but which he does not sell. The value of these geothermal resources used, but not sold, shall be determined by the commissioner and set out in the terms of the lease. The commissioner shall consider the cost of exploration and production and the economic value of the resource in terms of its ultimate utilization.

(4) Upon request of the commissioner, other state departments and agencies shall furnish him with any relevant data then in their possession or knowledge concerning or having bearing upon fair and adequate charges to be made for geothermal steam produced or to be produced for conversion to electric power or other purposes. Data given to a department or agency as confidential under law may not be furnished in a way which identifies or tends to identify the business entity whose activities are the subject of the data or the person or persons who furnished the information.

(5) The commissioner independently or upon the advice of the director, may waive, suspend, or reduce the rental or minimum royalty for the land included in any permit or lease, or any portion of it, and waive, suspend, alter or amend the operating requirements contained in the lease or regulations promulgated under this section affecting operations of the lease or permit, in the interests of conservation, and to encourage the greatest ultimate recovery of geothermal resources if he determines that that action is necessary or beneficial to promote development or finds that the permit or lease cannot be successfully operated under the permit or lease terms or under the regulations.

(6) If, after the discovery of geothermal resources in commercial quantities, the total royalties due to the state during any calendar year do not equal or exceed a sum equal to $2 an acre for each acre or fraction of an acre then included in the permit

or lease, the permittee or the lessee shall, within 60 days after the end of the year, pay whatever sum is necessary to equal a minimum royalty of $2 an acre.

(l) *Term of leases.* (1) Leases under this section shall be for a primary term of 10 years. If geothermal resources are produced or utilized in commercial quantities within this term, the lease shall continue for as long as geothermal steam or other byproducts are produced or utilized in commercial quantities, but the continuation may not exceed an additional 40 years.

(2) If, at the end of that 40 years, steam or other geothermal resources are produced or utilized in commercial quantities and the land is not needed for other purposes, the lessee has a preferential right to a renewal of the lease for a second 40-year term in accordance with the terms and conditions as the commissioner considers appropriate; but in any event a lease may not exceed a cumulative total of primary and subsequent terms of 99 years.

(3) A lease for land on which, or for which under an approved cooperative or unit plan of development or operation, actual drilling operations were started before the end of its primary term and are being diligently prosecuted at that time shall be extended for five years and as long thereafter, but not more than 35 years, as geothermal resources are produced or utilized in commercial quantities. If at the end of the extended term, steam or other resources are being produced or utilized in commercial quantities and the land is not needed for other purposes, the lessee has a preferential right to a renewal of the lease for a second term in accordance with this section and those terms and conditions the commissioner considers appropriate.

(4) For purposes of (1) of this subsection, production or utilization of geothermal resources in commercial quantities includes the completion of one or more wells producing or capable of producing geothermal resources in commercial quantities and a bona fide sale of geothermal resources for delivery to or utilization by a facility or facilities not yet installed but scheduled for installation not later than 15 years from the date of commencement of the primary term of the lease.

(5) Leases which have extended by reasons of production, or which have produced geothermal resources and have been determined by the commissioner to be incapable of further commercial production and utilization of geothermal resources may be further extended for a period of not more than five years from the date of that determination but only for as long as one or more valuable byproducts are produced in commercial quantities. If the byproducts are leasable under this chapter and the leasehold is primarily

valuable for the production of these byproducts, the lessee is entitled to convert his geothermal lease to a mineral lease under, and subject to all the terms and conditions of, this chapter upon application at any time before expiration of the lease extension by reason of byproduct production. The lessee is entitled to locate under the mining laws all minerals which are not leasable and which would constitute a byproduct if commercial production or utilization of geothermal resources continued. The lessee in order to acquire the rights granted him by this section shall complete the location of mineral claims within 90 days after the termination of the lease for geothermal resources.

(m) *Readjustment of lease terms.* (1) Except as otherwise provided, the commissioner may readjust the terms and conditions of any lease issued under this section at not less than 10-year intervals beginning 10 years after the date the geothermal resources are produced, as determined by the commissioner. Each lease issued under this section shall provide for that readjustment. The commissioner shall give notice of any proposed readjustment of terms and conditions, and, unless the lessee files with the commissioner objection to the proposed terms or relinquishes the lease within 30 days after receipt of the notice, the lessee conclusively shall be considered to have agreed to those terms and conditions. If the lessee files objections, and no agreement can be reached between the commissioner and the lessee within a period of not less than 60 days, the lease may be terminated by either party.

(2) The commissioner may readjust the rentals and royalties of any geothermal lease issued under this section at not less than 20-year intervals beginning 35 years after the date geothermal resources are produced, as determined by the commissioner. In the event of any readjustment neither the rental nor royalty may be increased by more than 50 per cent over the rental or royalty paid during the preceding period, and in no event may the royalty [illegible] per cent. Each geothermal lease issued under this section shall provide for that readjustment. The commissioner shall give notice of any proposed readjustment of rentals and royalties, and, unless the lessee files with the commissioner objection to the proposed rentals and royalties or relinquishes the lease within 30 days after receipt of the notice, the lessee conclusively shall be considered to have agreed to those terms and conditions. If the lessee files objections, and no agreement can be reached between the commissioner and the lessee within a period of not less than 60 days, the lease may be terminated by either party.

(n) *Rights* [illegible] In case of an application for a permit or lease [illegible] which has been sold by the state, subject to a reservation by the state of the geothermal resources in them by anyone other than the owner of that land, the owner has six months from the date of service of notice on the owner of the application within which to file his application for a permit or lease. The notice shall be served by the applicant together with a copy of the application. If the owner exercises his rights and is a qualified person, his application shall be granted but subject to all the other provisions of this section. If the owner fails to exercise the rights granted by this section, then the owner's rights under it shall immediately cease and terminate and the original applicant shall be permitted to proceed with his application. If the lands subject to classification are classified as within a known geothermal resource area, then, after the commissioner has determined the highest competitive bid on it the owner may within 10 days after notification by the commissioner submit a bid identical to the highest acceptable bid, in which case the commissioner shall issue a lease to the surface landowner. If the surface landowner does not file a bid within that period of time, the commissioner may proceed with the award of the bid to other than the surface landowner.

(o) *Termination of permits or leases.* (1) A permit or lease may be terminated by the commissioner, lessee or permittee only under the provisions of this section, or under the terms of the lease or permit or both. The commissioner shall insert in every permit or lease issued under this section appropriate provisions for its cancellation in accordance with the provisions of this section.

(2) The commissioner reserves the authority to cancel any prospecting permit or lease upon which a commercially valuable deposit of geothermal resources has not been discovered in paying quantities upon failure of the permittee or lessee (after 30 days written notice and demand for performance) to exercise diligence and care in the prosecution of the prospecting or development work in accordance with the terms and conditions of the permit or lease. After discovery of a commercially valuable deposit of geothermal resources on lands subject to any permit or lease issued under this section, the permit or lease may be forfeited and canceled only upon failure of the lessee after 90 days written notice and demand to comply with any of the provisions of the permit or lease or of the regulations applicable to it and in force at the date of the permit or lease. However, in the event of a cancellation the permittee or lessee under any geothermal resource permit or lease may retain under the permit or lease all drilling or producing wells as to which no default exists, together with a parcel of land surrounding each well and the rights-of-way through the land under

permit or lease, that may be reasonably necessary to enable the permittee or lessee to drill and operate the retained well or wells. In the event of the cancellation of a permit or lease the permittee or lessee has a reasonable time within which to remove all property, equipment and facilities owned or used by the permittee or lessee in connection with operations under the permit or lease.

(3) If there is no well on the leased lands capable of producing geothermal resources in commercial quantities, the failure to pay rental on or before the anniversary date terminates the lease by operation of law. However, whenever the commissioner discovers that the rental payment due under a lease is paid timely but the amount of the payment is deficient because of an error or other reason and the deficiency is nominal, as determined by the commissioner under regulations promulgated by him, he shall notify the lessee of the deficiency and the lease shall not automatically terminate unless the lessee fails to pay the deficiency within the period prescribed in the notice. If a lease has been terminated automatically by operation of law under this paragraph for failure to pay rental timely and it is shown to the satisfaction of the commissioner that the failure to pay timely the lease rental was justifiable or not due to a lack of reasonable diligence, he in his judgment may reinstate the lease if

(A) a petition for reinstatement, together with the required rental, is filed with the commissioner, and

(B) no valid lease has been issued affecting any of the lands in the terminated lease before the filing of the petition for reinstatement.

(4) A permit or lease issued under this section may be assigned, transferred, or sublet as provided for by law, or under regulations promulgated by the commissioner.

(5) The holder of a geothermal lease or permit at any time may make and file in the appropriate land office a written relinquishment or quit claim of all rights under the lease or permit or of any legal subdivision of the area covered by the lease or permit. The relinquishment is effective as of the date of its filing. Thereupon the lessee or permittee is released of all obligations accruing under the lease or permit with respect to the land relinquished, but no relinquishment releases the lessee or permittee, or his surety or bond, from liability for breach of any obligation of the lease or permit, other than an obligation to drill, accrued at the date of the relinquishment, or from the continued obligation, in accordance with the applicable lease or permit, terms and regulations.

(A) to make payment of all accrued rentals and royalties,

(B) to place all wells on the relinquished lands in condition for suspension or abandonment, and

(C) to protect or restore substantially the surface and surface resources.

(6) The commissioner, upon application by the lessee or permittee, may authorize the lessee or permittee to suspend operations and production on a producing lease or permit and he may, on his own motion in the interest of conservation suspend operations on any lease or permit but in either case he may extend the lease term for the period of any suspension, and he may waive, suspend, or reduce the rental or royalty required in the lease or permit.

(7) Leases or permits may be terminated by the commissioner for any violation of the regulations or lease or permit terms, or of this section after 30 days notice if the violation is not corrected within the notice period, or in the event the violation is of a nature that it cannot be corrected within the notice period then if the lessee or permittee has not started in good faith within the notice period to correct the violation and thereafter to proceed diligently to correct the violation. The lessee or permittee is entitled to a hearing on the matter of the claimed violation or proposed termination of lease or permit if request for a hearing is made to the commissioner within the 30-day period after notice. The period for correction of violation or commencement to correct the violation of regulations or of lease terms or of this section shall be extended to 30 days after the commissioner's decision after the hearing if the commissioner finds that a violation exists.

(p) *Conservation; prevention of waste and pollution.* (1) All leases or permits under this section are subject to the condition that the lessee or permittee will, in conducting his exploration, development and production operations, use all reasonable precautions to protect the environment and to prevent pollution of the state's waters and waste of geothermal resources developed in the land leased or granted for prospecting under a permit.

(2) With the approval of the commissioner, a permittee or lessee may drill special wells, convert producing wells or reactivate and convert abandoned wells for the sole purpose of reinjecting geothermal resources of their residue.

(3) The owner or operator of a geothermal well on land producing or reasonably presumed to contain geothermal resources shall properly construct the well in accordance with methods approved by the commissioner. The owner or operator shall make every reasonable effort to prevent damage to life, health, property and natural resources, to protect the geothermal resources de-

posits from damage or waste, to shut out detrimental substances from underground strata containing water suitable for irrigation or domestic purposes and from surface water suitable for these purposes, and to prevent the infiltration of detrimental substances into these strata and into surface water.

(4) The commissioner shall require those tests or remedial work of the owner or operator of a geothermal well that in his judgment are necessary to prevent damage to life, health, property, and natural resources, to protect geothermal resources deposits from damage or waste, or to prevent the pollution of the state's waters by the infiltration of detrimental substances into underground or surface water suitable for irrigation or domestic purposes, for the best interests of the neighboring property owners and the public. To this end he may request the assistance of the Department of Environmental Conservation under AS 46.03.

(5) Any act by a lessee or permittee, or by an owner or operator of a geothermal well, that pollutes the state's waters in violation of AS 46.03 shall be punished in accordance with AS 46.03.760.

(6) Subject to (o)(7) of this section, leases or permits may be canceled by the commissioner for any persistent, repeated violations of the water pollution provisions in AS 46.03. On recommendation of the director, the commissioner shall request the district attorney in the judicial district where the alleged violation occurs, or the attorney general, to bring an action to enjoin the acts prohibited by AS 46.03, or to impose the penalties authorized by AS 46.03.760. Nothing in this paragraph precludes the imposition of both injunctive relief, the criminal penalties, and cancellation of the lease or permit, or any combination of these remedies, that the commissioner or the court considers appropriate.

(q) *Definitions.* In this section

(1) "byproduct" means any mineral or minerals (exclusive of oil, hydrocarbon gas, helium or other hydrocarbon substances) which are found in solution or in association with geothermal resources and which have a value of less than 75 per cent of the value of the geothermal resource or are not, because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by themselves;

(2) "commissioner" means the commissioner of the Department of Natural Resources;

(3) "department" means the Department of Natural Resources;

(4) "director" means the director of the division of lands in the Department of Natural Resources;

(5) "division" means the division of lands in the Department of Natural Resources;

(6) "geothermal resources" means the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, the natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases, and steam, in whatever form, found below the surface of the earth, exclusive of oil, hydrocarbon gas, helium or other hydrocarbon substances, but including, specifically:

(A) all products of geothermal processes, embracing indigenous steam, hot water and hot brines;

(B) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations;

(C) heat or other associated energy found in geothermal formations, and

(D) any byproduct derived from them;

(7) "geothermal area" means a surface area which is underlaid, or reasonably appears, to be underlaid by geothermal resources;

(8) "known geothermal resources area" means an area in which the geology, nearby discoveries, competitive interests, or other indicia would, in the opinion of the commissioner, engender a belief in men who are experienced in the subject matter that the prospects for extraction of geothermal resources are good enough to warrant expenditures of money for that purpose;

(9) "lease" means a geothermal lease issued under this section;

(10) "operator" means any person drilling, maintaining, operating, pumping, or in control of any well; "owner" includes "operator" when any well is operated or has been operated or is about to be operated by any person other than the owner; "operator" includes "owner" when any well is or has been or is about to be operated under the direction of the owner;

(11) "permit" means a prospecting permit issued under this section;

(12) "person" includes any individual, firm, association, corporation or any other group or combination acting as a unit;

(13) "well" means any well for the discovery of geothermal resources or any well on land producing geothermal resources or

reasonably presumed to contain geothermal resources, or any special well, converted producing well or reactivated or converted abandoned well employed for reinjecting geothermal resources or their residue.

(r) *Construction.* This section shall operate prospectively and shall be liberally construed to meet its objectives, and the commissioner and director have all the powers necessary to carry out the purposes of this section.

(s) *Short title.* This section may be cited as the Geothermal Resources Act of 1971. (§ 1 ch 71 SLA 1971; am § 6 ch 104 SLA 1971; am §§ 34—36 ch 71 SLA 1972)

Revisor's note (1971).—The numbering, as it appeared in ch. 71, SLA 1971, of certain provisions in this section has been corrected, as follows: (d)(1), (2) and (3) changed to (d)(1)(A), (B) and (C), respectively; (d)(4) changed to ')(2); (i)(1), (2) and (3) changed to (i)(1)(A), (B) and (C), respectively; (i)(4), (5) and (6) changed to (i)(2), (3) and (4), respectively; (k)(1)(D) changed to (k)(C).

Effect of amendment. — The 1972 amendment, in subsection (p)(4), substituted "Department of Environmental Conservation under AS 46.03" for "Department of Health and Social Services under AS 46.05" in the last sentence; in subsection (p)(5), the amendment substituted "AS 46.03" for "AS 46.05" and substituted "AS 46.03.760" for "AS 46.05.210"; and in subsection (p)(6), the amendment substituted "water pollution provisions in AS 46.03" for "water pollution control act (AS 46.05)" at the end of the first sentence, substituted "AS 46.03" for "AS 46.05" in the second sentence, substituted "AS 46.03.760" for "AS 46.05.210" in that sentence, and substituted "considers" for "consider" in the last sentence.

Legislative committee report.—For report on ch. 71, SLA 1972 (HCSSB 383 am H), see 1972 House Journal, p. 898.

Sec. 38.05.182. Royalty on natural resources. Any royalty provided for in §§ 135—181 of this chapter may be taken in kind rather than in money at the discretion of the commissioner if he determines that the taking in kind would be in the best interest of the state. (§ 1 ch 56 SLA 1970; am § 7 ch 71 SLA 1971)

Revisor's note (1970). — In ch. 56, SLA 1970, AS 38.05.182 and 38.05.183 were numbered AS 38.05.362 and 38.05.363, respectively.

Legislative committee report.—For report on ch. 56, SLA 1970 (CSSB 185 am H), see 1969 House Journal, p. 571.

Sec. 38.05.183. Sale of royalty products. (a) The sale of any mineral, including oil and gas, obtained by the state as a royalty under § 182 of this chapter shall be by competitive bid and the sale made to the highest responsible bidder, except that competitive bidding is not required when the commissioner determines that the best interest of the state does not require it or that no competition exists.

(b) The commissioner may reject all bids if he determines that because of the amount of the bids or the lack of responsibility on the part of the bidders, the acceptance of the bids would not be in the best interest of the state.

(c) If the commissioner determines that a sale or other disposal of royalty products is not to be made by competitive bid, he shall make public, in writing, the specific findings and reasons on which his determination is based.

(d) Details of bidding shall be established by regulation by the commissioner. (§ 1 ch 56 SLA 1970)

Legislative committee report.—For report on ch. 56, SLA 1970 (CSSB 185 am H), see 1969 House Journal, p. 571.

Article 7. Mining Rights.

Sec. 38.05.185. Generally. (a) The acquisition and continuance of rights in and to deposits on state lands of minerals which on January 3, 1959, were subject to location under the mining laws of the United States shall be governed by §§ 185—280 of this chapter. Nothing in §§ 185—280 of this chapter affects the law pertaining to the acquisition of rights to mineral deposits owned by any other person or government. The director, with the approval of the commissioner, shall determine those lands from which mineral deposits may be mined only under lease, and, subject to the limitations of § 300 of this chapter, those lands which shall be closed to mining.

(b) The failure on the part of a mining lessee or a locator to comply strictly with §§ 185—280 of this chapter and regulations adopted under it does not invalidate his rights if it appears to the satisfaction of the commissioner that the locator complied as nearly as possible under the circumstances of the case, and that no conflicting rights are asserted by any other person. Unless otherwise provided, the usages and interpretations applicable to