

HB

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NATIONAL CONFERENCE OF STATE LEGISLATURES

ENERGY PROGRAM -- GEOTHERMAL PROJECT PROPOSED TECHNICAL ASSISTANCE PROGRAM FOR ALASKA

Study Areas

- A. Resource Characterization
- B. Resource Access
- C. Resource Allocation
- D. Permitting
- E. Finance
- F. District Heating
- G. Public Utility Commission

Staff Responsibilities

NCSL Energy staff, in conjunction with legislative staff, will identify issues, conduct research, analyze policy concerns, investigate administrative responses and prepare legislative proposals, as needed.

<u>Task</u>	<u>Staff</u>	<u>Status</u>
Project Introduction	NCSL	completed
Issue Identification	Joint	completed
Research & Analysis	NCSL	in progress
Supplemental Field Research	Joint	in progress
Project Milestones		
- Policy Profile	NCSL	completed
- Options & Recommendations	NCSL	11/1/79
- Discussion Bill Drafts	Optional	12/79
- Draft Legislation	Optional	1/80
Review of Proposed Legislation		

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INTRODUCTION

The NCSL Geothermal Project is assisting the Alaska Legislature in a review of geothermal policies. To date project staff have conducted field research on two occasions, as well as participating in a public workshop (9/13/79) co-sponsored by the Joint Special Committee on Renewable Energy Policy. As a result of these activities NCSL proposed a State Technical Assistance Program (see Appendix A) which was ratified by the committee leadership (9/14/79).

This document has been prepared pursuant to the state workplan as background material for a committee meeting (11/8/79) intended to consider the policy recommendations herein. The study areas identified in the state workplan are treated as follows:

I. Proposed Comprehensive Geothermal Resources Act

- includes resource characterization (definition), resource access (leasing), water law, permitting and well regulation, and resource allocation.

II. Financial Package

- includes a review of various tax and other incentives for geothermal producers and users, as well as suggestions regarding a state geothermal fund (this section should be considered in conjunction with the NCSL Small-Scale Hydro Policy Report which contains additional material regarding state financing of energy development).

III. District Heating

- includes a proposal to authorize publicly-owned heating districts, as well as a review of utility regulatory issues.

IV. Miscellaneous

- includes funding for administrative agencies, life-cycle costing, building codes and zoning, amendments to the Water Use Act and environmental procedures.

I. PROPOSED GEOTHERMAL RESOURCES ACT

Synopsis

It is recommended that the existing geothermal statute (38.05.181) be repealed and re-enacted in a simplified form. The NCSL draft geothermal statute is proposed for discussion purposes.

The proposed act would:

- (1) redefine geothermal resources via a temperature threshold (120°C/248°F)
- (2) provide for mineral leasing of geothermal resources on state lands
- (3) establish statewide regulatory authority in the Division of Minerals and Energy Management over geothermal drilling activity
- (4) indicate the applicability of the Water Use Act (46.15) to geothermal development
- (5) provide for simplified access to state lands for low-temperature development
- (6) establish regulatory authority over low-temperature development in the Division of Forest, Land and Water Management

The overall design of the proposed act is to distinguish between the development of high-grade thermal resources by major projects (e.g., electrical generation, industrial process heat) and the development of "hot groundwater" for small-scale direct uses (e.g., space heating, greenhouses, aquaculture). The proposed act would also establish the relationship of geothermal development to existing water uses. Certainty, simplification of procedures and stimulation of development are the objectives.

DISCUSSION DRAFT

TITLE 38. PUBLIC LANDS

Chapter _____. Geothermal Resources Act

Article

1. Declaration of Policy and Definitions
2. Geothermal Leasing and Regulation
3. Low-Temperature Development

ARTICLE 1. DECLARATION OF POLICY AND DEFINITIONS

Sec. 1

A. It is declared to be in the public interest to foster and promote the discovery, development, production, utilization and disposal of geothermal resources in the state of Alaska in such a manner as will prevent waste, provide for maximum economic recovery, protect correlative rights, and safeguard the natural environment and the public welfare.

B. It is declared to be in the public interest to foster and promote, under existing law, the utilization of the thermal energy contained in the groundwaters of the state of Alaska in an efficient and environmentally sound fashion.

Sec. 2

This act shall apply to all lands in the state of Alaska, including federal and Alaskan Native lands to the extent allowed by law. When any of these lands are committed to a unit agreement involving lands subject to federal jurisdiction, the operation of this act or any part of this act may be suspended, provided that the unit operations are regulated by the United States and that the conservation of geothermal resources is accomplished under such unit agreement.

Sec. 3

Administration of this chapter shall be under the principle of multiple use of public lands and, insofar as feasible, shall allow for the coexistence of other permits or leases of the same lands for other purposes. Leases or permits issued for lands withdrawn or acquired in aid of the functions of the Department of Natural Resources shall carry such conditions as will conform the lease operations to the purposes of such lands.

Sec. 4

A survey of the state's geothermal resources shall be performed by the state geologist and included in the complete geological survey of the state authorized by AS 41.07.020. A statement of the progress of the geothermal resources survey shall be contained in the annual report required by that section. A geothermal resources file shall be maintained and made available to the public in the offices of the State Geological and Geophysical Survey (and/or the State Division of Energy and Power Development).

Sec. 5

As used in this act, unless the context requires otherwise:

A. "byproduct" means dissolved or entrained minerals and gases (exclusive of hydrocarbon substances and helium) associated with geothermal resources, and demineralized water;

B. "correlative rights" means the right of each geothermal owner in a geothermal system to produce without waste his just and equitable share of the geothermal resources in the geothermal system;

C. "division" means the Division of Minerals and Energy Management in Article 2 of this chapter and means the Division of Forest, Land and Water Management in Article 3 of this chapter;

D. "geothermal area" means the general land area which is underlain or reasonably appears to be underlain by geothermal resources;

E. "geothermal fluid" means brines, water and steam naturally present in a geothermal system;

F. "geothermal resources" means (1) the natural heat of the earth at temperatures greater than 120 degrees Celsius; (2) the energy in whatever form, present in, resulting from, created by or which may be extracted from that natural heat, including pressure; (3) the material medium containing the energy; and (4) all dissolved or entrained minerals and gases which may be obtained from the material medium, but excluding hydrocarbon substances and helium;

G. "geothermal system" means any strata, pool, reservoir or other geologic formation containing geothermal resources;

H. "material medium" means geothermal fluids or water and other substances artificially introduced into a geothermal system to serve as a heat transfer medium;

I. "operator" means any person drilling, maintaining, operating, producing or in control of any well;

J. "owner" means any person who has the right to drill into, produce and make use of geothermal resources;

K. "person" means any individual, business entity, political subdivision or body politic of this or any other state;

L. "waste" means any inefficient, excessive or improper production, use or dissipation of geothermal resources, including, but not limited to:

(1) drilling, transporting or storage methods that cause or tend to cause unnecessary surface loss of geothermal resources;

(2) locating, spacing, drilling, equipping, operating, producing or venting of any well in such a manner that results or tends to result in reducing the ultimate economic recovery of geothermal resources.

M. "well" means any well drilled, converted or reactivated for the discovery, testing, production or subsurface injection of geothermal resources, or of groundwater valuable for its thermal energy.

ARTICLE 2. GEOTHERMAL LEASING AND REGULATION

Sec. 1

A. The Division of Minerals and Energy Management shall have and is hereby given jurisdiction over all persons and property, public and private, necessary to enforce the provisions of this article, and shall have the power and authority to make and enforce rules, regulations and orders reasonably necessary to carry out the purposes of the act.

B. Any affected person may apply for a hearing before the division, or the division may initiate proceedings upon any questions relating to the administration of this article, and jurisdiction is hereby conferred upon the division to hear and determine the same and enter its rule, regulation or order with respect thereto.

Sec. 2

The state of Alaska shall own all geothermal resources where it has title to the minerals or subsurface estate. Rights to explore for, develop and utilize geothermal resources owned by the state of Alaska may be obtained solely in accordance with the provisions of this article.

Sec. 3

The division may designate geothermal resource areas and declare certain of these, or portions thereof, as a "competitive geothermal resource area," each of which shall contain at least one well capable of producing geothermal resources in commercial quantities.

Sec. 4

A. The division may, under rules and procedures it shall adopt, grant prospecting permits and leases to any qualified person in order to explore for, develop or utilize state-owned geothermal resources.

B. Where title to the surface is held by a person other than the state, such person shall have a preferential right to a prospecting permit or lease for such parcel.

Sec. 5

A. On lands which have not been designated as a geothermal resource area, the division shall issue a prospecting permit to the first qualified applicant.

Such permit shall convey an exclusive right, for a period of two years, to prospect for geothermal resources on lands included within the permit. The division may, at its discretion, renew the permit for an additional one year. The division may revoke a permit should it find that the permittee has failed to diligently prosecute efforts to discover geothermal resources.

B. A holder of an exclusive prospecting permit shall have the right, within the permit term or thirty days thereafter, to convert such permit to a lease. Should the lands included within the permit be declared a "competitive geothermal resource area" during the permit term, the permittee must make application for a lease within thirty days or forfeit his conversion privileges and his exclusive right to prospect.

C. On lands which have been designated a geothermal resource area, prospecting permits may be granted on a non-exclusive basis for a one-year term. Such permits may, at the discretion of the division, be renewed annually. Holders of non-exclusive prospecting permits shall have no right to convert such permits to a lease; however, the division may allow expenditures made under such permits to be credited against lease payments for any lease covering the same lands, which is subsequently issued to the permittee.

Sec. 6

A. On lands which have not been declared a "competitive geothermal resource area," and which are not included under an exclusive prospecting permit, the division may issue a geothermal lease to the first qualified applicant.

B. On lands declared to be within a "competitive geothermal resource area," and which are not included under an exclusive prospecting permit, the division may issue geothermal leases by public auction to the highest qualified bidder. At the discretion of the division, competitive lease sales may be by oral or sealed bid, on the basis of a cash bonus, profit share or other single factor.

Sec. 7

A. The division shall, on all permits and leases, attach such conditions as it shall deem necessary to provide for multiple use of state lands, protect the rights of other persons holding an interest in the same lands, prevent waste and safeguard the natural environment and the public welfare.

B. The division shall require a geothermal permittee or lessee to compensate the owners of prior interests in the same lands for damage to those interests, or to post a sufficient bond pending judicial determination of the matter.

Sec. 8

A. Prospecting permits and leases granted under this article shall normally be issued on parcels at least 40 acres in size, but in no case more than 2560 acres in size.

B. No person shall own, or hold an interest in, geothermal leases covering more than 51,200 acres; except that leases in commercial production, individually or in concert, shall not be counted against this acreage limitation.

C. All prospecting permits and leases shall be subject to an annual rental, payable in advance, of at least one-dollar per acre.

Sec. 9

A. Geothermal leases shall be issued for a primary term of ten years and shall be renewed for an additional term of five years if the lessee is actively engaged in drilling operations. Geothermal leases shall be valid for the duration of commercial production up to a term of 40 years.

B. The division may renegotiate the provisions of a geothermal lease, including rentals and royalties, beginning 15 years after the initiation of commercial production and at 10 year intervals thereafter.

Sec. 10

A. The division shall charge a royalty of at least 10% but not more than 15% on the gross revenues derived from the production, sale or utilization of geothermal resources under a state lease. It shall also charge a royalty of at least 2% but not more than 10% on the net proceeds derived from the production, sale or utilization of byproducts under such lease. In no case shall the combined royalties on a lease be less than two-dollars per acre.

B. The division may, at its discretion and in the public interest, reduce, suspend or waive the royalties otherwise due under a state lease. In such cases, the lessee shall pay a minimum annual rental of three-dollars per acre.

Sec. 11

A. The division shall promulgate a development program on each discernible geothermal system, including well-spacing and pooling orders, limits on production and reinjection requirements, in order to prevent waste, promote maximum economic recovery and protect correlative rights.

B. Lessees on a geothermal system, or part thereof, may enter into a unit agreement for cooperative development, with the approval of the division. The division may suspend or modify its development program in accord with such unit agreement.

C. Should the owners of two-thirds of the leasehold interests in a geothermal system ratify a unit agreement approved by the division, the division may enforce the agreement as to lessees not a party to the agreement by allocating production under the principle of correlative rights and by apportioning costs and revenues.

D. Lease operations under a well-spacing and pooling order or an approved unit agreement shall be deemed to be in compliance with individual lease requirements.

Sec. 12

A. The division shall promulgate regulations covering the siting, spacing, drilling, casing, cementing, testing, logging, operating, producing and abandonment of geothermal wells so as to prevent:

(1) geothermal resources, water or other fluids, and gases from escaping into strata other than that in which they are found (unless in accordance with an approved reinjection program);

(2) pollution of surface and ground water;

(3) premature cooling of any geothermal system by water encroachment or otherwise;

(4) blowouts, cavings and seepage; and

(5) unreasonable disturbance or injury to neighboring properties, prior water rights, human life, health and the natural environment.

B. The division shall cause the operator of any geothermal well or wells to file adequate individual or blanket surety bonds to ensure compliance with its regulations.

C. The division shall have the right to enter upon any property, public or private, to inspect a geothermal operation for compliance with its regulations.

D. Geothermal wells regulated by the division shall be exempt from Oil and Gas Commission jurisdiction under AS 31.05.030(g).

Sec. 13

A. Operators shall, prior to drilling a geothermal well, file a notice of intent with the Chief Officer of the Water Management Section of the Department of Natural Resources. Such notice shall contain sufficient information to enable the Chief Officer to determine whether the operation of such well will interfere with and impair an existing water right.

B. Operators shall not commence the drilling of a geothermal well without the approval of the Chief Officer, who shall grant such consent upon finding that:

(1) the proposed geothermal well operation will not significantly interfere with or substantially impair an existing water right; or

(2) the geothermal owner has acquired through purchase or condemnation adequate water rights to offset the potential interference or impairment; or

(3) the geothermal owner has obtained and dedicated an equivalent amount of replacement water of comparable quality to the affected party or parties.

The Chief Officer shall retain his jurisdiction, including the authority to suspend well operation, in the event of unforeseen interference which occurs subsequent to his approval.

C. The withdrawal of geothermal fluid from a geothermal well and its sale or utilization for primary energy production shall not otherwise be subject to the Water Use Act (AS 46.15). The secondary use of spent geothermal fluids or of demineralized water obtained as a byproduct shall be subject to the provisions of the Water Use Act. However, the geothermal owner shall have a preferential right to appropriate such geothermal fluids or demineralized water, in order to make beneficial use thereof.

ARTICLE 3. LOW-TEMPERATURE DEVELOPMENT

Sec. 1

A. The Division of Forest, Land and Water Management shall have and is hereby given jurisdiction over all persons and property, public and private, necessary to enforce the provisions of this article, and shall have the power and authority to make and enforce rules, regulations and orders reasonably necessary to carry out the purposes of the act.

B. Any affected person may apply for a hearing before the division, or the division may initiate proceedings upon any questions relating to the administration of this article, and jurisdiction is hereby conferred upon the division to hear and determine the same and enter its rule, regulation or order with respect thereto.

Sec. 2

A. It is hereby declared that the beneficial use of groundwater includes the extraction for sale or use of thermal energy contained therein for domestic, commercial, industrial, agricultural, aquacultural or other purposes approved by the division.

B. Priority of appropriation includes the right to preserve thermal aspects of groundwater use from subsequent impairment.

C. The utilization of groundwater for thermal purposes shall be governed by the provisions of the Alaska Water Use Act (AS 46.15) and regulations promulgated thereunder.

Sec. 3

A. The division shall have the authority to issue a special land use lease to any qualified person who applies to use the surface of a state land parcel to construct a facility utilizing groundwater for thermal purposes, or utilizing spent geothermal fluids in a secondary application.

B. Prior to the issuance of such lease, the division shall determine that there is available unappropriated groundwater or spent geothermal fluids sufficient to achieve the purposes of the lease. In the case of groundwater, the appropriation shall be made in the name of the state of Alaska and dedicated to the benefit of the leasehold. Upon termination of the lease, the water right shall revert to the state, unless the division grants an extension of the water right for good cause and in the public interest.

Sec. 4

A. The division shall exercise discretion with regard to the term, renewal and acreage (not to exceed 160 acres in size) of any special land use lease issued under this article. Such conditions shall correspond to the intended use to be made of the state parcel. The division shall attach such other conditions to the lease as to protect the public interest and conform the lease operation to other established uses of such lands.

B. Lease payments to the state of Alaska shall be on the basis of an annual rental, payable in advance, or on the basis of a profit share, such payments to be negotiated between the lease applicant and the division. In no case shall such lease payments total less than three-dollars per acre.

Sec. 5

A. The division shall promulgate such regulations as are necessary to control the drilling of any groundwater wells for thermal purposes so as to prevent:

- (1) groundwater from escaping into strata other than that in which they are found (unless in accordance with an approved reinjection program);
- (2) pollution of surface and ground water;
- (3) impairment of prior water rights by premature cooling, or reduction in quality or quantity; and
- (4) unreasonable disturbance or injury to neighboring properties, human life, health and the natural environment.

B. The division shall have the authority to require any operator of a groundwater well for thermal purposes to file a notice of intent and receive the approval of the division prior to commencing actual drilling. The division may require the maintenance of such records and well logs as it may require and may enter upon any property, public or private, to inspect the operations for compliance with its regulations.

C. If the division finds that an encounter of oil, gas or other hazardous substance is likely to result from well drilling, the provisions of AS 31.05.030(g) shall apply.

ADDENDUM TO THE GEOTHERMAL RESOURCES ACT

Art. 1 § 1 B: (deletion)

It is declared to be in the public interest to foster and promote (under existing law) the utilization of the thermal energy

Art. 1 § 5: additional definition (E): reletter subsequent definitions

"geothermal effluent" means the material medium subsequent to electrical production or other primary energy extraction process;

Art. 1 § 5 F: (deletion)

. . . (3) the material medium (containing the energy); and

Art. 1 § 4 B: additional material

. . . preference right to a prospecting permit or lease for such parcel. Such right must be exercised at the time of the first application for a permit or lease on such lands, or it shall be forfeited.

Art. 1 § 5 A: additional material

. . . designated as a geothermal resource area or withdrawn from entry, the division shall issue

Art. 1 § 7: additional material (B); reletter existing B as C

B. Lease conditions shall include diligence requirements regarding drilling and lease development. Failure to comply with such conditions shall be grounds for termination of the lease, unless they be waived or suspended by the division for good cause shown and in the public interest.

Art. 2 § 10 B: addition and (deletion)

B. The division may, for good cause shown (at its discretion) and in the public interest, reduce, suspend or waive the minimum rentals and royalties otherwise due under a state lease. (In such cases, the lessee shall pay a minimum annual rental of three-dollars per acre.)

Art. 2 § 11 A: addition and (deletion)

. . . promulgate a development program on each producing (discernible) geothermal system

Art. 2 § 11 D: addition and (deletion)

D. Lease operations under an approved development program (a well-spacing and pooling order or an approved) or unit agreement shall be deemed

Art. 2 § 13 B: addition

. . . in the event of unforeseen interference to prior rights which occurs subsequent to his approval.

Art. 2 § 13 C: addition and (deletion)

. . . The secondary use of geothermal effluent (spent geothermal fluids) or of demineralized water . . . preferential right to appropriate such geothermal effluent (geothermal fluids) or demineralized water . . .

Art. 3 § 2 B: delete entire section; reletter C to B

Some degradation of thermal aspects should be allowed, by analogy to allowable changes in the "condition of water occurrence" (AS 46.15.050). Excessive or unreasonable thermal degradation can be prevented via the regulatory authority regarding the prevention of "premature cooling" (Art. 3, § 5 of the proposed act).

Art. 3 § 3 A: addition and (deletion)

. . . or utilizing geothermal effluent (spent geothermal fluids) in a secondary application.

Art. 3 § 3 B: addition and (deletion)

. . . available unappropriated groundwater or geothermal effluent (spent geothermal fluids) sufficient to achieve . . . Upon termination of the lease, (the) such groundwater right shall revert to the state, unless the division grants an extension (of the water right) for good cause shown and in the public interest. Water rights to geothermal effluent shall also be relinquished upon the termination of such lease and shall be available for subsequent appropriation, subject to the preference right of the original geothermal owner.

Art. 3 § 5 B: addition and (deletion)

. . . the maintenance of such records and well logs as it deems necessary (may require) and may enter . . .

II. FINANCIAL PACKAGE

A. Tax Incentives

(1) Relevant tax incentives for geothermal producers relate to the income tax and the property tax. With regard to the income tax, Alaska follows the Internal Revenue Code. Thus, the geothermal tax incentives enacted in the National Energy Act of 1978 will be available to geothermal producers in the state. These include: deductions for intangible drilling costs for development purposes; a declining depletion allowance; and, an additional investment tax credit (not necessarily applicable to state income taxes). The legislature may wish to consider allowing intangible costs for exploration purposes to be deducted and insuring that a state investment tax credit is allowed.

The ad valorem property tax looms as the major disincentive to geothermal development. Front-end capital costs to develop a geothermal lease are quite high -- a single well may cost from half to more than a million dollars. Assessing an ad valorem tax on the value of the resource in place during these early years and before commercial return, may constitute an unbearable financial burden. Alternative approaches include: exemption from property taxation until commercial production begins; deferral of property tax payments until commercial production begins; and, substitution of a well-head yield tax for ad valorem assessment.

(2) Relevant tax incentives for geothermal users also relate to the income and property taxes. Income tax credits for expenditures for equipment to use geothermal resources (or alternate energy sources) can significantly reduce front-end capital costs and reduce payback periods. A federal alternate energy income tax credit is available, but many states have enacted supplemental legislation. Another option is to exempt the added value of a home or business due to installation of geothermal (or alternate energy sources) equipment from property taxation. A bill draft along these lines developed by the Alaska Division of Power and Energy Development, as well as an NCSL bill draft on the subject, is attached (see Appendix B).

B. Funding of Energy Development (see Small-Scale Hydro report)

Many funding avenues are available for consideration by the legislatures; a memorandum from the Legislative Finance Division listing these possibilities is attached (see Appendix C). With regard to geothermal development, three options are particularly attractive:

(1) direct funding (via grants or low-interest loans) for exploration and drilling costs incurred by municipalities. Revenue bonding is inapplicable to discovery and drilling costs due to the inherent risk. Use of general obligation bonds for such purposes is subject to debt limits and political constraints. Direct state funding would constitute an important alternative (see HB 309, Appendix C).

(2) "double barrel" bonding is the pledge of both project revenues and general revenues (full faith and credit) to secure bond issues. Given the risky nature of reliance on "new" energy sources such as geothermal, such authority may enhance the marketability of municipal geothermal bond issues (see HB 241, Appendix C).

(3) state bond guarantees would be another option to enhance the marketability of geothermal bond issues. Using state funds to guarantee bonds rather than to directly fund project construction should allow the available dollars to go farther. In addition, private capital markets would be the primary source of equity, rather than state revenues. Such involvement of the private sector should be encouraged; direct state funding would reduce such participation.

III. DISTRICT HEATING

A. District heating is an attractive and potentially near term application of geothermal resources and hot groundwater. Indeed, even normal gradient groundwater may be effeciently utilized via a water-to-air (groundwater referenced) heat pump. Given the lack of a power transmission grid in Alaska, direct geothermal uses such as district heating may turn out to be the most widespread type of development.

Alaska has expressed a strong constitutional (Art. X, Sec. 5) and statutory (29.63.090(d)) preference against the creation of new political entities to provide services which might be provided by existing ones. Municipalities (boroughs/cities) are already authorized to provide "heat, light, power (and) water" services (29.48.030). This seems adequate to cover district heating services. Borough service areas (29.53.090), public corporations or other municipal instrumentalities (29.59.010) are possible district heating vehicles. Municipal bonding, taxing, property, franchise, regulatory and other powers also are adequate for implementing district heating (see Appendix D).

While the existing authority seems adequate, it may enhance the marketability of municipal bonds to enact a statute declaring that municipal bonds may be issued to finance heating districts using geothermal, waste heat and alternate energy services. Also, such bonds might be accredited as legal investments for banks, trust funds and other institutional investors.

Alaska has a statute regarding Area Redevelopment (41.30) which is administered by the Board of the State Development Corporation. The statute authorizes cooperation with political subdivisions and industry to promote business expansion in redevelopment areas, including loans to aid financing. It is suggested that the legislature direct the Board to consider the organization of heating districts for industrial/commercial parks utilizing geothermal resources in its administration of the redevelopment program.

B. Public Utility Commission policies relating to the certification of new utilities (i.e., heating districts), service rates and reliability of service may have a significant impact on the development of district heating. NCSL will be conducting additional field research on these issues during its November visit to Alaska and may make recommendations on these matters at a later date.

IV. MISCELLANEOUS

A. Agency Funding

Agencies designated to administer the proposed Geothermal Resources Act will require adequate staff and funding levels to implement its provisions. These agencies and their responsibilities under the act include:

- (1) State Geological and Geophysical Survey - conduct a statewide assessment of geothermal resources and maintain files available to the public.
 1. the Division of Energy and Power Development might also be directed to maintain public geothermal files under the proposed statute.
- (2) Division of Energy and Minerals Management - designate geothermal resource areas, issue prospecting permits and leases, conduct lease sales, manage geothermal system development, regulate geothermal wells, promulgate rules and procedures and inspect geothermal operations.
- (3) Division of Forest, Land and Water Management - investigate the impact of geothermal operations on existing water rights, issue leases, grant hot groundwater rights, regulate groundwater wells, promulgate rules and procedures, and inspect thermal groundwater operations.

The legislature may, if the act is adopted, memorialize these agencies with regard to submission of an annual operating budget request sufficient to fund the above activities. Such funding might be derived from general revenues, by earmarking geothermal and special land use lease payments, or a combination thereof.

Boroughs and cities will also be impacted by geothermal development. Such impact may include preparing geothermal zoning elements, revising land use plans, issuing various local permits and providing increased local services. Earmarking of geothermal lease revenues for such purposes is a possible funding option in this regard. A bill has been proposed in the California legislature directing the conveyance of federal geothermal lease payments to impacted counties. The administration is recommending an alternative bill. Copies of these proposals are attached (Appendix E).

B. Life-Cycle Costing

Life-cycle costing is a vital concept for the development of alternate and renewable energy sources. Construction of facilities to generate power from and installation or retrofitting of equipment to use such sources entails large front-end costs. The economic advantage of alternate energy sources vis-a-vis conventional fuels emerges only when costs are compared over the total useful life of a facility or building. That is, alternate energy development is capital intensive with relatively fixed, low fuel costs. Conventional fuel development is often less capital intensive -- due to established infrastructure -- but fuel costs are high and subject to escalation.

Thus, life-cycle costing should be incorporated into economic analyses of state-financed loans or grants for energy development (see the Small-Scale Hydro report on this subject).

Also, construction, expansion or revamping of public buildings should include life-cycle costing of various energy systems. An NCSL bill draft on this subject is attached (see Appendix F).

C. Building Codes and Zoning

Local building codes and zoning ordinances can constitute a severe impediment to the utilization of alternate energy systems. On the other hand, innovative ordinances such as the San Diego County solar hot water requirement and the Portland insulation program can serve as a stimulus to the commercialization of alternate energy. NCSL is building capacity regarding these initiatives and may be able to offer assistance to legislative policy reviews. One option would be the adoption of a Joint Resolution expressing the sense of the legislature with regard to removing local ordinance impediments.

D. Water Use Act

The Office of Water Management is in the process of promulgating regulations (11 AAC 93) to implement the Water Use Act (46.15 AS). Clarification of the ability to condition certificates of appropriation has been identified as a desirable remedial amendment (see the discussion of HB 186 in the Small-Scale Hydro report). With regard to geothermal and hot groundwater three initiatives are worth of examination:

- (1) explicitly authorize the protection of thermal aspects of a water right via priority of appropriation;
- (2) explicitly authorize the Office to appropriate thermal groundwaters in the name of Alaska on state lands and dedicate those water rights to special land use lessees;
- (3) declare geothermal fluids (over 120°C) to be exempt from appropriation and the Water Use Act.

E. Environmental Procedures

Alaska's Environmental Procedures Coordination Act (EPCA) has not been thoroughly implemented (see the Small-Scale Hydro report for further analysis). With regard to geothermal development, the legislature may wish to direct that all the relevant permits be included within the EPCA process. In addition, it might be appropriate to develop a true master permit application for hot groundwater development, whereby only a single form would need to be completed. This is suggested as a method of simplifying the permit process for small-scale developers.

APPENDICES

- A. Alaska Technical Assistance Program/Geothermal
- B. Tax Credit Proposals
- C. Alaska Funding Options
- D. District Heating Article
- E. California Proposals on Earmarking Geothermal Lease Revenues
- F. Life-Cycle Costing Bill

APPENDIX A

Alaska Technical Assistance Program/Geothermal

APPENDIX B

Tax Credit Proposals

ALTERNATIVE ENERGY DEVICE TAX CREDIT

1979

GENERAL SESSION

Discussion Draft

_____ B. No. _____

By _____

AN ACT RELATING TO ALTERNATIVE ENERGY DEVELOPMENT: DEFINING ALTERNATIVE ENERGY DEVICES; PROVIDING AN INCOME TAX CREDIT FOR SUCH DEVICES; ALLOWING A CARRY OVER TO SUCCEEDING TAXABLE YEARS; PROVIDING FOR AMORTIZATION OF ALTERNATIVE ENERGY DEVICES IN COMMERCIAL USE; DESIGNATING THE STATE TAX COMMISSION TO ADMINISTER THIS ACT AND ESTABLISH STANDARDS IN CONJUNCTION WITH THE UTAH DIVISION OF WATER RIGHTS AND THE UTAH ENERGY OFFICE.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF UTAH:

SECTION I. Definition of Terms

As used in this act:

(a) "Alternative energy device" means (1) any system, mechanism or series of mechanisms which uses solar radiation, wind or geothermal resource for space heating, water heating or cooling, or for generation of mechanical or electrical energy for use but not for resale, (2) a system that employs a fluid-to-air heat pump operating on groundwater reservoir or a fluid reservoir heated by solar radiation or geothermal resource, and (3) equipment necessary to utilize and connect to a private or municipal system for purposes of heating and cooling that employs an alternative energy device or heat from an industrial or utility cogeneration system.

(b) "Cogeneration system" means a system which produces electrical energy and steam or forms of useful energy (such as heat) which are used for industrial, commercial, heating or cooling purposes.

(c) "Installation costs" means the costs, as determined according to standards established in the administration of this act, for acquisition, installation, construction, reconstruction or remodeling properly attributable to the use of an alternative energy device.

SECTION II. Residential Tax Credit

(1) Any resident individual taxpayer who completes installation of an alternative energy device for use in such taxpayer's principal dwelling prior to June 30, 1985, or who acquires title to a dwelling prior to June 30, 1985,

which dwelling is to be used as a taxpayer's principal dwelling and is supplied energy from an alternative energy device for which the credit allowed by this section has never been claimed, shall be entitled to claim a tax credit in an amount equal to thirty-five percent (35%) of the installation costs of such system or three thousand dollars (\$3,000), whichever is less, against the income tax liability imposed against the taxpayer pursuant to Title 59 Chapters 14 and 14A of the Utah Code Annotated, 1953. Such tax credit shall be deducted from the taxpayer's income tax liability for the taxable year in which the alternative energy device was completed or acquired and placed in service by the taxpayer.

(2) If the amount of such tax credit exceeds the taxpayer's income tax liability for such taxable year, the amount thereof which exceeds such tax liability may be carried over for deduction from the taxpayer's income tax liability in the next succeeding taxable year or years until the total amount of the tax credit has been deducted from tax liability.

(3) The provisions of this section shall be retroactive to the 1979 taxable year.

SECTION III. Commercial Tax Credit

Any taxpayer who completes installation of an alternative energy device upon real property located within this state prior to June 30, 1985, which real property is either used in a trade or business or held for the production of income, or any taxpayer who acquires title to real property located within this state prior to June 30, 1985, which real property is used in a trade or business or held for the production of income and is equipped with an alternative energy device for which the credit allowed by this section has never been claimed, shall be entitled to claim an income tax credit in an amount equal to thirty-five percent (35%) of the installation costs of such system or six thousand dollars (\$6,000) or an amount equal to the taxpayer's income tax liability in the taxable year for which the credit is claimed, whichever is less, against the tax liability imposed against such taxpayer pursuant to Title 59 Chapters 14 and 14A of the Utah Code Annotated, 1953. Such tax credit shall be deducted from the taxpayer's tax liability for the taxable year in which such system is acquired and placed into service by the taxpayer. This provision shall apply retroactively to include the 1979 taxable year.

SECTION IV. Federal Tax Credit

The federal income tax credit for an alternative energy device as defined in this act shall be subtracted from the state credit prior to obtaining the state credit so that the combined credit, state and federal, would be 35% or \$3,000 for claimants under Section II, and for claimants under Section III, 35% or \$6,000.

SECTION V. Amortization of Alternative Energy Device

(1) Retroactive to the 1979 taxable year, and in addition to the income tax credit allowable, any taxpayer who completes installation of an alternative energy device upon real property located within this state prior to June 30, 1985.

It is the policy of the State of Alaska to reduce the State's dependency on fossil fuels for internal use. It is the policy of the State to utilize these resources to garner income to the State for needed improvements and services.

FOR AN ACT ENTITLED "ALTERNATE ENERGY TAX CREDIT AND POLICY".

- I. Be it enacted by the State of Alaska that a State Corporate or Income tax credit of 75% of the cost of installing an Alternate Energy System in a home or business be granted to the installers.

- A. Alternate Energy System is defined as systems that have the means of energy production utilizing energy sources other than fossil or nuclear fuels.

- B. This would include but not be limited to: Solar, Wind, Biomass, Low head hydroelectric and geothermal energy systems.

If credit exceeds tax liability for year of installation, it can be carried forward to future years until tax credit is used entirely. This Act will remain in effect until 1991.

- II. The State of Alaska authorizes local taxing authorities to exempt property with alternate energy systems from increased assessment due to the system. Exemption extends until the last day of December 1999. This applies to new construction and retrofits.

- III. Energy conservation techniques and passive solar design qualify for the tax credit under the following criteria:

- A. New construction can qualify if it saves more than 10% of the yearly fossil fuel or electrical resistivity consumption of the latest ASHRAE or State of Alaska lighting and thermal standard facility whichever is most energy efficient.

- B. Retrofit homes or business can qualify for the exemption based on a 10% savings of energy consumption for the previous year resulting from passive design or energy conservation measures.

- C. After the last day of December 1982, retrofit homes will qualify only on the portion of passive solar design or energy conservation measures that reduces fossil fuel or electrical resistivity consumption 10% above the latest ASHRAE or State lighting and thermal standards whichever is the most demanding.

- D. Maximum tax credit allowed is \$10,000 combined Federal and State allowances. Federal credits must be taken first before state tax credits will be allowed.

- IV. All new multiunit housing facilities must have individual metering for heating and lighting controls to qualify for this tax credit.

APPENDIX C

Alaska Funding Options



Alaska State Legislature

House

April 3, 1979

JUNEAU ALASKA

MEMORANDUM

TO: The Honorable Ernie Haugen
House Finance Committee

FROM: Milt Barker,¹³ Fiscal Analyst
Legislative Finance Division

SUBJECT: Power Project Financing

Following is a summary of the various funding sources and mechanisms that might be used to finance power projects:

1. General Funds can be appropriated to fund entire projects, front-end costs (reconnaissance and feasibility studies, engineering, etc.), reserves for revenue bonds, or partial project costs. Appropriation of general funds can be designated as coming from the reserve for energy facilities development account which is allocated 5% of mineral rents, royalties, and bonuses, or the reserve for capital outlay account which is allocated 25% of mineral revenues.

If the appropriation is made as a grant, it should probably be viewed as a subsidy. This would allow undertaking of projects that would not otherwise occur, although it is conceivable that a project would be subsidized even if capable of being conventionally financed in order to lower costs to users, say to fight inflation or provide or promote economic development.

If the general funds are appropriated as a loan or to the power project revolving fund or water resources revolving fund to be passed on as a loan which will ultimately be paid back out of project revenues, the appropriation may or may not involve a subsidy depending on the terms of the loan.

The payback of loans from these revolving funds will eventually create another source of funding; however, at present there are essentially no unloaned funds in these revolving funds.

2. Revenue bonds can be sold by the State or the Alaska Power Authority for construction costs. If the State were to combine its full faith and credit with the pledged revenues in a "double-barreled" bond a lower interest rate could be obtained. (See attached materials on RS 241 which proposes this combined revenue-general obligation bond.) Such bonds would need voter approval.

3. Guarantees of revenue bonds have been proposed from permanent fund income in HB 414. Bond underwriters estimate this technique could get interest rates down to within 1/4 to 1/2 of a percentage point of G.O. bonds. The advantage of this proposal is that permanent fund income is the only available source of revenue that can legally be dedicated, thus avoiding the necessity of making a large appropriation to a reserve or guarantee fund to assure the bondholder of monies to be paid in the event of a default.

4. Subsidies of revenue bonds are proposed in CS HB 414 (attached) by setting aside 50% of permanent fund income for guarantees of bonds for which it is estimated that project revenues will not be sufficient to pay debt service.

5. G.O. bonds or double-barrel bonds could be issued for projects that were not capable of paying the debt service. This would be another way of providing subsidies where needed and determined to be appropriate.

6. A loan can be made from the permanent fund principal. However, it will usually be cheaper for the State to issue bonds, at least G.O.'s or guaranteed revenue bonds, at tax-exempt interest rates of say 6% than to appropriate or loan their general and permanent funds which can be invested in taxable securities earning more like 8%.

7. The Alaska renewable resources corporation could fund power projects from their 5% of mineral revenues; however, generally their mandate is to assist innovative projects rather than standard hydroelectric facilities.

NED:pw

Attachments

APPENDIX D

District Heating Article

DISTRICT HEATING:
LEGAL & INSTITUTIONAL PARAMETERS

Kenneth A. Monstolen

National Conference of State Legislatures - Denver, Colorado
Geothermal Policy Project

ABSTRACT

District heating is a proven vehicle for the direct application of geothermal energy. Successful systems currently exist in Iceland, France and the U.S., with numerous others in planning or construction stages. As geothermal resources come on-line, district heating is likely to be a widespread method of utilization. Such systems will provide centralized space-conditioning, as well as "cascaded" uses where feasible. Legal and institutional factors should be examined to ensure an adequate foundation for implementing geothermal district heating.

INTRODUCTION

District heating basically means the centralized distribution of heat to multiple end-users within a particular service area. Cascaded utilization would involve the successive use of progressively cooler fluid (e.g. industrial process heat, space-conditioning, greenhousing, aquaculture). The heat source may be geothermal, solar or fossil fuel. The use of cogenerated or waste heat would be especially appropriate. If alternate energy sources are used, supplemental fossil fuel capacity may be necessary to meet peak demands or emergencies. Various entities, both private and public, may constitute vehicles to develop and operate a heating district. Such a heating district will be presumed to be a utility.

INVESTOR-OWNED UTILITIES

The private sector may organize a heating district by incorporating an investor-owned utility. Some existing utilities may already have a steam distribution system in place. In other states, specific legislative authorization for utilities to provide district heating services may be required. Such authorization should allow the production and transmission of various heat mediums, including geothermal, for public and private use.

In order to incorporate a new investor-owned utility, or expand the scope of an existing one, certification from the Public Service Commission (PSC) will ordinarily be necessary. Such a "certificate of public convenience and necessity" may be difficult to obtain where the

heating district would impinge on an existing heating utility (gas/electric) service area. State legislatures should consider exempting heating districts using alternate fuel sources or waste heat from the certification requirement. Alternatively, they may direct the PSC to grant certification where the public interest would be served, despite competition with an existing utility.

- Investor-owned utilities are under the rate-making jurisdiction of Public Service Commissions, although this may not be clear where heating/cooling services are newly authorized. PSC control of utility rates normally is justified due to the monopoly status accorded a utility in a particular service area. State legislatures may consider, as an incentive to investment, exempting heating districts using alternate or waste heat sources from PSC rate-making jurisdiction.

Thus, legislatures should review at least three aspects of district heating via investor-owned utilities: the authorization to provide district heating services; the requirement of PSC certification; and, the applicability of PSC rate-making jurisdiction.

PUBLICLY-OWNED UTILITIES

Counties, municipalities, special districts and other political subdivisions also are possible vehicles for implementing district heating. However, most political subdivisions possess no inherent powers. Thus, specific enabling legislation often will be necessary to authorize a political subdivision to organize a heating district. In some cases, municipal utility codes or authorizations to provide "water" may be liberally construed to cover district heating services. "Home rule" entities also may be able to implement district heating on their own initiative.

Where new enabling legislation is required, at least two approaches are possible. One is to enact a comprehensive, specific statute such as Oregon's Geothermal Heating Districts Act (ORS Chap. 523, 1977). Such an approach has the advantage of authorizing entities with a specific, single mandate. Alternatively, an existing political subdivision charter may be amended to include district heating, as Idaho has done with

its municipal code (S. 1062, 1979). While the district heating mandate to such entities may be diluted by existing functions, this approach has the advantage of utilizing personnel and infrastructure in place. In addition, where existing bonding and other powers are already adequate, the legislative drafting job is simplified.

Special districts, a species of local government, offer several advantages as district heating vehicles. They may usually cross other political subdivision boundaries and may sometimes include non-contiguous areas, important factors in matching resource and service load centers. Special districts may be able to impose differential taxing coincident with service areas. Their bond issues normally are exempt from constitutional debt limitations applied to cities and counties. And, they are organized and operated to perform a narrow range of similar functions.

Whatever political subdivision is chosen as a district heating vehicle, certain basic parameters need to be established. These relate to the method of heating district formation, the nature of its boundaries, its purposes and its powers, especially financial.

Formation of a heating district will normally involve resolutions of the governing bodies of participating political subdivisions or, perhaps, a local citizen initiative. A referendum on the matter may be required, especially where the district would have property taxation (ad valorem/special assessment) power. State legislative and/or Public Service Commission approval also may be necessary, although this is less common.

A heating district should have flexibility with regard to its boundaries. The crossing of municipal and county lines, and the inclusion of non-contiguous areas, may be necessary to match the heat source with load centers. Annexation capability would be a useful adjunct. The district also may require extra-territorial jurisdiction over sources of supply and facilities.

The purposes of a heating district will generally be to produce, distribute, utilize, sell and dispose of geothermal resources and other heat mediums for domestic, commercial and industrial use. The authority should be broad enough to include geothermal and cogenerated or waste heat sources, as well as the use of fossil fuels for peaking or emergencies such as well shut-downs. While centralized space-conditioning may often be the primary function, integrated development of cascaded uses should be within the purview of the district.

Since political subdivisions are inherently not risk-taking entities, the exploration function may require an innovative approach. Exploration may be an appropriate function for the district

where the geothermal resource is demonstrated or where outside (state/federal) capital is available. Otherwise, joint enterprise ability - joint power authorities (with other political subdivisions) and joint ventures (with private industry) - may be necessary to obtain financing. Alternatively, franchises may be granted to private companies to explore for and produce the resource under a contract of sale. Exemption of such production from PSC rate-making jurisdiction would be an appropriate incentive to attract private risk capital. Publicly-owned utilities already are exempt from PSC jurisdiction in most states.

A geothermal heating utility will require the range of powers of a body corporate and politic: legal status to sue and be sued; ability to contract for services and employ personnel; ability to acquire and dispose of property (within and without the district); ability to fix rates for service; ability to apportion user charges and enforce collection (usually v's liens); and, the ability to generate capital.

The most likely avenue for capital financing of a geothermal heating district will be revenue bond issues. Service charges would be designed, and may be statutorily required, to retire revenue bond principal and interest, as well as covering operating expenses. However, the ability to levy special assessments may be a necessary concomitant in order to cover revenue shortfalls. Revenue bond issues are not subject to constitutional debt limits and usually need not be approved in an election.

Where the district has ad valorem taxation power, it may be authorized to issue general obligation bonds. Such bonds also may be retired by project revenues but are supported by the full faith and credit (taxes) of the issuing district. General obligation bonds will usually be subject to debt limits if the issuing authority is a municipality or county. Debt limits for special districts are less common, and if applicable, special district debts are generally not cumulative with other local political subdivision debt. General obligation bond issues may need to be approved in an election.

Whatever the bond option chosen, marketability is subject to legislative initiative. State legislatures should consider declaring heating district bonds a legal investment for all banks, trust funds, school funds and other institutional investors. Such accreditation would expand the capital market for the bonds.

A final consideration regarding the powers of heating districts is the grant of easements and eminent domain. Easements along, across or under public byways and existing transmission corridors would assist the district in forming its distribution network. The power to condemn easements on certain private property also may be necessary to complete the system. Consideration may be given to extending the eminent

domain power to existing geothermal wells and sources of supply, although such a proposal is likely to be controversial.

The problem of condemning existing wells or their forced incorporation into a heating district may be unavoidable where single or multi-family wells are already in use. Geothermal production for a heating district may result in reservoir drawdowns, rendering such wells useless. District monetary liability for such events, as opposed to the issuance of an injunction restraining operations, would result, as a practical matter, in condemnation. A possible method to minimize such liability would be the designation of system-wide economic drilling levels, above which no liability would accrue to the district.

Thus, legislative agenda for public district heating is manifest. The charters of existing political subdivisions should be examined to identify suitable candidates and amended as necessary. Alternatively, a comprehensive, new district heating statute may be enacted. Formation, boundaries, purposes and powers are the parameters which need to be established for public heating districts.

CONCLUSION

While this paper has focused on the specific legal and institutional parameters of geothermal district heating, there are additional factors subject to legislative initiative which will generally affect the pace of implementing such systems. These include: public funding for demonstration projects; geoheating public buildings; innovative and compatible building codes and zoning ordinances; public education and technical assistance; loan programs and tax incentives for alternate energy systems; royalties and taxes on resource production; streamlined regulatory and leasing procedures; and, resolution of ownership and water rights issues. While beyond the scope of this paper, the NCSL geothermal project is prepared to assist states to deal with these policy areas.

APPENDIX E

California Proposals on Earmarking Geothermal Lease Revenues

State-mandated local program: no.

The people of the State of California do enact as follows:

1 SECTION 1. Chapter 6 (commencing with Section
2 3790) is added to Division 3 of the Public Resources Code,
3 to read:

4
5 CHAPTER 6. GEOTHERMAL REVENUES
6

7 3790. All moneys received by the state from the
8 federal government for sales, bonuses, royalties, and
9 rentals of public lands within the State of California
10 under the federal Geothermal Steam Act of 1970, as
11 amended (Chapter 23 (commencing with Section 1001)
12 of Title 30 of the United States Code) shall be deposited
13 in the State Treasury and allocated by the Department of
14 Finance to the counties socially or economically
15 impacted by the federal geothermal leases generating
16 such revenues. The revenues allocated to counties under
17 this section shall be for the purpose of planning,
18 construction and maintenance of public facilities, and
19 provision of public services.

20 SEC. 2. This act is an urgency statute necessary for
21 the immediate preservation of the public peace, health,
22 or safety within the meaning of Article IV of the
23 Constitution and shall go into immediate effect. The facts
24 constituting such necessity are:

25 Moneys will be received from the federal government
26 in July from geothermal revenues and it is essential that
27 act be effective at that time.

FACT SHEET

COMPARISON OF THE GEOTHERMAL RESOURCES DEVELOPMENT FUND (GRDF) AND THE BOSCO BILL (AB1905)

- o Both bills establish procedures for dispersing the revenues returned to the State as a result of base scales on federal land pursuant to the Federal Land Policy and Management Act (FLPMA). Under FLPMA, half the revenue from bonus bids on geothermal leases, as well as from rentals and production royalties are returned to the State. The State is directed to place priority on using the funds to offset the impacts of geothermal development.

AB 1905

- o All of the funds returned to the State go directly to the county where the lease sale is held (county of origin)

GRDF

- o 60% of the funds go to the county of origin. 25% is available to assist other counties with known or potential resources plan for such development 15% is available to supplement State agency programs which will promote environmentally sound and expeditious geothermal development.

- o No such provision
- o Specifies that funds would be available to local governments and State agencies to provide public services necessary to support geothermal activities.
- o No such provision
- o Would make funds available to local governments and State agencies to install geothermal district heating systems and demonstrate other direct heat and electrical applications.
- o No such provision
- o Provides for an interagency counsel with local and public membership to determine projects which merit funding support.
- o No such provision
- o Requires biennial reporting of expenditures and accomplishments made as a result of projects undertaken.
- o No such provision
- o Requires reevaluation of program at the end of 10 years.

o Allows counties of origin
to spend funds on anything.

o Funds would go only to counties
where a federal lease sale has
occured. There are at least 17
counties in California with
geothermal resources on federal,
state or private lands. At least
4 of these counties will not have a
federal lease sale, although there
will be development occurring on
State and private lands. They
would receive no funds under this
bill to plan for geothermal
development.

o Counties of origin will not be able
to receive funds until 6 to 12 months
after the lease sale has occured.
This would make it difficult, if not
impossible, to carry out advance
planning prior to development
pressures already occurring.

o Requires that funds only
be expended on geothermal
related activities.

o Funds would be available
to all counties where it is
needed to plan for geothermal
development and not just
counties with federal lands
or lease sales.

o Funds would be available for
all counties, well ahead of
lease sales and development
pressures.

o Specifies that funds would
be available to local and
State agencies to permit,
monitor and inspect geothermal
activities.

APPENDIX F

Life-Cycle Costing Bill

LEGISLATIVE INTENT

It is the intent of the Legislature to encourage alternative energy development in the State. Further, the Legislature recognizes that California has substantial geothermal energy potential. Geothermal resources offer excellent energy sources which are advantageous in that: (1) they are indigenous to California; (2) their development provides a stimulus to the State's economy; (3) the environmental impacts of geothermal direct heat may be more acceptable than those associated with traditional electrical generation, and mitigation of such impacts is better understood than those associated with traditional electric generation technologies; (4) their development reduces dependence on other fossil fuel sources; (5) geothermal power plants are small scale distributed technologies which can increase system reliability and flexibility; and (6) the lead time for electric power plant construction is relatively short. Based on the opportunities afforded by geothermal development, it is the intent of the Legislature to promote environmentally sound geothermal resources development.

POLICY

It is the policy of the Legislature to encourage environmentally sound geothermal resources development. It is further the policy of the Legislature to reduce the State's dependency on scarce fossil fuels. Therefore, in order to ensure that geothermal development occurs in an orderly and sound fashion, the Legislature hereby declares that all revenues derived from the U. S. Bureau of Land Management's activities under the Geothermal Steam Act of 1970 and distributed through Section 317 of the Federal Land Policy and Management Act (FLPMA), PL 94-579, be appropriated in the following ways:

GENERAL PURPOSES

All monies returned to the State pursuant to Section 317 of FLPMA shall be used to promote geothermal resources development related activities including, but not limited to:

- (1) Carrying out necessary planning activities to ensure orderly, environmentally sound geothermal development in as expeditious a manner as possible, including, but not limited to:

- (A) resource assessment and exploration technology
 - (B) local and regional planning and policy development and implementation for complying with State and federally mandated programs
 - (C) identification and incorporation of feasible mitigation measures necessary to offset adverse impacts to the State's natural resources including the necessary collection of baseline data and monitoring
 - (D) preparing geothermal elements to county general plan, zoning and other ordinance and accompanying environmental and planning documents.
- (2) Providing the necessary public services required to implement, mitigate and enhance geothermal resources development, including, but not limited to:
- (A) processing requests and preparing permit applications related environmental documents, monitoring and inspection of geothermal activities to insure compliance with local, regional and State laws, regulations, ordinances and other geothermal related activities: identifying and carrying out actions necessary to mitigate impacts as well as participating in research and development activities
 - (B) planning, construction, operations and maintenance of necessary public services.
- (3) Projects demonstrating the technical feasibility and economics of geothermal direct heat and electrical applications.
- (4) Other projects that can be shown to promote development consistent with the policies of this Act.

SPECIFIC PROVISIONS

Public Services means those services which local jurisdictions must provide as a result of geothermal development activities.

Local Jurisdictions means legal subdivisions of the State, including cities, counties, and special districts.

County of Origin means any county in which the Bureau of Land Management lease sale occurred.

Geothermal Resources Development Account means the account established in the State Controller's Office which shall consist of all monies returned to the State by the U. S. Treasury pursuant to Section 317 of the Federal Land Policy and Management Act.

Geothermal Resources Development Fund means those funds which are earmarked for disbursement by the Council and which shall consist of 40 percent of the Geothermal Resources Development Account.

Potential or Known Geothermal Resources means those areas of the State in which there is an identified geothermal resource either as: a) known geothermal resource area (KGRA) as designated by the U. S. Geological Survey; b) geothermal resource areas as designated by the Division of Oil and Gas; or, c) areas with surface manifestations and other indications of the presence of a geothermal resource.

The Geothermal Resources Development Fund and the Geothermal Resources Development Account are hereby created. All monies in the Account shall be expended for the purposes stated in the Act.

There is in the Department of Finance an advisory body known as the Geothermal Coordinating Council, hereafter known as the Council which shall establish guidelines for the administration of monies in the Geothermal Resources Development Fund.

The Council shall have the authority to determine which local jurisdictions have potential or known geothermal resources for the prescribed purposes of this Act.

The Council shall coordinate with the California Energy Commission's statewide planning policy and research and development efforts, as well as other affected State agencies' geothermal planning and program activities, for the promotion or regulation of geothermal energy resources in establishing its guidelines for the administration of the Geothermal Resources Development Fund.

ASSEMBLY BILL

No. 1905

Introduced by Assemblyman Bosco
(Principal coauthor: Senator Keene)

May 21, 1979

REFERRED TO COMMITTEE ON RESOURCES, LAND USE, AND ENERGY

An act to add Chapter 6 (commencing with Section 3790) to Division 3 of the Public Resources Code, relating to geothermal revenues, and declaring the urgency thereof, to take effect immediately.

LEGISLATIVE COUNSEL'S DIGEST

AB 1905, as introduced, Bosco (Res., L.U., & E.). Geothermal resources: federal lease sales: disposition of revenues.

Existing state law does not provide for the distribution of moneys received by the state from federal geothermal lease sales of public lands. Existing federal law provides for 30 percent of the moneys received for geothermal leases under the federal Geothermal Steam Act of 1970, as amended, to be paid to the state where the leased lands are located.

This bill would provide that all moneys received by the state from the federal government for federal geothermal leases within California be deposited in the State Treasury and allocated by the Department of Finance to the counties socially or economically impacted by the federal geothermal leases generating the revenues.

This bill would take effect immediately as an urgency statute.

Vote: $\frac{2}{3}$. Appropriation: no. Fiscal committee: yes.

ALTERNATIVE ENERGY SYSTEMS FEASIBILITY STUDY ACT

1979

GENERAL SESSION

Discussion Draft

_____ B. No. _____

By _____

AN ACT RELATING TO THE PREPARATION OF FEASIBILITY STUDIES ON ALTERNATIVE ENERGY SYSTEMS FOR NEW OR RENOVATED PUBLIC BUILDINGS.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF UTAH:

SECTION 1. A new clause (c) is added to Section 63-9-49 (2) (UCA 1953) to read:

(c) (new material) Prepare an alternative energy systems feasibility study prior to the commencement of siting, construction or major renovation of buildings owned by the State of Utah and its political subdivisions. This provision applies to buildings having more than 20,000 square feet of usable floor space. The study shall employ life cycle cost analysis and include simulations of system performance over a year's operating period. At least ~~two~~ non-fossil energy systems shall be evaluated, including the utilization of geothermal or hot water resources where available. The study shall guide the selection of building site, design and energy systems.

which real property is either used in a trade or business or held for the production of income, may elect to amortize the adjusted basis of the alternative energy device based upon a period of sixty (60) months. In computing Utah taxable income, such amortization shall be allowed as a deduction from Utah adjusted gross income ratably over such sixty-month period beginning with the month in which such alternative energy device was completed or acquired and placed into service by the taxpayer. The election of the taxpayer to claim the amortization deduction allowed by this section shall be indicated in an appropriate statement attached to the taxpayer's income tax return for the taxable year in which such alternative energy device was completed or acquired and placed into service. As used in this section, "adjusted basis of the alternative energy device" shall mean an amount that is properly attributable to the construction, reconstruction, remodeling, installation or acquisition of such system.

(2) In any case where a taxpayer, hereinafter referred to as transferor, has qualified and elected to amortize the adjusted basis of an alternative energy device pursuant to subsection (1) and the real property equipped with such system is acquired and used in a trade or business or held for the production of income by another taxpayer, hereinafter referred to as transferee, and the transferor has not fully amortized the adjusted basis of such system as provided in subsection (1), the transferee shall be entitled to amortize that portion of the transferor's adjusted basis of such system remaining unamortized, but the total amount to be amortized by the transferee shall not exceed said transferee's adjusted basis in the system. The transferee shall amortize such remaining amount based upon the remaining portion of the sixty-month period unused by the transferor. The amount by which the transferee's adjusted basis exceeds the amount of the transferor's adjusted basis remaining unamortized shall be amortized over the useful life of the system.

SECTION VI. Administration

The Utah State Tax Commission in conjunction with the Utah Division of Water Rights and the Utah Energy Office is hereby authorized to administer this act and shall prescribe such rules, regulations and standards as may be deemed necessary to carry out the purposes of this act.

Alaska House of Representatives



COMMITTEE ON NATURAL RESOURCES

POUCH V • JUNEAU, ALASKA 99811

MEMORANDUM

TO: House Legislators

FROM: Bill Miles *Bm*

RE: CS for Sponsor Substitute for House Bill 779

DATE: April 15, 1980

Attached is a Sectional Analysis for CS for Sponsor Substitute for House Bill 779 - an act relating to State resources and the development of geothermal resources. The bill is tentatively scheduled for floor consideration Wednesday, April 16.

CO-CHAIRMEN

REP. ALVIN EYENBACH (465-3715) • REP. BILL MILES (465-3770)

VICE-CHAIRMAN

REP. FRED ZHAROFF

REP. PAT CARNEY • REP. C.V. CHAT CHATTERTON • REP. SAM COTTEN
REP. DICK ELIASON • REP. JACK FULLER • REP. RICK HALFORD

**SECTIONAL ANALYSIS FOR COMMITTEE SUBSTITUTE FOR SPONSOR SUBSTITUTE FOR
HOUSE BILL 779**

Section 1 - Declaration of Policy

**Section 2 - Technical amendment; adds geothermal resources to mineral
and surface use reservation clause**

**Section 3 - Technical amendment; geothermal resource users must
make provision to pay surface owners for all damages sustained by the
owner relating to the development of the resource.**

Section 4 - Permits and Leases:

A. Commissioner is authorized to grant prospecting permits and leases to qualified persons. When the surface title is held by someone other than the State, he has the preference right to a permit or lease for the area underlying the surface parcel.

B. Competitive geothermal areas may be designated by the Commissioner on the basis of "substantial geologic indications" or "competitive interest".

C. Commissioner may issue prospecting permits to the first qualified applicant in areas not designated for competitive sale or withdrawn from geothermal prospecting. Permits are for two years, and may be renewed for an additional one year term. If the permit holder discovers commercial quantities of geothermal resources, he has the right to convert the permit to a lease within 30 days after the expiration of the permit.

D. Competitive leases must be issued to the highest bidder on State land designated competitive and not subject to a prospecting permit. Competitive sales may be by oral or seal bid on the basis of a cash bonus, profit share, or royalty share.

E. Prospecting permits and leases must include at least 40 acres but not be more than 2,560 acres. No person may hold more than a total of 51,200 acres. Geothermal leases in commercial production do not count against the acreage limitations. Permits and leases are subject to a \$3.00 per acre per year rental. Rentals are credited against royalties for the same year.

F. Geothermal leases are issued for a primary term of 10 years and may be renewed for an additional term of 5 years if the lessee is actively drilling. Leases are good for the duration of commercial production. Royalties and rentals may be renegotiated by the Commissioner 20 years after the initiation of commercial production and at 10 year intervals thereafter.

G. Royalties are no less than 10% and no more than 15% of gross revenues. They may be taken in kind or in value.

Section 5 - Definition:

"Geothermal resources" - Over 120 degrees celsius.

Section 6 - Geothermal resource development. This section, which gives the Commissioner jurisdiction over all persons and property subject to the police power of the State, authorizes the regulation of the geothermal resource. It prohibits waste, requires development and operation plans and authorizes the Commissioner to issue well spacing and pooling orders, limits on production and reinjection requirements in order to "prevent waste, promote maximum economic recovery, and protect correlative rights". Lessees are authorized to enter into unit agreements, with the approval of the Commissioner. If more than two-thirds of the leasehold interests ratify a unit agreement, the Commissioner may enforce the agreement as to all parties. Production under these agreements is allocated under principle of correlative rights; costs and revenues apportioned among the participants. The Commissioner must also adopt drilling regulations with respect to the development and abandonment of geothermal wells. Geothermal resources which are regulated by the Commissioner under this chapter are exempt from the jurisdiction of the Alaska Oil and Gas Conservation Commission.

Operators need approval before beginning drilling operations. The date of filing the application for approval establishes a priority as to later appropriators of non-geothermal fluids. Approval may be conditioned to protect prior water rights. However, geothermal fluid is not subject to appropriation of Water Use Act, and no priority may be established among geothermal owners in a geothermal system.

Section 7 - Requires the state geologist to conduct surveys to determine geothermal resource potential.

Section 8 - Appropriation permits required under the Water Use Act may be terminated under the Administrative Procedures Act if the permittee has violated a term of the permit.

Section IX - Appropriation certificates may contain conditions including conditions that are necessary to protect the prior rights of other persons and the public interest.

Section X and XI - Geothermal resources are not water, for purposes of the constitutional requirement that water is subject to appropriation. The Constitution exempts "mineral and medicinal water" from this requirement. Geothermal resources are "mineral and medicinal waters".

STATE OF ALASKA

JAY S. HAMMOND, GOVERNOR

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF RESEARCH & DEVELOPMENT

323 E. 4TH AVENUE
ANCHORAGE, ALASKA 99501
279-5577

March 21, 1980

Representative Bill Miles
Co-chairman
House Resources Committee
Alaska State Legislature
Pouch V
Juneau, AK 99811

Dear Representative Miles:

SSHB 779, the proposed legislation relating to the development of geothermal resources, contains a subsection in its drilling regulations section (Sec. 41.06.040, page 7, line 27) that says:

(d) Geothermal wells regulated by the commissioner under this chapter are exempt from the jurisdiction of the Alaska Oil and Gas Conservation Commission under AS 31.05.030(g).

This subsection was included at the request of the AOGCC in order to clarify that the commission would not be responsible for geothermal resources under the "hazardous substance" clause in Sec. 31.05.030(g) (attached). It has been brought to my attention that the proposed Sec. 41.06.040(d) does not accomplish this purpose and creates some confusion as to when AOGCC regulations do apply.

Sec. 31.05.030(g) provides that the AOGCC may designate areas where there is likelihood of an unexpected encounter of oil, gas or other hazardous substance, and specify drilling depths in those areas below which any well or boring would be subject to AOGCC regulations.

According to the definition in proposed Sec. 41.06.060(9) of SSHB 779, geothermal well "means a well drilled converted or reactivated for the discovery, testing, production or subsurface injection of geothermal resources." Thus, exempting "geothermal wells" from AS 31.05.030(g) does not release the AOGCC from responsibility if a person drilling for some other purpose unexpectedly encounters geothermal resources or hot water under pressure.

Furthermore, by exempting "geothermal wells" from the jurisdiction of AS 31.05.030(g), we are in essence saying that if a geothermal operator drills in an area of the state designated by the AOGCC as an area where there is likelihood of an unexpected encounter of oil, gas, or other hazardous substance, the geothermal operator would not be subject to AOGCC regulations and requirements, even when drilling below the depth

specified by AOGCC. Consequently, if the geothermal operator drilling in a designated area does encounter oil, gas or a hazardous substance other than geothermal resources below the specified depth, it is not clear whether or not his operation is subject to AOGCC regulations. Common sense dictates that it should be. However, the specific exemption of "geothermal wells" from AS 31.05.030(g) indicates that it may not be.

The Department of Natural Resources has drafted a new proposal to replace subsection (d) of proposed Sec. 41.06.040 in SSHB 779 that we feel will accomplish the purpose for which it was intended and avoid confusion in determining when AOGCC regulations apply. The attached DNR proposal establishes a mechanism whereby persons drilling for purposes unrelated to geothermal resources who unexpectedly encounter geothermal resources or hot water under pressure will be regulated by geothermal well drilling regulations under 41.06.040--not AOGCC regulations. It also specifically exempts geothermal resources and hot water under pressure from the term "hazardous substance" as used in AS 31.05.030(g).

The Department feels that this proposal could be further improved by deleting the last sentence that clarifies the term "hazardous substance" and actually amending AS 31.05 to define that term. DNR has offered assistance to the AOGCC if it wishes to submit such an amendment to be included in SSHB 779.

Sincerely,



Amos C. Mathews
Director

Attachments

DNR proposed replacement for Sec. 41.06.040(d) in SSHB 779 (page 7, line 27):

(d) Whenever a person engaged in a drilling operation not otherwise subject to this chapter encounters geothermal resources or water hot enough or under such pressure as to be hazardous, he shall be subject to regulations and requirements adopted under this chapter. When the commissioner finds sufficient likelihood that drilling in an area of the state will result in such an unexpected encounter, he may designate the area and specify conditions under which wells or any borings into the soil not otherwise subject to this chapter are subject to regulations and requirements adopted under this chapter. Neither geothermal resources nor water hot enough or under such pressure as to be hazardous shall be considered a "hazardous substance" for the purposes of AS 31.05.030(g).

STATE OF ALASKA

JAY S. HAMMOND, GOVERNOR

DEPARTMENT OF NATURAL RESOURCES

OFFICE OF THE COMMISSIONER

POUCH M - JUNEAU 99811

March 13, 1980

Representative Bill Miles, Co-Chairman
House Resources Committee
Alaska State Legislature
Pouch V
Juneau, Alaska 99811

Dear Representative Miles:

The Department of Natural Resources appreciates this opportunity to comment on SSHB 779, "An Act relating to the development of geothermal resources." The Department has worked closely with the National Conference of State Legislatures (NCSL) during the drafting of this bill. We believe this bill is a tremendous improvement over the lengthy and outdated Geothermal Resources Act (AS 36.05.181) now on the books, and we strongly support the bill's intended purpose of encouraging the beneficial use of thermal resources in Alaska, especially direct applications of hot-water resources.

The Department feels that SSHB 779 effectively consolidates the essential aspects of our Geothermal Resources Act and appropriately deletes nonessential items to produce a shorter, more concise bill that will ease administration of and remove obstacles to development of thermal resources.

We are in favor of the bill's separation of functions and authorities affecting only state-owned lands and resources from statewide police powers, by retaining the former in Title 38 and placing the latter in Title 41. This is consistent with the approach of other state statutes and helps clarify the applicability of the proposed legislation.

The Department is particularly supportive of the bill's provision to define "geothermal resources" based on a temperature threshold (120°C.). This will allow for simplified procedures for obtaining rights to the use of hot-water resources (below 120°C.) by requiring nothing more than an ordinary water appropriation as opposed to the much more stringent leasing requirements. Consequently, it provides an incentive for the small scale development and local use of thermal energy, thus decreasing dependency on more expensive, nonrenewable energy resources.

We also support the submission of the Water Use Act "house-keeping" amendment, HB 186, as a companion bill to this legislation. Attached is DNR's recommended substitute bill for HB 186. Since HB 186 was introduced in the first session, the Revisor of Statutes has made several of renumbering and punctuation changes proposed in HB 186. The attached substitute deletes those sections of HB 186 that are now irrelevant for housekeeping purposes and contains minor modifications to make it more compatible with SSHB 779.

DNR's recommended substitute for HB 186 contains several provisions that are significant to SSHB 779 and that will prevent conflicts between geothermal development and water rights. Sec. 46.15.120 would clarify the State's ability to place conditions on certificates of appropriation in order to protect the correlative rights of geothermal owners in a geothermal system. Sec. 46.15.115 would clarify the grounds for termination of a permit as provided in AS 46.15.100. This would emphasize the State's ability to enforce safety and resource conservation aspects of drilling hot-water resources (below 120°C.) acquired under the Water Use Act.

The recommended HB 186 substitute would also include a definition of the phrase "mineral and medicinal water" which appears in both the constitution and the Water Use Act. "mineral and medicinal water" would be defined to include springs reserved by the federal government as was the intent of the framers of the Constitution, and also to include "geothermal fluids." In the Water Use Act, "water means all water of the state, surface and subsurface, occurring in a natural state except mineral and medicinal water." Therefore, the definition of "mineral and medicinal water" in HB 186 would exempt geothermal fluids from the definition of water in, and thus management and appropriation under the Water Use Act.

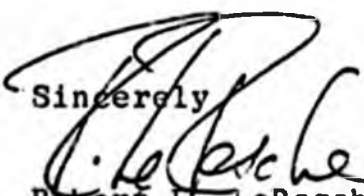
✓ This provision is absolutely essential to SSHB 779. If geothermal fluid were not exempted from the definition of "water", SSHB 779 would create severe legal conflicts with the Water Use Act that would diminish or prevent the beneficial effects it was meant to encourage.

In analyzing SSHB 779, the Department has identified potential conflicts between the management of geothermal resources and water. We feel that SSHB 779 goes a long way to preventing these conflicts. However, there are some questions that have not been totally resolved. Due to the complexity of this issue, it is likely that some questions may not be resolved short of litigation and a judicial ruling DNR believes the intended purpose of SSHB 779 is extremely worth while and, if enacted with DNR's recommended substitute for HB 186, we think it would achieve that purpose. Once the Department has had some experience with the management

March 13, 1980

of geothermal resources and its relationship to water under this new legislation we will be in a position to consider potential amendments to resolve conflicts or questions which may arise.

Sincerely,



Robert E. LeResche, Commissioner
Dept. of Natural Resources

Alaska Water Resources Board
323 East Fourth Avenue
Anchorage, Alaska 99501

PRESS RELEASE - March 17, 1980

For immediate release

For further information
contact:
Richard H. Sims - Kodiak
486-3157, 486-3613

WATER BOARD RECOMMENDS
GEOTHERMAL, STREAMFLOW, FLOOD
LEGISLATION

Meeting in Juneau on Tuesday through Friday the seven-member state water resources advisory board to the Governor has approved resolutions supporting legislation revamping the state's geothermal leasing laws, a bill establishing a process to adjudicate claims to instream flows of waters for navigation and fisheries, and a repeal of a territorial statute which provides broad liability of the state for flood control projects. The Board considered the existing geothermal leasing act a complex impediment to development and supported a provision in SSHB 779 which set a low end temperature cut-off of 120°C for geothermal leasing although some recommended a lower temperature. Water under 120°C would be handled as a relatively simple water right rather than by lease. The Board strongly endorsed HB 118 to set up a process for solving disputed claims to streamflows for navigation, fisheries, and other purposes. The Board recommended additional language to close a loophole in existing state law and require the federal government to use this procedure as well as state or local agencies.

In a surprising vote, the generally conservative board recommended the licensing of operators of highly portable suction dredges as a means to limit their unauthorized use on existing

valid mineral claims and fish streams by an expected influx of inexperienced outsiders from the lower 48.

In Thursday action the Board met with officials of the Yukon Territory Water Resources Agency and discussed common concerns over the expected summer "gold rush" from inexperienced non-resident operators. On Friday the Board reviewed Department of Environmental Conservation water quality studies and proposals related timber harvesting, mining, and road construction.

Members of the Board are Chairman Richard Sims - Kodiak, LeVake Renshaw - Anchorage, Charles Johnson - Nome, Peg Tileston - Anchorage, Wayne Westberg - Anchorage, David Vanderbrink - Homer, and Frederich Boness - Anchorage.

ALASKA WATER RESOURCES BOARD
323 E. Fourth Avenue
Anchorage, AK. 99501

March 14, 1980

Honorable Jay S. Hammond
Governor
State of Alaska
Pouch A
Juneau, Alaska 99811

Dear Governor:

At its March 11-12, 1980 meeting in Juneau the board heard testimony and discussed several pieces of pending legislation. Attached are the Board's recommendations on HB 186, HB 118, SSHB 779, and SB 395.. Because of the possibility of imminent mark-up of some of these bills, by copy of this letter I am transmitting the Board's recommendations to members of the House Resources Committee.

We would be happy to elaborate on our position regarding this legislation. We feel all four bills are very important and we support their passage with the changes we have recommended.

Sincerely,



Richard H. Sims, Chairman

cc: Representative Miles
Representative Osterback
Representative Zharoff
Representative Carney
Representative Cotten
Representative Fuller
Representative Chatterton
Representative Eliason
Representative Halford

ALASKA WATER RESOURCES BOARD

March 1980

Resolution 80-1

Whereas HB 118 introduced in the Eleventh Legislature proposes changes in the Water Use Act that would allow the inclusion of maintenance of instream flow and water level under the provisions of the Water Use Act; and

Whereas in Alaska the maintenance of instream flows and water levels is important to navigation, fish and wildlife habitat, recreation and other beneficial uses of streams, rivers and lakes; and

Whereas the present statute governing water rights, the Water Use Act, AS 46.15, presently states that a diversion, impoundment or withdrawal is a prerequisite for a use of water to be considered an appropriation and maintenance of instream flows and water levels does not meet this prerequisite; and

Whereas instream flows and water levels are presently being reserved under procedures that are distinct from the Water Use Act, creating reservations that have no standing in time within the water rights system, resulting in duplication and conflicts in water management efforts and delays in resolving conflicts and may not be enforceable in problem situations; and

Whereas the federal government may assert water rights in federal court when no state procedures exist for quantification of federal water rights; and

Whereas the lack of state procedure for allocation of stream flows and water levels is the only area in existing state statutes where the federal government does not come under state procedures for the allocation of claimed "non-reserved" federal water rights; and

Whereas state rules for the adjudication of water use are preferable to federal court action on such issues; and

Whereas the provision in HB 118 resolve these problems and streamline the state's water management system; and

Whereas HB 118 is a necessary companion bill to effect implementation of HB 953.

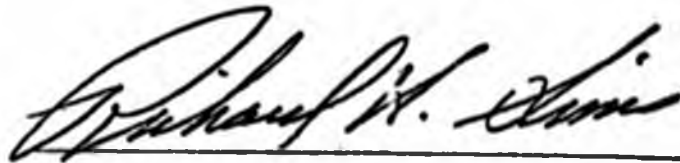
Now therefore be it resolved that the Alaska Water Resources Board recommends passage of HB 118 with the following changes:

page 1. line 16 add ", " after subdivision, delete "or" and add
.after state "or agency of the United States."

page 1. line 23 add "and other beneficial uses" and most
importantly

page 2. line 1 delete "exists" and insert "is demonstrated"

Dated this 14 th day of March, 1980

A handwritten signature in dark ink, appearing to read "Richard H. Sims", written over a horizontal line.

Richard H. Sims, Chairman

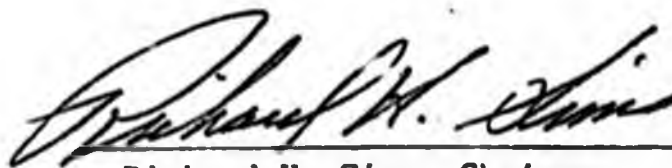
Alaska Water Resources Board
Resolution 80-2

Whereas a DNR substitute for HB 186 proposed in the Eleventh Legislature, second session proposes changes in the Water Use Act that will make it compatible with and a necessary companion to HB 779, the Geothermal Resources Act; and

Whereas HB 186 also proposes housekeeping amendments to the Water Use Act which will streamline and improve the efficiency of water rights processing in Alaska;

No therefore be it resolved that the Alaska Water Resources Board recommends passage of the DNR substitute HB 186 with the provision that in section 46.15.120, "correlative rights" be changed to "leasehold rights" since allocation of correlative rights would involve more than one leaseholder and since even a single geothermal leaseholder may need protection against later depletion of geothermal medium by subsequent water users.

Dated this 14 th day of March, 1980.

A handwritten signature in dark ink, appearing to read 'Richard H. Sims', written over a horizontal line.

Richard H. Sims, Chairman

Alaska Water Resources Board
Resolution 80-3

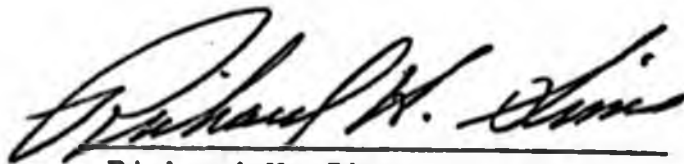
Whereas SSHB 779 introduced in the Eleventh Legislature, second session proposes changes in state law concerning development of Alaska's geothermal resources; and

Whereas the existing statutes are unnecessarily long and complex, and do not distinguish between large scale high temperature development and small scale lower temperature uses of geothermal resources and are an impediment to the development of geothermal resources;

Whereas SSHB 779 makes significant improvement in these deficiencies and attempts to remedy potential conflicts between high temperature geothermal development and rights in groundwater use.

Now therefore be it resolved that the Alaska Water Resources Board recommends passage of SSHB 779 in conjunction with Department of Natural Resources proposed substitute for HB 186.

Dated this 14 th day of March, 1980

A handwritten signature in dark ink, appearing to read "Richard H. Sims", written over a horizontal line.

Richard H. Sims, Chairman

Alaska Water Resources Board
Resolution 80-4

Whereas, Senate Bill No. 395 has been introduced to repeal AS 44.80.020 to AS 44.80.050, an act relating to flood control project damages; and

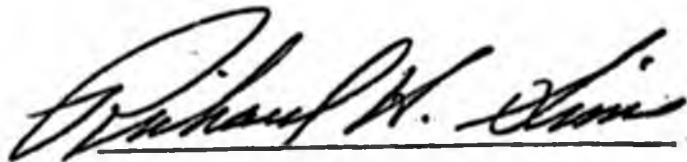
Whereas, the existing legislation provides automatic liability on behalf of the State for any flood control project; and

Whereas, under existing legislation that measure of liability is that of a private party rather than that of the sovereign; and

Whereas, each individual federally funded flood control project requires an acceptance of only federal liability by the State or municipality upon completion.

Therefore be it resolved, that the Alaska State Water Resources Board strongly recommends passage of Senate Bill 395.

Date this 14 th day of March, 1980

A handwritten signature in dark ink, appearing to read "Richard H. Sims", written over a horizontal line.

Richard H. Sims, Chairman

Alaska Water Resources Board

Resolution 30-5

Whereas the Water Resources Board perceives that the increased value of precious metal has triggered a large influx of inexperienced persons who wish to prospect for those metals through the use of small portable suction dredges; and

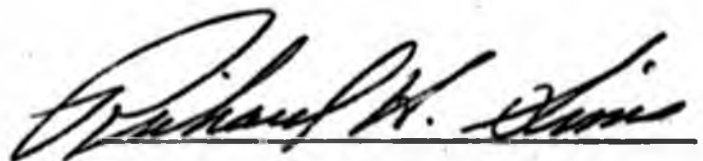
Whereas there is a significant potential for degradation of Alaskan streams through the increased use of small portable suction dredges; and

Whereas the use of portable suction dredge can have great detrimental effect on water quality and the habitat of anadromous fish; and

Whereas the extreme portability of the suction dredge and their use in non-established mineral claims results in great difficulty in preventing damage through stream surveillance.

Now therefore be it resolved that the Department of Environmental Conservation via legislation or regulation adopt a policy of licensing the operators of portable suction dredges on other than established mineral claims as a means of insuring that these operators are aware of the constraints placed on all citizens concerning stream degradation and protection of anadromous fish streams.

Dated this 14 th day of March, 1980.

A handwritten signature in dark ink, appearing to read "Richard H. Sims", written over a horizontal line.

Richard H. Sims, Chairman

ALCO-UTILITY Line Form No. 50-176 NCH-480 Cs

P H O N E M E M O	TO	DATE	TIME	AM PM									
	FROM	AREA CODE-TELEPHONE NO.-OR OPER.											
	M	EXTENSION #											
	OF												
MESSAGE	With testify on bill												
	CSSSHB 779-												
	Don Mittel Dpt Commerce & con												
	SIGNED												
Phoned	☐	Call Back	☐	Returned Call	☐	Wants To See You	☐	Will Call Again	☐	Was In	☐	See Operator	☐

new bill
CSSSHB 779

Original sponsor: Gardiner

IN THE HOUSE

BY THE FINANCE COMMITTEE

CS FOR HOUSE BILL NO. 241

IN THE LEGISLATURE OF THE STATE OF ALASKA

ELEVENTH LEGISLATURE - FIRST SESSION

A BILL

For an Act entitled: "An Act relating to state bonding."

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF ALASKA:

* Section 1. AS 37.15.010 is amended by adding a new subsection to read:

(b) General obligation bonds issued for acquiring, constructing, improving and equipping a state-owned utility or other revenue-generating enterprise may be additionally secured by a pledge of the revenue derived from operation. The bonds may contain the covenants which the state bond committee considers advisable concerning

(1) the rates or fees to be charged for services rendered by the public facilities, the revenue of which is pledged to the payment of the bonds;

(2) the deposit and use of the revenue of the public facilities;

(3) the issuance of additional bonds payable from revenue of the public facilities;

(4) the rights of the bondholders in case of default in the payment of the principal or interest on the bonds, including the appointment of a receiver to operate the public facilities;

(5) other covenants as the state bond committee determines.

CSSSHB 779- Synopsis

Cheryl-

This isn't an in-depth analysis in that I talked with someone at DNR in Anchorage to give it to me in a nutshell.

The present~~4~~ statutes dealing with geothermal resources are long, complicated and cumbersome. This bill would simplify the present statutes by:

- 1) Clearly defining the difference between geothermal and a water resource. Geothermal constitutes any water source found while drilling that is over 120 degrees Celsius. Anything under would be just a water resource.
- 2) The reason for the distinction is if the source is defined as geothermal, then it will fall into the same category as oil, minerals etc. The state then has a much higher interest particularly in land disposal areas and may want to develop the resource.
- 3) If the source is not geothermal, someone finding ^{water} under 120 degrees Celsius ~~water~~ may use it for their own purposes and not be subjected to the present complicated permit process.

According to the guy at DNR, no one is against the bill or at least didn't testify against it at the House Resources hearings.

Fiscal impact is approx. \$48,400 the first year, by the creation of one civil engineering position at DNR.

THE LEGISLATURE OF THE STATE OF ALASKA
ELEVENTH LEGISLATURE

FISCAL NOTE

I. REQUEST

Bill/Resolution No. HB 779

Title An Act relating to the development of geothermal resources

Requested by House Resources Committee

Date 2/25/80

II. FISCAL DETAIL

Agency Affected Department of Natural Resources

Program Category Affected NRMEC

BRU, Program, or Subprogram(s) Affected Water Management

(Note: If more than one budget component is affected, separate line-item amounts and funding for each component in the analysis section.)

EXPENDITURES (Thousands of Dollars)

	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85
100 PERSONAL SERVICES		38.4	40.3	42.3		
200 TRAVEL		4.5	4.5	4.5		
300 CONTRACTUAL		3.0	3.0	3.0		
400 COMMODITIES		1.0	1.0	1.0		
500 EQUIPMENT		1.5	.5	-0-		
600 LAND & STRUCTURES						
700 GRANTS, CLAIMS, ETC.						
TOTAL		48.4	49.3	50.8		

FUNDING (Thousands of Dollars)

GENERAL FUND		48.4	49.3	50.8		
FEDERAL FUNDS						
OTHER (Specify Fund Source)						

POSITIONS

FULL TIME		1	1	1		
PART TIME						
TEMPORARY						

III. ANALYSIS (See Fiscal Note Preparation Instructions, Section III)

SEE ATTACHMENT

IV. DATE 2/29/80

PREPARED BY *Dave Davis - Chakoff*

AGENCY Division of Research & Development, DNR

PHONE 279-5577

Original: Legislative Finance

cc: Budget and Management

Prime Sponsor (First Legislator Named)

STATE
of ALASKA

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF RESEARCH AND DEVELOPMENT

MEMORANDUM

FR / file

TO: JEFF HAYNES, Deputy Commissioner
Department of Natural Resources

DATE: February 29, 1980

FILE NO.

TELEPHONE NO.

FROM: MO MATTHEWS, Director
Division of Research & Development

SUBJECT: Fiscal Note for House
Geothermal Bill

The House Resources Committee has requested a Fiscal Note for the proposed geothermal bill, HB 779. Most of DNR's responsibilities with respect to this bill are already adequately covered in the FY 81 budget. These include DGGs' inventory project, a project to revise geothermal leasing regulations and support for a modest level of geothermal leasing. Descriptions of these projects are attached to the Fiscal Note. However, additional funding will be needed as HB 779 will create increased demands on the Department in three important areas not addressed in the FY 81 budget:

1. regulation of resource conservation and operation safety aspects of geothermal development;
2. management of water associated with thermal resources; and
3. technical assistance for geothermal and low-temperature hydrothermal development, and groundwater heat pump applications.

As indicated on the attached Fiscal Note, I feel that the increased demands on the Department for FY 81 can best be met by establishing one Civil Engineer II position in the Water Management Section of the Division of Forest, Land and Water Management. This position would set up a regulatory and procedural framework to meet DNR's safety and conservation responsibilities for geothermal resources and handle the increased water management responsibilities that accompany development of non-leasable (below 120° C.) hot-water resources that HB 779 is designed to encourage. The Water Section already has statewide responsibilities under the Water Use Act, regardless of surface land ownership, and this position could provide construction review and assistance in development on non-state lands as well. Both Tom Cook and Ross Schaff have been contacted by phone and have indicated that they have no problem with placing the regulatory responsibility in the Water Management Section. For future budget cycles, we can appropriately integrate these management and regulatory aspects of hot-water and geothermal resource use into the project budget framework.

The Fiscal Note for HB 779 should be forwarded to the Legislative Finance Committee and Bob Speed in the House Speakers Office as soon as possible.

cc: Tom Cook
Ross Schaff
Ted Smith/Brent Petrie

III ANALYSIS FOR HB 779

The Governor's FY 81 budget includes several projects that relate to geothermal resource inventory and management. (See attached budget sheet.) Because of this, the department feels that much of HB 779's fiscal impact can be absorbed without appropriating additional funds by redirecting slightly these already scheduled projects. However, additional support is necessary to carry out the department's new statewide responsibility per HB 779 for regulating the safety and resource conservation aspects of geothermal development.

Not only does HB 779 give to DNR this important, new regulatory responsibility for geothermal resources, but the department is also given the responsibility to regulate all hydrothermal resources that fall below the 120°C temperature threshold that is used to define geothermal resources. Recent experience indicates that sub-120°C hot water resource development (such as the Pilgrim Hot Spring project) may require regulation for safety and conservation purposes even though the resources involved are not considered "geothermal resources" for leasing purposes.

This fiscal note outlines what is needed for the department to expand its geothermal resource management program to include resource conservation and operation safety regulation of geothermal and hydrothermal development on a statewide basis. Specific program objectives are:

1. Develop and adopt simple and workable regulations and procedures dealing with operation safety and resource conservation of geothermal and hydrothermal development on all lands in Alaska as provided by HB 779;
2. Develop and maintain a program to promote safety and prevent waste of geothermal and hot water resources in the state.

The program would also include provisions for technical assistance to those wishing to develop geothermal resources and other agencies that are involved in such resource development.

To accomplish these objectives in FY 81, the department needs a minimum of one full time Civil Engineer II with special knowledge of drilling methods and operations, groundwater geology and fluid mechanics. A detailed description of this position's duties and associated position costs are outlined in the attached Request for New Position Form 13.

1	POSITION TITLE CIVIL ENGINEER II			RANGE/STEP 20A	BARG. UNIT. G	LOCATION Anchorage	GOV.	APPROV.	DISAPP.
2	TYPE OF POSITION PFT	STAFF MONTHS 12	JIP No.	PCN No. NEW	PRIORITY	FORM 12 PAGE/LINE	LEG.		
3	TYPE OF EXPENDITURE			AMOUNT					
	1			2					
	3								
4	PERSONAL SERVICES:								
	SALARY \$2,532/month			30,384					
5	BENEFITS			4,548					
6	FICA			1,975					
7	HEALTH INS.			1,524					
8	TOTAL PERSONAL SERVICES			38,431					
9	TRAVEL			4,500					
10	CONTRACTUAL			3,000					
11	COMMODITIES			1,000					
12	EQUIPMENT			1,500					
13	OTHER								
14	TOTAL COST			48,431					
	CODE	FUNDING SOURCE							
15		FED RCPTS							
16		GF MATCH							
17		GEN FUND		48,431					
18		I-A RCPTS							
19		IUM RCPTS							
20		OTHER							
21	CONTINUATION								
22	ADDITION			X					
FOR B&M USE ONLY									
4A KEY NUMBER _____ COLUMN NO. _____									

JUSTIFICATION:
 Proposed legislation requires that the Department of Natural Resources adopt regulations and implement a program to prevent waste, contamination and injury caused by exploration, development and production of geothermal resources in the state. This new position will prepare regulations based on the new geothermal legislation and develop guidelines, standards and administrative procedures to implement DNR's new regulatory responsibilities. For each geothermal development project in the state, the position will (1) review and evaluate development and operation plans to determine compliance with its regulations; (2) perform site inspections of projects to ensure adherence to plans and specifications; (3) provide technical assistance with engineering and hydrologic problems as needed; and (4) maintain records on all aspects of development. Finally, in order to allow appropriation of hot water under AS 46.15 (Water Use Act) for the use of its heat value, to ensure an appropriator's right to that water and its thermal properties, to protect the rights of prior appropriators and to protect the public interest, this position will develop and apply criteria and standards for evaluating permit applications, issuing permits and making appropriations for the use of hot water. The position will also perform site inspections to ensure that appropriations are being perfected in accordance with the water use permit and to provide technical assistance to hydrothermal development projects.

In addition to the general civil engineering position

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requirements, this position will require knowledge and experience in drilling high pressure fluids for monitoring the design, operation and maintenance of water, oil or gas wells; groundwater hydrology and fluid mechanics.

Because the position will be responsible for implementing a safety and resource conservation program for hot-water and higher temperature geothermal resources that is independent of state-land ownership, considerations include but are not limited to development of state geothermal leases, and because of the inextricable connection between Water Use Act procedures and those tasks outlined above, this position and its support will be placed in the Water Management Section of the Division of Forest, Land and Water Management.

The responsibilities of the Water Management Section under the Water Use Act, especially its function of reviewing water use permits and making water appropriations, already transcend state-land management. The Department therefore feels that the safety and resource conservation regulatory aspects of hot-water and geothermal development is most efficiently and effectively placed with the Water Management Section.

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Project: Field Investigations of Coal Fields

Coal is a resource which is abundant in Alaska, although the obstacles to producing and transporting it are serious in many areas. It is desirable to conduct detailed investigations of potential large coal prospects to assist the State in the development of this resource. Under this Project, the Department would initiate a series of field projects to map coal fields where information is needed to assess the State's coal resources, and would compile coal resource atlases. Field study would be conducted at the Ikroavik Bay/Chignik Bay coal district on the Alaska peninsula or a like area.

COMPONENT: Geothermal Leasing/Development

Project: Geothermal Resource Inventory/Analysis

Geothermal energy, a renewable resource, is the least known of Alaska's energy resources. Nevertheless, indications are that a large portion of Alaska may constitute a geothermal resource province. As the cost of importing energy into rural areas continues to increase in real terms, local development of geothermal energy resources for power generation and/or heat becomes increasingly attractive. Geothermal prospects which are cooler than the boiling point of water may be used to heat buildings or be employed with greenhouses for commercial agriculture. Geothermal steam may be converted into electrical energy through the construction of power generating plants. Planning for any future geothermal development will require investigation of hot springs (surface indications of potential prospects) as well as volcanic and intrusive igneous rocks. The Department's current drilling program at Pilgrim Hot Springs in Nome and its assessment of hot springs and geothermal anomalies around the State are generating important information about geothermal prospects which are suitable for development, and should be continued. Under this Project, the Department will complete by FY 1982 a geothermal atlas, and design development plans based on detailed geologic investigations for 12 specific hot springs sites; it will also complete detailed geologic investigations of at least three specific quaternary volcanic sites including relative volcanic hazard potential and advisability of site selection.

Project: Revision of Geothermal Regulations

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Alaska presently has on the books a Geothermal Steam Act which governs the leasing, use and development of geothermal energy. This Act was adapted from Federal legislation and is probably much too complicated to be suitable for development purposes in Alaska. Anticipating legislative action during FY 1980, the Department wishes to be prepared to revise its regulations at the beginning of FY 1981 to prepare for lease sales in FY 1981. Under this Project, the Department would (1) develop and adopt revised State regulations dealing with geothermal energy resources management and utilization, (2) establish intra- and interdepartmental procedures to implement the regulations, and (3) develop a program to promote utilization of geothermal resources where in the public interest.

Project: Geothermal Lease Sales

Pending outcome of Statewide geothermal resource inventories, the Department will not be certain of the best prospects for development. Consequently, it cannot be stated at this time what the ownership status is of lands determined to be good prospects. Nevertheless, the Department anticipates having this information by FY 1981 and desires to be prepared to lease geothermal prospects occurring on State land. Under this Project, the Department will conduct one or more geothermal lease sales during FY 1981.

AGENCY Natural Resources PROGRAM AREA NRMEC

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	PROJECT COSTS						Associated Capital
	<u>100</u>	<u>200</u>	<u>300</u>	<u>400</u>	<u>500</u>	<u>Other</u>	<u>Total</u>
Revisions of Mining Rights Acquisition Regulations*	11.2	.6	.2	.1	0		12.1
Mineral Claim Adjudication	72.9	1.8	1.9	.9	.5		78.0
Plans of Operation/Mining and Exploration	13.1	1.0	.1	.1	.5		14.8
Mining Offices	173.3	0	0	6.8	0		180.1
Public Assays	62.9	0	0	3.8	0		66.7
Mineral Development Policy Analysis*	7.2	.5	.2	.1	0		8.0
Surface Mining Control	36.7	5.1	.2	.1	0		42.1
Revision of Coal Regulations*	3.1	0	2.7	0	0		5.8
Field Investigations of Coal Fields	98.3	6.8	10.4	2.6	0		118.1
Geothermal Resource Inventory/Analysis*	190.0	12.2	84.7	4.7	0		291.6
Revision of Geothermal Regulations*	10.0	.6	4.6	.2	0		15.4
Geothermal Lease Sale*	10.0	4.0	5.8	.2	0		20.0
Total projects within continuation	457.2	14.7	12.6	14.3	1.0		499.8
Total incremental projects	231.5	17.9	98.2	5.3	0		352.9
Total all projects	688.7	32.6	110.8	19.6	1.0		852.7

*submitted as an increment on Form 6

**not submitted in detailed budget

AGENCY Natural Resources PROGRAM AREA NRMEC

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HB 779

(1980)

BOB SPEED
SPEAKER'S OFFICE

MANAGEMENT OF LAND, WATER AND HYDROTHERMAL RESOURCES
ASSOCIATED WITH HOT SPRINGS IN ALASKA

Dave Denig-Chakroff
Geothermal Program Coordinator

STATE OF ALASKA
Department of Natural Resources
Division of Research and Development
Policy Research/Land Entitlement Section

January 1980

Jack

Please return this
document when through
with it.

Thx

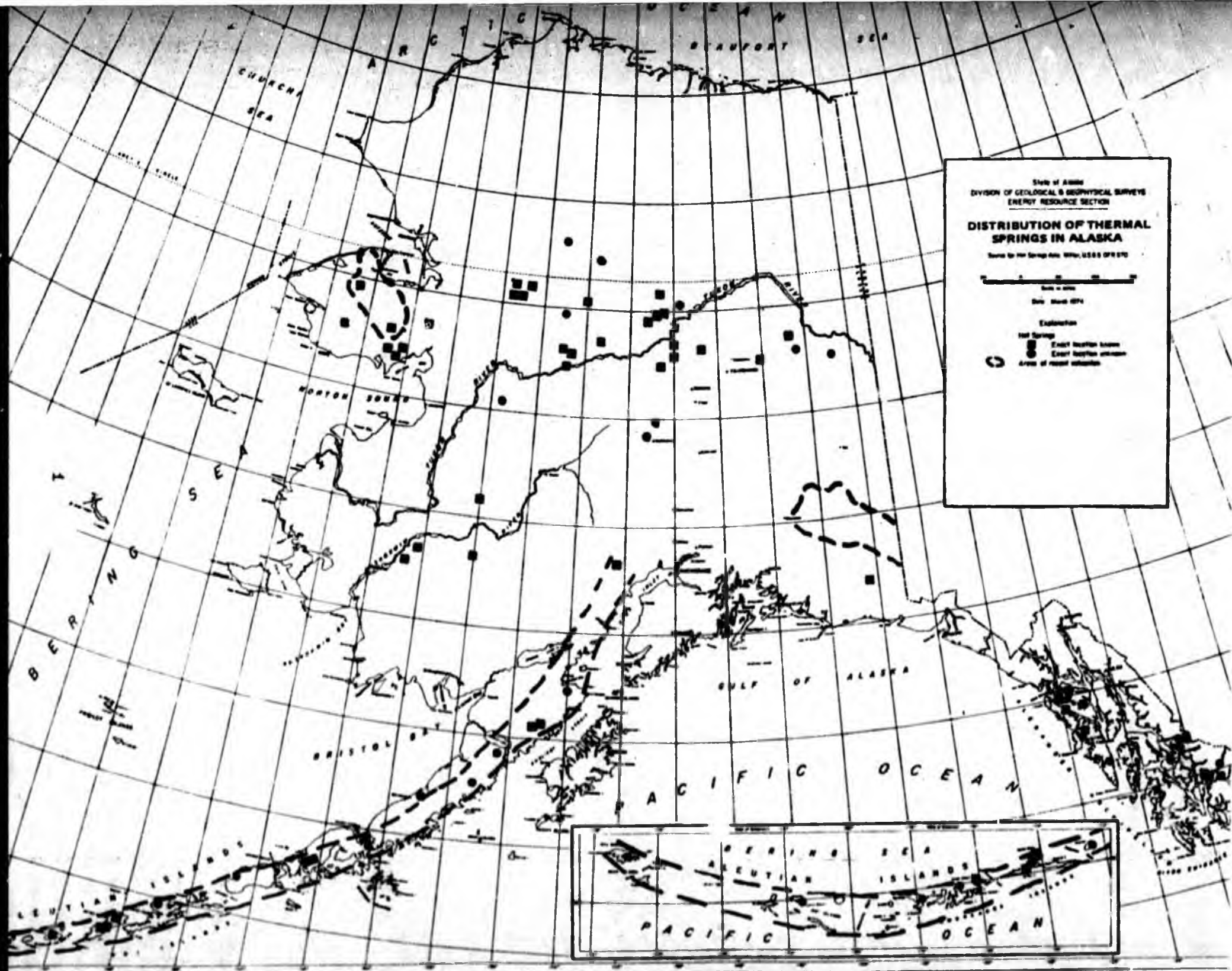
Bob Speed

**MANAGEMENT OF LAND, WATER AND HYDROTHERMAL RESOURCES
ASSOCIATED WITH HOT SPRINGS IN ALASKA**

**Dave Denig-Chakroff
Geothermal Program Coordinator**

**STATE OF ALASKA
Department of Natural Resources
Division of Research and Development
Policy Research/Land Entitlement Section**

January 1980



State of Alaska
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS
ENERGY RESOURCE SECTION

DISTRIBUTION OF THERMAL SPRINGS IN ALASKA

Source for Hot Springs Data: WHP, USGS OFR 870

Scale = miles
0 100 200
Date: March 1974

Explanation
● Hot Springs
■ Exact location known
□ Exact location unknown
--- Areas of recent subsidence



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Introduction

The Department of Natural Resources has recently completed a review of legal and institutional issues relating to geothermal resources in Alaska in order to develop recommendations for amendments to state statutes affecting the management of those resources. During this review, a number of issues have been raised and ambiguities noted regarding the management of land, water and hydrothermal resources associated with hot springs.

Questions regarding land management which have been raised and will be addressed in this paper include:

- What federal laws apply to land surrounding hot springs, and what is their effect?
- What is the ownership status of land containing hot springs in Alaska?

Water management questions to be addressed include:

- What are the state and federal government's respective roles regarding the management of water associated with hot springs?
- What is the effect of federal reserved water rights?
- What is meant by the phrase "mineral and medicinal waters" in the Alaska Constitution and why does the Constitution exclude such waters from appropriation under state water law? What is the effect of this exclusion?

Finally, the following questions regarding hydrothermal resources management will be addressed:

- What is the potential for use of thermal resources associated with hot springs in Alaska?
- What is the effect of federal laws on such use?
- What state laws apply to the use of thermal resources and what is their effect?

Federal Land Withdrawals Affecting Hot Springs

A series of executive and public land orders issued as early as 1911 have had a significant effect on the lands surrounding hot springs in Alaska. These orders have reserved for federal use an area around hot springs outside national forests which were located on vacant, unreserved land in 1911.

The first federal law specifically addressing land containing hot springs in Alaska came in the form of Executive Order 1324 $\frac{1}{2}$ signed by President Taft, March 28, 1911 (Appendix 1). It withdrew and reserved for public purposes 160 acres around every hot spring on public land in the Territory of Alaska. This order was later amended by Executive Order 1883 of January 24, 1914 (Appendix 2) so that it would not apply to land within national forests.

In 1947, Public Land Order 399 (Appendix 3) revoked Executive Orders 1324 $\frac{1}{2}$ and 1883, and amended Executive Order 5389 of July 7, 1930 (Appendix 4) to take their place. Executive Order 5389 withdraws public land containing hot springs or springs "the waters of which possess curative properties" and reserves such land for lease for the construction of facilities or improvements to accommodate the public. Prior to the issuance of PLO 399, Executive Order 5389 did not apply to Alaska; however, as amended, it applies to land in Alaska except for land within national forests.^{1/}

Section 704(n) of the Federal Land Policy Management Act of 1976, 43 U.S.C. §1701, (FLPMA), repealed the authorizing statutes under which Executive

^{1/} A 1961 Department of the Interior Solicitor's Opinion (M-36625) indicates that any public land on which wells are drilled for the development of geothermal water would be subject to withdrawal and reservation under Executive Order 5389. The Solicitor's basis for this opinion is that "there is no language in [Executive Order 5389] or the regulations issued pursuant thereto which restricts the term 'hot spring' to a spring created solely by the forces of nature." This opinion, however, has been reversed by a more recent Solicitor's Opinion (M-36914, June 25, 1979). Although the 1979 Opinion discusses a 1926 Executive Order which withdraws land containing springs and water holes, it states that the general approach adopted also applies to Executive Order 5389. In his 1979 Opinion, the Solicitor states, "I cannot agree . . . with the inference in some of the opinions of my predecessors that the . . . Order causes a reservation of all artificially developed water sources . . . I am therefore overruling expressions in prior opinions . . . to the extent they apply the . . . Order to artificially developed water sources on the public lands." The Solicitor further defines the term "spring" to mean "a discrete natural flow of water emerging from the earth at a reasonably distinct location . . ." (emphasis added).

Order 5389 was issued.^{2/} Consequently, hot springs which come into existence after the effective date of FLPMA (October 21, 1976) are not withdrawn by Executive Order 5389, but could be withdrawn under other, still-existing legislative authority.^{3/}

FLPMA appears to have a potentially significant effect on land containing hot springs within national forests. Even though such land was not withdrawn by Executive Order 5389 as amended, the State has been prevented from receiving title to it. When land within a national forest is selected, it is removed from the forest system and placed in the public domain prior to transfer. At that point, the land was (before FLPMA) subject to Executive Order 5389 and could not be transferred if it were within the prescribed locality of a hot spring. FLPMA, however, has repealed the federal statutes which authorized Executive Order 5389. All previously withdrawn land remains unaffected by the repeal, but no new withdrawals can be made. Since Executive Order 5389 never withdrew lands containing hot springs in national forests in Alaska; and now, cannot withdraw them if they are removed from the forest system, it appears that the Order no longer prohibits the State from selecting and receiving title to such land through the forest selections process.

In a few cases in Alaska, lands containing hot springs were in private ownership prior to Executive Order 13244 of 1911; otherwise, all such lands outside national forests have been withdrawn and reserved by the federal government. Regulations pursuant to Executive Order 5389 require that applicants, in order to select land outside national forests, must show that no hot springs exist on the land or within the area prescribed by the order (43 C.F.R. 2311.2(a), Appendix 5B). Since Executive Order 5389 was in effect before Statehood and no title to land containing hot springs within national forests has been obtained, the State does not control any hot springs by virtue of its land ownership.

^{2/} Section 10 of the Act of December 29, 1916 (43 U.S.C. §300) and The Pickett Act of June 25, 1910 (43 U.S.C. §141).

^{3/} Solicitor's Opinion M-36914 of June 25, 1979 implies that Executive Order 5389 has withdrawn lands containing hot springs regardless of whether the water source is known to exist or has been specifically located. Thus, the fact that a hot spring in existence before October 21, 1976 was not identified until after that date would not affect the withdrawal of land around it.

Summary of Federal Laws Affecting Land Containing Hot Springs

<u>Date</u>	<u>Law</u>	<u>Effect</u>	<u>Appendix</u>
June 25, 1910	43 U.S.C. §141 (Pickett Act)	Authorizes the President to make withdrawals of public lands in certain cases.	-
March 28, 1911	E.O. 1324½	Withdraws land containing hot springs in Alaska.	1
January 24, 1914	E.O. 1883	Amends E.O. 1324½ to exclude land in national forests.	2
December 29, 1916	43 U.S.C. §291	Authorizes reservation of land containing public springs and water holes.	-
March 3, 1925	43 U.S.C. §971	Authorizes leasing of withdrawn land containing hot springs for resort purposes.	5A
July 7, 1930	E.O. 5389	Withdraws land containing hot springs in the U. S. except for Alaska.	4
August 20, 1947	PLO 399	Revokes E.O.'s 1324½ and 1883, and amends E.O. 5389 to include land in Alaska except for land in national forests.	3
October 21, 1976	43 U.S.C. §1701 (FLPMA)	Repeals Acts of 1910 and 1916; however, existing withdrawals remain in force unless changed in accordance with FLPMA.	-

Water Rights

The federal orders and subsequent regulations affecting hot spring locations are fairly clear as to their intent with respect to withdrawal and reservation of land. However, the issue of water rights remains somewhat clouded not only on this land, but on all federal withdrawals and reservations. Federal versus state water rights has been the subject of several landmark Supreme Court cases and a recent Department of the Interior Solicitor's Opinion. A review of federal legislation, Court decisions relating to water law and the recent Solicitor's Opinion can help clarify the issue of water management on federal land containing hot springs in Alaska.

Water Rights in the State of Alaska are based on the appropriation doctrine. Under this doctrine, the federal government generally recognizes the State's authority to manage and appropriate surface and subsurface waters.

The Act of Congress of 1866 as amended by the Act of 1870 established the appropriation doctrine of water rights in the western United States.^{4/} The Act of 1866 is primarily a mining law; however, Section 9 contains provisions which give formal sanction of the federal government to appropriations of water on public lands of the United States when such appropriations are obtained through, and are acknowledged by, local customs, laws and court decisions. The Act further provides that the rights of appropriators will be protected by state or territorial laws.

The appropriation doctrine received further support in western states with the enactment of the Desert Land Act of 1877.^{5/} This Act provides that water rights on desert land are subject to prior appropriation and that all unappropriated water should be held free for appropriation by the public subject to existing rights. In 1935, a Supreme Court decision held that the Desert Land Act applied not only to desert land but to all land of the public domain in the affected states and territories.^{6/} It further held that the Act severed all waters from the public land leaving waters subject to appropriation under the laws of the states and territories.

In Alaska, the United States District Court at Sitka recognized and applied the appropriation doctrine as early as 1890, holding that prior appropriations were entitled to protection under the Act of Congress of 1866.^{7/} It was 100 years after the enactment of the Act of 1866 that

^{4/} 14 Stat. 253, §9 (1866) and 16 Stat. 217 (1870).

^{5/} 19 Stat. 377 (1877), 43 U.S.C. §321 et seq. (1964).

^{6/} California Oregon Power Co. v. Beaver Portland Cement Co., 295 U. S. 142, 160-163 (1935).

^{7/} Noland v. Conon., 1 Alaska 36, 37-38 (1890).

the State of Alaska, in 1966, adopted the Water Use Act based on the appropriation doctrine.8/

Although the laws and court decisions thus far cited affirm state regulatory authority over water rights in the western United States, several Supreme Court decisions have placed limitations on this authority. These limitations have traditionally been referred to as "federal reserved water rights" or the "Winters Doctrine." This doctrine gives the federal government reserved rights to water on federally reserved lands. These water rights are protected against subsequent state appropriations.

The Winters Doctrine was foreshadowed by the 1899 Supreme Court case of United States v. Rio Grande Dam and Irrigation Company. This Court decision held that the United States, as owner of lands bordering a stream, cannot be deprived by a state of the right to the continued flow of the stream's waters as may be necessary for the beneficial use of the property.9/

The Winters Doctrine was later articulated in the 1908 case for which it was named, Winters v. United States.10/ In the "Winters" case, the Supreme Court held that the Indians of the Fort Belknap Indian Reservation in Montana were entitled to reserved water rights which were protected against rights acquired later under state law.

The next judicial influence on the Winters Doctrine came in the 1955 Supreme Court case of Federal Power Commission v. Oregon (also known as the "Pelton Dam" case).11/ The Court's decision essentially extended the Winters Doctrine to apply not only to Indian reservations, but to any lands "withdrawn, reserved, or withheld from private appropriation and disposal under the public land laws."

The decisions of the "Winters" and "Pelton Dam" cases have subsequently been reaffirmed in two Supreme Court cases. In the 1963 case of Arizona v. California, the Court granted reserved water rights to the Indians of the Colorado Indian Reservation and went on to say that the United States has the power to reserve water rights for other federal reservations and property.12/ In discussing its Arizona v. California decision in a 1971 case, the Supreme Court said:

[T]he Federal Government had the authority both before and after a State is admitted into the Union "to reserve waters for the use and benefit of federally reserved lands." . . . The federally reserved lands include any federal enclave.13/

8/ A.S. 46.15.

9/ 174 U. S. 690 (1899).

10/ 207 U. S. 564 (1908).

11/ 349 U. S. 435 (1955).

12/ 373 U. S. 546 (1963).

13/ United States v. District Court in and for the County of Eagle, 401 U. S. 521 (1971).

A concise description of the effect of the Winters Doctrine as it had evolved to this point was written in 1971 by Frank Trelease, a noted authority on water law and primary author of the Alaska Water Use Act.

If the United States by treaty, act of Congress or executive order reserves a portion of the public domain for a federal purpose which will ultimately require water, and at the same time the government intends to reserve unappropriated water for that purpose,^{14/} then sufficient water to fulfill that purpose is reserved from appropriation by private users. The effect of the doctrine is twofold: 1) when water is eventually put to use the right of the United States will be superior to private rights in the source of water acquired after the date of the reservation, hence such private rights may be impaired or destroyed without compensation by the exercise of the reserved rights, and 2) the federal use is not subject to state laws regulating the appropriation and use of water.^{15/}

Mr. Trelease describes the doctrine as "wild cards that may be played at any time, blank checks that may be filled in for any amount or may never be cashed."^{16/}

In more recent years, however, two Supreme Court cases have resulted in a curtailment of the effects of the Winters Doctrine. A 1976 Court decision stated, "the implied-reservation-water-rights doctrine, however, reserves only that amount of water necessary to fulfill the purpose of the reservation, no more . . ."^{17/} The most recent modification of the Winters Doctrine came in July of 1978 in the case of United States v. New Mexico.^{18/} In its decision, the Supreme Court held that the Gila National Forest in New Mexico has reserved water rights only for the primary purposes for which it was established, but not for any secondary purposes. It also stated that "[w]here water is only valuable for a secondary use of the reservation . . . there arises the contrary inference that Congress intended . . . that the United States would acquire water in the same manner as any other public or private appropriator."

^{14/} The government's intent to reserve water need not be explicitly stated. A 1976 Supreme Court decision holds that this intent "is inferred if the previously unappropriated water is necessary to accomplish the purpose for which the land reservation is created," (Cappaert v. United States, 426 U. S. 128). Historically, federal reserved water rights have most often been created by implication rather than by express reservation.

^{15/} F. Trelease, Federal-State Relations in Water Law, 109 (1976).

^{16/} Id. at 160.

^{17/} Cappaert v. United States, 426 U. S. 128 (1976).

^{18/} 98 S. Ct. 3012 (1978).

A recent Department of the Interior Solicitor's Opinion affirms the U.S. v. New Mexico Supreme Court decision.^{19/} In his 1979 Opinion, the Solicitor states:

The United States retains water rights by reserving federal lands and waters necessary to fulfill specified purposes [T]here is an important distinction between the purposes of a land reservation and secondary or subsidiary management apart from the reservation purpose(s); i.e., only the former obtain water rights by the act of reserving the land for particular purposes. [Emphasis added.]

The Solicitor later acknowledges that "land management agencies of the Department of the Interior have, throughout their history, appropriated water on the lands they administer This appropriation of water is necessary to carry out the secondary uses for which many federal reservations are administered." He advocates continuance of this policy saying, "application should be made pursuant to state procedural law for all uses of water interior land management agencies are making and plan to make on the federal lands they manage which are not covered by reserved rights"

According to the Solicitor, the purposes of a federal withdrawal may require reservation of the "total yield" of a water source. Such is the case, in his opinion, on lands containing a spring or water hole withdrawn by a 1926 Executive Order.^{20/} The Solicitor broadly interprets the primary purposes of the 1926 Order to include, "(a) stockwatering, (b) human consumption, (c) agriculture and irrigation, including sustaining fish, wildlife and plants as food and forage sources, and (d) flood, soil, fire and erosion control."

Unfortunately, the Solicitor does not specifically address the amount of water reserved by Executive Order 5389, but says only that "[t]he general approach adopted . . . in relation to the 1926 Order is . . . applicable to these reservations." He does acknowledge, however, that "reserves [created by Executive Order 5389] are generally local in character or otherwise minor." Unlike the broad purposes of the 1926 Order which require reservation of the "total yield," Executive Order 5389 has a very specific purpose which could certainly be fulfilled with a much smaller water reservation in most cases. The lands withdrawn by Executive Order 5389 have only one primary purpose, which is clearly stated in the Code of Federal Regulations, 43 C.F.R. 2311.0-3(b)(2) (Appendix 5B):

Purpose of withdrawal. The Executive order [5389] . . . was designed to preserve for general public use and benefit the unreserved public lands, containing hot springs or springs the waters of which

^{19/} Solicitor's Opinion #M-36914, (June 25, 1979), Leo Krulitz, Solicitor.

^{20/} Executive Order of April 17, 1926 which creates Public Water Reserve No. 107, withdraws and reserves vacant, unappropriated, unreserved public land which contains a spring or water hole, or other body of water needed or used by the public for watering purposes. Alaska was excluded from the reserve created by this Order by Executive Order 5106 of May 4, 1929.

possess curative properties, in order that they might be leased under the provisions of the act of March 3, 1925 (43 Stat. 1133; 43 U.S.C. 971), and the regulations issued thereunder, contained in §2311.4.

Thus, the federal water reservation would, presumably, be limited to an amount needed for "bathhouses, hotels, or other improvements for the accommodation of the public," as stated in the provisions of 43 U.S.C. 971 (Appendix 5A) and 43 C.F.R. §2311.4 (Appendix 5B). Any water available over and above this reservation would be subject to appropriation under state law.

This state appropriation authority is acknowledged in the federal regulation pertaining to both Executive Order 5389 and the 1926 Order (43 C.F.R. §3211--Public Water Reserves, Appendix 5B). In granting a permit to conduct water from a public water reserve to a point outside the reserve, including unreserved public land, Section 2311.3(f) requires, "[t]hat the right to appropriate the waters of the State to the uses contemplated shall be obtained within 1 year from and after the issuance of the permit and the permittee shall file a certificate to that effect issued by the proper State Authority In the event that the State certificate as to the right to appropriate the water is not filed within 1 year, . . . then such permit shall become and be subject to cancellation." Since the 1926 Order reserves the total water yield at each source, this section is apparently applicable only to lands withdrawn by Executive Order 5389.

In the past, there has been a great deal of misunderstanding with respect to the appropriation and granting of rights to water associated with hot springs in Alaska. In some cases, the State of Alaska has denied issuance of water appropriation certificates based solely on the fact that the water in question was naturally hot. However, the federal regulations, Solicitor's Opinion and Supreme Court decisions cited above indicate that such denials are not justified unless the water is reserved and needed for use by a resort on a federal leasehold containing a hot spring. If this is not the case, the water is subject to appropriation under the state Water Use Act.

Alaska Constitution

Water rights are addressed in the Constitution of the State of Alaska in Article VIII, Section 13, which states:

Water Rights. All surface and subsurface waters reserved to the people for common use, except mineral and medicinal waters, are subject to appropriation. Priority of appropriation shall give prior right. Except for public water supply, an appropriation of water shall be limited to state purposes and subject to preferences among beneficial uses, concurrent or otherwise as prescribed by law, and to the general reservation of fish and wildlife.

Inherent in this statement are two often-asked questions: (1) What are "mineral and medicinal waters"? and (2) Why are they excluded from the appropriation doctrine? The answers to these questions can be found in the Alaska Constitutional Convention Proceedings (selected portions in Appendix 6). Transcripts of the proceedings indicate that by inserting the phrase "except mineral and medicinal waters" into Article VIII, Section 13, delegates intended to preclude appropriation by the State of "hot springs or springs with proven medicinal value." The following quotes from the proceedings show that this preclusion was made in deference to federal law which allegedly maintained the authority for such appropriations.

January 18, 1956
[morning]

TAYLOR: . . . the federal law provides that all hot springs or springs with proven medicinal value are reserved to the federal government, so people can have beneficial use of those springs-- those waters that do have a distinct medicinal value. And I thought, . . . in the section which is now 13, we could include some provisional clause along that line.

[afternoon]

RILEY: . . . this goes to the question raised by Mr. Taylor earlier today. He drew attention to the fact that the federal government reserves the disposition of hot springs. And some of us have talked with some of the federal land office people since that time, in an attempt to arrive at language as nearly like the federal reservation as possible, and this ["except mineral and medicinal waters"] is what we have offered. ■

It appears that the federal law to which the delegates were referring was Executive Order 5889 of July 7, 1930 and its subsequent amendment and regulations (Appendices 3-5). However, these orders and regulations effect a withdrawal and reservation of land and do not specifically give the federal government authority for the disposition of waters. As noted above, this issue was left for the courts to decide.

At the time of the Constitutional Convention in January of 1956, the Winters Doctrine was well established; and in the previous year, the Supreme Court had held, in the "Pelton Dam" case, that federal reserved water rights applied to any lands "withdrawn, reserved, or withheld from private appropriation and disposal under the public land laws."^{21/} Thus, the understanding of the delegates, that the law withdrawing lands containing hot springs included a reservation of the waters, was certainly well founded. However, the exemption of "mineral and medicinal waters" from the water appropriation clause in the Constitution is misleading in the following ways:

- 1) The phrase "mineral and medicinal waters" does not adequately describe what the delegates intended to exclude from the appropriation clause. Furthermore, this phrase is not defined either in the Constitution or in the Water Use Act where it is also used.
- 2) The exclusion of "mineral and medicinal waters" singles out one type of federal withdrawal (lands containing hot springs) for which the State acknowledges federal reserved water rights by Constitutional reference, whereas the Court has declared that the federal government maintains certain water rights on all withdrawals and reservations where they are needed.
- 3) The exclusion of "mineral and medicinal waters" could be interpreted to mean that the federal government reserves rights to all water associated with hot springs. However, the Supreme Court has held, in recent years, that federal reserved water rights apply only to the primary purposes for which the withdrawal was made.^{22/} Other water uses are subject to appropriation under state law, a fact acknowledged by the Court, federal regulations and a Department of the Interior Solicitor's Opinion.

These ambiguities could be clarified by amending the Water Use Act to define "mineral and medicinal waters" to mean waters of a hot spring or spring with curative properties, that is reserved by the federal government under PLO 399 and Executive Order 5389. This would not resolve the disparity caused by a Constitutional reference to one type of federal reserved water right and not to others; however, it would certainly help explain the intent of delegates to the Constitutional Convention and would clarify the State's role with respect to water management on land containing hot springs.

^{21/} 349 U. S. 435 (1955).

^{22/} United States v. New Mexico, 98 S. Ct. 3212 (1978).

Hydrothermal Resources

Due to their close proximity to the surface, the thermal resources associated with hot springs are easily utilized. In addition to traditional uses for baths and spas, these resources have potential for a wide variety of other applications such as space heating, district heating, agriculture and aquaculture uses, food processing and small-scale electric power generation. In Alaska, hot springs have historically been used for bathing purposes; first by Native Alaskans and later by immigrants to the state. Homesteaders developed most of the privately owned lands containing hot springs as spas or resorts in the early 1900's; and in a few cases, also used thermal energy from these hot spring waters for space heating and agriculture purposes. The State of Alaska is currently engaged in a geothermal demonstration project at Pilgrim Hot Springs located about 50 miles north of Nome where 90°C. (194°F.) water has been encountered at a depth of 90 feet. The thermal resources at Pilgrim have the potential for supporting a large agriculture or aquaculture facility and some geologists believe they may even be capable of supplying a district heating system for the City of Nome.

The Act of March 3, 1925 (43 U.S.C. 971, Appendix 5A) was rather narrow in its scope, providing for leasing of federal lands containing hot springs for "bathhouses, hotels or other improvements for the accommodation of the public." However, a growing awareness of geothermal resource potential and advancement of geothermal technology to pursue it led to the enactment of the Geothermal Steam Act of 1970 (84 Stat. 1566). This federal law provides for leasing and utilization of geothermal resources on both the public domain and withdrawn lands. Lands containing hot springs withdrawn by Executive Order 5389 fall under its authority and may be leased for hydrothermal uses other than hotels and bathhouses. However, these uses would not be considered a primary purpose of the withdrawal.

Currently, two State laws could apply to hydrothermal development on federal or private lands containing hot springs in Alaska. The Oil and Gas Conservation Act provides that the Alaska Oil and Gas Commission may regulate drilling, producing and plugging of wells drilled to a specified depth when it is likely that a hazardous substance may be encountered (AS 31.05.030(g)). Recently, the Commission established that hot groundwater under pressure is hazardous. Also, any withdrawal of water from a groundwater source is subject to the Water Use Act. Even in the case of land withdrawn under Executive Order 5389, it appears (based on past Supreme Court decisions), that development of hydrothermal resources for anything other than bathhouses, hotels or other resort improvements would be subject to prior appropriation under the state Water Use Act, since such development would not be a primary purpose of the withdrawal. Furthermore, this type of development on federal land would require a lease under the Geothermal Steam Act, which states, "[n]othing in this act shall constitute an express or implied claim or denial on the part of the Federal Government as to its exemption from State water laws." (84 Stat. 1573, Sec. 22.). It is anticipated that the State Legislature will consider amendments to statutes affecting geothermal resources

management during the 1980 legislative session. The application of state laws to hydrothermal development on federal and private lands containing hot springs could be affected by such legislation.

Conclusions

Based on the above discussion and citations pursuant to questions set forth in the Introduction, I have reached the following conclusions concerning the management of land, water and hydrothermal resources associated with hot springs in Alaska.

Land Management:

- Federal laws (summarized in the Table on page 4) have withdrawn and reserved vacant, unappropriated land in the state surrounding all hot springs which were in existence prior to October 21, 1976 and which were not within a national forest. This land is reserved for leasing for bathhouses, hotels or other improvements for the accommodation of the public. Land containing hot springs which is within a national forest is neither withdrawn nor reserved for such purpose and may be able to be selected under the forest selections process.
- Land containing hot springs which was occupied, appropriated or otherwise reserved prior to March 28, 1911 may be in private ownership. Otherwise, land in Alaska surrounding hot springs is in federal ownership.

Water Management:

- On federal withdrawals containing hot springs, the federal government maintains reserved rights to an amount of water needed for bathhouses, hotels or other improvements for the accommodation of the public. All other surface and subsurface water is subject to state jurisdiction under the Water Use Act.
- The effect of the reserved water right is that when water is eventually put to use for the purpose specified in the federal withdrawal, water rights for that purpose are superior to rights granted by the State after the date of the federal withdrawal. Water reserved for the federal purpose is not subject to the state Water Use Act.
- The phrase "mineral and medicinal waters" as used in the Alaska Constitution means waters of a hot spring or spring with curative properties, that are reserved by the federal government under PLO 399 and Executive Order 5389. The State Constitutional Convention excluded these waters from appropriation under state law in deference to the federal reserved rights which pertain to them. This exclusion affects only an amount of water needed to fulfill the primary purpose of the withdrawal. All other water is subject to the Water Use Act.

Hydrothermal Resources Management:

- There is great potential for the use of hydrothermal resources associated with hot springs in Alaska including applications to

space heating, district heating, agriculture and aquaculture uses, food processing and small-scale electric power generation.

- Federal withdrawals containing hot springs may be leased under provisions of the Act of March 3, 1925 for bathhouses, hotels or other improvements for the accommodation of the public. Withdrawn land and land in the public domain may be leased for geothermal development under provisions of the federal Geothermal Steam Act of 1970.
- State statutes which could affect hydrothermal development on federal or private lands containing hot springs include the Oil and Gas Conservation Act (AS 31.05) and the Water Use Act (AS 46.15). The Oil and Gas Conservation Act regulates development for safety and resource conservation purposes. The Water Use Act provides for determination and adjudication of rights in the waters of the state; and for water appropriation and distribution. The application of state statutes to hydrothermal development may be affected by a pending proposal for amendments to statutes affecting geothermal resources development in Alaska.

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APPENDICES

APPENDIX 1

(COPY)

DEPARTMENT OF THE INTERIOR

WASHINGTON

March 27, 1911.

Sir:

The Commissioner of the General Land Office has called to my attention the fact that there are a number of hot springs and other springs in the District of Alaska, the waters of which possess curative medicinal properties and suggest that the public interest, particularly that of the natives of Alaska, would be served by the withdrawal of the lands containing such springs from disposition pending the consideration by Congress of some measure providing for their use.

Under existing laws, lands containing mineral springs, not of a saline character, are subject to sale under the general land laws applicable to Alaska with the exception of the acts relating to the sale of mineral lands.

I concur in the opinion of the Commissioner with respect to public lands containing these springs and have the honor to submit with favorable recommendation an order of withdrawal.

Very respectfully,

(Sgd) Walter L. Fisher,

Secretary

E.C.F.

(1324½)
ORDER OF WITHDRAWAL.

It is hereby ordered that the following described lands be, and the same are, hereby withdrawn from settlement, location, sale, or entry and reserved for public purposes; to wit, to enable Congress to consider legislation providing for the use of medicinal springs in the public lands in the District of Alaska, subject to all the provisions, limitations, exceptions, and conditions contained in the Act of Congress entitled, "An Act to authorize the President of the United States to make withdrawals of public lands in certain cases," approved June 25, 1910.

All tracts of public lands in the District of Alaska upon which hot springs, or other springs, the waters of which possess curative medicinal properties, are located, to the extent of 160 acres surrounding each spring, in rectangular form with side and end lines equidistant, as near as may be, from such spring or group of springs.

(Signed) W.H.Taft

President.

Referred to the Commissioner
of the General Land Office for
appropriate action.

March 28, 1911.

(Signed) WALTER L. FISHER

Secretary of the Interior.

Executive Order

ALASKA

Under authority of the Act of Congress entitled "An Act To Authorize the President of the United States to make withdrawals of public lands in certain cases," approved June 25, 1910 (36 Stat., 817), as amended by the Act of August 24, 1912 (37 Stat., 497), it is hereby ordered that the Executive Order dated March 28, 1911, withdrawing "all tracts of public lands in the District of Alaska upon which hot springs, or other springs, the waters of which possess curative medicinal properties, are located, to the extent of 160 acres surrounding each spring, in rectangular form with side and end lines equidistant, as near as may be, from such spring or group of springs," be revoked so far as it applies to lands within National Forests.

WOODROW WILSON

THE WHITE HOUSE,

24 January, 1914.

[No. 1883.]

APPENDIX 3

[Public Land Order 389]
UNITED STATES AND ALASKA

REVOCATION OF EXECUTIVE ORDER 13844,
WITHDRAWING PUBLIC LANDS CONTAINING
HOT OR MEDICINAL SPRINGS IN ALASKA AND
AMENDING EXECUTIVE ORDER 9389 WITH-
DRAWING SUCH LANDS IN UNITED STATES

By virtue of the authority contained in section 1 of the act of June 25, 1910, c. 421, 36 Stat. 847 (U. S. C., Title 43, sec. 141), and pursuant to Executive Order No. 9337 of April 24, 1943, it is ordered as follows:

Executive Order No. 13244 of March 30, 1911, withdrawing certain public lands in the Territory of Alaska containing hot or medicinal springs, as amended by Executive Order No. 1883 of January 24, 1914, is hereby revoked; and Executive Order No. 5352 of July 7, 1930, withdrawing certain public lands containing hot or medicinal springs, exclusive of such lands in Alaska, is amended by deleting therefrom the words "exclusive of Alaska", so that the said order shall apply to lands containing hot or medicinal springs in both Alaska and the United States. Executive Order No. 5389, as herein amended, shall not apply to lands within National Forests.

This order shall not otherwise become effective to change the status of the surveyed or unsurveyed public lands in Alaska released from withdrawal by this order until 10:00 a. m. on October 22, 1947. At that time, subject to valid existing rights and the provisions of existing withdrawals, the unsurveyed lands shall become subject to settlement and other forms of appropriation in accordance with applicable laws and regulations, but the surveyed lands shall become subject to application, petition, location, or selection as follows:

(a) *Ninety-day period for preference-right filings.* For a period of 90 days from October 22, 1947, to January 20, 1948, inclusive, the surveyed public lands in Alaska released from withdrawal by this order shall be subject to (1) application under the homestead laws, or the small tract act of June 1, 1938 (52 Stat. 609, 43 U. S. C. sec. 632a), as amended, by qualified veterans of World War II, for whose service recognition is granted by the act of September 27, 1944 (58 Stat. 734, 43 U. S. C. secs. 278-283), subject to the requirements of applicable law, and (2) application under any applicable public-land law, based on prior existing valid settlement rights and preference rights conferred by existing laws or equitable claims subject to allowances and confirmation. Applications by such veterans shall be subject to claims of the classes described in subdivision (2).

(b) *Twenty-day advance period for simultaneous preference-right filings.* For a period of 20 days from October 2, 1947 to October 21, 1947, inclusive, such veterans and persons claiming preference rights superior to those of such veterans, may present their applications, and all such applications, together with those presented at 10:00 a. m. on October 22, 1947, shall be treated as simultaneously filed.

(c) *Date for non-preference right filings authorized by the public-land laws.* Commencing at 10:00 a. m. on January 21, 1948, any of the lands remaining unappropriated shall become subject to such application, petition, location, or selection by the public generally as may be authorized by the public-land laws.

(d) *Twenty-day advance period for simultaneous non-preference right filings.* Applications by the general public may be presented during the 20-day period from January 1, 1948, to January 20, 1948, inclusive, and all such applications, together with those presented at 10:00 a. m. on January 21, 1948, shall be treated as simultaneously filed.

Veterans shall accompany their applications with certified copies of their certificates of discharge, or other satisfactory evidence of their military or naval service. Persons asserting preference rights, through settlement or otherwise, and those having equitable claims, shall accompany their applications by duly corroborated affidavits in support thereof, setting forth in detail all facts relevant to their claims.

Applications for these lands, which shall be filed in the proper district land office in Alaska shall be acted upon in accordance with the regulations contained in § 253.8 of Title 43 of the Code of Federal Regulations (Circular No. 324, May 22, 1916, 43 L. D. 234), to the extent that such regulations are applicable. Applications under the homestead laws shall be governed by the regulations contained in Part 65 of Title 43 of the Code of Federal Regulations and applications under the small tract act of June 1, 1938, shall be governed by the regulations contained in Part 257 of that title.

Inquiries concerning these lands shall be addressed to the proper district land office in Alaska.

The lands released from withdrawal by this order and for which applications may be filed as stated above are described as follows:

All surveyed public land in Alaska containing hot springs, or other springs the waters of which possess curative medicinal properties, to the extent of 160 acres surrounding each spring, in rectangular form with side and end lines equidistant, as near as may be, from such spring or group of springs, not including, however, any existent legal subdivision of the public land surveys which contains a hot spring, or a spring the waters of which possess curative properties.

C. GRASB DANIELSON,
Assistant Secretary of the Interior.

August 20, 1947.

(P. S. Dns. 67-8007; Filed Aug. 27, 1947;

Executive Order

Withdrawal of Public Lands Containing Medicinal Springs

United States

Under authority of the act of Congress approved June 25, 1910 (36 Stat. 847), as amended by the act of August 24, 1912 (37 Stat. 497), it is hereby ordered that every smallest legal subdivision of the public land surveys which is vacant unappropriated unreserved public land and contains a hot spring, or a spring the waters of which possess curative properties; and all land within one-quarter of a mile of every such spring located on unsurveyed public land, ~~exclusive of Alaska~~, be, and the same is hereby, withdrawn from settlement, location, sale, or entry, and reserved for lease under the provisions of the act of March 3, 1925 (43 Stat. 1133), subject to valid existing rights.

This order shall remain in full force and effect unless and until revoked by the President or by act of Congress.

HERBERT HOOVER

THE WHITE HOUSE,

July 7, 1930.

[No. 5389]

APPENDIX 5A

43 § 971

PUBLIC LANDS

Ch. 22

Title 15, the right of way granted in sections 966-970 of this title shall be forfeited without further action or declaration on the part of the Government or any proceedings or judgment of any court. Apr. 12, 1910, c. 155, § 5, 36 Stat. 296.

§ 971. Bathhouses, hotels, etc., adjacent to mineral, medicinal, etc., springs on public lands

The Secretary of the Interior, upon such terms and under such regulations as he may deem proper, may permit responsible persons or associations to use and occupy, for the erection of bathhouses, hotels, or other improvements for the accommodation of the public, suitable spaces or tracts of land near or adjacent to mineral, medicinal, or other springs which are located upon unreserved public lands or public lands which have been withdrawn for the protection of such springs: Provided, That permits or leases hereunder shall be for periods not exceeding twenty years. Mar. 8, 1926, c. 458, 43 Stat. 1133.

CHAPTER 23.—GRANTS OF SWAMP AND OVERFLOWED LANDS

Sec.

- 981. Indemnity to States on sale of lands.
- 982. Grant to States to aid in construction of levees and drains.
- 983. Lists and plats of lands, for governors of States.
- 984. Legal subdivisions mostly wet and unfit for cultivation.
- 985. Patents to prior purchasers and locators.
- 986. Selection of lands confirmed.
- 987. Lands to be certified to State of California within one year.
- 988. Act extended to Minnesota and Oregon.
- 989. Homestead entries by purchasers from Missouri of lands declared not to be swamp lands.
- 990. Grant to Missouri.
- 991. Title of purchasers of unconfirmed lands in Arkansas confirmed.
- 992. Sale of erroneously designated water-covered areas in Arkansas.
- 993. Sale of lands in Louisiana; preference rights; application for purchase; appraisal; payment for land.
- 994. Sale of lands in Wisconsin.

§ 981. Indemnity to States on sale of lands

Upon proof by the authorized agent of the State, before the Director of the Bureau of Land Management that any of the lands purchased by any person from the United States, prior to March 2, 1855, were "swamp lands," within the true intent and meaning of the Act

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§ 2311.0-3

1902 (32 Stat. 388; 43 U.S.C. 372 et seq.), respectively.

(3) With respect to mineral lands, the said orders do not prevent prospecting, locating, developing, mining, entering, leasing, or patenting of the withdrawn lands, under the provisions of the applicable mineral or mineral leasing laws.

§ 2300.0-5 Definitions.

As used in §§ 2351.1 to 2351.6, and 2357.1, the term "withdrawal or reservation" means "withdrawal, reservation, or restriction" and "land" includes both land and water areas.

**PART 2310—WITHDRAWALS—
BUREAU OF LAND MANAGEMENT**

Subpart 2311—Public Water Reserves

Sec.

2311.0-3 Authority.

2311.0-8 Lands subject to withdrawal

2311.1 Selections, filings, or entries.

2311.2 Application to select or enter lands.

2311.3 Use of lands withdrawn as public water reserves.

2311.4 Leasing of public lands near or adjacent to springs, for bath houses, hotels or other improvements.

Subpart 2313—Stock Driveways

2313.0-3 Authority.

2313.1 Application for stock-driveway withdrawal.

Subpart 2317—Public Aviation Fields

2317.0-3 Authority.

2317.0-7 Cross references.

2317.1 Procedures.

Subpart 2311—Public Water Reserves

Authority: Sec. 11, 39 Stat. 868; 43 U.S.C. 361, unless otherwise noted.

Source: 35 FR 8552, June 13, 1970, unless otherwise noted.

§ 2311.0-3 Authority.

(a)(1) Withdrawal of lands from settlement, location, sale, or entry; reservation for public use. By executive order of April 17, 1926, it was ordered that every smallest legal subdivision of the public-land surveys which is vacant, unappropriated, unreserved, public land and contains a spring or

water hole, and all land within one quarter of a mile of every spring or water hole located on unsurveyed public land be, and the same is hereby, withdrawn from settlement, location, sale, or entry, and reserved for public use in accordance with the provisions of section 10 of the act of December 29, 1916 (39 Stat. 868; 43 U.S.C. 300), and in aid of pending legislation.

(2) Purpose of withdrawal. The Executive order of April 17, 1926, was designed to preserve for general public use and benefit unreserved public lands containing water holes or other bodies of water needed or used by the public for watering purposes. It is not therefore to be construed as applying to or reserving from homestead or other entry lands having small springs or water holes affording only enough water for the use of one family and its domestic animals. It withdraws those springs and water holes capable of providing enough water for general use for watering purposes.

(b) Withdrawal of land from settlement, location, sale, or entry; reservation for lease. (1) By E.O. 5389, July 7, 1930, as amended by P.L.O. 309 of August 20, 1947, it was ordered "that every smallest legal subdivision of the public land surveys which is vacant, unappropriated, unreserved public land and contains a hot spring or a spring the waters of which possess curative properties; and all land within one-quarter of a mile of every such spring located on unsurveyed public land be, and the same is hereby, withdrawn from settlement, location, sale, or entry, and reserved for lease under the provisions of the act of March 3, 1925 (43 Stat. 1133), subject to valid existing rights."

(2) Purpose of withdrawal. The Executive order mentioned in paragraph (b)(1) of this section was designed to preserve for general public use and benefit the unreserved public lands containing hot springs or springs the waters of which possess curative properties, in order that they might be leased under the provisions of the act of March 3, 1925 (43 Stat. 1133; 43 U.S.C. 711), and the regulations issued thereunder contained in 43 CFR 1.4.

§ 2311.0-8

§ 2311.0-8 Lands subject to withdrawal.

(a) Lands not needed or used by the public for watering purposes. (1) The object of the Executive order of April 17, 1926, was to:

• • • preserve for general public use and benefit unreserved public lands containing water holes or other bodies of water needed or used by the public for watering purposes.

(2) In the States of Alabama, Arkansas, Florida, Louisiana, Michigan, Minnesota, Missouri, Mississippi, and Wisconsin the springs or water holes, if any, on the public lands are not needed or used by the public for watering purposes. The conditions in those States are entirely different from those in the other public-land States where grazing is carried on to a considerable extent and not only springs and water holes but other available sources of water supply are sometimes quite scarce. There are no lands in the States mentioned that come within the purview of the Executive order of April 17, 1926. Therefore, a nonwater hole and nonspring statement is not required in connection with applications for lands in such States. Neither will such statement be required in connection with applications for lands in Federal reclamation projects.

(3) By E.O. 5108 of May 4, 1929, Alaska was excluded from the public water reserve created by E.O. of April 17, 1926.

§ 2311.1 Selections, filings, or entries.

(a) It must be shown by a duly corroborated statement in connection with every selection, filing, or entry made upon or subsequent to the date of Executive order of April 17, 1926, or theretofore filed but not allowed, that no spring or water hole exists, if it be a fact, upon any legal subdivision of the land sought to be appropriated, if surveyed, and if unsurveyed, within one-quarter of a mile from the exterior boundaries of said land. If there be any spring or water hole the showing should state the exact location and size thereof, together with an estimate of the quantity of water in gallons which it is capable of producing daily, and any other information necessary

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to determine whether or not it is valuable or necessary as a public water reserve.

(b) The showing mentioned will not be required in connection with proposed State exchanges or indemnity school and other State selections, involving public lands in grazing districts where agreements as to the exchanges or selections have been reached by representatives of the State, and the Bureau of Land Management.

(c) Where orders of designation under the said acts contain the quoted paragraph in paragraph § 2311.0-8(a) of this section, it will not be necessary for an entryman to make the showing required by §§ 2311.1(a) and (b) of this section.

(d) *Application of order of withdrawal to specified cases.* (1) In case the attempted appropriation of the land is one the allowance of which is within the discretion of the Secretary of the Interior or the Bureau of Land Management, the showing required by § 2311.1(a) of this subpart must be furnished, irrespective of the date of filing of the application, entry, or selection, before favorable action is taken thereon.

(2) This requirement shall not apply, however, to selections or filings made in pursuance of grants which have been determined to be "grants in present," and to have attached and become effective prior to April 17, 1926.

(3) Geological Survey designation lists, under the Enlarged Homestead Act will contain a paragraph that:

This area contains no springs or water holes of the type intended to be withdrawn by Executive order of April 17, 1926, creating public water reserve No. 107, and, therefore, is unaffected by it.

§ 2311.2 Application to select or enter lands.

(a) Showing as to hot or medicinal springs required with applications to enter or select permission to use lands. (1) An applicant to enter or select lands situated outside of a national forest in any State must show that no hot spring or other spring having waters possessing curative

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properties exists. If it be a fact, upon any legal subdivision of land sought to be appropriated, if surveyed, and if unsurveyed, that no portion of the land applied for is within an area of one-quarter of a mile from such spring.

(2) If there be any such spring upon or adjacent to the land as stated, the applicant must show the exact location and size thereof, together with an estimate of the quantity of water in gallons which it is capable of producing daily and any other information necessary to determine whether or not it is valuable or necessary within the meaning of said Executive order. The showing must be duly corroborated.

(3) Permission may be obtained to use or improve lands containing such springs under the said act of March 3, 1925.

(4) The showing mentioned will not be required in connection with proposed State exchanges or indemnity school and other State selections involving public lands in grazing districts, where agreements as to the exchanges or selections have been reached by representatives of the States and the Bureau of Land Management.

(5) Application of order of withdrawal to specific cases. (a) In case the attempted appropriation of lands is one of the allowance of which is within the discretion of the Secretary of the Interior or the Bureau of Land Management, the showing referred to in paragraph (1) of this section must be furnished irrespective of the date of filing of the application, entry, or selection before favorable action is taken thereunder.

(2) Geological Survey designation lists, under the Enlarged Homestead Act, will contain a paragraph stating:

This area contains no spring of the type intended to be withdrawn by Executive order of July 7, 1930, No. 5389, and therefore is unaffected by it.

(3) Where orders of designation under the Enlarged Homestead Act contain the above-quoted paragraph, it will not be necessary for entrymen to make the showing required by paragraph (1) of this section.

(4) Also in cases of applications or entries for lands within Federal reclamation projects, where a report is

made by the Bureau of Reclamation that the lands contain no spring of the type intended to be withdrawn by E.O. 5389, July 7, 1930, it will not be necessary for the claimant to make the showing required by paragraph (1) of this section.

(R.S. 2476; 43 U.S.C. 1201)

§ 2311.3 Use of lands withdrawn as public water reserves.

(a) Authority; governing regulations. Permission may be obtained to use or improve lands withdrawn as or in connection with public water reserves, under the act of June 25, 1910 (36 Stat. 847; 43 U.S.C. 141-143, 16 U.S.C. 471), or any other act, by filing application for such permission under the act of February 15, 1901 (31 Stat. 790; 43 U.S.C. 959), in accordance with the regulations governing said act, as found in Parts 2850, 2860, and 2870 of this chapter, as supplemented by this section.

(b) Who may make application; form and contents. (1) Any citizen, or association of citizens of the United States, or any corporation, duly created and existing under and by virtue of the laws of any State of the United States, who may desire to improve the productivity of any water hole or source of water supply within the boundaries of any public water reserve, or to conduct such waters from their source within such a reserve to a point of discharge more convenient for public use, may file in the proper office for the district, within which the reservation is situated, an application for permission so as to use the reserved land, or conduct the waters over or through the same.

(2) Such application should be in the form of a statement, duly corroborated by at least two persons, setting forth in detail the plan of the applicant for the improvement and care of the public water reserve, the public necessity for such improvement, the reasons why such plan will be more conducive to the public good and better conserve the waters for public use, and any other facts and circumstances pertinent thereto.

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(c) *Map and field notes required when water is to be conducted outside of the reserve.* If the waters are to be conducted from their source within the reserve to a point outside of the reserve, the application should be accompanied by a map and separate field notes in duplicate, the map being delineated upon tracing linen, and prepared in accordance with the regulations governing the submission of applications under the act of February 15, 1901, also evidence that applicant has applied to the proper State official for permission to appropriate the waters to the uses contemplated and has prosecuted such application in good faith to date of the filing of the application.

(d) *When reservoir declaratory statement may be required.* If the place of use of the water is upon unreserved public land the applicant may be called upon to file a reservoir declaratory statement under the act of January 13, 1897 (29 Stat. 484; 43 U.S.C. 952-955), as well as the application under the act of February 15, 1901, if deemed advisable.

(e) *Stipulations and agreements required.* As a condition precedent to the granting of any such permission, the applicant will be required to execute such stipulations and agreements as may be deemed proper and necessary by the authorizing officer of the proper office, to safeguard the public interests, after investigation of the facts, circumstances, and conditions in connection with each individual case.

(f) *Conditions of permit; failure to comply with the same.* (1) Each permit shall contain, besides those found necessary in individual cases, the following conditions:

(i) That the right to appropriate the waters of the State to the uses contemplated shall be obtained within 1 year from and after the issuance of the permit and the permittee shall file a certificate to that effect issued by the proper State authority.

(ii) That the proposed system shall be fully completed in substantial conformity with the plan upon which the permit is predicated, within 2 years from and after the issuance of such permit, unless a different period is

specifically provided for in such permit.

(iii) That of the permittee shall, during the month of January, in each year after the completion of such system, file with the authorizing officer of the proper office within which the system is located, a statement of maintenance, in substantially the following form: _____

(Name) of _____ (Address), states that he is the President of the _____ company (or person) to whom permit (give land district and serial number), was issued by _____, (give date), in connection with public water reserve No. _____ that the system as set forth and described in said permit has been kept in repair and water sufficient for the public needs has been kept therein during the whole of the calendar year of 19____, that the same has been kept open to the public at all times during the year, and that the said permittee has in all things, complied with the provisions of said permit, and the stipulations therein contained and the acts under which said permit was issued.

(Signature) _____

(Date) _____

(2) In the event that the State certificate as to the right to appropriate the water is not filed within 1 year, or proof of the construction of the system, consisting of the statement of the permittee duly corroborated by two witnesses within 2 years or such other period as may be mentioned in the permit, or statement of maintenance is not filed as hereinbefore provided or in case any of the terms, conditions, provisions, or stipulations of the permit shall not be well and in good faith performed, observed, and carried out, then such permit shall become and be subject to cancellation. Nothing hereinbefore contained, however, is to be construed as limiting the power or authority of the authorizing officer to cancel and terminate the permit at any time when in his judgment such action is desirable.

Chapter II—Bureau of Land Management

§ 2311.4

(3) Permits issued hereunder are transferable only upon the written authority and consent of the authorizing officer.

(g) *Changes in system or new structures may be authorized.* If, at any time, it becomes necessary for the permittee to change his system or to erect structures other than those authorized by his permit, application for permission so to do, in the form of a statement setting forth in detail the reason and necessity for the change must be filed, and no such change shall be made until authorized in writing by the authorizing officer.

(R.S. 2478; 43 U.S.C. 1201)

§ 2311.1 Leasing of public lands near or adjacent to springs, for bath houses, hotels, or other improvements.

(a) *Statutory authority.* The act of March 3, 1925 (43 Stat. 1133; 43 U.S.C. 971) authorizes the issuance of leases for periods not exceeding 20 years of tracts of land near or adjacent to mineral, medicinal, or other springs located upon unreserved public lands or public lands withdrawn for the protection of such springs, for the erection of bath houses, hotels, or other improvements for the accommodation of the public. Leases may issue under the act to any responsible persons or associations, which words are construed to include private corporations and municipalities.

(b) *Lands which may be leased.* Leases may be issued for surveyed or unsurveyed unreserved public lands in the several States, situated near or adjacent to mineral, medicinal, or other springs, which are located upon unreserved public lands, and for public lands which have been withdrawn for the protection of such springs.

(c) *Form and contents of application.* An application for lease should be filed in duplicate in the proper office and should include the following:

- (1) Applicant's name and address.
- (2) If applicant is a private corporation, a certified copy of the articles of incorporation.
- (3) If applicant is a municipality, the law or charter and procedure taken by which the municipality has become a

legal body corporate. An application by a private corporation or municipality should show that it is legally qualified to take the lease requested and that the taking of such lease has been duly authorized by its governing body.

(4) An accurate description of the land desired. If the land is surveyed it should be described with reference to the public-land surveys. A lease may be granted for part of a legal subdivision or for more than one legal subdivision, in the discretion of the manager.

(5) The names and addresses of three persons to whom reference may be made as to applicant's reputation and business standing and as to his ability, both from a financial standpoint and otherwise, to carry out the contemplated project.

(6) The period of time for which the lease is desired, not to exceed 20 years, and the purpose for which the lease is sought, whether for the erection of a bathhouse, hotel, or other improvement for the accommodation of the public. It is important that the application should specify all purposes for which it is intended or desired to use the land, as a lease, if issued, will authorize the use of the land only for the purposes specified in the application, and its use for any other purpose will not be permitted. Thus, if an applicant for a hotel in addition to using the land for ordinary hotel purposes, wishes to operate a billiard hall or moving-picture theater, etc., on the land, that fact should be disclosed in the application.

(7) Details as to the proposed improvements, including the estimated cost of construction and of subsequent maintenance; also the time when construction work will begin and when it will be completed, if the proposed lease is granted.

(d) *Granting of lease is discretionary.* The granting of an application for lease is discretionary, and any application may be granted or denied in part or in its entirety as may appear to be warranted in the particular case.

(e) *Authority of the authorizing officer to regulate prices.* All leases issued under the act of March 3, 1925, will contain stipulations authorizing the

§ 2313.0-3

authorizing officer to fix the rates and prices for accommodations and services whenever this is deemed necessary. The charges which may be made may or may not be regulated by the authorizing officer as may be deemed proper in the particular case.

(43 Stat. 1133; 43 U.S.C. 971)

Subpart 2313—Stock Driveways

Source: 35 FR 9554, June 13, 1970, unless otherwise noted.

§ 2313.0-3 Authority.

The reservation of driveways for stock provided for in section 10 of the act of December 29, 1916 (39 Stat. 865; 43 U.S.C. 300) will be considered on application of parties interested on recommendation of other departments of the Government, or on the reports of agents of this Department. Lands withdrawn for driveways for stock or in connection with water holes can not thereafter be entered.

§ 2313.1 Application for stock-driveway withdrawal.

(a) Upon the receipt in the proper office of a duly executed application, in duplicate, for the withdrawal of public lands for a stock driveway by responsible parties in interest, the lands described therein shall be segregated from disposition temporarily, pending final action thereon by the Bureau of Land Management.

(b) Pending and during such temporary segregation, applications to enter or select any affected lands may be received and suspended.

(c) Lands withdrawn for driveways for stock or in connection with water holes are not subject to entry or disposition, and applications for the acquisition of lands so withdrawn will be rejected by the authorizing officer. Applications for the exchange of such lands, which show that they are filed pursuant to a program for the improvement of stock driveways, and applications to lease or use such lands under any appropriate public land law, until such time as they may be needed for the purposes of the withdrawal, and where the proposed use will not

Title 43—Public Lands: Interior

interfere with such purpose, will receive consideration.

Subpart 2317—Public Aviation Fields

Source: 35 FR 9554, June 13, 1970, unless otherwise noted.

§ 2317.0-3 Authority.

(a) The act of May 24, 1928 (45 Stat. 728; 49 U.S.C. 211), as amended, authorizes the Secretary of the Interior to withdraw lands for beacon lights and other air-navigation facilities, under such rules as he may prescribe.

(b) Under the authority given to the President by the act of June 25, 1910 (36 Stat. 847; 43 U.S.C. 141, 16 U.S.C. 471) to withdraw lands for public purposes, withdrawals may be made for beacon lights, emergency or intermediate landing fields, except terminal airports.

§ 2317.0-7 Cross references.

To the extent applicable, the procedures in Part 2350 of this chapter shall apply.

§ 2317.1 Procedures.

(a) Withdrawals under the act of May 24, 1928 (45 Stat. 728; 49 U.S.C. 211) may be made on motion of the Bureau of Land Management, or upon application of the Federal Aviation Agency or any other Federal agency, or the lease of a terminal airport or the applicant for such a lease.

(b) In addition to the requirements of Part 2350 of this chapter, all applications for withdrawal shall contain a statement by the authorized officer of the Federal Aviation Administration as to the need and feasibility of the facility for which the withdrawal is requested.

PART 2320—WITHDRAWALS FOR OTHER INTERIOR AGENCIES**Subpart 2322—Bureau of Reclamation**

Rev.

2322.0-3 Authority.

2322.0-5 Definitions.

2322.0-7 Cross references.

2322.1 Effect of withdrawals.

2322.1-1 Under first form.

APPENDIX 6
ALASKA CONSTITUTIONAL CONVENTION PROCEEDINGS

JAN. 18, 1956

PRESIDENT EGAN: What is your pleasure, Mr. Riley?

RILEY: Mr. President, I move its adoption.

PRESIDENT EGAN: Mr. Riley moves the adoption of the proposed amendment.

ROBERTSON: May we have it read again, please.

PRESIDENT EGAN: Will the Chief Clerk please read it again.

(The Chief Clerk read the proposed amendment again.)

PRESIDENT EGAN: Mr. Riley so moves. Do you ask unanimous consent, Mr. Riley?

RILEY: I do, Mr. President.

PRESIDENT EGAN: Mr. Riley asks unanimous consent for the adoption of the proposed amendment. Mr. Ralph Rivers.

R. RIVERS: I object, just for the moment, Mr. President. Would we not say "subordinate property rights" instead of "inferior"?

RILEY: Either would do, I would think. This is one proposed by a delegate and the Committee accepted it.

R. RIVERS: That could be referred to Style and Drafting. I will support that.

PRESIDENT EGAN: Is there objection to unanimous consent request for the adoption of the amendment? If there is no objection, the proposed amendment is ordered adopted. Are there other amendments to Section 17? Section 18? Mr. Taylor.



TAYLOR: Seventeen, Mr. President. I have a question regarding that particular section. It says the person should not be divested of his right to use of waters, except for a superior beneficial or public use. I was thinking about matters which have not been brought up by the Committee, and I brought it up today: the federal law provides that all hot springs or springs with proven medicinal value are reserved to the federal government, so people can have the beneficial use of those springs -- those waters that do have a distinct medicinal value. And I thought, possibly, in 17, or in the section which is now 13, we could include some provisional clause along that line.

PRESIDENT EGAN: Do you have an amendment, Mr. Taylor?

★ TAYLOR: I have no amendment right now. I just brought it up, that we might prepare an amendment after the dinner recess.

PRESIDENT EGAN: Mr. Ralph Rivers.

R. RIVERS: Mr. President, I have an amendment to Section 16, if I may have the privilege of backing up a bit. The new Section 16.

PRESIDENT EGAN: The Chief Clerk will please read the proposed amendment to the new Section 16.

CHIEF CLERK: "Line 13, page 6, delete the period after the word 'law' and add 'with just compensation'."

PRESIDENT EGAN: Mr. Ralph Rivers.

R. RIVERS: Mr. President, I move the adoption of the amendment. I might state that I talked to Mr. Riley and a couple of others on the Committee; I don't know whether I referred it to the Committee as a whole, but I talked to members of the Committee about it.

PRESIDENT EGAN: Mr. Ralph Rivers moves the adoption of the proposed amendment. Is there a second?

TAYLOR: Would you read it again?

KNIGHT: I'll second it.

PRESIDENT EGAN: Mr. Knight seconds the motion. Would the Chief Clerk please read the proposed amendment.

(The Chief Clerk read the amendment again.)

TAYLOR: I'd like to raise a point of inquiry. Do you think it would not be better if that were done only by operation of law "and with just compensation".

PRESIDENT EGAN: Mr. Ralph Rivers.

TAYLOR: Do you want a conjunction in there?

R. RIVERS: I don't care whether the "and" is in there or not. That would be for Style and Drafting. I'm not sure if "operation of law with just compensation". I think it's adequate with the "and". Mr. President and delegates, the reason I bring this up is that the very next section says "Proceedings in eminent domain may be undertaken for private ways of necessity to permit essential access for extraction or utilization of resources."

JAN. 18, 1956

PRESIDENT EGAN: That would be at the end of the line. Mr. Riley asks unanimous consent that the proposed amendment be adopted. Is there objection? Hearing no objection, it is so ordered. Are there other amendments from the Resources Committee?

CHIEF CLERK: "Page 5, line 14, strike 'nonmetallic'."

PRESIDENT EGAN: Mr. Riley.

RILEY: I ask unanimous consent, Mr. President, for the adoption of the amendment.

PRESIDENT EGAN: Mr. Riley asks unanimous consent for the adoption of the amendment. Is there objection? Hearing no objection, the proposed amendment is ordered adopted.

CHIEF CLERK: "Page 3, Section 8, line 13, strike lines 13 and 14, and insert in lieu thereof: 'selection of lands granted to the State by the United States and for the administration of the State public domain.'"

RILEY: Mr. President, I ask unanimous consent for the adoption of the amendment.

PRESIDENT EGAN: Mr. Riley asks unanimous consent for the adoption of the amendment. Would the Chief Clerk please read the amendment once more.

(The Chief Clerk read the proposed amendment again.)

PRESIDENT EGAN: Is there objection to the unanimous consent request for adoption of the amendment? If not, the proposed amendment is ordered adopted.

★ CHIEF CLERK: "Page 5, Section 13, line 20, after the word 'use' insert a comma, and add 'except mineral and medicinal waters'."

PRESIDENT EGAN: Mr. Riley.

RILEY: Mr. President, I ask unanimous consent for adoption of the amendment.

PRESIDENT EGAN: Mr. Riley asks unanimous consent for the adoption of the amendment. Is there objection?

COOPER: I object.

PRESIDENT EGAN: Objection is heard by Mr. Cooper.

COOPER: Just for a point of clarification -- "except mineral waters" -- what is that?

PRESIDENT EGAN: Mr. Riley.

RILEY: Mr. Cooper, this goes to the question raised by Mr. Taylor earlier today. He drew attention to the fact that the federal government reserves the disposition of hot springs. And some of us have talked with some of the federal land office people since that time, in an effort to arrive at language as nearly like the federal reservation as possible, and this is what we have offered.

PRESIDENT EGAN: Mr. Cooper.

COOPER: Mr. President, I'll have to ask further. The term "mineral waters" -- anyone living in this area certainly is well aware of the fact that there is plenty of mineral in this water; and, therefore, there could be a question at a future date.

PRESIDENT EGAN: Mr. Riley, do you have an explanation? Do you so move, Mr. Riley, for the adoption of the amendment?

RILEY: I have, yes.

PRESIDENT EGAN: Mr. Riley moves. Is there a second to the motion?

KNIGHT: I'll second it.

PRESIDENT EGAN: Mr. Knight seconds the motion. The question is open for discussion. The question is, "Shall the proposed amendment, as offered by the Committee on Resources, be adopted by the Convention?" All those in favor of adopting the proposed amendment will signify by saying "aye", all opposed, by saying "no". The "ayes" have it and the proposed amendment is ordered adopted. Are there other amendments?

CHIEF CLERK: No more committee amendments.

PRESIDENT EGAN: If not, then we will start with the second time around on the amending process.

KILCHER: Mr. President.

PRESIDENT EGAN: Mr. Kilcher.

KILCHER: Will this be the second reading?

PRESIDENT EGAN: Does the Committee desire a recess at this time, for the purpose of hearing any proposed amendments? Mr. Smith.

SMITH: I would like to ask if there are amendments to be offered?

JAN. 25, 1956

proposed amendment will signify by saying "aye"; all opposed, by saying "no". The "ayes" have it, and the proposed amendment is ordered adopted. Are there other proposed committee amendments?

CHIEF CLERK: "Page 4, lines 1 and 2, strike 'or interests therein'."

RILEY: Mr. President, I move the adoption of the amendment as read.

STEWART: I second the motion.

PRESIDENT EGAN: Mr. Riley moves the adoption of the amendment, seconded by Mr. Stewart. Mr. Riley.

RILEY: That is simply a redundancy. It appears in a subsection and it appears earlier on page 3 in the language qualifying the subsection.

PRESIDENT EGAN: Mr. Riley has moved, it has been seconded that the proposed amendment be adopted by the Convention. Mr. Hurley.

HURLEY: May I ask Mr. Riley again where it appears before that?

RILEY: On page 3, Mr. Hurley, on line 24.

PRESIDENT EGAN: Is there further discussion? If not, the question is, "Shall the proposed committee amendment be adopted by the Convention?" All those in favor of adopting the amendment will signify by saying "aye"; all opposed, by saying "no". The "ayes" have it and the proposed amendment is ordered adopted. Are there other committee amendments?

★ CHIEF CLERK: "Page 5, line 20 --"

RILEY: I would like to suggest to the Clerk that the word, "the" might help the sense of that amendment. Shall I read the amendment?

CHIEF CLERK: Yes, please.

PRESIDENT EGAN: Mr. Riley.

RILEY: On line 20, we had, by action of the Convention, inserted, "except mineral and medicinal waters". That particular insert should, under this amendment, follow the word "shall" instead of the word "use". It was adopted following the word "use", but in the judgment of the Committee it would better follow the word "shall" for clarity of meaning -- "except mineral and medicinal waters" inserted after the word "shall"

and set off by commas. I move its adoption.

PRESIDENT EGAN: Mr. Riley moves the adoption of the proposed amendment. Is there a second to the motion?

KNIGHT: I second it.

PRESIDENT EGAN: Mr. Knight seconds the motion. Mr. Taylor.

TAYLOR: I am not objecting; this is just for information. Mr. Riley, did your Committee, in considering this amendment as to mineral springs or mineral and medicinal waters--is that the definition as given in the Bureau of Land Management regulations?

RILEY: I would say that it is not full, but representatives of BLM in town, in Fairbanks that is, suggested to us that it would satisfy the point raised by you and others the other evening.

TAYLOR: That is right. I think that was my amendment and I wasn't sure whether that was as it was set forth.

RILEY: Yes, that is right. I am sorry I didn't check with you before.

PRESIDENT EGAN: Mr. Hellenenthal.

HELLENTHAL: Mr. Riley, I take it this is a matter of substance or we wouldn't be asked to pass on it.

RILEY: I would say it is a matter of substance.

HELLENTHAL: How is it a matter of substance?

RILEY: As I read it now, Mr. Hellenenthal, it states, "All waters reserved to the people for common use except mineral and medicinal waters..." which would suggest that mineral and medicinal waters may not be reserved to the people for common use; but, if it is read following the word "shall": "All waters reserved to the people for common use shall, except mineral and medicinal waters, be subject to appropriation." There is a prospect there of misunderstanding, we feel, of a substantive nature. The point of the whole sentence is that these waters with that exception shall be subject to appropriation. We don't want to suggest that all other waters except mineral and medicinal waters are subject to reservation. The reservation applies across the field.

HELLENTHAL: Style and Drafting can still work on it after this amendment?

RILEY: I am sure, but with this to clarify our meaning.



PRESIDENT EGAN: The question is, "Shall the proposed amendment be adopted by the Convention?" All those in favor of adopting the proposed amendment will signify by saying "aye"; all opposed, by saying "no". The "ayes" have it, and the proposed amendment is ordered adopted. Are there other committee amendments?

CHIEF CLERK: "Page 5, line 24, strike 'of' and substitute 'among'."

RILEY: Mr. President, I move the adoption of the amendment.

PRESIDENT EGAN: Mr. Riley moves the adoption of the amendment. Is there a second?

MARSTON: I second the motion.

PRESIDENT EGAN: Mr. Marston seconds the motion. Mr. Riley.

RILEY: The Committee feels that the substitution of the word "among" in that instance ties in more clearly with the concept of concurrent use. That, too, might have been a Style and Drafting change but we feel that it does touch on substantive matter.

PRESIDENT EGAN: The question is, "Shall the proposed amendment be adopted by the Convention? All those in favor of adopting the proposed amendment will signify by saying "aye"; all opposed, by saying "no". The "ayes" have it and the proposed amendment is ordered adopted. Are there other amendments?

CHIEF CLERK: "Transpose Sections 7 and 8, page 3."

PRESIDENT EGAN: Transpose Sections 7 and 8. Mr. Riley.

RILEY: Here, Mr. President, I would waive the motion to adopt, thinking it would serve the purpose to call the matter to the attention of Style and Drafting.

PRESIDENT EGAN: Are there other amendments for Committee Proposal No. 8/a?

R. RIVERS: May I address a question to Mr. Riley?

PRESIDENT EGAN: If there is no objection, Mr. Rivers.

R. RIVERS: Mr. Riley, I refer to page 3, first to line 7, which I have marked down as a new Section 8, and it speaks of "lands and interests therein". The same question applies to new Section 10 on line 24, "or interests therein", and I would like to know what that means: "or interests therein"?

RILEY: I should like to ask for a five-minute recess and

STATE OF ALASKA

OFFICE OF THE GOVERNOR

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ALASKA ENERGY OFFICE

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April 23, 1976

The Honorable Kathryn Ostrosky
State House of Representatives
Pouch V
Juneau, Alaska 99811

Dear Representative Ostrosky:

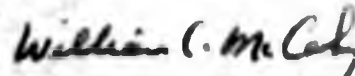
In July, 1975, the Energy Office and the Geophysical Institute of the University of Alaska co-sponsored a conference on the potential use of wind and geothermal power in Alaska. Over 250 people attended and participated. The National Science Foundation funded the convention and the report.

After the two day conference several working groups continued to work on analyzing these two alternative energy sources. Enclosed is a copy of the report of that conference and its working groups.

Alaska is blessed with alternative energy sources. Careful and planned use may well allow us to improve the standard of living for all Alaskans, protect our environment and provide for many of our energy requirements while still being the major domestic source for our nation's oil and gas needs.

I will be pleased and honored to answer any questions you might have concerning this document and energy research and development within Alaska.

Sincerest best wishes,



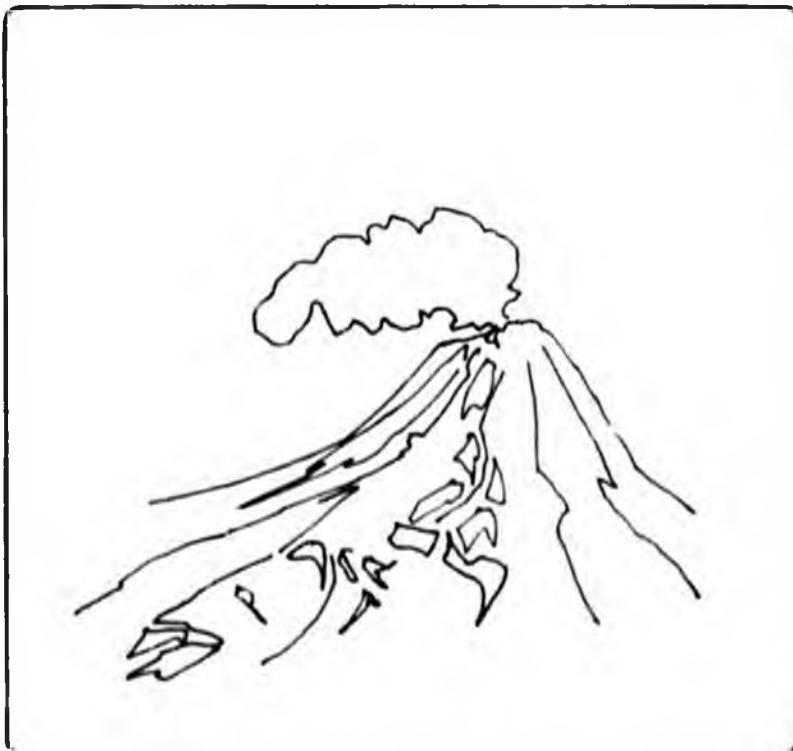
William C. McConkey
Director
Alaska State Energy Office
WMcC/mgf
Encl:

GEO THERMAL ENERGY AND WIND POWER . . .

ALTERNATE ENERGY SOURCES FOR ALASKA

Resource assessments and recommended plans and programs developed from the proceedings of the Alaskan Geothermal and Wind Power Resources Planning Conference, July 8-9, 1975; Anchorage, Alaska

EDITED BY
ROBERT B. FORBES

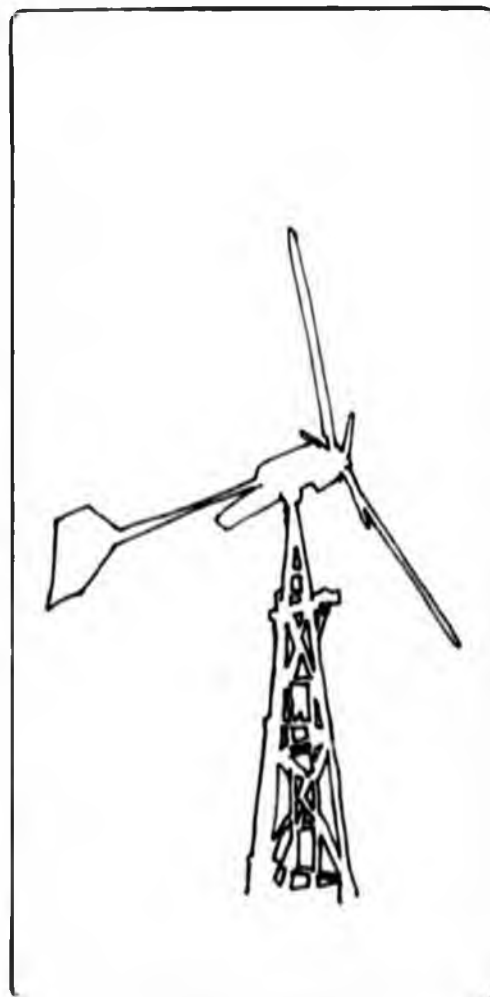


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and

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University of Alaska
College, Alaska

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April, 1976



GEOHERMAL AND WIND POWER...
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Recommended plans, policies and programs developed
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William McConkey, Director

Edited by Robert B. Forbes

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Grant FAER75-20207

The 1973 oil embargo by the OPEC (Oil Producing Export Countries) shocked the United States and its leaders and accentuated the seriousness of the nation's declining energy reserves. Project Independence, as initiated by Richard Nixon and reaffirmed by President Ford, was designed to achieve American "energy self-sufficiency" by 1980. However, our dependence on foreign oil imports has actually increased since the embargo was lifted. Crude oil imports during the first six months of 1975 were 24.5% above the same period in 1973. At the same time, domestic production of crude oil and lease condensate during the first half of 1975 decreased 5.2% from the same period in 1974.

Diminishing oil and gas reserves in the "Lower 48" states will result in the accelerated consumption of Alaskan oil and gas when these resources are developed and available for delivery. It is clear that Alaska and the nation must find and develop alternate energy sources as rapidly as possible.

Rising transportation and petroleum product costs, particularly in rural Alaska, accentuate the need for alternate energy sources. Preliminary surveys have indicated that the State of Alaska has many areas which have high wind power potential, as well as known geothermal resource areas.

On July 8 and 9, 1975, over 150 people, including scientists, state and federal government officials, and representatives from the private sector, attended the Alaska Geothermal and Wind Resources Planning Conference in Anchorage, Alaska (see Appendix B).

Objectives of the Conference were:

- (1) To review and evaluate the potential of geothermal and wind resources as alternative Alaskan energy sources,
- (2) To assemble a small and highly competent group of conferees, from Alaska and other states, to conduct an assessment as outlined in (1) above,
- (3) To encourage dialogue between potential Alaskan consumers, scientists and planners, with special attention to rural and native populations,
- (4) To develop short- and long-range plans and programs for the utilization of Alaskan geothermal and wind resources in harmony with national and international needs and priorities, and
- (5) To produce, publish and distribute a comprehensive report which summarizes the findings of the conferees on (1), (3) and (4) above.

Working groups were formed to define plans and programs in several areas including:

1. agriculture
2. electrical power
3. fisheries and aquaculture
4. geothermal resource research and development
5. space heating and industrial application
6. wind power development and applications

Conference data including the technical program, the list of attenders and working group assignments are contained in Appendices A, B and C.

This report attempts to define Alaskan energy problems which can be alleviated through the efficient use of wind power and geothermal resources, and to present recommended short- and long-range plans for the initiation of state and federal programs in the more promising areas.

The content of this report is based on input from Conference working groups and many published (acknowledged) and unpublished sources, including data from various state and federal agencies.

We are particularly grateful to the Geothermal Program Office, National Science Foundation, for a grant (NSF #AER75-20207), which helped defray Conference expenses and the publication costs of this report.

We hope that future accomplishments show that the Alaskan Geothermal and Wind Resources Planning Conference was a very important first step in the efficient and timely development of alternate energy resources in Alaska.

The Organizing Committee
Alaska Geothermal and Wind
Resources Planning Conference

ACKNOWLEDGMENTS

So many people have contributed so much to this report, that it is neither possible nor practical to personally acknowledge all of the contributors. However, I do wish to offer my special thanks to the following persons who played key roles in the organization of the Planning Conference and the completion of this report.

Mr. William Ogle, energy consultant to the Alaska Energy Office, contributed his expertise to many sections of this report; he was also one of the principal architects of the Planning Conference.

Mr. Tom Miller, of the U. S. Geological Survey, Anchorage, was a major contributor to the section on Alaska's Geothermal Potential; and much of the recent material on Alaskan geothermal and resource assessment has been derived from the work of Tom and his co-workers.

Ms. Clarissa Quinlan, of the Alaska Energy Office, helped prepare the section on Energy Economics and devoted weeks of her time to the organization and planning of the Conference.

My special gratitude to Mrs. Fran Pedersen, my secretary, who typed, assembled and indexed the manuscript and supervised the final compilation and publication of the report.

We are deeply grateful to the National Science Foundation for a grant which defrayed many of the costs associated with the Planning Conference and the preparation and publication of this report.

RBF

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ALASKA AND THE "ENERGY CRUNCH"

(R. B. Forbes and W. McConkey)

Socio-Economic Framework

Alaskan Economic Setting: When considering Alaskan energy problems, it is important to remember that Alaska may have more in common with the developing countries of Africa and Latin America than it does with the other forty-nine states. At first hearing, this sounds like an overstatement, but hard facts reinforce this comparison.

Alaska, the largest of the fifty states, has a land area which is equal to about one-fifth the total area of the continental United States. The Alaskan population is around 300,000. Alaska has only three communities (Anchorage, Fairbanks and Juneau) which could be classified as cities when compared to other states.

Over one-half of the Alaskan population lives in or immediately adjacent to these three cities. The residual population is scattered throughout the rest of the state in hundreds of towns, villages, and settlements. Very few of these outlying communities can be conveniently reached by any form of transportation other than air. Modern communications are often limited to a single radio facility located in a Bureau of Indian Affairs or state-operated school, or some other federal or state administrative facility. Traditionally, long transportation routes and high maintenance costs have made the Alaskan cost of living higher than that in other states. Rural communities are at the end of the "logistics pipeline" as emphasized by the cost of fuel oil, for example, which exceeds \$1 per gallon in many villages (Table 1).

The Alaskan economy tends to be resource oriented, and most of the revenue is derived from the export of raw materials to other states or

TABLE 1

Representative Fuel Prices in Rural Alaska

<u>VILLAGE</u>	<u>OIL/per GALLON</u>	<u>GAS/per GALLON</u>
ALAKANUK	\$1.00	\$1.00
AMBLER	.95	1.19
ARCTIC VILLAGE	2.10	2.20
BARROW	2.40	2.37
BEAVER	2.00	1.85
BETTLES	1.60	1.60
CHEVAK	.85	1.05
EMMONAK	.97	.82
FOOPER BAY	.93	1.27
KIANA	1.74	1.25
KIPNUK	.82	.91
KOTLICK	.80	1.00
NULATO	1.00	1.25
PILOT STATION	1.00	1.00
SHUNGNAK	.95	1.30

ALASKA STATE ENERGY OFFICE
November, 1975

countries where they are processed, marketed and consumed. Fish, timber, metals and petroleum comprise the major exports. Alaska's small population base, high operating costs and lack of local markets have discouraged resident processing and manufacturing.

Alaska shares the problems of underdeveloped countries which have become the economic domains of more highly industrialized nations. In common with such countries, a significant portion of Alaska's population (about 20%) lives in poverty. This segment of the population is dominated by Natives who exist, for the most part, in socio-economic limbo between traditional hunting and fishing economies and the complexities of 20th century civilization. The Native peoples account for a little over one-half of the state's rural population; and it is these Alaskans who suffer the most from the nation's economic problems and continuing inflation. Cross-cultural blocks and the lack of investment capital have left many villages with little cash income other than welfare checks. Few villagers are regularly employed, and if so, the jobs are usually government related. Generally speaking, the economic base of rural Alaska is that provided by federal and state support.

Consumer Prices Versus Income and Earnings: High Alaskan consumer prices have received worldwide attention, dating back to the days of the Klondike and Nome gold stampedes. It does indeed cost more to live in Alaska than elsewhere in the United States. A quotation from a recent report, "Consumer Prices, Personal Income and Earnings in Alaska," by the University of Alaska's Institute of Social, Economic and Government Research (Tussing and Thomas, 1974), summarizes the current economic differential:

"Almost everything costs more in Alaska than it does in the 'lower forty-eight.' How much more varies widely among places in the state, with the lowest differential occurring in the Anchorage area. The highest differentials occur in the northern and western regions, with costs there sometimes two or three times the national average. Alaska price differentials also vary by commodity. For instance, the costs of housing and all construction in Alaska exceed the U.S. average far more than the costs of such factory-manufactured or processed goods as automobiles, food, or clothing.

"Table 2 summarizes autumn 1973 family budget costs for three levels of living in Anchorage, relative to the U.S. urban average. Housing accounted for the largest part of the absolute difference between the Anchorage budget and the U.S. urban average: 39 percent of the difference between the budgets of the lower income families and 42 percent in the budgets of intermediate and higher income families.

"Living cost differentials between Alaska and other states are *steeply biased against low income families*. The total cost of a budget for higher income families in Anchorage in 1973 was 26 percent higher than its U.S. average urban counterpart, but the 'lower level' budget was 47 percent higher. Differentials are greatest in the lower income budget level in almost every expenditure category, but as previously stated, the most extreme contrasts are in housing costs. The Anchorage cost of housing for lower level income families was 92 percent higher than the national urban average, but only 45 percent higher for the higher income families."

Although Alaskans enjoy a 14% nominal income advantage over "average" United States residents, this advantage does not offset even the Anchorage cost of living differential (+31%) which is probably the lowest of any locality in the state of Alaska, based on the U.S.D.C. Consumer Price Index for 1974. If one compares the per capita income data in Table 2 with the market basket food costs and average annual food expenditures in Tables 3 and 4, respectively, it is painfully apparent that many seasonally-employed residents in rural Alaska communities are living at poverty levels.

TABLE 2

Per Capita Personal Income and Comparative Ratios for
Alaska and the United States, 1969 and 1972

	1969 Census	1972 BEA ^a	Ratio to State Total (Alaska=100)		Ratio to U.S. Total (U.S.=100)	
			1969 Census	1972 BEA	1969 Census	1972 BEA
Alutian Islands	\$3,317	\$8,354	88	162	106	186
Anchorage	4,747	5,582	113	109	135	124
Anchorage City	4,741		126		151	
Spennard	4,639		123		148	
Barrow	1,833	10,831	49	211	59	241
Bethel	1,336	2,456	35	48	43	55
Bristol Bay Division	1,637	3,753 ^b	97	73	116	84
Bristol Bay Borough	3,641		43		52	
Cordova-McCarthy	4,072	7,189	108	140	130	160
Fairbanks	3,932	5,606	106	109	127	125
Fairbanks City	5,049		134		161	
Haines	3,662	3,906	97	76	117	87
Juneau and Angoon		8,020 ^b		150		179
Angoon	516		14		16	
Juneau	5,053		134		161	
Kenai-Cook Inlet	3,806	4,197	101	82	121	93
Ketchikan	3,720	5,606	99	109	119	125
Kobuk	1,527	2,658	41	62	49	59
Kodiak	3,356	5,245	89	102	107	117
Kuskokwim	1,670	3,578	44	73	53	80
Matanuska-Susitna	2,894	4,051	77	79	92	90
Nome	1,937	3,300	53	64	63	73
Outer Ketchikan	2,634	3,091	70	72	84	82
Prince of Wales	4,036	7,470	108	145	129	165
Seiad	3,508	4,067	93	79	112	90
Sitka	3,899	5,673	104	110	124	126
Sligo-Wy - Yakutat	3,339	4,641	80	90	106	103
Southeast Fairbanks	3,250	3,913	86	76	108	87
Upper Yukon	3,963	4,848	105	90	126	103
Valdez-Chitina-Whittier	4,353	4,279	116	83	139	95
Wade Hampton	1,069	1,877	28	37	34	42
Wrangell-Petersburg	3,376	4,051	90	96	108	110
Yukon-Koyukuk	3,369	3,219	89	63	107	72
State Total	3,765	5,142	100	100	120	117
U.S. Total	3,169	4,492	83	87	100	100

^a Bureau of Economic Analysis

^b Because of symmetrical errors in source tables, BEA figures for "Bristol Bay" and "Juneau and Angoon" were estimated by interpolation between per capita income figures for adjacent census divisions, SMSA's or counties.

Source: U.S. Department of Commerce, Bureau of the Census, 1970 Census of Population, General Social and Economic Characteristics, Alaska and United States Summary, and Survey of Current Business, May 1974.

(Taken from Tussing and Thomas, 1974)

TABLE 3

Market Basket Food Costs^a in Selected Alaska Cities and Seattle, Washington, 1963-1974

	1963	1964	1965 ^b	1966	1967	1968	1969	1970	1971	1972	1973	1974 (March)	1974 (June)
Anchorage	\$22.67	\$22.68	\$20.80	\$22.26	\$22.03	\$22.00	\$23.05	\$22.97	\$24.32	\$25.03	\$23.43	\$34.32	\$34.04
Bethel	N/A	N/A	N/A	N/A	N/A	32.19	33.79	35.09	37.24	38.40	41.19	45.02	45.84
Fairbanks	25.26	25.13	23.34	24.45	23.99	24.44	25.82	26.35	26.71	27.01	30.83	35.55	35.57
Juneau	21.11	21.54	20.67	21.40	21.19	21.90	22.76	22.63	23.78	24.99	29.01	32.99	33.17
Kenai-Soldotna	N/A	N/A	N/A	N/A	N/A	23.42	24.36	24.32	25.01	26.47	30.53	33.90	37.09
Ketchikan	20.40	20.85	19.89	10.75	20.85	21.62	22.73	23.24	23.54	24.62	27.92	30.96	31.78
Kodiak	22.91	22.82	21.43	22.33	22.38	23.25	24.47	25.96	26.79	27.96	31.67	34.77	36.12
Nome	28.91	29.55	28.70	28.96	29.45	30.28	31.66	33.20	35.03	36.59	39.97	45.40	49.17
Palmer	21.85	21.85	21.14	21.91	21.23	21.65	23.13	23.65	24.21	24.89	28.60	33.03	34.53
Petersburg	21.12	21.40	21.24	22.02	22.17	23.01	24.03	24.29	25.43	27.11	30.92	33.79	35.83
Seward	22.50	22.25	21.77	22.36	21.94	23.05	24.08	24.73	25.44	26.80	31.57	36.41	37.75
Sitka	21.01	22.20	21.82	22.70	22.44	23.23	24.02	24.90	25.42	26.32	29.62	33.17	32.54
Valdez	N/A	N/A	N/A	24.60	24.50	25.31	26.67	28.42	28.52	29.03	34.02	33.49	39.17
Seattle	17.70	17.90	N/A	N/A	16.69	17.36	18.45	19.08	19.63	20.71	23.69	26.81	27.45

^aAt home food costs.^bChange in combination of forty-five food items used in market basket.

Source: "Retail Prices of 45 Food Items in Thirteen Alaska Cities," Palmer: Alaska Agricultural Experiment Station.

(Taken from Tussing and Thomas, 1974)

TABLE 4

Average Annual Food Expenditures for Twenty-four
Alaska Communities (October 1972 Survey)
and Comparisons with Anchorage Data

Alaska Community	Expenditures Per Household	% of Anchorage Food Expenditures Per Household	Expenditures Per Person	% of Anchorage Food Expenditures Per Person
Anchorage	\$2,907	100	\$ 971	100
Barrow	3,878	131	954	98
Bethel	4,156	140	950	98
Cold Bay	3,033	104	1,178	121
Cordova	3,175	107	1,006	104
Dillingham	4,420	149	1,319	136
Emmonak	3,103	105	601	62
Fairbanks	3,206	109	1,035	107
Fort Yukon	4,426	150	1,070	110
Haines	3,858	130	1,024	105
Juneau	2,879	97	920	95
Kenai	3,436	116	987	102
Ketchikan	3,625	122	731	75
Kodiak	3,862	130	1,163	120
Kotzebue	4,484	151	1,030	106
Nenana	4,129	139	1,214	125
Nome	3,406	115	902	93
Palmer	3,388	114	942	97
Seward	3,244	110	894	91
Sitka	4,150	140	1,145	118
Tanana	5,340	180	951	98
Valdez	3,369	114	1,193	123
Wrangell	2,653	90	884	91
Yakutat	4,255	144	1,324	136
Summary — All locations	3,185	108	978	101

Source: State of Alaska, Division of Personnel, *Survey of Salaries and Benefits, Housing and Food Costs and Salary Recommendations, Part III Housing and Food Costs*, December 1972

(Taken from Tussing and Thomas, 1974)

Rural Alaskan Economics: Although some villages owe their locations to aboriginal subsistence patterns involving fishing sites, caribou migration routes and various animal populations, others are situated according to more recent developments including gold camps, river transportation routes and airstrips. In some cases, the present location of settlements and villages reflects old patterns or activities which no longer exist; and in others, natural and/or man-made changes have created a hostile environment for village life.

Poverty is said to be a state of mind. Although both native and white rural Alaskans do not think of themselves in those terms, living conditions in most rural areas would be equated with poverty based on inadequate lighting, the lack of central heating or plumbing, and fresh fruits and vegetables. According to Tussing and Thomas (1974), the lowest per capita incomes were found in rural divisions with predominantly native populations (e.g., Angoon, Wade Hampton, Bethel, Kobuk).

Poverty in rural Alaska is related to high import costs and little or no local cash income. A dollar expended for a gallon of fuel oil or a head of lettuce leaves the village....never to return. Under current conditions, there is very little cash flow within the village communities.

Energy Problems in Villages and Remote Areas: To most Americans, the energy crisis is something new. To rural Alaskans, it is a way of life. Isolation, high transportation costs and unforgiving winters have equated energy conservation with survival. Inflation and the recent "energy crisis" have brought an added increment of economic hardship.

Heat is a precious commodity in the Alaskan arctic. All communities in the more isolated areas are forced to import expensive fossil fuels to maintain adequate communications and living standards. Most of the

fresh produce consumed by such villages is also imported. Electricity, where present, is generated by gasoline- or diesel-powered generators, resulting in an additional fossil fuel demand -- and a dependence on exterior supply.

The high cost of imported fossil fuels in the outlying communities restricts improvements and depresses the standard of living. The high cost of fresh and canned vegetables creates an additional economic stress on these communities and is a source of dietary problems in the more isolated populations during the winter.

Before any discussion of Alaska's geothermal and wind potential can be undertaken, it is necessary to address two important issues affecting the State's future. These are the Native Land Claims Settlement Act and the further development of Alaska's onshore and offshore oil and natural gas reserves.

The Alaska Native Claims Settlement Act: Stewart French (1972) has conducted an excellent analysis of the Native Claims Settlement Act. French's introductory statement introduces the reader to the social and economic impact of the Act on the peoples of Alaska:

"No event since the 1968 Prudhoe Bay oil discovery, and perhaps even Statehood in 1958, has had as great a potential social and economic impact on the people of Alaska--both Native and non-Native--as has the enactment of the Alaska Native Claims Settlement Act (Public Law 92-203, 85 Stat. 688). The Act is a complex legislative resolution of a 104-year old question and a source of conflict that have been bars to full achievement of the social and economic aspirations of Natives, non-Natives, and the State."

The Native Claims Settlement Act provides that the Native peoples of Alaska will receive:

- (1) legal title to 40 million acres of land together with mineral estate, plus nearly a billion dollars from federal appropriations and shared revenue from state and federal mineral leases;
- (2) membership in regional (profit) and village (profit or non-profit) stockholder corporations;
- (3) an Alaskan Native Fund, totaling \$462.5 million in federal monies, to be paid over 11 years; and \$500 million derived from 2% of the revenues acquired from mineral leases on state and federal lands.

Among many other benefits, new mechanisms and sources of support for village improvement will become available, including help from the respective regional corporations. The potential now exists for cooperative village development programs and economic experiments, as joint enterprises between native and federal and/or state agencies.

The Alaskan Native, represented through 12 regional native corporations and a multitude of village corporations, will become one of the largest landowners in the State along with the federal and state governments. The growth and development policies of these corporations will play key roles in shaping the State's future economic, environmental and social systems.

Petroleum Impact: Completion of the trans-Alaska oil pipeline, with an estimated total cost of over \$6.5 billion, is scheduled for July, 1977. Employing over 20,000 workers during peak construction periods, the pipeline is the largest privately-financed project in history.

The impact of this construction on Alaska's social, economic and governmental institutions has been considerable and may not be totally understood for several years to come. The very foundations of the State's economic structure are being altered by this first large-scale development of an Alaskan energy source. Routing of the natural gas

pipeline from the North Slope is another major issue which must be decided within the next year or so. If the trans-Canadian pipeline the next year or so. If the trans-Canadian pipeline is selected rather than the trans-Alaskan route, it is possible that the State will experience a significant slowdown in economic activity.

What lies ahead? By 1978 only two major oil fields (Cook Inlet and North Slope) containing an estimated 20 billion barrels of oil will be in a production mode; however, the recoverable petroleum reserves in Alaska total 76.1 billion barrels. Continuation of the "energy crisis" in the "lower forty-eight" and the depletion of other domestic petroleum resources over the next few years will most certainly mean additional exploration and development of Alaska's onshore and offshore oil and gas reserves. Needless to say, the impact of these activities on the State will be extensive.

ENERGY ECONOMICS

Statewide Requirements

The electric utilities operations in the State of Alaska bear little resemblance to the complex systems of the lower 48 states. Although Alaskan generation and transmission equipment is modern and efficient, the great distances between population centers prohibit grid system interties, and there is no long-range service to outlying rural communities. The Alaskan power scene is much like that which existed in the United States before the rural electrification drive which took place in the early 1930's.

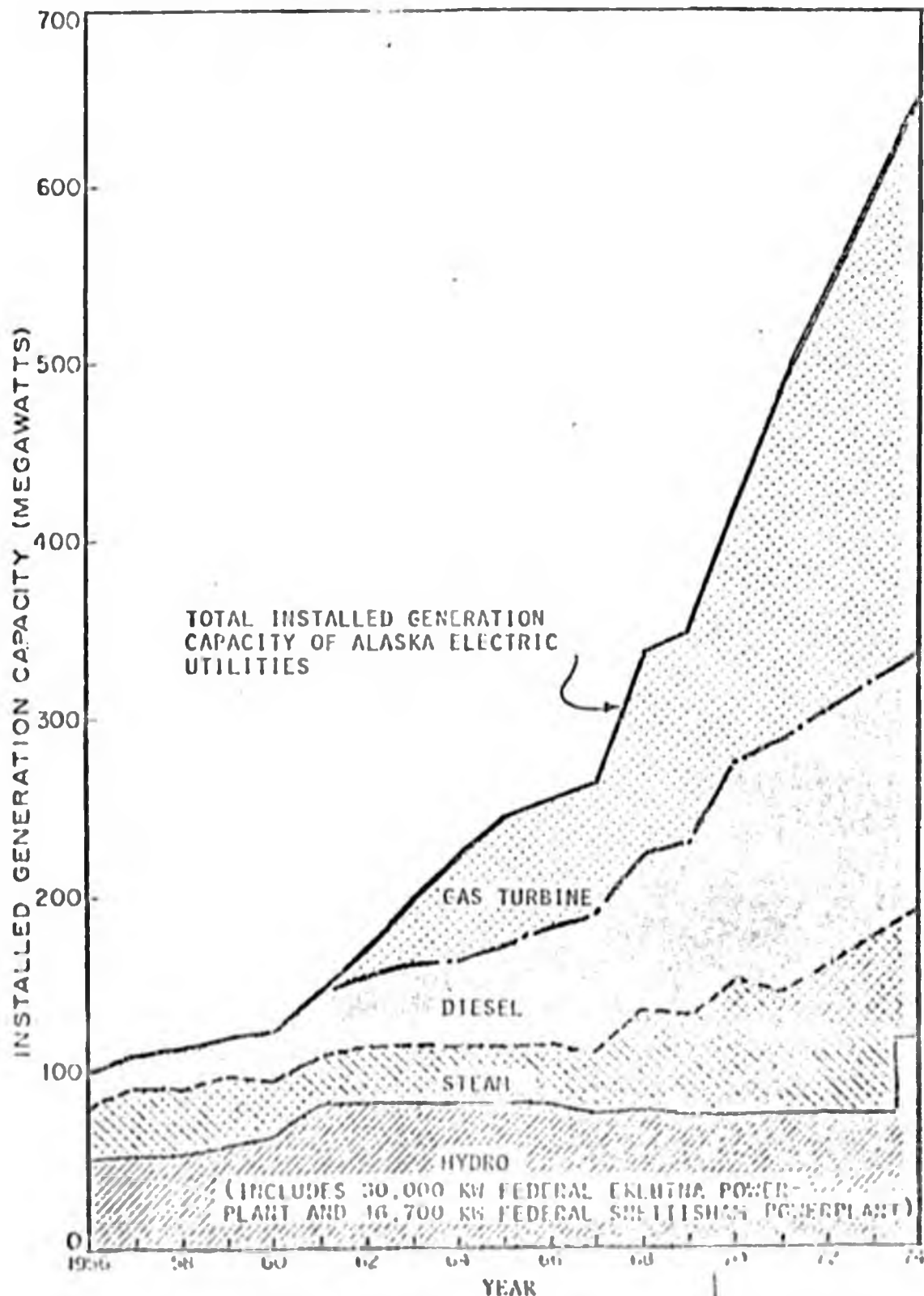
Alaskan electricity is derived from several sources including hydro-electric, oil-fired and coal-fired steam, gas turbine and diesel-generating systems (Figure 1). Figure 1 shows the relatively large contribution of diesel-electric power plants. The increasing use of diesel-electric power is creating a problem in Alaska which geothermal energy sources could help to alleviate. Although the portability and relatively low capital cost of diesel-electric plants has brought electricity to many communities in rural Alaska, the high cost of fuel and accompanying maintenance problems are escalating the cost of electricity in remote areas.

Urban Electric Power

Anchorage, Fairbanks, Juneau and Ketchikan have electric utility systems comparable to those in small cities in the other states (without the interties with larger systems). In 1970 these systems were providing electricity to homes in Alaska at an average rate of 3.01¢ per kWh

ALASKA ELECTRIC UTILITIES

INSTALLED GENERATION - YEARLY GROWTH BY TYPE



(Taken from Alaska Electric Power Statistics, 1960-1970)

Figure 1: Diagram showing cumulative and individual growth curves for electric generating plants (by type) in Alaska.

as compared to 2.10¢ per KWh for the rest of the nation. This is a small differential considering the higher cost of living in Alaska, and the absence of power-sharing with larger systems. As of 1970, the electric power consumed by the urban communities (which include unusually large peripheral suburban areas) accounted for 75% of the yearly electricity consumed in the State of Alaska. Some idea of the present variation between power costs in Alaska and those in another state can be seen in Table 16.

The success of urban power systems and the related abundance of accessible fossil fuels indicate that the bulk of the State's electrical power requirements can be met by such facilities. The large natural gas reserves and relatively untouched hydroelectric potential of the south-central region should insure an adequate supply of low-cost electricity to the Anchorage area for many years to come. The coal resources of interior Alaska, coupled with access to crude from the trans-Alaska pipeline, should more than meet power requirements of the Fairbanks area, the second largest urban area in the State. The Juneau area is presently supplied with hydroelectric power, and the hydroelectric potential of the area is more than adequate to meet projected needs over the next 50 years. It is unlikely that geothermally-produced electricity could be economically competitive in the foreseeable future with the present systems in these cities.

Alaskan urban energy use patterns are similar to those of the 48 states, in that consumption approaches available supply until limits are established by economic constraints. The usual diurnal and seasonal load cycles are amplified by Alaskan winters. Figure 2 shows monthly cycles and peak loads for Anchorage, Fairbanks and Ketchikan from 1963 to 1971.

MONTHLY PEAK LOADS

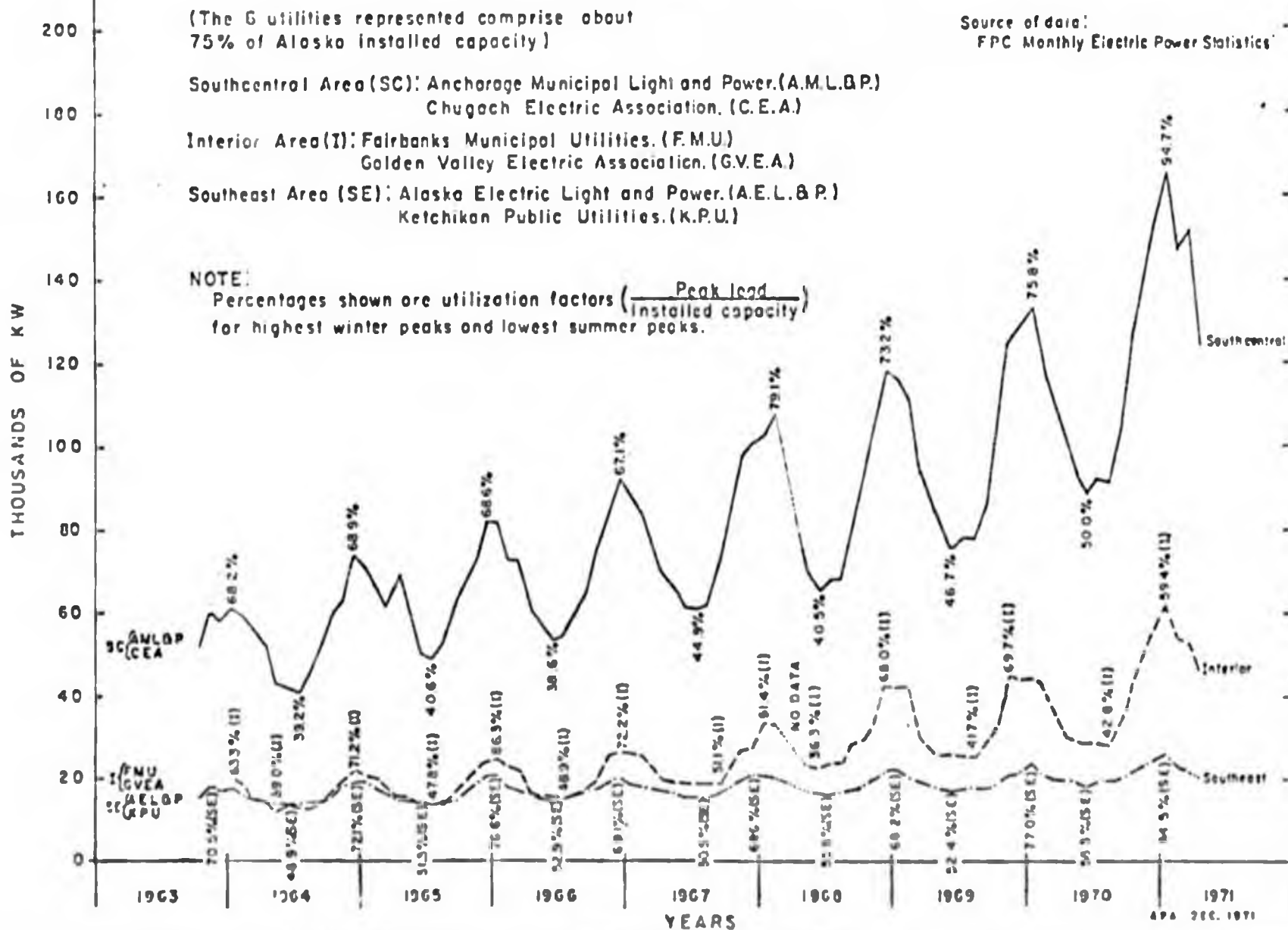


Figure 2: Monthly peak loads in three Alaskan geographical areas (on major utilities; most rural suppliers not included)

Energy Consumption in the Rural Communities

Larger Communities: Small communities, such as Barrow, Bethel, Cold Bay and Kotzebue, are either too remote to use the large power plants and grids which supply Anchorage and Fairbanks, or are unable to use local energy resources (if they exist). For instance, Cold Bay and Bethel have no local energy resources, but Kotzebue is in potential range of rich but undeveloped coal fields. Barrow is powered largely by local subsurface gas fields, but cost rate increases and pressure depletion may make this usage unattractive in the near future. The above cities are powered by small, privately-owned utility companies (about 0.7 to 3.0 MW).

The important point here is that these communities (except Barrow) derive most electricity and heat from expensive fuel oil which is transported over large distances. The utilities currently pay about 40¢/gal. Costs to individuals now range from 50¢ to above \$2/gal. in the bush communities. The requirement for more highly refined grade number one versus grade number two fuel oil, due to the cold, increases the oil costs.

The Villages: Of the nearly 200 small villages in Alaska with 50 to 300 inhabitants, about 50 communities are powered by the Alaska Village Electric Cooperative (AVEC). Many other villages have no central source of electricity. Energy use patterns vary considerably, but electricity is chiefly used for lighting, communications and household appliances. Heat is mostly derived from oil stoves. The accelerated use of over-snow and all-terrain vehicles has caused a recent increase in gasoline consumption in the bush communities.

A vivid example of the energy situation in a typical Alaskan native village is presented in a paper entitled "Chevak's Current Energy Picture: A Study of a Southwestern Alaskan Eskimo Village" (see Appendix D).

Rural Electric Power

As mentioned previously, the lack of interties between urban electric utility systems prevents power distribution from larger systems to remote areas. There are many communities throughout the State which have less than 1,000 people and which must produce their own power.

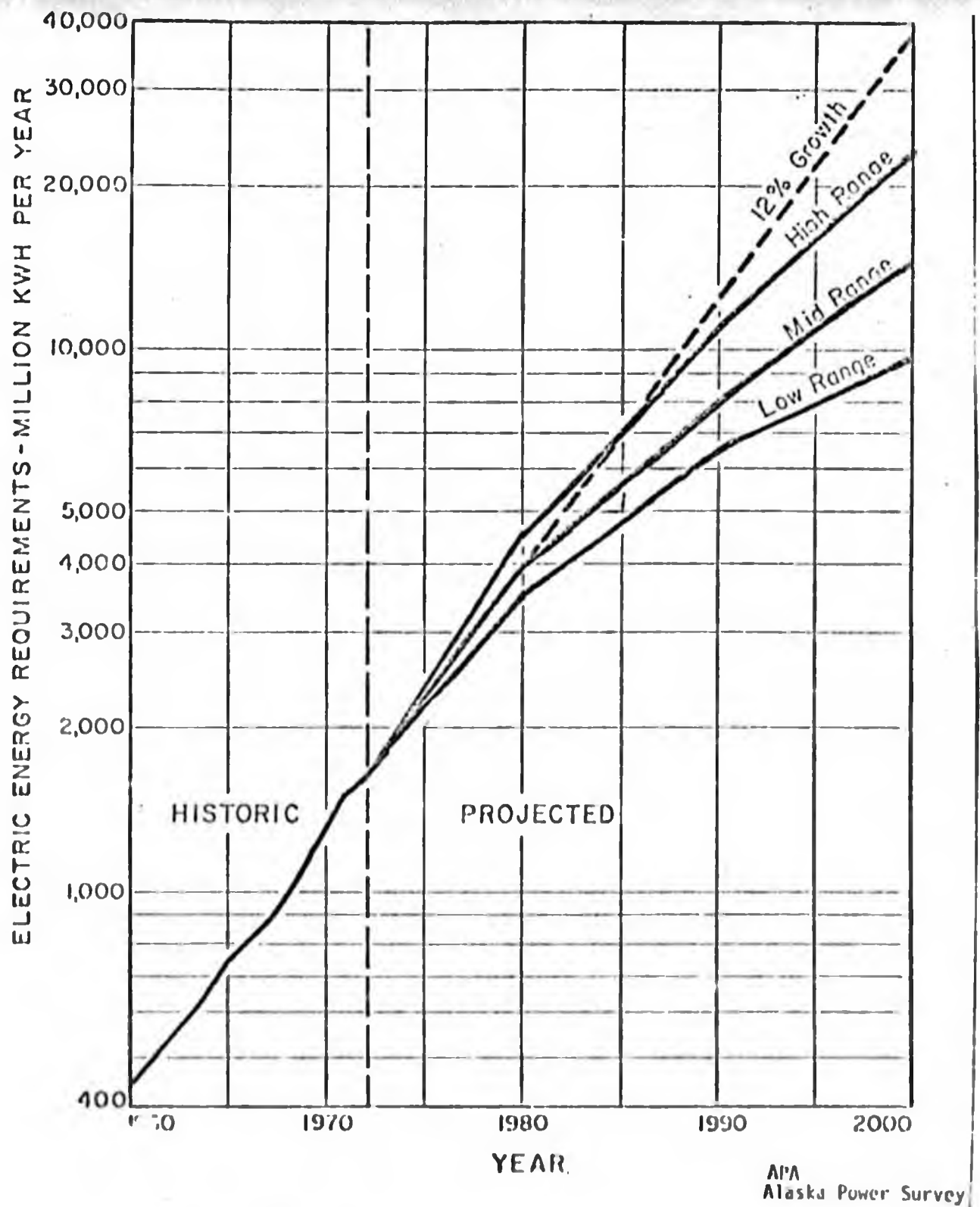
The agency which has had the most experience in such systems is the Alaska Village Electric Cooperative, Inc. (AVEC). This non-profit power co-op was formed in 1967, and received its initial operating capital from the Rural Electrification Administration of the U. S. Department of Agriculture. Since its formation, AVEC has installed power systems in 48 Alaskan villages which previously had little or no electricity. These systems range in size from 100 KW at Shaktolik, a small Eskimo village on Norton Sound, to the 450 KW plant at Savoonga on St. Lawrence Island in the Bering Sea.

Due to the small power needs of these villages, diesel-electric generators have been installed. But the high diesel fuel and maintenance costs in these remote areas have resulted in power costs up to 20¢ per KWh. This rate is highly damaging to the village consumer as it is roughly six times the cost of electricity in other parts of Alaska; the average annual cash income of rural residents is far below that of the urban population, and this imposes the highest cost on those least able to pay.

Forecast of Alaska Power Requirements

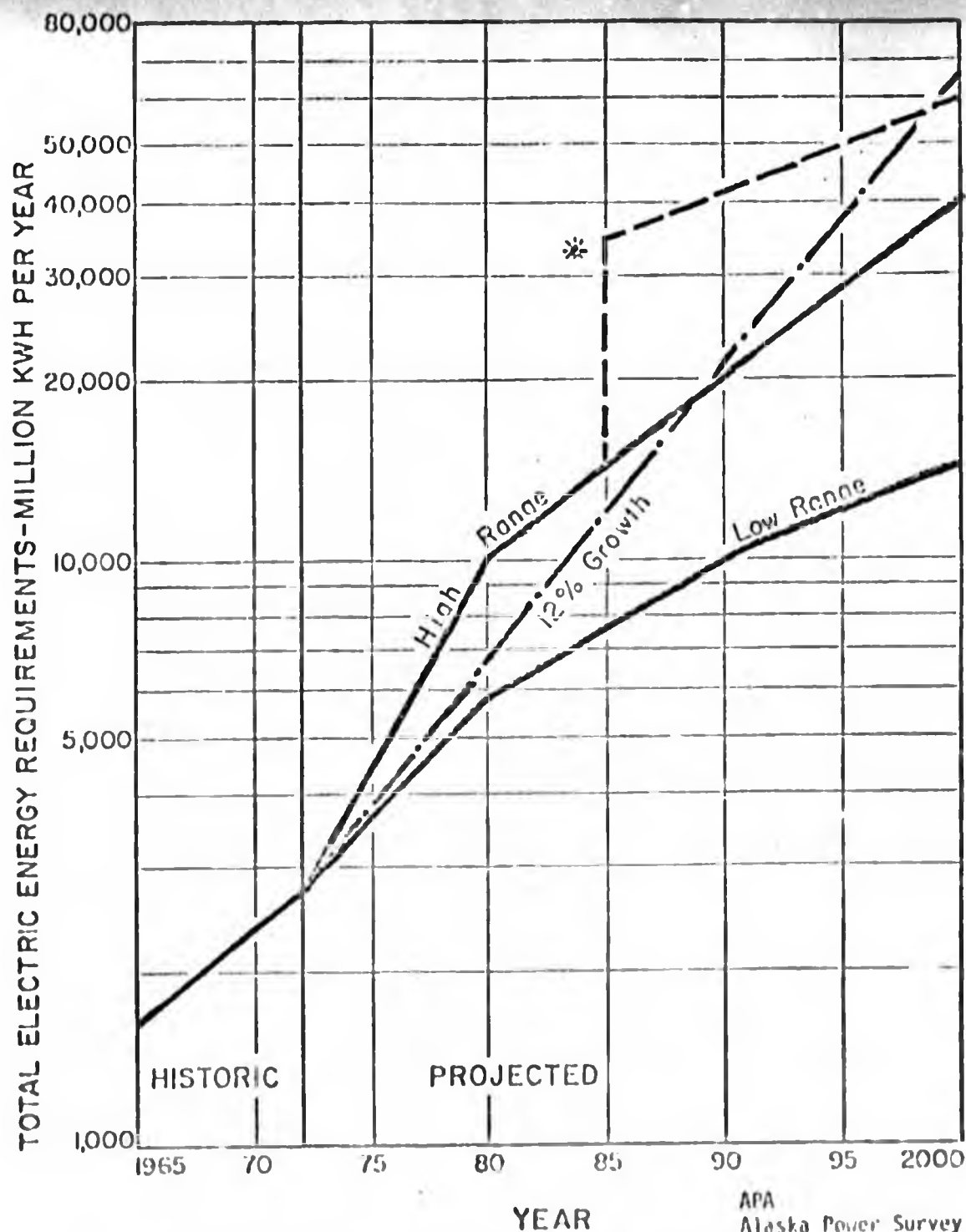
A current overview of statewide power system needs and alternatives is contained in the 1974 Reports of the Advisory Committee for the Federal Power Commission's Alaska Power Survey. The more important points are summarized below (see Figures 3, 4 and 5).

1. The power survey indicated statewide electric energy requirements of 2.6 billion kilowatt-hours in 1972 and installed generating capacity of one million kilowatts in mid-1973. The largest portion of the requirements is for the electric utility system (1.6 billion kilowatt-hours in 1972) and utility loads have been increasing about 12 percent per year (doubling every 5 to 6 years). Self-supplied industrial power systems and national defense installations account for the remainder of the power requirements.
2. Requirements of 3 to 10 million kilowatts of new generating capacity will be needed by the year 2000 under alternative assumptions for future development in the State.
3. In recent years, most new generator additions have been oil and natural gas-fired units, and in 1972 about 60 percent of the State's total electric energy came from these premium fuels. Based on current trends, this percentage may increase to about 90 by 1980; hence the very real concern for considering alternative power sources.
4. Unlike the rest of the U.S., Alaska does not have extensive power grid systems. The load centers in the various regions of the State are served by isolated power systems. Anchorage and nearby areas in the Matanuska-Susitna and Kenai Peninsula Boroughs



(Taken from Alaska Electric Power Statistics 1960-1970)

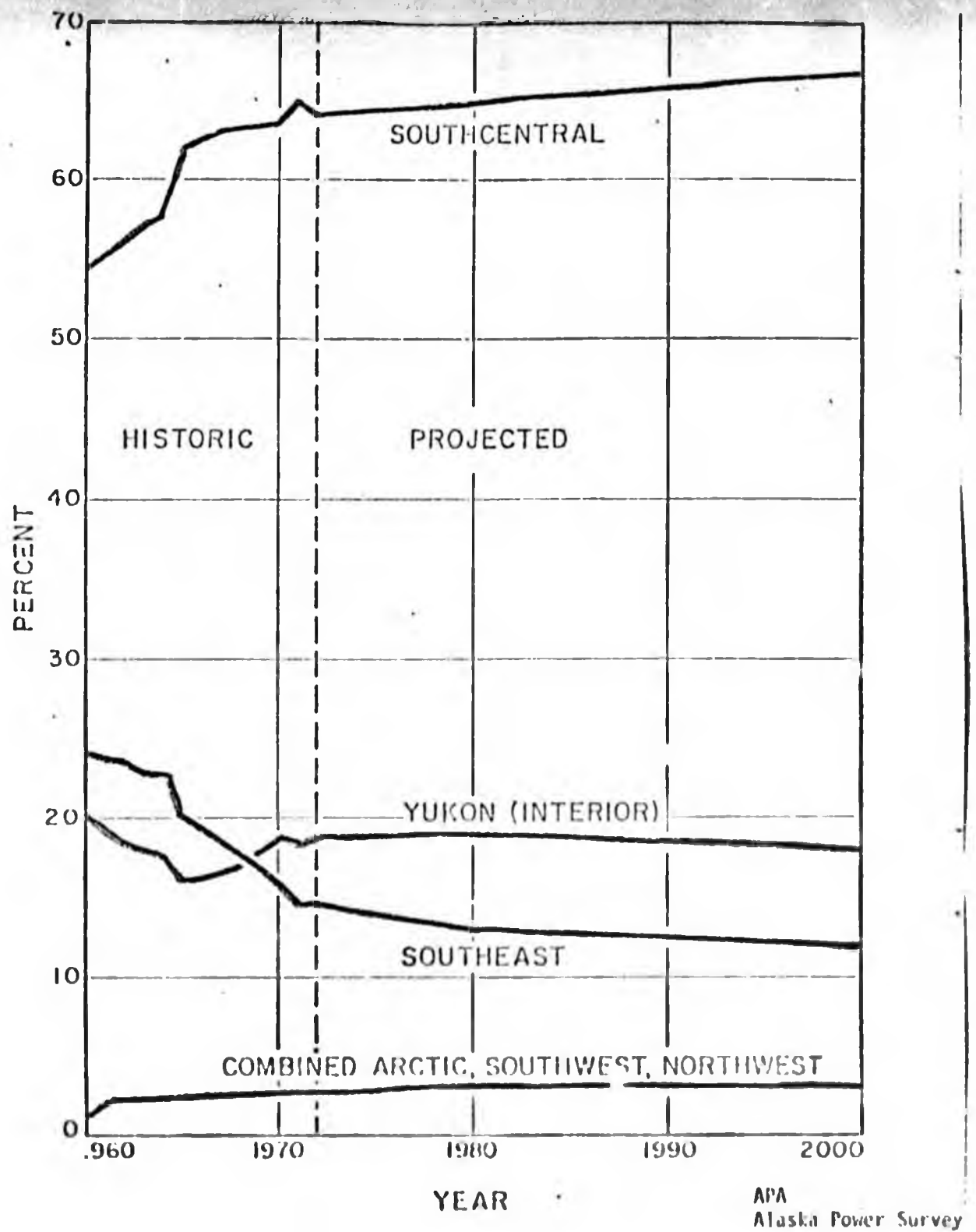
Figure 3: Utility system power requirements 1960-2000.



* SHOWS EFFECT OF LARGE INDUSTRIAL LOAD, SUCH AS A NUCLEAR FUEL ENRICHMENT PLANT OR OTHER VERY LARGE ENERGY INTENSIVE FACILITY.

(Taken from Alaska Electric Power Statistics 1960-1970)

Figure 4: Total Alaska Power Requirements 1965-2000.



(Taken from Alaska Electric Power Statistics 1960-1970)

Figure 5: Regional Utility Power Requirements, Percent
Statewide Total

account for roughly one-half of the total statewide power requirements. The Fairbanks area and a handful of coastal cities from Ketchikan to Kodiak account for most of the rest.

5. There is a unique set of power concerns for Alaska's remote cities and villages. These number around 175 and account for around 2 to 3 percent of total State power needs. Included are a few fairly large regional centers (Bethel, Nome, Kotzebue, and Barrow with populations of 2,000 to 3,000). Most of the rest have populations of 100 to 500. Barrow now has access to natural gas; most of the rest are totally dependent on costly, imported petroleum products for their energy needs. Many of the smaller villages don't even have power systems.
6. There is likelihood the major railbelt load centers will be fully interconnected in about 10 years, and the railbelt area power requirements will be about 70 to 80 percent of total State needs for the foreseeable future. There are possibilities that regional power systems will develop in other portions of the State, but many of the remote cities and villages will likely remain isolated from larger power systems for the foreseeable future.

ALASKA'S GEOTHERMAL POTENTIAL

Geothermal Energy in the National Interest

Until the last few years, the United States has not shown much concern or interest in the assessment or development of its geothermal resources. More recently, however, possible worldwide energy shortages, growing pollution problems and the awakening of a national environmental conscience have developed an accelerated interest in geothermal energy. This new cognizance has been reinforced by the Congress with the passage of the "Geothermal Steam Act of 1970" (84 Stat 1566), which authorizes and delineates geothermal resource "provinces" and "areas," and defines leasing and regulative policies for federal lands.

U. S. Geological Survey Circular 647, "Classification of Public Lands Valuable for Geothermal Steam and Associated Geothermal Resources" (Godwin, et al., 1971), presents the criteria for determining which federal lands are classifiable as geothermal steam and associated geothermal resources lands under the Geothermal Steam Act of 1970 (84 Stat 1566). This publication includes a map of Alaska showing lands classified for geothermal resources as of December 24, 1970 (Figure 6).

The Alaska Geothermal Resources Act of 1971

The State of Alaska enacted a Geothermal Resources Act in 1971, which establishes procedural, regulatory and administrative policies governing future exploration, development and production of geothermal resources on state lands (see Appendix C).



Figure 6: Map of Alaska showing lands classified for geothermal resources effective December 24, 1970. Numbers correspond to localities shown in inset. From U. S. Geological Survey Circular 647, Godwin, et al., 1971.

1. Pilgrim Springs
2. Geyser Spring Basin and Okmok Caldera
3. Wrangell Mountains

Classification of Geothermal Resources

A comprehensive assessment of potential Alaskan geothermal resources or targets must consider the following:

1. Surface Resources
 - a. Thermal springs
2. Subsurface Resources
 - a. Two phase reservoir systems (steam and water)
 - b. One phase reservoir systems (hot water)
 - c. Geopressured hot water reservoirs
 - d. Hot water reservoirs in sections with normal geothermal gradients
 - e. Hot dry rock
 - (1) Potential reservoir rocks; water injected from surface
 - (2) Impermeable rocks; reservoir space must be artificially created by hydrofracture or explosives
 - f. Hot dry rock in volcanic piles adjacent to subsurface magma bodies, or recently extruded plugs or domes
 - g. Subsurface magma tap

Previous Work and Publications

The earliest contribution to our knowledge of the geothermal framework of Alaska was G. A. Waring's "Mineral Springs of Alaska" (1917), a pioneering work which included data on the geologic setting, chemistry, and thermometry of Alaskan hot springs which were known to the author in 1917. This work, and the accompanying spring location map, was the authoritative reference for over 50 years.

In 1971, Ms. Norma Biggar, Geophysical Institute, University of Alaska, compiled a revision of Waring's map (Figure 7), which showed the location and temperature range of known Alaskan thermal springs.

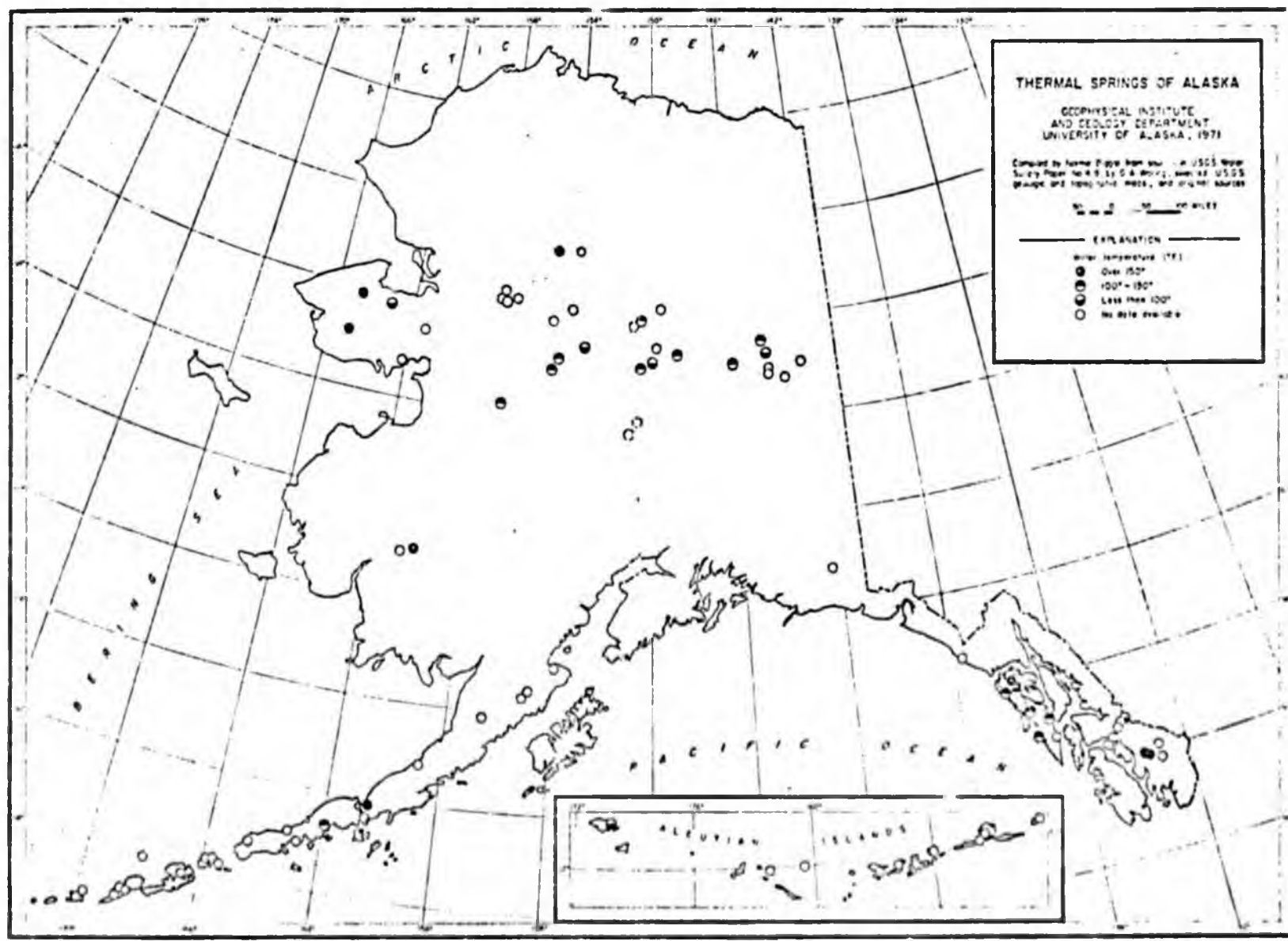


Figure 7: Location map of Alaskan thermal springs as compiled by Ms. Norma Biggar in 1971.

Biggar's map was accompanied by relevant tables of data on spring water temperature and chemistry. Subsequently, T. P. Miller, Alaskan Branch, U.S.G.S., produced a similar location map which included more recently-discovered thermal springs and new chemical and temperature data from the collaborative work of Ivan Barnes, of the U.S.G.S. (1973). A more recent report entitled "Geologic setting and chemical characteristics of hot springs in West-Central Alaska" (Miller, et al., 1975), provides additional data on the geothermal potential of thermal springs in that region.

Ms. Biggar completed a University of Alaska M.S. dissertation on "A geological and geophysical study of Chena Hot Springs, Alaska" in May 1973. The thesis investigation included geomagnetic, microseismic and soil temperature surveys, in addition to site geology and geochemistry (Biggar, 1973).

Forbes, et al. (1975), conducted geophysical studies of Pilgrim Springs in summer 1974. The data and findings of this study are contained in "A Geophysical Reconnaissance of Pilgrim Springs, Alaska," a report published by the Geophysical Institute, University of Alaska.

U.S. Geological Survey Circular #726, "Assessment of Geothermal Resources of the United States - 1975," contains new and relevant material on Alaska's geothermal resource potential, with particular attention given to hot-water and high-temperature hydrothermal convection and volcanic systems.

Heat Flow and Thermal Gradients

High heat flow and/or geothermal gradients are the characteristic signatures of economically significant geothermal anomalies. Although

high heat flow values can be obtained on many active Alaskan volcanoes, published heat flow determinations in drill holes have not exceeded 2.6 hfu (one heat flow unit = $1 \text{ microcalorie/cm}^2/\text{sec.}$).

We know very little about the thermal gradient at Alaskan localities other than those located in the petroleum provinces, and there are only a few reliable heat flow measurements reported for Alaska (Lachenbruch and Marshall, 1969; Lachenbruch, personal communication).

According to Lachenbruch (personal communication), no more than 20 reliable heat flow measurements have been recorded from Alaskan localities although temperature data are available for many holes which have been drilled in Alaskan petroleum provinces. Heat flow values calculated from data taken from drill holes near Cape Thompson, Barrow and Umiat (Lachenbruch and Marshall, 1969) were not far from the world average, and low to average values ($1.3 \text{ microcalories/cm}^2/\text{sec.}$) have been reported by Sass and Munroe (1970) for the Amchitka deep drill holes.

Heat flow data have been taken from other drill holes in the Cook Inlet and Prudhoe Bay areas, but analyses of these data are still in process (Lachenbruch, personal communication). Preliminary data from a deep test hole near Eielson Air Force Base (Fairbanks district), however, indicates that the heat flow is anomalously high at this locality (Lachenbruch, personal communication). Although it is not known at this time whether the anomaly is more than 1.5 times that of the worldwide average of $1.5 \text{ microcalories/cm}^2/\text{sec.}$, the presence of Chena and Circle Springs, and other thermal springs in the Salcha River drainage, indicates that the Yukon-Tanana Uplands deserve additional study.

Volcanism and Geothermal Resources

Alaska has more than 80 late Cenozoic volcanoes. Most of these have been active within the last million years (Miller and Barnes, in press) and more than 40 have erupted during historic time (Figure 8). Geothermal resources are closely associated with geologically-young volcanoes and volcanic fields, with particular emphasis on silicic volcanism (i.e., rhyolitic-dacitic domes and ejecta) and collapsed calderas.

Silicic Volcanism: The most promising Alaskan volcanic targets are located in the Aleutian-Alaska Peninsula segment of the circum-Pacific volcanic belt and in the Wrangell Mountains. Following the views of Smith and Shaw (1975) and others, silicic magmas are more likely to be stored and/or erupted from shallow (<10 km) chambers than basaltic (basic) melts, in the circum-Pacific volcanic belt. Conversely, however, basaltic melts are stored and erupted from shallow magma reservoirs under Kilauea Volcano, Hawaii, in the oceanic setting.

Following Smith and Shaw's rationale, geothermal targets are more likely to be associated with young silicic volcanic centers, where silicic magmas may still remain in the subsurface conduit and reservoir system. Such targets may range from hot dry rock to convective systems in suitable reservoir rocks. Possible subsurface targets would be signalled by very young (<10 million years) silicic domes and collapsed calderas with peripheral blankets of silicic pyroclastic rocks. The silicic ejecta domes and/or caldera association is known to occur at Katmai, Peulik, Aniakchak, Black Peak, Veniaminof, Emmons and Dana

Figure 8: Location of the main volcanic centers in Alaska showing volcanoes active in the last 200 years and other important recent volcanoes of the Aleutians, recent volcanoes of southern and southeastern Alaska, and alkalic Tertiary and Quaternary volcanic centers of western and eastern Alaska. (Taken from Kienle, 1974)

Volcanoes on the Alaska Peninsula, Fisher Volcano on Unimak Island, and Mt. Drum in the Wrangell Mountains (recent reconnaissance work by Miller, Barnes and Smith [Miller and Barnes, in press]).

All the known late Cenozoic volcanoes of the Aleutian volcanic arc could be considered as potential geothermal target areas because they indicate anomalously high heat flow in geologically recent time. The maximum depth at which geothermal systems might be exploited is thought to be less than 10 km (Muffler and White, 1972; White, 1973). Geothermal target areas can therefore be reduced, as a first approximation, to those volcanoes that have, or had, large magma chambers relatively close to the surface. A possible criterion for selection of such sites is the presence of a collapsed caldera, which in itself implies a magma chamber at relatively shallow depths for collapse to have occurred following magma withdrawal. Furthermore, Smith and Shaw (1973) have postulated that most large ($10^2 - 10^5 \text{ km}^3$) magma chambers that have formed in the upper 10 km of the crust are either silicic or have silicic differentiates.

Powers (1958) listed 20 known calderas in the Aleutian arc. One of these, the Buldir depression in the western Aleutian Islands, has since been referred to as a volcanic-tectonic depression rather than a true caldera (Marlow and others, 1970). Recent work has shown that at least three more calderas on the Alaska Peninsula, including Black Peak, Peulik, and Emmons can now be added to the list of known calderas (Miller and Barnes, in press).

Because of the length and subsequent remoteness of the Aleutian Islands, the calderas on the Alaska Peninsula such as Peulik,

Aniakchak, Black Peak, Dana and Fisher and those on the easternmost islands, perhaps as far west as Okmok Caldera on Umnak Island, may be considered as having more immediate potential for commercial development. Calderas farther out on the Islands such as Great Sitkin or Kanaga may have some potential for use by military bases. Some of these calderas could be eliminated from consideration because of inaccessibility. The conjectured caldera at Davidof, for instance, is under water and the Veniaminof caldera is completely filled with ice and snow.

Basaltic Volcanic Fields: Late Cenozoic volcanic rocks underlie a total area of about $25,000 \text{ km}^2$ ($9,600 \text{ mi}^2$) in interior Alaska, mostly in the western part of the region. These volcanic rocks are chiefly olivine tholeiite and alkalic basalt; no intermediate or silicic rocks of Pliocene or younger age have been reported in this part of Alaska. Potassium argon (K/Ar) age dates obtained on basalt from the western part of this province range from 6.12 ± 0.18 million years (m.y.) to $30,000 \pm 20,000$ years Before Present (B.P.) on Nunivak Island (Hoare and others, 1968) and from 2.19 ± 0.1 m.y. to $65,000 \pm 100,000$ years B.P. on the Pribilof Islands (Cox and others, 1966). Stratigraphic and morphological evidence, moreover, suggests that volcanic activity has continued almost to the present time; Hopkins (1963) states that the Lost Jim Lava Flow on the Seward Peninsula may be as young as a few hundred years.

The volcanic province, ranging in age from 6 m.y. to 30,000 years or younger, may still be volcanically active. No hot springs, fumaroles or other manifestations of current volcanic activity, however, occur within areas underlain by these basalts and the known thermal springs in interior Alaska show no spatial association with them.

Volcanism in Southeastern Alaska: Late Cenozoic volcanic rocks occur in a few scattered localities in southeastern Alaska. The most important occurrence is Mount Edgecumbe, an inactive composite volcano about 980 m in elevation located about 26 km west of Sitka. The volcano (Figure 8) is part of a volcanic field of Quaternary age that covers about 260 km² on the southern end of Kruzof Island and ranges in composition from olivine-augite basalt to rhyolite. Radiocarbon dates indicate that eruptions that deposited ash and lapilli as far away as 225 km occurred as recently as 9,000 to 11,000 years B.P. (Brew and others, 1969; McKenzie, 1970). Volcanic rocks of probable late Cenozoic age also crop out in several other small areas in southeast Alaska. As is the case with Quaternary volcanic rocks of interior Alaska, little or no spatial relation is shown between the thermal springs of southeastern Alaska and the young volcanic rocks.

The geothermal energy potential of areas underlain by late Cenozoic volcanic rocks in interior parts of southeastern Alaska appears to be low. Most geothermal areas now exploited in other parts of the world are associated with calc-alkaline volcanism whereas the Quaternary volcanic rocks of interior Alaska are primarily basalt and basaltic andesite and probably originated from considerable depth without large magma chambers relatively close to the surface. These volcanic areas display no signs of current activity such as fumaroles, geysers or thermal springs. The Mount Edgecumbe volcano area, however, with its relatively recent calc-alkaline volcanism, has higher geothermal potential.

Estimated Magnitudes and Heat Contents of Alaskan Volcanic Systems: Smith and Shaw (1975) have calculated estimated magnitudes and heat contents of Alaskan volcanic systems. These data are shown in Table 5.

Direct Extraction of Energy From Volcanoes

In the last few decades, the production of geothermal power has experienced a very slow growth, based on the discovery and development of vapor phase reservoirs. New concepts, such as artificially-induced reservoirs in hot-dry rock and the direct magma tap, offer new avenues for the exploitation of geothermal energy. Two approaches seem to offer the most promise for the direct extraction of volcanic energy:

- 1) Production and packaging of hydrogen, produced from the disassociation of water by volcanic heat
- 2) Generation of electricity by heat transfer from a magma to a conventional power plant on the surface via a heat exchanger immersed in the magma (an approach under investigation by Sandia Laboratories)

The problem, however, is to locate a suitable shallow magma reservoir, which is amenable to such an experiment. Very little is known about the physical characteristics of magma reservoirs and the internal plumbing of volcanoes. It is not certain that molten lava pools exist at depth. The geophysical evidence for magma at depth is highly speculative and inferential.

The depths of the magma chambers discussed in the literature range from about 4 km to greater than 60 km. Unfortunately, we do not yet know of one proven shallow magma reservoir in Alaska, although recent seismic studies (Eaton, et al., 1975) indicate such a reservoir under Yellowstone Park.

TABLE 5

**Magnitudes and Heat Contents of Identified Volcanic System
(As taken from Smith and Shaw, 1975)**

ALASKA

S-S No.	NAME OF AREA	LAT	LONG	CONSTITUTION LAST Eruption	AGE DATA	CHAMBER AREA km ²	CHAMBER VOLUME km ³	CHAMBER TEMPERATURE °C	SEISMIC STATION No.	AQ TOTAL CALORIES x 10 ¹²	AQ NOW CALORIES x 10 ¹²	AQ EST CALORIES x 10 ¹²	REMARKS
A-1	Elmoro	52°13'N	174°30'E	BASIC	<10 ³								110 m DEPTH
A-2	Nishna	52°08'N	172°30'E	BASIC	ACTIVE								110 m DEPTH
A-3	SEGULA	52°04'N	173°03'E	BASIC SILIC?	<10 ³								NEED MORE DATA ON COMPOSITION AND AGE
A-4	DAVIDOFF	51°58'N	170°25'E	No DATA	<10 ³	5 A ₂	125 3000	125	>850°	7	7		
A-5	LITTLE SITRAIN	51°57'N	173°32'E	BASIC	ACTIVE	73 A ₂	95 3000	73	>850°	43	43		
A-6	SEMSUDCHEN (CERBERUS)	51°56'N	172°55'E	BASIC	ACTIVE	42 A ₂	50 3000	150	>850°	88	88		
A-7	SUGARLOAF	51°51'N	171°38'E	BASIC	<10 ³								110 m DEPTH
A-8	GARELOF	51°48'N	173°43'W	BASIC	ACTIVE								110 m DEPTH
A-9	TASAGA	51°53'N	173°07'W	BASIC?	ACTIVE	65 A ₂	210 3000	420	>850°	233	233		
A-10	KARABAYCHA	51°52'N	173°23'W	BASIC?	<10 ³	67 A ₂	225 3000	>225	>850°	13	13		
A-11	BOSSOFF	51°53'N	172°17'W	BASIC?	<10 ³								110 m DEPTH?
A-12	NANAGA	51°53'N	172°23'W	BASIC?	ACTIVE	83 A ₂	575 3000	75	>850°	43	43		
A-13	PIOFFET	51°55'N	170°43'W	BASIC	<10 ³								110 m DEPTH
A-14	ACASZAR	51°55'N	173°16'W	BASIC	<10 ³								110 m DEPTH
A-15	GREAT SITRAIN	51°04'N	172°17'W	BASIC	ACTIVE	18 A ₂	45 3000	>5	>850°	3	3		
A-16	KASATOCHI	52°11'N	173°20'W	BASIC?	ACTIVE?								110 m DEPTH?
A-17	AGNUJI	52°13'N	173°43'W	BASIC?	ACTIVE?								110 m DEPTH?
A-18	SERGIEF	52°18'N	174°23'W	No DATA	No DATA								NEED COMPOSITION AND AGE DATA
A-19	MOROVIN	52°23'N	174°41'W	BASIC	ACTIVE								110 m DEPTH
A-20	KELICHER	52°19'N	174°03'W	No DATA	No DATA	24 A ₂	70 3000	>60		53			NEED COMPOSITION AND AGE DATA
A-21	SARICHER	52°19'N	174°23'W	BASIC?	ACTIVE?								110 m DEPTH
A-22	SEGULAM	52°18'N	172°23'W	No DATA	ACTIVE	2221 A ₂	100 3000	2221	>850°	118	118		APPEARS TO BE A BUBBLE CHAMBER AND DISCLOSED ALL 3000° C
A-23	KHUMTA	52°30'N	171°10'W	BASIC?	ACTIVE								110 m DEPTH?
A-24	CHUGULAN	52°38'N	171°31'W	BASIC?	<10 ³								110 m DEPTH?
A-25	TUNASNA	52°31'N	170°31'W	No DATA BASIC?	ACTIVE	121 A ₂	31 3000	60	>850°	23	23		
A-26	MERRERI	52°45'N	170°01'W	BASIC?	<10 ³								110 m DEPTH?
A-27	EARLBLE	52°59'N	170°24'W	BASIC?	ACTIVE								110 m DEPTH?
A-28	CLEVELAND	52°49'N	169°28'W	BASIC?	ACTIVE								110 m DEPTH?
A-29	UAGGA	53°00'N	169°41'W	BASIC?	<10 ³								110 m DEPTH?
A-30	TAGA	53°03'N	167°00'W	BASIC?	No DATA								110 m DEPTH?
A-31	MAGAMIL	53°38'N	166°49'W	BASIC?	ACTIVE								110 m DEPTH?
A-32	VORNOOF	53°38'N	166°41'W	BASIC?	ACTIVE								NEED MORE DATA
A-33	RECHESCHNOV	53°39'N	168°31'W	BASIC?	<10 ³								NEED MORE DATA
A-34	OMYGA	53°23'N	168°31'W	BASIC	ACTIVE 8100° T _c	61 A ₂	15 3000	600	>850°	100	100		
A-35	TAMU	53°25'N	168°31'W	BASIC	No DATA								110 m DEPTH
A-36	CHUGULAN	53°20'N	168°31'W	BASIC	ACTIVE								110 m DEPTH

TABLE 5 (continued)

Magnitudes and Heat Contents of Identified Volcanic Systems
(As taken from Smith and Shaw, 1975)

ALASKA

1 S-S No	2 NAME OF AREA	3 LAT	4 LONG	5 COMPOSITION LAST ERUPTION	6 AGE DATA	7 CHAMBER AREA km ²	8 CHAMBER VOLUME km ³	9 CHAMBER PRESSURE kg/cm ²	10 SEISMO- LOGICAL STATE	11 ΔQ TOTAL CALORIES x 10 ¹²	12 ΔQ NOW CALORIES x 10 ¹²	13 ΔQ EST CALORIES x 10 ¹²	14 REMARKS
A-37	MANUSHIN	55°31'N	166°36'W	SILICIC ¹	ACTIVE	3.6 A ₁	9.36 V ₁	>10	>850	6	6		
A-38	TABLE TOP	55°38'N	166°40'W	BASIC	NO DATA								>10 km DEPTH
A-39	ANUTAN	54°03'N	166°33'W	BASIC ²	ACTIVE	3.5 A ₁	9.30 V ₁	>10	>850	6	6		
A-40	Mt GILBERT (ARUN)	54°16'N	165°39'W	BASIC ²	NO DATA								>10 km DEPTH ²
A-41	POORONNI	54°34'N	166°42'W	BASIC	ACTIVE								>10 km DEPTH
A-42	WESTDAHL	54°31'N	166°39'W	NO DATA	ACTIVE								NEED MORE DATA
A-43	FISHER	54°38'N	166°23'W	BASIC	ACTIVE ² +1100° F _g	12.8 A ₁	30.72 V ₁	600	>850	345	345		
A-44	SHISHALDIN	54°45'N	165°38'W	BASIC	ACTIVE								>10 km DEPTH
A-45	ISANUTSKI	54°45'N	165°44'W	BASIC ²	ACTIVE								>10 km DEPTH ²
A-46	ROUNDTOP	54°48'N	165°36'W	NO DATA	ACTIVE ² +1100° F								
A-47	ANAK	55°25'N	165°09'W	BASIC ²	NO DATA								>10 km DEPTH ²
A-48	FROSTY	55°04'N	162°38'W	SILICIC ¹ BASIC ²	NO DATA								
A-49	WALRUS (MORZHOVOY)	55°00'N	162°30'W	BASIC	NO DATA +100° F								>10 km DEPTH
A-50	DUTTON	55°11'N	162°46'W	BASIC	NO DATA								>10 km DEPTH
A-51	EMMONS	55°20'N	162°01'W	BASIC	ACTIVE	11.3 A ₁	28.12 V ₁	600	>850	345	345		
A-52	PIGUE	55°21'N	161°58'W	BASIC	ACTIVE								
A-53	POURLE COTTON	55°23'N	161°53'W	BASIC	ACTIVE ²								
A-54	PAVLOF	55°23'N	161°31'W	BASIC	ACTIVE								>10 km DEPTH
A-55	PAVLOF SISTER	55°27'N	161°51'W	BASIC	ACTIVE								>10 km DEPTH
A-56	DANA	55°37'N	161°42'W	SILICIC	NO DATA +100° F	1.6 A ₁	4.16 V ₁	>3	>3				NEED MORE DATA
A-57	HUPRELAND	56°04'N	159°46'W	NO DATA BASIC ²	ACTIVE								NEED MORE DATA
A-58	VENIAMINOF	56°10'N	159°21'W	BASIC	ACTIVE 1110° F _g	50.4 A ₁	125.50 V ₁	200	>850	115	115		
A-59	BLACK (POURLE)	56°32'N	158°37'W	SILICIC	+100° F	8.9 A ₁	21.79 V ₁	>20	>850	12	12	6	NEED MORE DATA
A-60	ANARCHAK	56°33'N	158°10'W	SILICIC	ACTIVE 1010° F _g	3.8 A ₁	9.48 V ₁	225	>850	124	124		
A-61	CHIGNIKAR	57°48'N	157°03'W	BASIC ² SILICIC ¹	ACTIVE								NEED MORE DATA
A-62	KIALADIN	57°52'N	156°41'W	NO DATA	110° F _g								NO DATA
A-63	PELUM	57°45'N	156°21'W	BASIC ² SILICIC ¹	ACTIVE ²	10.5 A ₁	25.92 V ₁	>30	>850	17	17		SILICIC IN MOUNTAIN OF BOTH VOLCANOS AT PEAKS. PEAKS FORMED BY ERUPTIONS OF SILICIC MELTS DURING 1911-1912
A-64	MARTIN	58°19'N	155°24'W	BASIC ²	ACTIVE								>10 km DEPTH ²
A-65	MALEIN	58°12'N	155°15'W	"	ACTIVE								SILICIC DOMES ² NEED MORE DATA
A-66	AKURUPPA	58°17'N	155°10'W	SILICIC	ACTIVE	8.1 A ₁	20.62 V ₁	>30	>850	20	20		
A-67	Mt GRUBS (MOUNT PEAK)	58°22'N	155°08'W	BASIC ²	ACTIVE								>10 km DEPTH ²
A-68	TAIDENT	58°14'N	155°07'W	BASIC	ACTIVE								>10 km DEPTH ²
A-69	KAPPAI	58°16'N	154°38'W	BASIC	ACTIVE	3.1 A ₁	7.82 V ₁	>20	>850	12	12		
A-70	34000	58°20'N	154°44'W	NO DATA	NO DATA								NO DATA
A-71	DEMSON	58°23'N	154°22'W	NO DATA	NO DATA								NO DATA
A-72	STELLEN	58°26'N	154°24'W	NO DATA	NO DATA								NO DATA

TABLE 5 (continued)

Magnitudes and Heat Contents of Identified Volcanic Systems
(As taken from Smith and Shaw, 1975)

ALASKA

S-3 No.	NAME OF AREA	LAT	LONG	COMPOSITION LAST Eruption	AGE DATA	CHAMBER AREA km ²	CHAMBER VOLUME km ³	CHAMBER SHAPE No. km ²	SECTOR LOCATION STATE	ΔQ TOTAL CALORIES x 10 ¹⁵	ΔQ NEW CALORIES x 10 ¹⁵	ΔQ OLD CALORIES x 10 ¹⁵	REMARKS
A-13	ANAKAP	58°22'N	156°21'W	NO DATA	Active								NO DATA
A-14	DEVILS DESH	59°25'N	159°12'W	NO DATA	NO DATA								NO DATA
A-25	MAGUIAN	58°31'N	156°25'W	SILICIC	10 ³ y	41 A ₂	10 40 B ₂	15	>250	5	9	3	NEED AGE DATA
A-26	FOURPEAKED	59°41'N	153°42'W	NO DATA	10 ³ y								NO DATA
A-27	DOUGLAS	58°38'N	155°23'W	NO DATA	Active								NO DATA
A-28	AUGUSTINE	59°22'N	153°21'W	SILICIC	Active								NEED GEOPHYSICAL DATA
A-29	ILIAMNA	63°02'N	153°00'W	BASIC	Active								>10 KM DEPTH
A-30	REDoubt	63°28'N	152°45'W	BASIC	Active								>10 KM DEPTH
A-31	DOUBLE	60°41'N	152°35'W	NO DATA	NO DATA								NO DATA
A-32	BLACK	63°51'N	152°23'W	NO DATA	NO DATA								NO DATA
A-33	SOLARA	61°18'N	152°15'W	BASIC	Active								CALDERA NEED MORE DATA
A-34	DRUM	62°01'N	149°18'W	SILICIC	10 ³ y 10 ³ y 10 ³ y 10 ³ y	100 A ₂	100 40 B ₂	400	>850	250	-200	>100	
A-35	JANFORD	62°13'N	149°21'W	NO DATA	10 ³ y								NEED DATA ON ENERGETIC LEVEL AND ON PLANNING OF SOURCES (UNRELIABLE DATA)
A-36	WHALE	62°00'N	149°15'W	SILICIC	Active 10 ³ y	15 A ₂	15 10 B ₂	30	>850	25	25		
A-37	WHITE PLAINS	61°27'N	149°18'W	SILICIC	10 ³ y		80 40 B ₂	80	>100	60	15		
A-38	DOCCUMBE	57°01'N	155°46'W	SILICIC	Active 10 ³ y 10 ³ y	10 A ₂	10 10 B ₂	250	>850	100	100	20	3-4 KM IN FOCUS BASIC ON PLANNING

A direct magma tap to extract thermal energy from subsurface magma reservoirs is a new concept in the geothermal energy field. The Sandia Laboratories, Albuquerque, New Mexico, which is presently pioneering magma tap research, estimates that one cubic mile (4 km^3) of 1000°C magma contains enough energy to drive several 100 MW electrical plants for a hundred years. Vast quantities of thermal energy are dissipated by passive and active volcanoes throughout the world. Table 6 is a compilation of energy released in historic volcanic eruptions. The energy yields are impressive. The Krakatoa eruption of 1883 released about 10^{25} ergs of energy, which compares to the total power consumption in the U.S. in 1970. The 1952 eruption of Kilauea represents a value of \$350 million if converted to commercial electrical power today! Volcanoes represent a very high-grade energy source if we could somehow tap them.

Volcanoes also dissipate large amounts of energy (Table 7, which represents but a fraction of the energy stored in the depths of the volcanoes.

Thermal Springs as Geothermal Resources

Origin of Thermal Spring Water: Just a few years ago, most of the steam and/or water that was erupted by thermal springs and/or fumaroles was thought to be primary or magmatic water. More recently, however, based on oxygen and hydrogen isotope studies and other evidence, we have learned that less than 5% of this water is of magmatic origin and about 95% is recirculated ground water (Figure 9).

Vapor-Dominated Versus Hot Water Systems: Geothermal systems, as discussed by White, Muffler and Truesdell (1971), have been subdivided into two types:

- (1) Hot water systems
- (2) Vapor-dominated (dry steam) systems

TABLE 6

Total Energy Released in Volcanic Eruptions

Volcano	Year	Energy Released	Volcano	Year	Energy Released
Tambora ¹	1815	8.4×10^{26}	Una-Una ¹	1898	1.8×10^{22}
Sukurajima ¹	1914	4.6×10^{25}	Mihara ¹	1954	1.2×10^{22}
Bezymianny ¹	1955-1966	2.2×10^{25}	Adatarasan ¹	1900	6.4×10^{21}
Krakatoa ¹	1883	ca. 1.0×10^{25}	Asama ¹	1938	4.0×10^{21}
Asama ¹	1783	8.8×10^{24}	Mihara ¹	1912	6.3×10^{20}
Fuji ¹	1707	7.1×10^{24}	Tokachidake ¹	1926	2.8×10^{20}
Sukurajima ¹	1945	2.1×10^{24}	Kusatsu-Shirane ¹	1932	1.6×10^{13}
Torishima ¹	1939	9.7×10^{23}	Showa Shin-San ¹	1944	1.4×10^{20}
Komagatake ¹	1929	5.6×10^{23}	Capelinhos ¹	1957	4.0×10^{24}
Miyakeshima ¹	1940	4.8×10^{23}	Arenal ¹	1968	1.0×10^{22}
Bandaisan ¹	1888	ca. 1.0×10^{23}	Kilauea ²	1952	1.8×10^{24}
Pematang Bata ¹	1933	4.5×10^{22}	Nyamagira ³	1938-1940	8.4×10^{25}

¹ After Yokayama (1957) with additions.² After MacDonald (1972).³ After Verhoogen (1948).

After Verhoogen (1948).

(As prepared by Kienle, 1974)

TABLE 7

Heat Energy Released from Lava Lakes

Volcano	Year	Energy Released	Remarks
		(ergs/sec)	
Halemaumau (Kilauea)	during 1909	9.6×10^{15}	As heat energy (R.A. Daly, 1911).
Nyiragongo	during 1959	9.3×10^{15}	As heat energy in the form of radiation and conduction away from the surface by convecting air (Bonnet, 1960).
Nyiragongo	during August 1959	3.6×10^{19}	Total heat output by radiation, transport outward by gases and conduction into surrounding rocks (Delsemme, 1960).

(As prepared by Klenle, 1974)

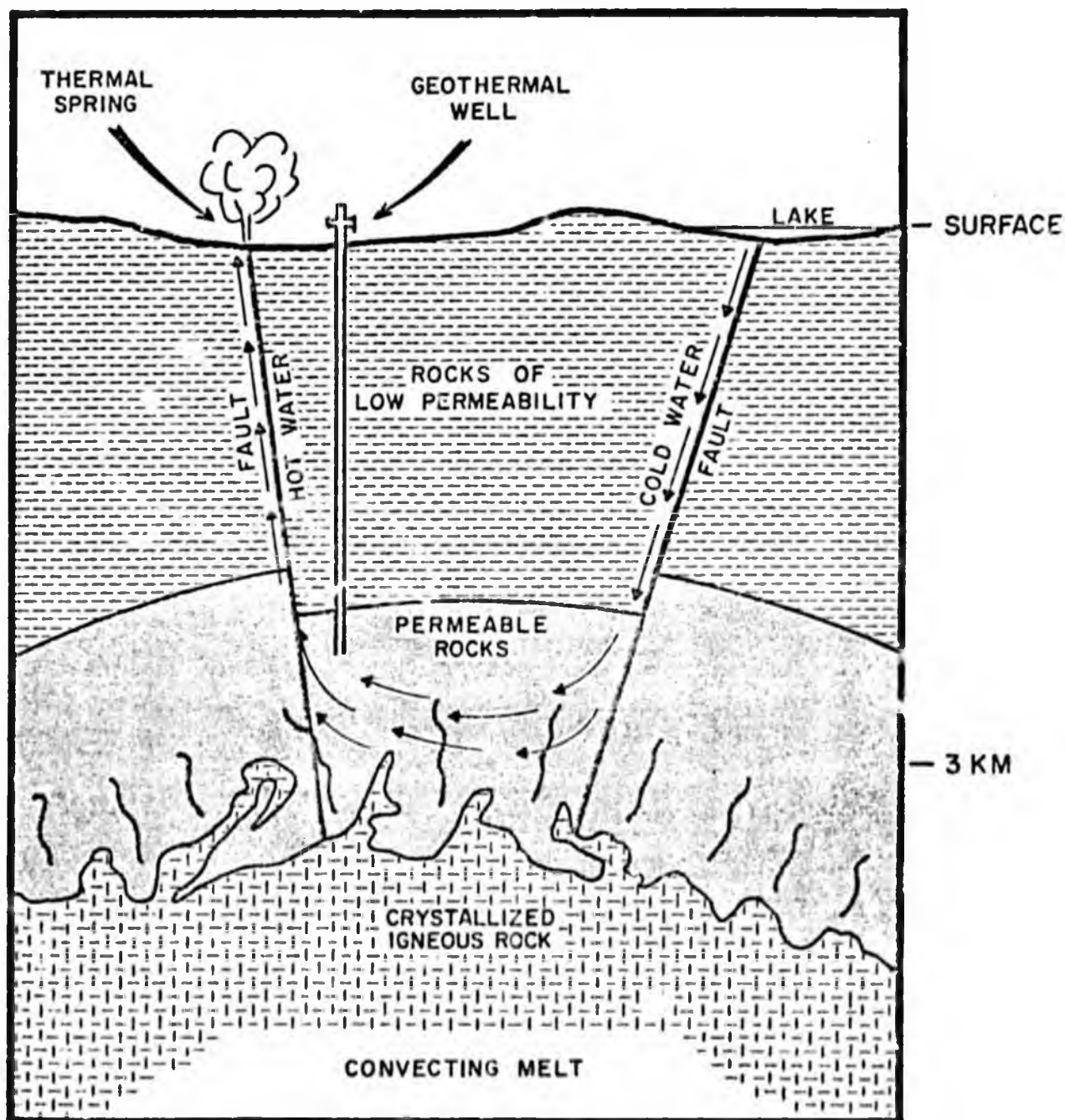


Figure 9: Diagram showing a hypothetical vapor-dominated, two-phase geothermal system as driven by convecting melt at depth. Meteoric (cold) water descends along fault line to hot permeable reservoir rock where it is heated by the cooling melt. Due to lowered density, the hot water ascends along another fault system to emerge at the surface as a thermal spring. A geothermal well has been driven into the reservoir rocks. In vapor-dominated systems, boiling will begin before the water reaches the surface.

Hot water systems appear to be about 20 times as common as the vapor dominated type (White, 1970).

In hot water systems, only a small part of the volume is steam, and the water and steam are separated mechanically before the steam is routed to the turbine system. If heat exchange systems utilizing low boiling point fluids such as freon or isobutane are proved feasible, this will increase the number of hot water systems which can be used for the generation of electricity. Producing geothermal fields of this type include the New Zealand fields and more recent discoveries in Mexico and the Salton Sea in California.

The vapor-dominated systems produce superheated steam with subordinate amounts of carbon dioxide (CO_2) and hydrogen sulfide (H_2S). Only three commercial vapor-dominated systems are in production today, including those at Lardello, Italy, (since 1904); the Geysers, California; and a field at Matsukawa, Japan.

Geothermometry: Subsurface reservoir temperatures of thermal systems can be estimated through the use of geochemical techniques. Various geothermometers have been developed based on analyzed concentrations and ratios of the dissolved mineral constituents. The more commonly used indicators are the silica (SiO_2) content (Figure 10), the Na-K ratios^{*} (Figure 11), the Mg content and Mg-Ca ratio, and the Na-Ca and Cl-F ratios.

The assumptions involved in the use of geothermometers have been outlined by White (1970). These include (1) the availability of constituents from the reservoir rocks; (2) the equilibration of water-rock reactions at the reservoir temperature; (3) the rapid flow of water from the reservoir to the surface to eliminate reactions in transit at lower temperatures and to retain the composition of reservoir temperatures; and (4) a lack of mixing with other waters at intermediate levels.

^{*}Na=sodium; Mg=magnesium; K=potassium; Ca=calcium; F=fluorine; Cl=chlorine.

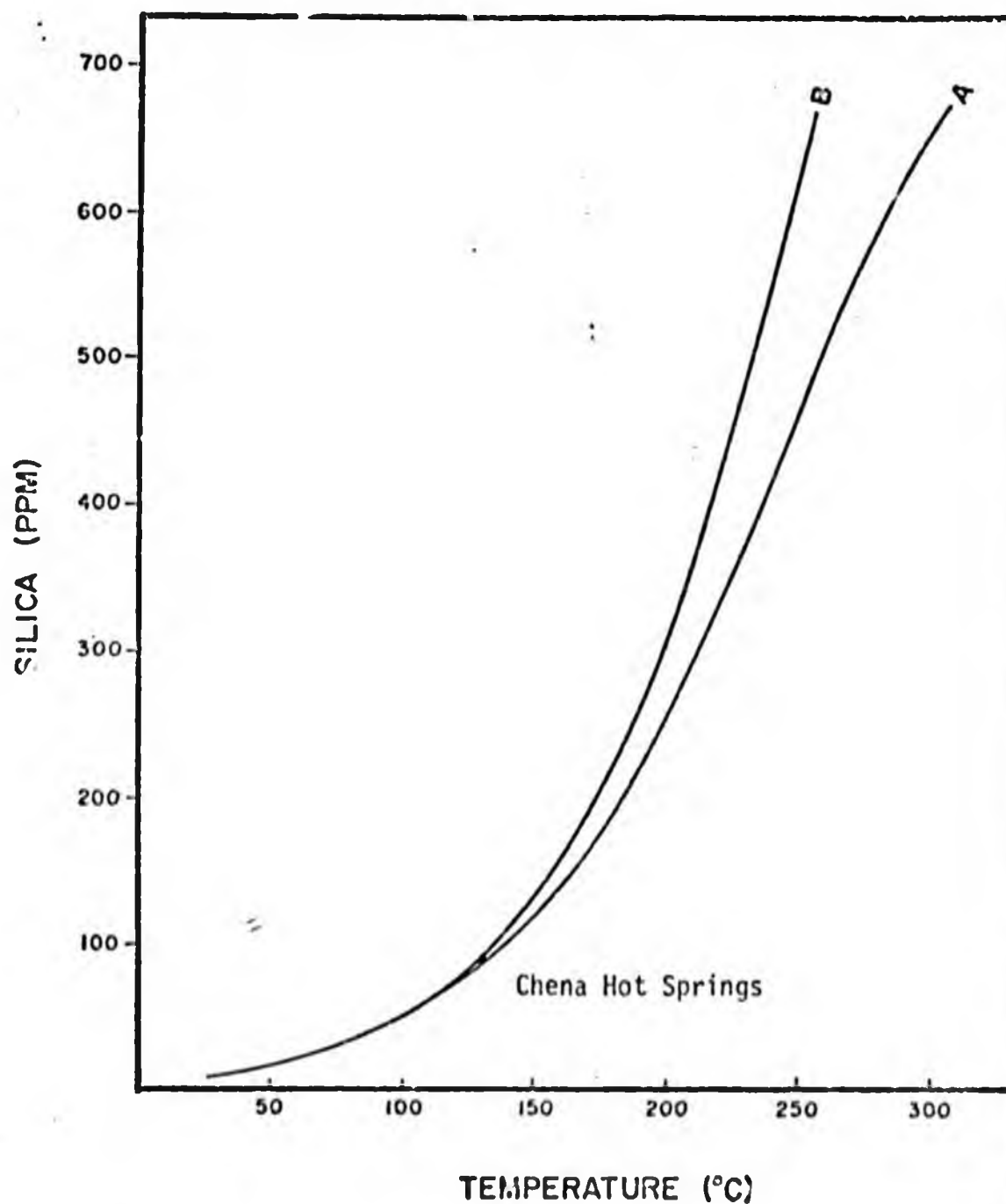


Figure 10: Silica concentration in geothermal water versus estimated temperature of last equilibration. Curve A applies to waters cooled entirely by heat conduction. Curve B applies to waters cooled entirely by adiabatic expansion at constant enthalpy. (From Fournier and Truesdell, 1970)

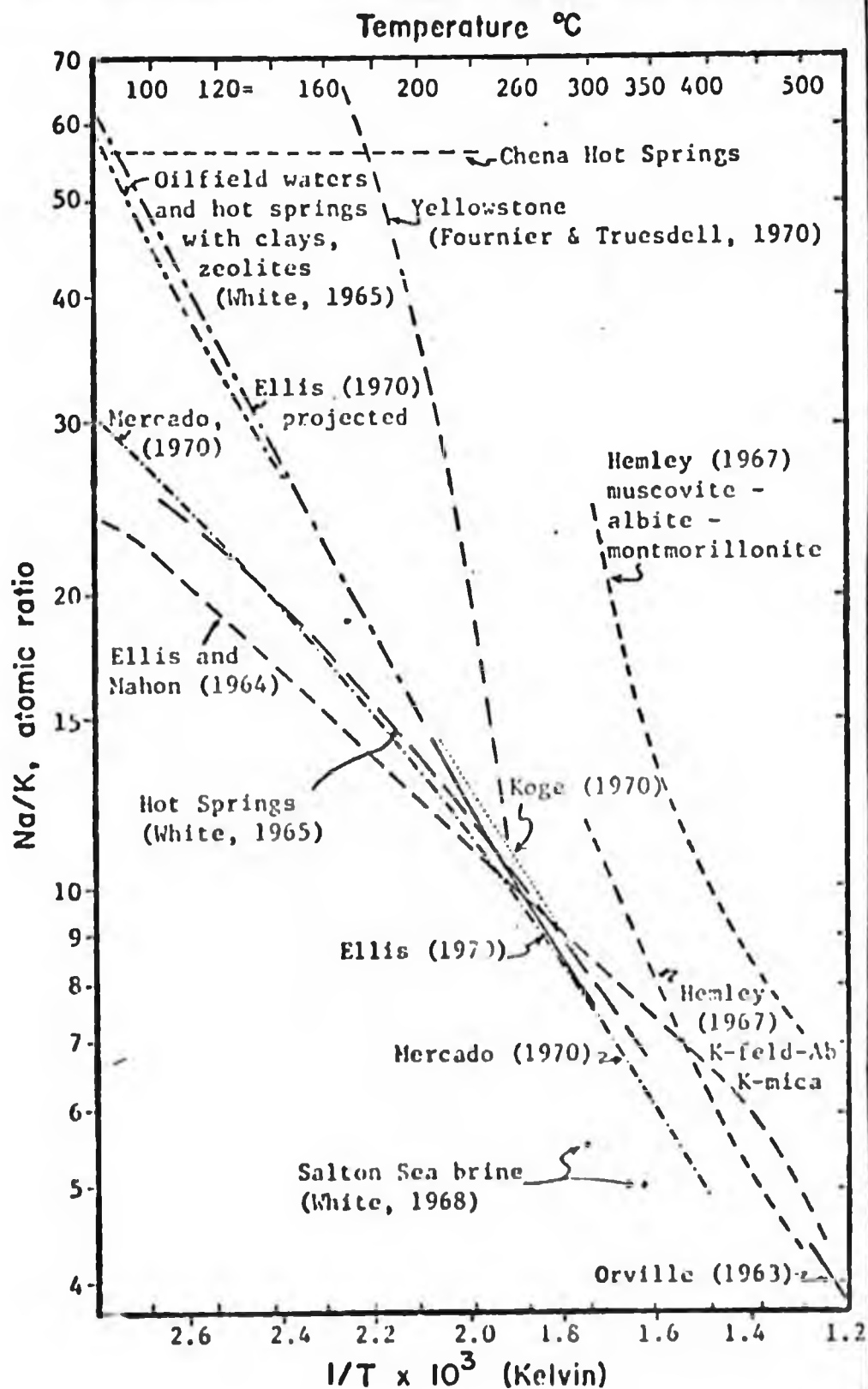


Figure 11: Atomic Na/K ratios versus temperature, showing experimental and empirical curves. (White, 1970)

If equilibrium has been obtained in the subsurface waters, the Na-Ca-K geothermometer should be in general agreement with estimated reservoir temperatures determined from dissolved SiO_2 .

Thermal springs which have a high dissolved SiO_2 content, and/or those which deposit silicious sinter at the surface, are probably related to high temperature subsurface reservoirs. Geysers are also a favorable indication of high temperatures at depth.

The Na-Ca-K geothermometer is based on the temperature-dependent base exchange or partitioning of alkalis between solution and solid phases. Discussion of the sodium-potassium equilibria generally applied to systems with temperatures above $175^\circ\text{--}200^\circ\text{C}$, as the alumino-silicate equilibria at lower temperatures, are uncertain (Ellis, 1970).

Factors limiting the possible use of this method are the dilution effects of the deeper water as it rises to the surface, the effect of different mineral suites as source rocks, the effect of continual base exchanges as the waters move toward the surface, and the formation of complex ions. These factors are discussed in greater detail by Fournier and Truesdell (1970).

Geologic Setting of Alaskan Thermal Springs: According to the compilation by Biggar (1973) and the later work of Miller, et al. (1973), there are about 95 recognized Alaskan thermal springs. The geographical distribution patterns indicate that the thermal springs occur in three tectonic settings or geologic associations:

- (1) Adjacent to Quarternary volcanoes (i.e. Aleutian Archipelago, Alaska Peninsula, Wrangell Mountains);
- (2) In a broad east-west trending zone in northcentral Alaska associated with late Cretaceous or Tertiary granitic plutons; and

- (3) In southeastern Alaska, south of the Chatham Strait Fault, in a zone which may be involved in a transform fault system.

Quaternary Volcanic Belts

Some thermal springs in the Aleutian Islands exhibit relatively high surface temperatures (over 100°C), such as Geyser Bight (Table 8). The Aleutian arc also shows evidence of extensive mid-Tertiary intrusive activity (Cameron and Stone, 1970), and is believed to be a consuming plate margin between the Pacific and North American plates.

Many of the Aleutian Islands have not been mapped in detail, and it is probable that there are more thermal springs in the Aleutian Archipelago than those recognized to date.

Southeastern Alaska

Thermal springs on the south side of the Chatham Strait Fault appear to be located along a trend which can be projected underneath the continental block from the North Pacific Rise, where it appears to plunge under the Southeastern Alaskan Archipelago. Quaternary volcanic eruptive centers are also located along this same trend in the Canadian Coast Ranges.

In plate tectonic terms, this area appears to be essentially a transform fault system that connects the actively spreading Explorer and Juan de Fuca Ridges, and the Gorda Rise with the Aleutian Arc system.

Central Alaska

This belt of thermal springs forms a broad zone which extends from the Yukon-Tanana Uplands to the Seward Peninsula. These springs are located on or near the contacts between late Cretaceous or early Tertiary granitic plutons. Portions of this belt may also be underlain by zones of high heat flow.

TABLE 8

Identified hot-water convection systems with indicated subsurface temperatures above 150°C

(As taken from Renner, White and Williams, 1975)

Location			Temperatures °C				Reservoir Assumptions				Comments
Name	Latitude N	Longitude W	Surface	Geochemical		Sub-surface	Sub-surface area	Thickness	Volume	Heat content 10 ¹⁸ cal	
			1/	2/ SiO ₂	2/ Na-K-Ca	3/	km ² 4/	km 5/	km ³ 6/	7/	
ALASKA											
Geyser Bight	53 13	168 28	100	210	236	210	4	2	8	.9	22 springs and geysers in 3 thermal areas 1 2 km long zone, near Okmok Caldera; siliceous sinter deposit.
Hot Springs Cove	53 14	168 21	89	131	154	155	2	2	4	.3	Hot springs and geysers in area about 1 km ² near Okmok caldera.
Shakes Springs	56 43	132 02	52	142	175	155	1.5	1.5	2.25	.2	Several springs discharging ~380 l/m; chemical data not reliable.
Hot Springs Bay	54 10	165 50	83	152	179	180	1.5	1.5	2.25	.2	Hot springs and fumaroles on active Katmai volcano.

1/ Maximum surface temperature reported from a spring or fumarole.

2/ Predicted using chemical geothermometers, assuming last equilibration in the reservoir; assumes saturation of 51% with respect to quartz, and no loss of Ca from calcite deposition.

3/ Assumed average reservoir temperature based on data presently available.

4/ From surface manifestations, geophysical data, well records and geologic inference. Assumes 1.5 km² if no data pertinent to size is available.

5/ Top assumed at depth of 1.5 m if no data available. Bottom assumed at 3 m depth for all convection systems.

6/ Calculated from assumed area and thickness.

7/ Calculated as product of assumed volume, volumetric specific heat of 0.8 cal/cm³ °C, and temperature in degrees C above 150°C.

Maximum Surface Water Temperatures: The hottest water temperatures discovered in Alaska have been measured in thermal springs or hot lakes or pools associated with volcanoes on the Alaska Peninsula or in the Aleutian Islands (e.g., 102°C, Hot Springs Cove, Umnak Island). Water temperatures up to 88°C have been measured in the waters of Bailey Bay Hot Springs, southeastern Alaska.

Estimated Reservoir Temperatures: To date, geochemical studies (Miller and Barnes, in press) indicate that there are only two springs (Geyser Springs Basin, Umnak Island; Chiginigiak Hot Springs, Alaska Peninsula) which are likely to have reservoir temperatures which are over the practical minimum of 180°C, which is needed to drive steam turbine generators, utilizing today's technology. Based on geochemical data reported by Waring (1917), Byers and Brannock (1949), Miller (1973a), the reservoir temperature estimates given by Miller, et al. (1975), and Renner, White and Williams (1975), thermal springs in western and central Alaska are associated with subsurface systems of the hot water types. Maximum estimated reservoir temperatures for 10 springs, as determined by the quartz and Na-Ca-K geothermometers, were 137°C and 167°C respectively.

Reservoir and Conduit Systems

Over 90% of the thermal springs in central Alaska are located near the contact of late Cretaceous and early Tertiary granitic plutons with surrounding country rock. In many cases, the country rocks are crystalline schists with relatively no interstitial porosity and very poor permeability other than that associated with fractures and faults (Figure 12a). In such settings, the probability of large reservoirs at depth is very low.

Considering the low estimated reservoir temperatures there, the prognosis is poor for the discovery of large vapor-dominated geothermal systems in such settings (Miller, et al., 1975). A few springs occur in west-central Alaska near the margins of plutons which have been emplaced in Jr-k sediments (Figure 12b). The probabilities of finding large hot-water reservoirs are higher in such terranes.

Flow Rates

Flow rates of Alaskan thermal springs have been observed which range from slow seepage to rates as high as an estimated 400 gpm at Clear Creek Hot Springs. In some cases, such as that at Pilgrim Springs, spring water flow rates are difficult to determine due to lateral flow, convective circulation and mixing with ground water. Potential electric and nonelectric applications of hot water systems are constrained by flow rates and whether or not such rates can be improved by subsurface drilling.

The potential application of drilling techniques to these systems is an unknown area, as the geometry and reservoir mechanics of the conduits and reservoirs are not understood.

Saline Springs: Four saline springs are known in central and western Alaska including Pilgrim, Serpentine, Kwiniuk and Tolovana (Miller, et al., 1975). These springs are characterized by high concentrations of Cl, Na, Ca, and K. Pilgrim and Serpentine Springs are the most saline (Pilgrim: Na=1450 ppm/Cl=3346 ppm. Serpentine: Na=800 ppm/ Cl=1450 ppm).

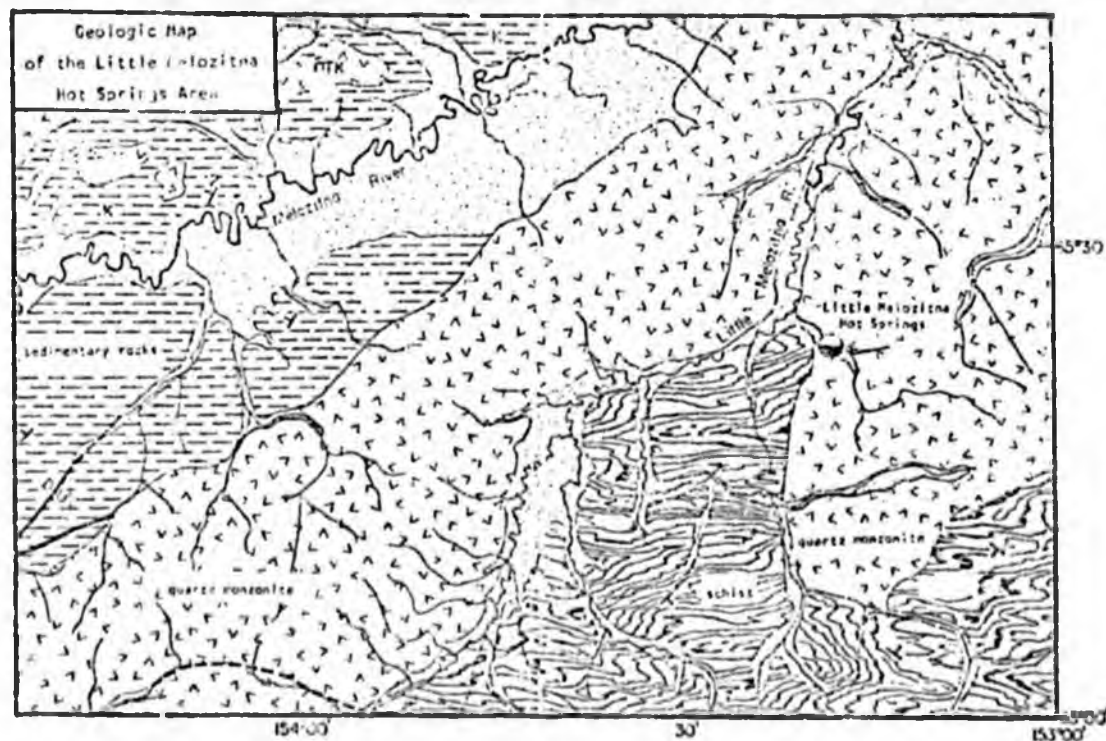


Figure 12a: Geologic map of the Little Melozitna Hot Springs area.

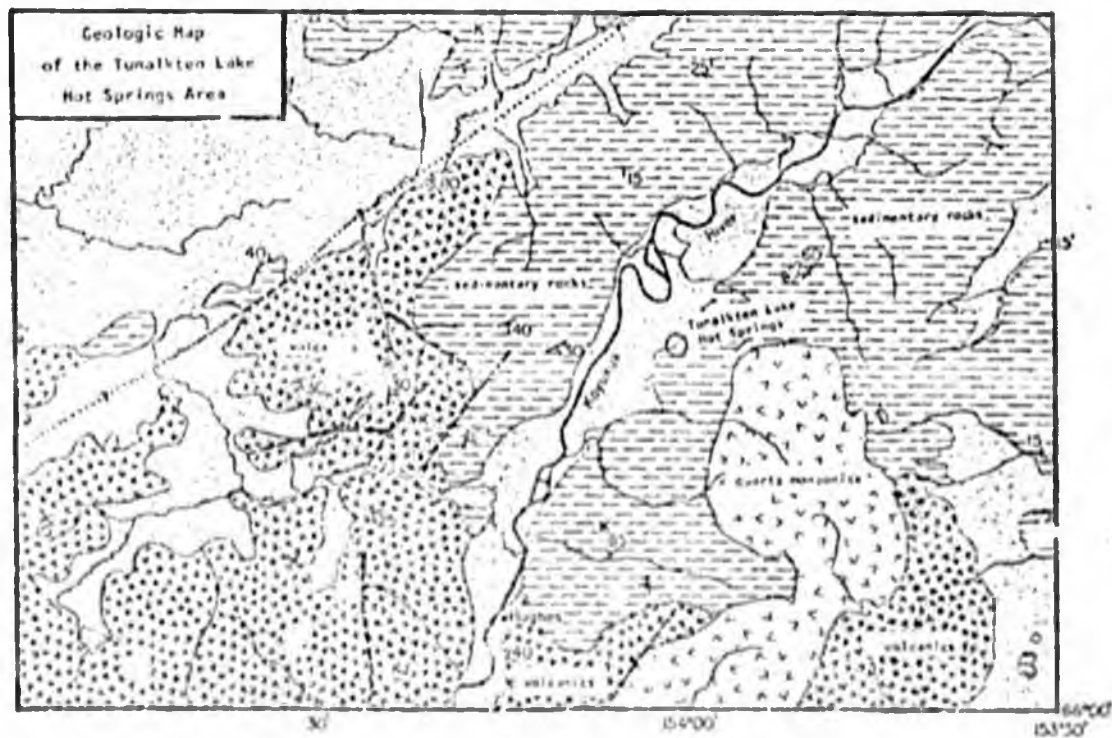


Figure 12b: Geologic map of the Tunakten Lake Hot Springs area.

Both of these springs exceed the salinity threshold of acceptable potable water, and are potentially troublesome in terms of corrosion of casing, pipe and other hardware.

GEOHERMAL RESOURCE APPLICATIONS

Utilization of Alaskan Thermal Springs

The thermal springs of Alaska were first utilized and developed by early stampeders and entrepreneurs. For example, Circle and Chena Hot Springs, in the Fairbanks District, were used by early prospectors for bathing and recreation; and subsequently, roadhouses and small settlements appeared. In these early cases, primitive engineering techniques were used, and the applications were limited to bathing pools, hot tap water, and space heating, using hot water convectors. At Manley Hot Springs, the utilization of thermal waters was more advanced, as spring water was used to heat greenhouses, animal barns, and a 60-room hotel, in addition to that used in the bathing pools and the hot water system. Agriculture also became an important part of the activity at Pilgrim Springs during the Nome gold rush in the early 1900's.

These early attempts to utilize the energy of thermal springs passed with the wave of gold seekers, but the energy remains. If properly utilized, such energy sources could play an important part in the economic and cultural life of many rural communities.

The ideal utilization of a geothermal resource in a rural Alaskan community would provide the following:

- (1) Heat and electricity for the entire community, to reduce and perhaps eliminate the dependence on imported fossil fuels, and
- (2) Energy for local industries which would aid the economy with minimum impact to village culture and lifestyle.

The following sections discuss the more promising applications of thermal spring resources to rural needs.

Electricity: There are many techniques for producing electric power from geothermal resources. Unfortunately, most of these are very complex and require vapor phase reservoirs or high temperature waters which can only be reached by deep drilling. Such techniques are not economically feasible, if very small amounts of power are needed, as in the case of a small Alaskan village.

Techniques must be found to produce relatively small amounts of electricity from geothermal resources with as little impact on the environment as possible. The most promising of these resources in Alaska are the thermal springs. The Geophysical Institute, University of Alaska, has been investigating a method that might be used to produce electricity directly from hot spring water, which utilizes the organic Rankine cycle and the temperature difference between the spring water and the ambient air. An experimental plant, utilizing this technique is now operating at Paratunka, Kamchatka, USSR, and uses water at a temperature of 81.5°C (Facca, 1970).

The Geophysical Institute, University of Alaska, has been working informally with Ormat Turbines Ltd. of Israel, to determine whether or not one of their organic Rankine cycle turbines could be coupled to thermal spring water as an energy source. Ormat has determined that one of their units could be so adapted and that useful, but small, amounts of power could be produced from waters with temperatures as low as 60°C, a temperature which is obtainable in many Alaskan hot springs. Shallow drilling to minimize dilution by ground water could increase the water temperature and enhance the efficiency of the Ormat turbine. Such drilling would not be cost prohibitive and could be easily accomplished by small rigs in remote locations.

Ormat engineers estimate overall efficiencies of approximately 5-1/2% which would require about 40 gpm of 60°C thermal spring water to produce 5 KW of continuous power. This efficiency would, of course, be increased if the temperature of the input water were greater. A schematic diagram illustrating the Ormat system as applied to a thermal spring source is shown in Figure 13.

The electrical system of the Ormat turbine produces a high frequency voltage at the generator which is rectified to DC, thus eliminating the need for costly speed control equipment. The DC output can then be inverted to AC, or it can be used to charge batteries. Such a system could be integrated with wind-generating equipment and circuitry. The combined use of alternate energy sources such as wind power and geothermal energy is especially attractive and should be evaluated in demonstration experiments.

While Rankine cycle power generation at small temperature differences is not very efficient, compared to conventional steam plants, the continuous free supply of the geothermal "fuel" makes it attractive. But in addition to fuel savings, the Ormat turbine has advantages which make it well adapted to use in remote regions:

1. The synthetic organic working fluid allows for low working pressures and temperatures. This results in the elimination of sophisticated pressure vessels and the need for elaborate safety equipment;
2. The entire vapor system is closed, eliminating the need for constant monitoring of the working fluid;
3. The only moving part is the common, turbine-generator shaft. Lubrication is provided by the working fluid which contains a lubrication agent;

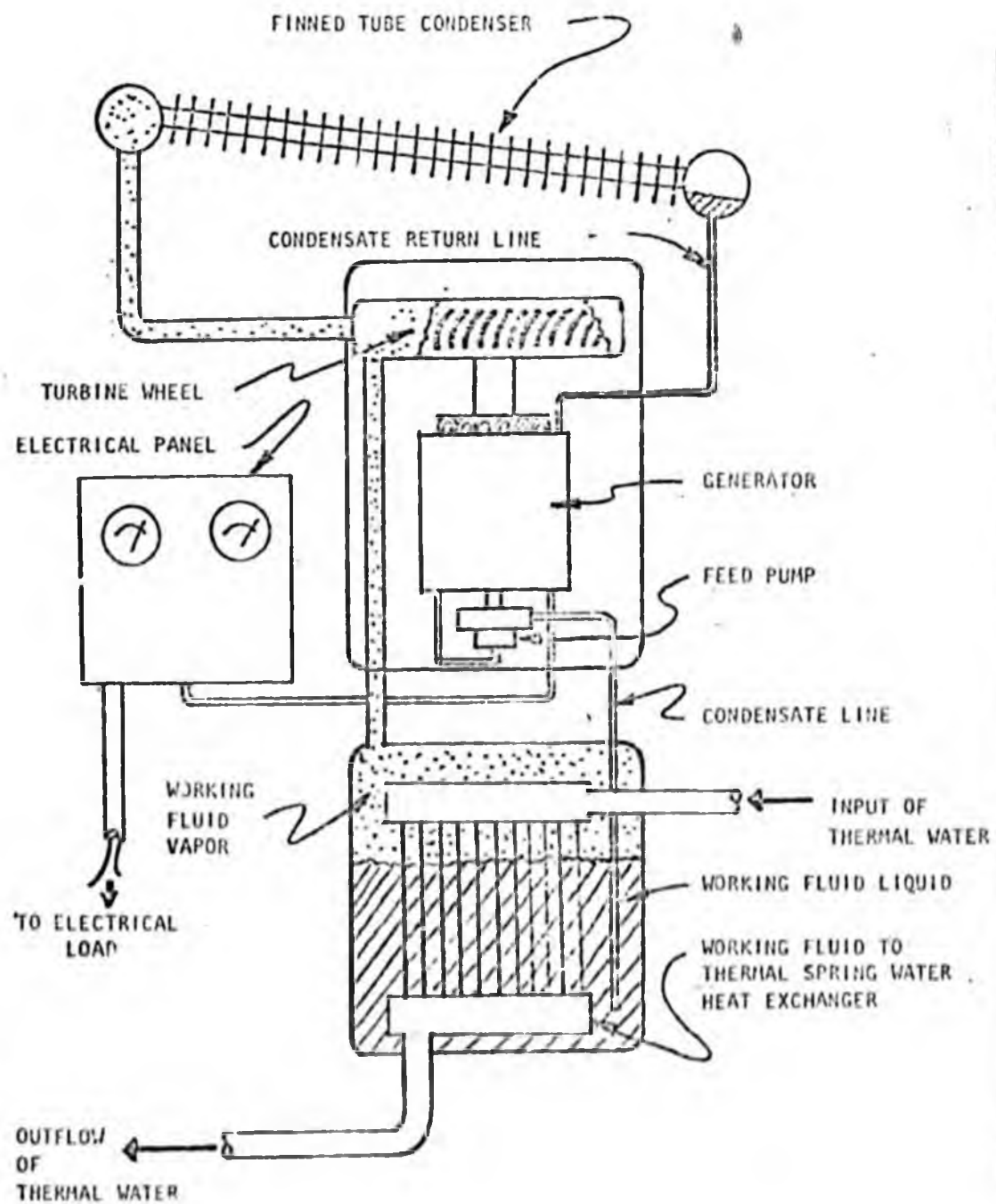


Figure 13: Diagram of Ormat system applied to thermal spring heat source.

4. The working fluid-air condenser is of the free convection type which makes cooling fans and similar devices unnecessary; and
5. The turbo-generating system is hermetically sealed and Ormat claims a 20-year operating life without maintenance.

All of these factors, as well as the previous experience of Ormat Turbines Ltd. in manufacturing organic Rankine cycle systems for the communications industry in other arctic and subarctic areas, make the Ormat system ideally suited for rural Alaska. If an optimum system for a rural Alaskan village could be found, it would be one in which:

1. A local fuel could provide the basic energy input.
2. No maintenance was necessary, and the system could operate unattended for extended periods.
3. The system would be simple enough to be operated by personnel with basic technical skills, and without extensive formal training.
4. The cost would be low.

An Ormat type system appears to meet most of these criteria, but the system has not been demonstrated in the field. If a successful demonstration is achieved, cost factors will fall with increased demand. To date, the largest Ormat unit of this type is a 15-KW unit. However, Ormat engineers are now working on a 100-KW system. Hopefully, the production of this size unit could coincide with the final phase of a successful small-scale feasibility demonstration of a geothermally-powered Ormat turbine.

Ormat Turbines Ltd. has agreed to work with the Geophysical Institute on a co-sponsored research and development investigation. Ormat has agreed to design and construct a 2500-W test unit with a hot water-to-working fluid heat exchanger suitable for the experiment.

Space Heating: The cost of home heating in Alaska is high. In many rural villages without local fuels such as wood or coal, imported fuel oil is the only source of heat. Presently, No. 1 stove oil costs are as high as \$1 per gallon in some remote villages and recently have risen to over 50¢ per gallon in many Alaskan cities. At this rate, \$900 would be an annual cost for home heating that many village residents can expect to pay this year. With the typical head of a household making less than \$3,000 per year, the heating bill alone would constitute about 30% of the family's annual income. Under these conditions, the burden of heating costs alone can seriously depress the potential for economic growth of rural communities.

The heating of buildings with thermal spring waters is one of the oldest and most basic applications of geothermal energy. In areas where thermal springs exist, obvious benefits could be realized by the construction of a geothermally-powered municipal heating system. Figure 14a shows a simple system in which thermal waters from the spring would be directly circulated through convectors in homes. Since many thermal springs contain dissolved salts and other minerals which are corrosive to piping, binary systems as shown in Figure 14b could be constructed which would limit the corrosive effects to a heat exchanger which could be built of stainless steel, or other non-corrosive material.

Various methods could be employed to circulate the thermal spring water. Thermal siphons could help reduce the required pump work. This particular method was used at Pilgrim Hot Springs, Alaska, during the 1930's when the waters of the spring were used to heat buildings at the Catholic mission school.

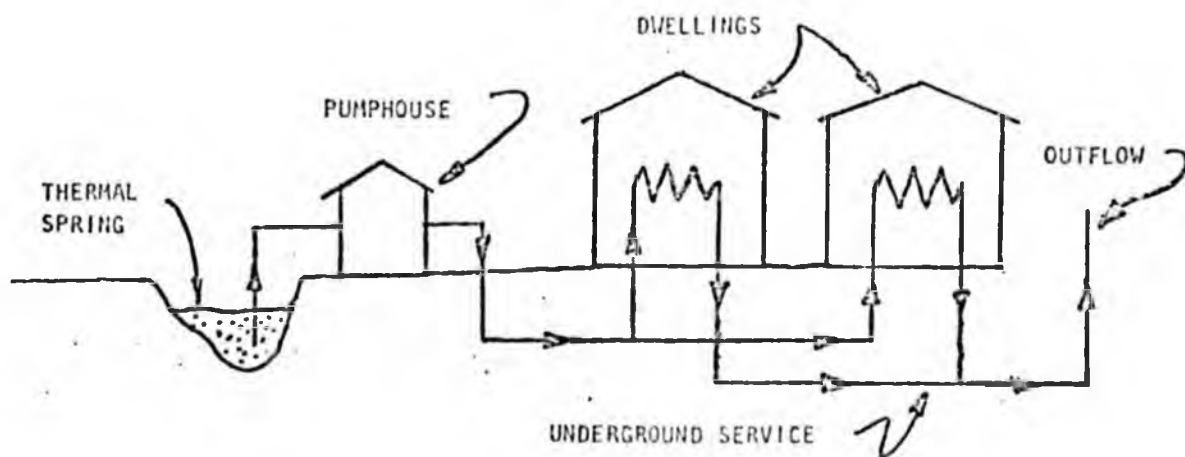


Figure 14a: Primary space heating system.

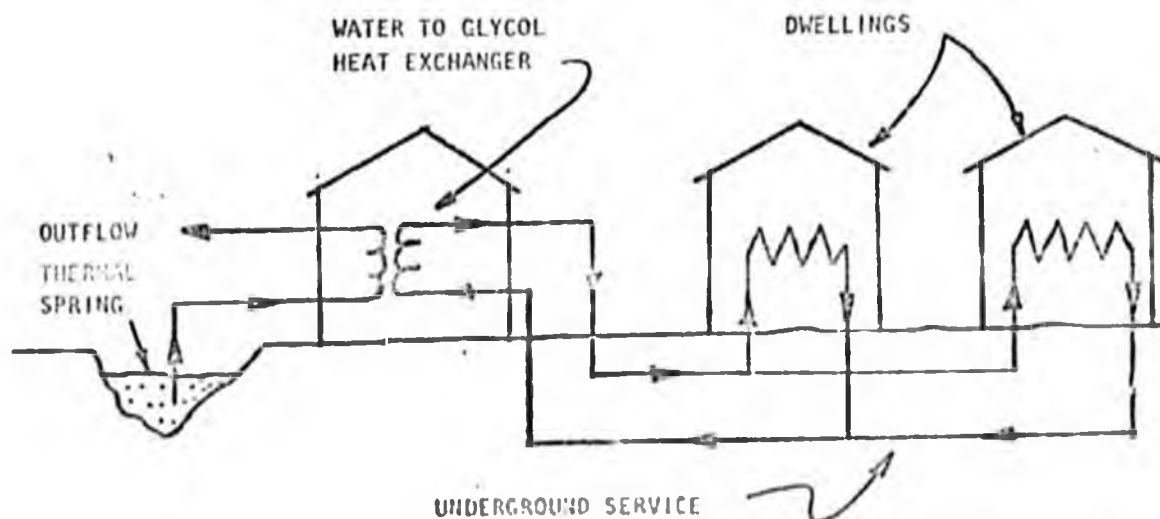


Figure 14b: Binary space heating system.

Space heating techniques are not new and probably do not require further experimental development. A careful literature and design investigation should be made, however, to gain full advantage of existing equipment which could be applied to Alaskan needs.

Refrigeration: Several villages such as Elim and Mary's Igloo on the Seward Peninsula, and Manley in Interior Alaska, could benefit greatly from low-cost refrigeration systems. Small coastal villages cannot presently take full advantage of commercial fishing opportunities due to the lack of cold storage facilities. The reindeer industry is another example of the need for cold storage or freezer facilities as such facilities could eliminate the need for immediate sale and shipment of meat after the reindeer are harvested.

Transmission of Geothermal Energy

Since geothermal resources often exist in areas which are some distance from the location where they could be best utilized, the transmission of this energy becomes an applications engineering problem. If electricity was the only concern, it could be transmitted from the generating site to the users by the usual transmission lines. But since we are also concerned with non-electric applications and the total utilization of the available energy, the problem is more complex.

High Temperature Pipelines: To date, no large reservoir geothermal systems have been discovered in Alaska; thus we are not immediately concerned with the transmission of large quantities of energy. If such a discovery should be made, however, pipeline transmission of hot water might present formidable problems. The Icelandic operations are the most valuable model that we currently have for hot water transmission

technology. The Alaskan climate is more extreme, however, and hot water pipelines will face the same environmental problems that confronted the trans-Alaska oil pipeline. High moisture content permafrost is a costly handicap, and non-stable soil problems can offer many challenges to pipeline engineers. This report does not contain a complete economic analysis of hot water pipelines in Alaska, but we believe that the cost would be highly prohibitive, unless a great number of people could be served, and there was a large magnitude energy potential.

Low Temperature Pipelines: Low temperature waters such as those emitted by many thermal springs, offer similar transmission problems to those which would be encountered by high temperature water pipelines, with the added hazard of lower outflow temperatures due to heat loss.

Pipeline transmission of low temperature thermal waters (60°C or lower) is not practical in permafrost terrane for distances over two or three miles. Where low temperature springs are to be utilized, it is more feasible to move the user to the source than to attempt pipeline transmission of the water.

SPACE HEATING AND INDUSTRIAL APPLICATIONS

Space Heating

Alaska should be an ideal place for the use of geothermal space heating because of the large number of days per year that heating is necessary; thus the "on line" factor would be high. Temperature extremes might require supplemental booster heating for a cost efficient system.

The use of existing hot springs is an ideal way to initiate this program, as the "front end" costs of exploration and drilling could be avoided. Small projects (a dozen to several hundred homes) should be proposed and implemented as soon as possible. A survey should be conducted at the earliest date to determine which communities are amenable to space heating by hot spring sources.

It does not seem practical to use wind power for space heating, unless heat pumps could be integrated into the system.

The Industrial Belt

The possible applications of geothermal or wind power in the industrial belt should be investigated in the near future. Fairbanks is potentially interesting since it is already known that 100°C temperatures exist at 10,000 feet in the subsurface, and that the present heating methods cause serious ice fog problems.

The New Capital Site

The working group felt that in spite of the possible adverse political effects, the possibility of heating the new capital with geothermal heat should be again pointed out to the Capital Site Committee. After a site

is picked, the possibility should again be studied. At least the town should be planned to be centrally heated so that such a heat source could be used later, if developed.

Industrial Applications

The following is a list of possible industrial applications:

1. The use of geothermal energy to make electricity for the aluminum or fertilizer industry using the apparently large resource along the Aleutian Chain. Wind energy might be a good candidate for this use also.
2. The use of geothermal steam in the southeast for pulp processing. This is being done in New Zealand with appreciable success.
3. The use of geothermal hot water to allow gold mining year-round, as is done in Siberia.
4. The use of geothermal hot water for other mining processing, for instance at Lost River.

Recommended Projects

Specifically, a few projects should be started as soon as possible:

1. A survey of all rural Alaska villages should be conducted to determine where wind and/or geothermal energy might be competitive with present energy sources.
2. Based on that survey, a number of projects should be initiated to demonstrate the practicability of such applications.
3. The needs of larger population centers should also be evaluated, in terms of municipal wind power and geothermal applications.

ENVIRONMENTAL HAZARDS AND PROTECTION

Environmental Hazards

Chemical Pollution: Steam brought up from subsurface reservoirs contains about 0.5-5% noncondensable gas which is principally carbon dioxide with varying amounts of hydrogen sulfide, methane and ammonia.

These gases are released directly from the condensate in cooling towers. Condensates usually contain trace amounts of boron, arsenic and other volatile elements which can be hazardous in excessive concentrations. Hydrogen sulfide is a dense gaseous pollutant which can be dangerous to human and animal life.

Most geothermal steam fields are the wet rather than the dry type (vapor dominated) and contain approximately 80% water at the wellhead. The water often contains higher concentrations of trace elements than the steam. The most common dissolved constituents include carbonate, silica and sodium chloride.

Some of the liquid-dominated systems are characterized by brines which contain very high concentrations of sodium, potassium, bromine and heavy metals. Such brines are extremely corrosive, and potentially hazardous to plant and animal life if released into the environment without treatment.

Noise Pollution: When superheated water flashes to steam, an intense roar is produced which is very offensive to workers, residents and nearby communities.

Thermal Pollution: Hot water which is wasted from geothermal power plants and other uses is potentially troublesome if it is allowed to

flow into streams, rivers, lakes or ground water tables. The chemical effect on the ecosystem may be far less in some cases than the thermal shock created by the inflow of hot water.

Anti-Pollution Measures

In the case of steam fields, water and condensates may be reinjected into another drill hole. Acoustic problems from flashing steam can be solved with silencers.

In the next few years, a technology will no doubt be developed for desalinization systems which will extract valuable salts and metals from brines, after steam has been extracted for the turbines, with a final outflow of potable water (Figure 15).

Environmental Vulnerability of Alaskan Thermal Springs

The utilization of thermal waters emitted from springs is not beset by some of the hazards associated with geothermal steam operations. Thermal waters which well up from the springs flow into streams which are part of the same ecosystem. The chemical composition of the spring waters should not be greatly changed by the planned demonstrations and experiments, as only the heat will be extracted....and concentrations of dissolved constituents are not high enough to cause accelerated precipitation during the cooling process. The water can be rechanneled into the same outflow streams with relatively little environmental impact.

If shallow drilling at Pilgrim Springs should indicate a possible geothermal steam reservoir, with more highly concentrated brines as the liquid phase, adequate protection measures will have to be taken before proceeding to demonstrations involving deeper drilling and the possible release of steam and condensates at the wellhead.

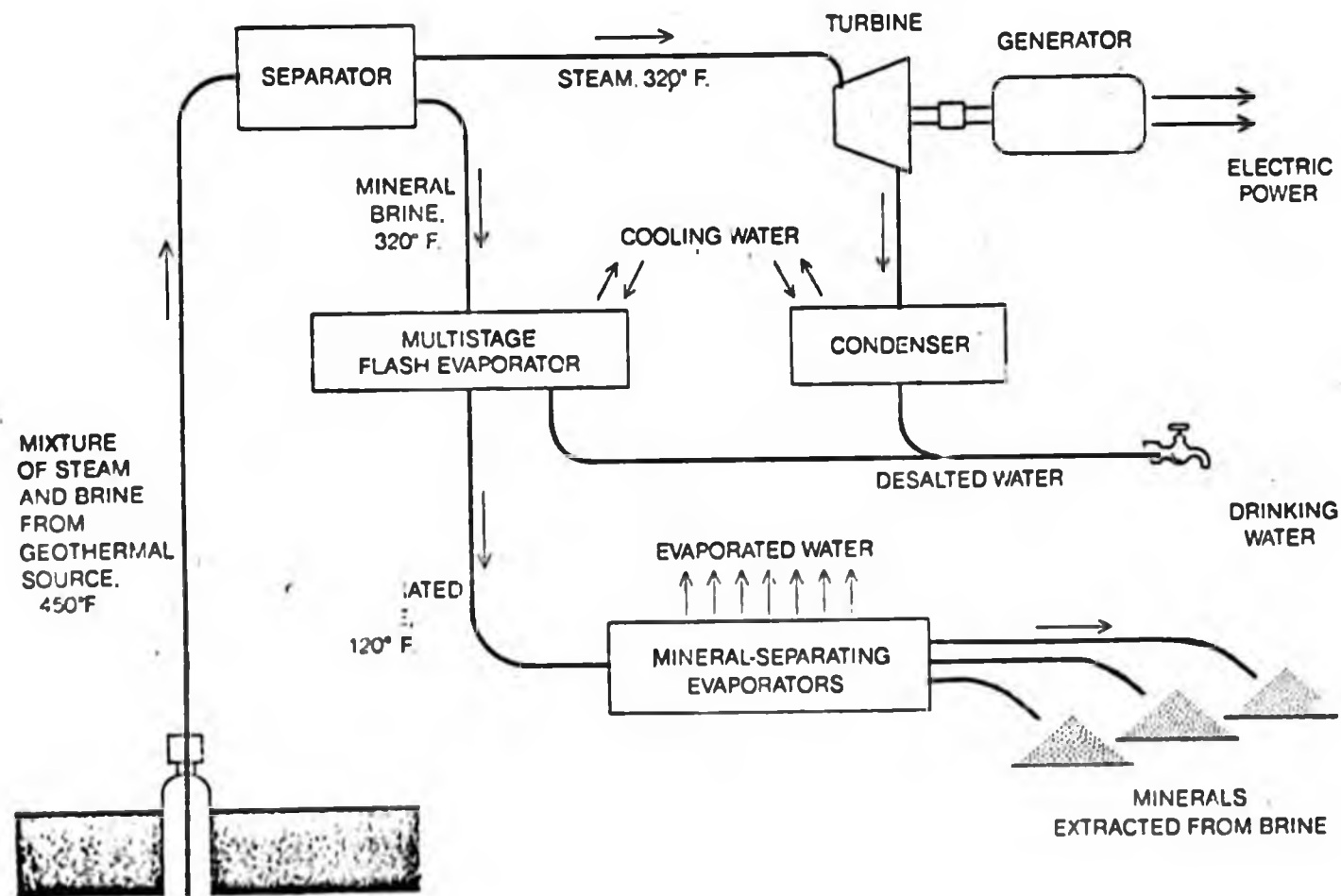


Figure 15: Multipurpose geothermal system, as designed by the UN and the Government of Chile. From "Geothermal Power" by Joseph Barnea. Copyright January, 1972, by Scientific American, Inc. All rights reserved.

Some concern has been voiced for thermal springs and the adjacent terrane as possible island ecosystems surrounded by a hostile arctic environment. It has been suggested, for example, that such ecosystems and the accompanying microenvironment (unless destroyed by man.) may contain relict biological populations which have survived glacial episodes, dating back to Pliocene time. Although it remains to be proved, the reported presence of vigorous earthworms in the warm soil around Pilgrim Springs is of more than passing interest....even though the earthworms may have arrived via plants which were imported during the Nome gold rush.

Manley and Pilgrim Springs have been thoroughly overprinted by the works of man. Channelways, pools and seeps have been reworked and altered by several generations of residents. Indeed, it would be difficult, or perhaps impossible, to reconstruct the original setting. Nevertheless, each of these microenvironments should be carefully assessed and evaluated so that future developments can be accompanied by attempts to restore the former biological equilibrium, if possible.

Clear Creek Springs will be a more sensitive site, as it has not been obviously altered or disturbed by the white man. It would be prudent to conduct a thorough biological assessment of these springs and the surrounding terrane during the reconnaissance studies.

WIND POWER POTENTIAL OF ALASKA

Wind Power Potential Defined

Wind power potential can be defined in several ways, including the available wind energy (in a meteorological sense), and wind energy that can actually be converted to useful work at a given site. The meteorological wind power potential of Alaska is high. However, due to the high cost of installing windmills versus marketing the exported energy, the economic climate is poor in uninhabitated places like Architka and Cape Thompson where near-surface wind speeds are almost ideal for large wind-driven power plants. Alternately, Cold Bay, with its excellent harbor and wind resources, is a promising location for the utilization of wind-derived power.

In Alaska, the availability of wind-derived energy, and the attendant practical wind power potential, will be limited by economics for some time to come. The economics will be influenced greatly by the huge land area, much of it not settled, and the dispersed population outside of the few major cities. In the area of the two largest cities, Anchorage and Fairbanks, fossil fuels and hydro-electric power will be more than competitive with wind. However, an underlying concern in all wind power investigations is that what appears to be economic folly now may be an attractive proposition or even a necessity in the year 2000 (only 24 years away).

The wind energy of the entire atmosphere is really not of interest here. Rather, the central question seems to be what power (or power flux) is available for windmill purposes in the atmospheric layer ranging from the earth's surface to about 1100 meters. Sellers (1966) and

Flohn (1966) separately estimated that the dissipation of energy by the worldwide combination of winds, waves, tides and currents ranges from 250 to 2500×10^{12} watts. We estimate that 1130×10^{12} watts are generated and dissipated in the same layer. On an areal basis, 3.4×10^{12} watts are dissipated over Alaska. These power flux and power estimates are shown in Table 9. Kung (1966a, 1966b) has published extensively on the kinetic energy generation and dissipation of the atmosphere, based on data from about 120 weather stations throughout the entire United States and most of Alaska and Canada. Thus, computed values of the kinetic energy in various atmospheric layers are available for most of North America. Below 1100 meters these power fluxes are (Kung, 1966b) about 2.21 watts/m^2 . (In his earlier paper, Kung (1966a) estimated 1.8 watts/m^2 .) Additionally, Kung concludes that despite the difference in land and ocean surface roughness, the dissipation rates in the boundary layer are about the same over land masses and the oceans.

Thus, we can assume here that 2.21 watts/m^2 represent the mean worldwide annual power flux for dissipation and generation in the lower boundary layer (defined here as the first 1100 meters of the atmosphere). Our estimate for the world surface area ($1.965 \times 10^8 \text{ mi}^2$ or $5.10 \times 10^{14} \text{ m}^2$) of the wind energy in the boundary layer is 1130×10^{12} watts.

We can also conclude that in the Alaskan boundary layer (area = 5.86×10^6 , or 0.30% of the earth's total area), the available kinetic energy is 3.4×10^6 megawatts.

If we arbitrarily assume that 1/1000 of the kinetic energy in the first 1100 meters of air above Alaska could be extracted by windmills, then the practical annual mean wind power potential of Alaska is

TABLE 9

FRICTIONAL POWER FLUXES IN THE EARTH-ATMOSPHERE INTERFACE
AND ESTIMATES OF POWER OF DISSIPATION POTENTIALLY AVAILABLE
FOR WIND POWER.

<u>Author (year, ref.)</u>	<u>Frictional Power flux watts/m²</u>	<u>World-Wide⁺ "Wind Power"^{**} in 10¹² watts</u>
Flohn (1966, 12)	1-2	510-1020
Sellers (1966, 11)	0.49-4.9**	247-2470**
Hubbert (1972, 6)	various, averaged	370
Kung (1966, 7)	1.8	-
Kung (1966, 8)	2.21	-
von Arx (1974, 13)	-	1
Wentink (this work)	Used 2.21	1130 (3.4 for Alaska)

* In a near-surface boundary layer, about 1100 meters thick, originally wind-driven and eventually dissipated by energy sinks like waves, surface currents, and (in part) convection.

** Computed by Hubbert⁹ from Seller's 1-10 langleya/day;
1 ly/day = 0.485 watts/m².

[†] Earth total surface area = $1.97 \times 10^8 \text{ mi}^2 = 5.10 \times 10^{14} \text{ m}^2$.

about 3400 megawatts. This is six times the present electric power generation capability of all Alaskan utilities. Clearly, a renewable resource with a power generation potential of this magnitude warrants closer examination.

Wind Power Calculations

The discussion of wind power involves several wind speed (V , for velocity) quantities. It is important to differentiate these quantities as instantaneous wind speed (V), average or mean wind speed ($\bar{V}$), and rated wind speed (V_R). The latter is the wind speed necessary for maximum power output of a given windmill or wind energy conversion system (WECS). Thus, for example, a particular windmill may have $V_R = 32$ mph to develop a 6 KW power output. As described later, however, that particular machine will produce an average power ($\bar{P}$) output of only 0.8 KW to about 4 KW, for a range in $\bar{V}$ of 10 to 25 mph. The latter average is only attained in very unusual situations, such as that recorded on Anchitka in January.

Hence, the determination of the average wind velocity ($\bar{V}$) of a site is important. Also, generally, V increases with height, so increasing tower heights are important (recommended 40 to 60 feet for small windmills). In the ($\bar{V}$) tables presented in this report (Tables 10, 11), it is important to note that the height of wind measurement varied from about 13 to 100 feet above ground, and in all cases the station data were acquired for purposes other than the evaluations of wind power.

While the following discussion deals mostly with $\bar{V}$, frequency (duration) data are also important (i.e., the amount of time that various winds reach or exceed V at a given site). For our purposes in this paper the comparison of $\bar{V}$, as measured for Alaskan sites, is adequate.

Meaningful Variables: The average or arithmetic mean wind speed ($\bar{V}$), the variance of the wind speed (V), and the vertical profile of V are the most important variables in the evaluation of a site for wind power generation.

The instantaneous power in kilowatts (P) depends on the windmill disc area (A), and the cube of (V), with a constant (K) for the unit system and the air density. These relations have been treated extensively in most publications on wind power. Thus:

$$P(KW) = K A V^3 \quad (3)$$

K is about 3.1×10^{-6} for an ideal windmill, and in actual practice, is obtained by multiplying P by the actual efficiency, which usually ranges from 50 to 70%. The mean power $\bar{P}$ does not vary with $\bar{V}^3$ in the same way, but we will show the importance of using $\bar{V}$ to compute $\bar{P}$.

The vertical gradient of horizontal wind speeds is an important design and operating parameter. Data on the gradient are essential in determining optimum tower height in order to optimize energy productivity and to cope with the difference in forces on the turbine blades at the top and bottom of the swing of the rotating blades.

The relationship between the wind velocity (V) at a height above the ground (h) is given by:

$$V_u V_l = (h_u / h_l)^p \quad (4)$$

where u and l refer to the upper and lower heights. Here p can vary from 0 to 1. For estimation, p of 0.15 to 0.30 is useful.

We have examined the wind speed data from other sources such as the National Weather Service, from various heights, and for several stations

in an attempt to establish the vertical gradients of horizontal wind speed (see calculations for Cold Bay, Table 11 in Wentink, 1974). These attempts have failed, for various reasons. Our strong conviction is that further such attempts are not worthwhile, unless simultaneous measurements at various heights are made on the same tower. Long-term mean values of V do not serve the purpose. In the case of Cold Bay, subsequent and extensive simultaneous measurements did indeed reveal a well-defined vertical wind velocity profile.

Alaskan Wind Data

The collection of Alaskan wind data has been a formidable task, as the National Climatological Center (NCC) lists 90 Alaskan land stations for which some wind data are available. There are data from other stations which have not yet been reduced to usable form, such as those from the Arctic Distant Early Warning radar stations (DEW line). Reed (1975) has published wind data for 63 Alaskan sites taken from an NCC computer tape. There are several different climatological provinces in Alaska as defined and separated by extensive mountain ranges. This report emphasizes mainland coastal Alaska, including the Alaskan Peninsula, the Aleutian and other offshore Alaskan islands.

Wentink (1974) covers 10 sites in the Aleutian Islands (west of False Pass and Cold Bay); 4 sites on the Alaska Peninsula; and 3 sites on the northwest coastal mainland. In more detail, these sites are listed on the next page.

Aleutians

Shemya
 Amchitka
 Adak
 Atka
 Nikolski
 Fort Glenn (Cape AFB)
 Driftwood Bay
 Dutch Harbor
 Cape Sarichef
 St. Paul Island

Alaska Peninsula

Cold Bay
 Port Moller
 Port Heiden
 King Salmon

Northwest Coast

Kotzebue
 Tin City
 Cape Lisburne

Data from additional locations are also included in this report, including:

"Panhandle" and
Gulf of Alaska

Annette Island
 Juneau
 Yakutat
 Cordova
 Middleton Island
 Kodiak

West
Coast

Cape Newenham
 Cape Romanzof
 Bethel
 Northeast Cape*
 Nome
 Koyuk
 Moses Pt.
 Cape Thompson
 Pt. Hope

North
Coast

Barrow
 Barter Island

Interior

McGrath
 Fairbanks

* St. Lawrence Island

Most of these locations have considerable potential for wind power installations of various sizes. It is important to remember that none of the wind data from these sites analyzed by us were taken at locations that had been previously selected as possible wind power installations; on the contrary, the anemometer positions had been selected, and often moved, to favor aviation observations. Thus, mean wind speeds given in Tables 10 and 11 probably represent conservative lower limits for estimation of wind energy.

In general, a $\bar{V}$ of 12 mph (10.4 knots) or more at expected propeller heights is desirable for satisfactory windmill performance.

TABLE 10

NEAR-SURFACE YEARLY MEAN WIND SPEEDS AT VARIOUS ALASKAN LOCATIONS

<u>General Area</u>	<u>Station</u>	<u>Yearly Mean Speed* (knots)</u>	<u>Data Period</u>	<u>Anemometer Height (feet)**</u>
Aleutian Islands	Shemya	16.2	1950-72	184-20
	Amchitka	18.3	1943-50	?
	Adak	13.1 (sh)	1942-65	75-15
	Atka	10.9 (sh)	1942-45	?
	Nikolski ^a	14.0	1959-69	30-13
	Ft. Glenn ^a	13.6	1942-48	?
	Driftwood Bay ^b	8.3 (sh)	1959-69	?
	Dutch Harbor ^b	9.6 (sh)	1946-54	33
	Cape Sarichef	13.7	1952-56	?
Alaska Peninsula	St. Paul ^c	16.0	1962-71	42
	Cold Bay	14.9	1956-72	88-21
	Port Moller	8.9 (sh)	1959-59	30-20
	Port Heiden	12.8	1942-67	29
	Ugashik	Under measurement by us		
	King Salmon	9.6	1956-72	38-20
Alaska "Panhandle" and Gulf of Alaska	Annette Island	9.5	1942-70	53-20
	Juneau	7.4 (sh)	1948-70	32-37
	Yakutat	7.0	1941-70	59-20
	Cordova	4.4 (sh)	1946-70	36-20
	Middleton Isl.	11.9	1945-63	30-20
	Kodiak	8.9 (sh)	1941-69	60-16

TABLE 10 (cont'd.)

<u>General Area</u>	<u>Station</u>	<u>Yearly Mean Speed*</u> (knots)	<u>Data Period</u>	<u>Anemometer Height (feet)**</u>
Kuskokwim and Yukon Rivers and Deltas	Cape Newenham	9.8	1953-70	30-13
	Cape Romanzof	11.7	1953-70	15-11
	Bethel	11.2	1958-72	69-20
	McGrath ^d	4.3	1949-73	26
Norton and Kotzebue Sounds, Seward Peninsula	Koyuk	9.5	1944-45	?
	Moses Point	10.6	1945-67	?
	Nome	9.5	1955-73	75-21
	Northeast Cape ^e	11.0	1952-69	30-13
	Tin City	14.9	1953-70	?
	Kotzebue	11.1	1945-70	31
Northwestern and Northern coasts	Cape Thompson	17.4	1960-61	?
	Pt. Hope	10.7	1945-48	?
	Cape Lisburne	10.5	1953-70	13
	Barrow	10.6	1945-68	39-31
	Kaktovik ^f	11.2	1945-70	27-20
Fairbanks (interior)	Fairbanks	4.3		

** Last value is usually the most recent height. Large horizontal shifts may also have occurred.

* (sh): pronounced topographic shielding effects may be involved.

a: Umnak Island

b: Unalaska Island

c: Pribilof Island

d: Interior location

e: St. Lawrence Island

f: Barter Island

Ranking of Wind Power Sites

In Table 11, 67 Alaskan sites have been ranked on the basis of measured mean yearly wind speeds and/or the yearly average potential wind power. These stations are representative of more than 100 Alaskan sites. The means are taken from data acquired during our literature survey, and the wind power figures are from the excellent compilation by Reed (1975). Readers who refer to this table should realize that:

1. None of the data involve optimization of wind instrument location for wind power surveys.
2. No attempt has been made to correct for the changes in anemometer location (vertically or horizontally) over extended observation periods.
3. Close agreement should not be expected when average powers derived from our $\bar{V}$ are compared to Reed's watts/m², because:
 - a. In some cases the recording periods for the two sets of data are different; and
 - b. Reed's power fluxes are means for long time periods derived by averaging monthly power fluxes (Reed, 1975).
4. The wind power fluxes are high in terms of what can be extracted by presently available windmills. The theoretical Betz (1966) extraction limit of 59.3% for unshrouded windmills is not included, and neither are the normal mechanical and electrical efficiencies taken into account. Also, the cut-in speed and the power limiting at higher velocities (25 knots or 12.9 m/s), as planned for present windmill design, are not included.

Nevertheless, simple conversions may be applied to Reed's results in order to estimate the actual power obtained from a particular windmill at a specific location. For example, the "Elektro WVG-50G" 6KW machine (disc area 19.9m^2) gives a factor $f=0.59$ (Betz limit $\times 10^{-3}\text{KW/w}$ $\times 19.9\text{m}^2 = 1.17 \times 10^{-2}/\text{w}$). An empirical factor K (0.39) seems to express the machine versus wind speed characteristics when coupled with the speed duration curves. It may be considered a composite "shape factor"; it includes variables such as cut-in speed, practical efficiencies, and calms. Then, for this particular windmill, $fk = 4.5 \times 10^3 \text{KW-m}^2/\text{w}$. As shown in Table 12, fk , when multiplied by Reed's values, leads to useful estimates of the yearly mean power which compare well in most cases with our results, derived from computed power productivity curves.

TABLE 11

RANKING OF ALASKAN WIND POWER SITES

RANK	¹ Average yearly wind velocity (V)	$\bar{V}$ yearly, meters/ sec.	Site	² Wind Power watts/m ²	Remarks
1	18.3	9.41	Amchitka Is.	1025	Uninhabited
2	17.4	8.95	Cape Thompson		Uninhabited
3	16.2	8.33	Shemya Is.	633	Restricted area
4	14.9	7.66	Cold Bay	574	Prime test site
5	14.9	7.66	Tin City	549	
6	16.0	8.23	St. Paul Is.	547	
7	13.7	7.05	Cape Sarichef (Unimak Is.)		
8	13.6	7.00	Cape AFB (Unimak Is.)	498	
9	14.0	7.20	Nikolski (Unimak Is.)	482	
10	12.8	6.58	Port Heiden	430	
11	13.1	6.74	Adak Is.	405	
12	11.7	6.02	Cape Romanzof	381	
13	11.9	6.12	Middleton Is.	377	
14	11.3	5.81	Attu Is.	369	Site probably shielded; V low should rank near #3.
15	11.2	5.76	Kaktovik (Barter Is.)	341	
16	11.0	5.66	Northeast Cape (St. Lawrence Is.)	329	
17	10.9	5.61	Atka Is.		V probably lower limit
18	10.7	5.50	Point Hope		

TABLE 11 (cont'd.)

RANK	¹ Average yearly wind velocity ($\bar{V}$)	$\bar{V}$ yearly, meters/ sec.	Site	² Wind Power watts/m ²	Remarks
19	10.5	5.40	Cape Lisburne	315	
20	11.1	5.71	Kotzebue	292	
21	11.4	5.86	Unalakleet	265	
22	9.8	5.04	Cape Newenham	242	
23	10.6	5.45	Moses Point	241	
24	NA*	-	Golovin	241	
25	9.6	4.9	Dutch Harbor (Unalaska Is.)	233	Shielded instrument site (?)
26	9.5	4.9	Nome	218	
27	8.1	4.2	Big Delta	216	
28	9.5	4.9	Koyuk		
29	9.5	4.9	Annette Is.	199	
30	10.6	5.45	Point Barrow	193	
31	9.6	4.9	King Salmon	191	
32	8.9	4.6	Kodiak	189	
33	8.9	4.6	Port Moller	172	
34	11.2	5.76	Bethel	172	
35	NA*	-	Flat	172	
36	7.9	4.1	Haines	147	
37	8.3	4.3	Driftwood Bay (Unalaska Is.)		
38	NA*	-	Craig	129	
39	7.4	3.8	Juneau	116	
40	7.0	3.6	Yakutat	115	

* = Not yet available.

TABLE 11 (cont'd.)

RANK	¹ Average yearly wind velocity (V)	$\bar{V}$ yearly, meters/ sec.	Site	² Wind Power watts/m ²	Remarks
41	5.7	2.9	Gulkana	81	
42	NA*	-	Ruby	79	
43	6.0	3.1	Umiat	76	
44	6.6	3.4	Kenai	75	
45	5.6	2.9	Tanana	73	
46	5.4	2.8	Indian Mtn.	70	
47	5.6	2.9	Fort Yukon	65	
48	4.7	2.4	Sparrevohn	64	
49	NA*	-	Manley Mt. Spngs.	63	
50			Anchorage (Int. Apt.)	61	
51	6.4	3.3	Galena	59	
52	NA*	-	Ketchikan	58	
53	NA*	-	Kaltag	57	
54	6.6	3.4	Valdez	53	
55	5.8	3.0	Bettles	49	
56	5.6	2.9	Homer		
57	5.0	2.6	Nenana	42	
58	4.6	2.4	Anchorage (Merrill Field)	38	
59	4.4	2.3	Cordova (Mile 13 Apt.)	37	Shielded instrument site (?)
60	5.7	2.9	Anchorage (Elmendorf AFB)	36	

* - Not yet available.

TABLE 11 (cont'd.)

RANK	¹ Average yearly wind velocity ($\bar{V}$)	$\bar{V}$ yearly, meters/ sec.	Site	² Wind Power watts/m ²	Remarks
61	6.6	3.4	Sitka	33	
62	7.9	7.9	Petersburg	33	
63	4.3	2.2	Tatalina	31	
64	4.2	2.2	Northway	29	
65	4.3	2.2	McGrath	28	
66	4.3	2.2	Fairbanks (Int. Apt.)	27	
67	3.8	2.0	Wiseman	24	

Notes:

- (1) Taken from Wentink (1976).
- (2) As taken from Reed (1975); these values are the averages of the 12 mean monthly wind powers calculated from unsmoothed duration curves.

TABLE 12

YEARLY MEAN POWER* FOR SPECIFIC ALASKAN SITES AND WIND MACHINE "X"

<u>Site</u>	<u>Annual average wind velocity (V) mph</u>	<u>Annual average wind velocity (V), m/s</u>	<u>watts/m² (Reed)</u>	<u>Mean Power (P) in KW Reed x f k (1)</u>	<u>Mean Power (P) in KW Wentink (2)</u>
Amchitka Island	21.1	9.43	1025	4.7	3.27
Cold Bay	17.4	7.78	574	2.64	2.70
St. Paul Island	17.1	7.64	548	2.52	2.59
Umnak Island	15.6	6.97	498	2.29	2.25
Middleton Island	13.7	6.12	377	1.73	1.79
Cape Romanzof	13.4	5.99	381	1.76	1.90
Ketzebue	13.2	5.90	292	1.34	1.63
Cape Lisburne	12.1	5.41	315	1.45	1.62

*Not optimum power, which also depends on site selection and machine height.

(1) $f = 1.17 \times 10^{-2} \text{ KW m}^2/\text{w}$; $k = 0.39$ (empirical).

(2) From machine power vs windpseed characteristics and actual mean yearly speed duration curve.

POWER AND ENERGY PRODUCTIVITY OF SMALL WINDMILLS IN ALASKA

Present State of Technology

As of March 1976 the actual availability of "WECS" is in a state of flux. Foreign windmills that can be ordered "off the shelf" are rated at 2.5 to 6 KW, but delivery to the U.S. and Alaska is often delayed and erratic. U.S. production is almost nil, although many tens of thousands of 3 KW units were sold during the period 1930-1955. In the late 1976-early 1977 period, U.S. manufactured units in the 6 to 15 KW range are expected to appear on the market. Many small companies are developing prototypes, but development and production have been somewhat retarded by lack of an assured market. Paradoxically, however, the market is not developing rapidly due to the lack of field tested, cost acceptable windmills.

Table 13 lists some small windmills that are possibly available to the consumer, and which may be of specific interest to individuals or small, remote communities. Most of these have not been tested in Alaska.

Table 13 does not include the large (100 KW or greater) WECS that are under development by the Energy Research and Development Administration (ERDA) and the National Aeronautics and Space Administration (NASA). We believe that in Alaska a complex of several small units is preferable to one large machine (i.e., four 25 KW WECS instead of one 100 KW WECS). Windmill farms offer redundancy, reduced erection and maintenance problems due to lower tower heights and the technical advantage of proved WECS in the lower power output range.

TABLE 13

Some Small (0.2-15 KW) Windmills Currently or Potentially Available

Manufacturer	Model	Propeller Disc Diameter, ft. (Note 2)	P _{max} , KW (Note 3)	V _R , mph (Note 3)	Voltage Output (Note 4)	Approximate Cost, \$(1976) (Note 5)	Remarks (Note 1)
Grumman Aerospace Corp.	Windstream 25	25 (3b, vp, dw, nt)	15	26	115	20,000 (?)	Available mid-1976 (?) Prototype in test.
Zephyr Wind Dynamo Co.	Zephyr	17 (3b, fp, dw, nt)	7.5 (to 15)	22 (30)	250	3,500	Prototype in test; limited production pending.
Elektro GmbH (Swiss)	Various; data for WVG-50G	16.5 (3b, vp, wt)	6.1	32	115	6,500	In production; long history.
Aerowatt (French)	Various; data for largest.	3 ^{or} 1 (2b, vp, wt)	4.1	17	220	23,000 (?)	Limited production; excels in low V regimes.
Jacobs Wind Electric Co.	Various (pre-1955)	14 (3b, vp, wt)	1.5 (to 3.0)	18	32 or 110	2,500 to 5,000	Prices for recondi- tioned machines; long history of excellent performance. (Note 6)
Quirks (Australian)	Various	13 (3b, vp, wt)	2.5 (3.0)	25 (30)	24 to 110	3,000 (?)	Rated at 2KW continuous Long history of proven performance. In production.
Sanderson Wind Electric	750-16	12 (3b, fp, wt)	0.8	20	14	1,400 (kit, 1050)	In production.
Windcharger	1222H	6 (2b, fp, wt)	0.2	23	14	450	Long production history; cost includes stub tower.

Notes:

- Inclusion in this list, or omission from it, does not imply any recommendation. A question mark means only our uncertainty of lack of current information. All information is to the best of our knowledge, mostly from vendor literature or private communications.
- b = number of blades; vp = variable pitch; fp = fixed pitch; dw = downwind pusher type; nt = no tail boom; wt = with tail boom.
- Power output P_{max} achieved at wind speed V_R; limiting by various means then occurs; at some larger V controlled shut-down usually occurs.
- Nominal voltage or generator of alternator; larger voltages (within design limits) are often encountered.
- f.o.b. manufacturer or dealer locations and without tower.
- Jacobs may announce new models in 1976 or 1977; for reconditioned units inquire elsewhere.

The Use of Mean Wind Speeds

The instantaneous power output (P) of a given wind turbine (treated elsewhere) depends on the cube of the wind speed:

$$P(KW) = K A V^3$$

where with (V) in mph and the area (A) in ft^2 , (P) is in KW. However, as pointed out previously, the cube of the average (mean) wind speed of a site is appreciably different from the mean of the cubes of various wind speeds, i.e.,

$$\bar{V} \equiv \frac{1}{n} \sum_i V_i$$

where n is the number of V_i data and

$$\bar{V}^3 \neq \sum_i V_i^3 \text{ and } c \bar{V}^3 \approx \sum_i V_i^3$$

For instance, a Lockheed study (1975) shows that c of the last equality is about 1.73 (for a 3 km height above ground). Of course, this c factor will be different for near-surface winds, and 1.73 also is not directly applicable to the problem of wind turbines having a threshold cut-in speed above zero and probable power limiting at some specified velocity. In most any case $\bar{V}^3$ is an approximate and usually pessimistic lower limit in estimating the absolute power of a WECS in a given $\bar{V}$ regime. However, $\bar{V}$ is still a very useful parameter, (Wentink, 1976).

Evaluation of Available WECS Units

The output of a given windmill can be predicted for a given location, if one has the necessary wind data for that location, even though only average wind speeds are known. In the latter case, synthesized

(calculated, wind duration curves can be used instead of measured field wind duration curves (Wentink, 1976). This approach is useful, in that economic analyses and predictions can be made, including estimated costs of wind-derived electricity and resultant savings in fossil fuel consumption for various WECS and locations.

Grumman WS25 Prototype: We correlated the manufacturer's preliminary power (P) versus wind speed duration curves, using synthetic V duration curves computed from our "Planck" distribution function (Wentink, 1976). These calculations gave curves of P versus time. The integral of each curve gives the energy produced during the period of wind measurement that yielded the duration curve.

The average energy $\bar{E}$ (and $\bar{P}$) are a linear function of $\bar{V}$ up to about 22 mph; above the 22 mph limit, the energy productivity starts to decline since the WS 25 limits quite abruptly at 26 mph (V_R). Where $\bar{V}$ is 12 or 17 mph, the $\bar{P}$ would be 2.3 or 5.8 KW, respectively, for 15 KW-rated WECS.

The Elektro WVG50: The evaluation included the same analytical procedures, with the application of measured V duration curves and two different models for synthetic (artificial) V duration curves. Also, preliminary results based on hand and desk computer calculations, used for the previous section (the WS25), were extended by IBM 360 machine computations.

As shown in Table 14 and Figure 16, it appears that very reasonable values for the average monthly and annual power from a given windmill, in this case the 6 KW Elektro, can be estimated from reliable knowledge of the $\bar{V}$ encountered at the hub of the windmill propeller. The agreement of the analytical data with the field data is remarkably good, lending support to our contention that a long-term measured $\bar{V}$ can be used to predict, for WECS, $\bar{P}$ in the absence of long-term V frequency (i.e., velocity duration) data.

The considerable time spent on the Elektro 6 KW windmill and calculations does not imply any endorsement of this machine or the manufacturer; it merely reflects the fact this machine was used in the Ugashik tests. (The Elektro 6 KW is the highest power rated windmill presently in production.) Other machines may be more desirable, especially for Alaskan use.

The Aerowatt 4.1 KW: We considered in a preliminary way the French Aerowatt Model 4100FP7, rated at 4.1 KW output at $V = 16$ mph. It has a claimed superiority at low wind speeds, mostly due to large (30.7 feet diameter) light blades. However, it is apparently very rugged, with a claimed survival wind speed of 115 knots (132 mph).

The power characteristic shown in Figure 17 was deduced from Aerowatt sales literature. An empirical $\bar{P}$ vs $\bar{V}$ curve from the fit to 46 field points, as described for the Elektro unit, is given in Figure 18.

The computed values are higher than Aerowatt claims, given as points on Figure 13, but they are still in good agreement. While the productivity at low $\bar{V}$ is indeed excellent (39% of maximum at $\bar{V} = 10$ mph), the high cost (\$23,000) is discouraging. The Elektro 6 KW seems to be as productive as the Aerowatt 4.1 KW at $\bar{V} = 21$ mph, but of course few locales have a $\bar{V}$ of 21 mph. To date, we know of only one

TABLE 14

MEAN POWER FROM ELEKTRO WVC50 (6 KW rated) WINDMILL, USING MEASURED
AND SYNTHETIC (F3) SPEED DURATION CURVES (Six Alaskan Locations)

$\bar{V}$, kts	$\bar{V}$, mph	Site, Month (Note 1)	$\bar{P}$, KW (q-meas) (Note 2)	$\bar{P}$, KW (calc) (Note 3)	Δ , % (Note 4).
22.9	26.4	A, Jan.	4.07	4.07	0
21.9	25.2	A, Dec.	3.98	3.92	1.5
21.1	24.3	A, Feb.	3.78	3.80	0.5
20.7	23.8	A, Mar.	3.84	3.73	3.4
19.4	22.3	A, Nov.	3.57	3.49	2.2
18.9	21.8	A, Oct.	3.46	3.41	1.4
18.7	21.5	A, Apr.	3.48	3.36	3.6
18.3	21.1	A, Annual	3.27	3.28	0.3
17.8	20.5	SP, Feb.	3.38	3.19	5.6
17.4	20.0	SP, Dec.	3.28	3.09	5.8
17.0	19.6	SP, Jan.	3.19	3.02	5.3
16.6	19.1	SP, Nov.	3.06	2.92	4.6
16.5	19.0	SP, Oct.	3.05	2.90	4.9
16.4	18.9	A, May	2.98	2.88	3.6
16.4	18.9	A, Sept.	2.85	2.88	1.1
16.3	18.8	SP, Mar.	2.96	2.86	3.4
15.1	17.4	CB, Annual (1a)	2.71	2.58	4.8
15.1	17.4	CB, Annual (1a)	2.70	2.58	4.4
15.1	17.4	SP, Apr.	2.65	2.58	2.6
15.0	17.3	M, Dec.	2.58	2.56	0.8
14.9	17.1	SP, Annual	2.59	2.51	3.1
14.8	17.0	M, Jan.	2.58	2.49	2.7
14.7	16.9	M, Nov.	2.49	2.47	0.8
14.6	16.8	A, Aug.	2.53	2.45	3.2
14.1	16.2	A, June	2.36	2.32	1.7
14.1	16.2	A, July	2.34	2.32	0.9
13.5	15.5	SP, Sept.	2.23	2.16	3.1
13.4	15.4	M, Oct.	2.15	2.13	0.9
13.4	15.4	SP, May	2.19	2.13	2.7
12.4	14.3	SP, Aug.	1.87	1.87	0

TABLE 14 (Cont'd.)

$\bar{V}$, kts	$\bar{V}$, mph	Site Month (Note 1)	$\bar{P}$, KW (q-meas) (Note 2)	$\bar{P}$, KW (calc) (Note 3)	Δ , % (Note 4)
11.9	13.7	M, Annual	1.79	1.72	3.9
11.8	13.6	B, Nov.	1.70	1.70	0
11.8	13.6	B, Oct.	1.69	1.70	0.6
11.5	13.2	K, Aug.	1.62	1.60	1.2
11.4	13.1	K, Oct.	1.62	1.57	3.1
11.4	13.1	SP, June	1.53	1.57	2.6
11.3	13.0	K, Sept.	1.57	1.55	1.3
11.1	12.8	K, July	1.49	1.50	0.7
10.7	12.3	SP, July	1.34	1.37	2.2
10.6	12.2	M, Sept.	1.38	1.34	2.9
10.5	12.1	B, May	1.26	1.31	4.0
10.4	12.0	K, June	1.32	1.29	2.3
10.0	11.5	B, Apr.	1.19	1.15	3.4
9.9	11.4	B, Dec.	1.22	1.13	7.4
9.3	10.7	K, May	1.10	0.93	15.5
7.7	8.9	M, July	0.68	0.40	41.1
Mean (all points)					3.7
Mean (omit last 2 points)					2.6

- Notes:
1. A = Amchitka Isl., B = Barrow, CB = Cold Bay, K = Kotzebue, M = Middleton Isl., SP = St. Paul Isl.; 1a = separate 5-year periods at CB.
 2. q. meas. or q.m. = quasi-measured; from measured wind data and manufacturer's power vs. wind speed curve.
 3. From Weibull Function ($k=2$) and manufacturer's power curve.
 4. $\Delta = 100 (\bar{P}_{qm} - \bar{P}_{syn.}) / \bar{P}_{qm}$.

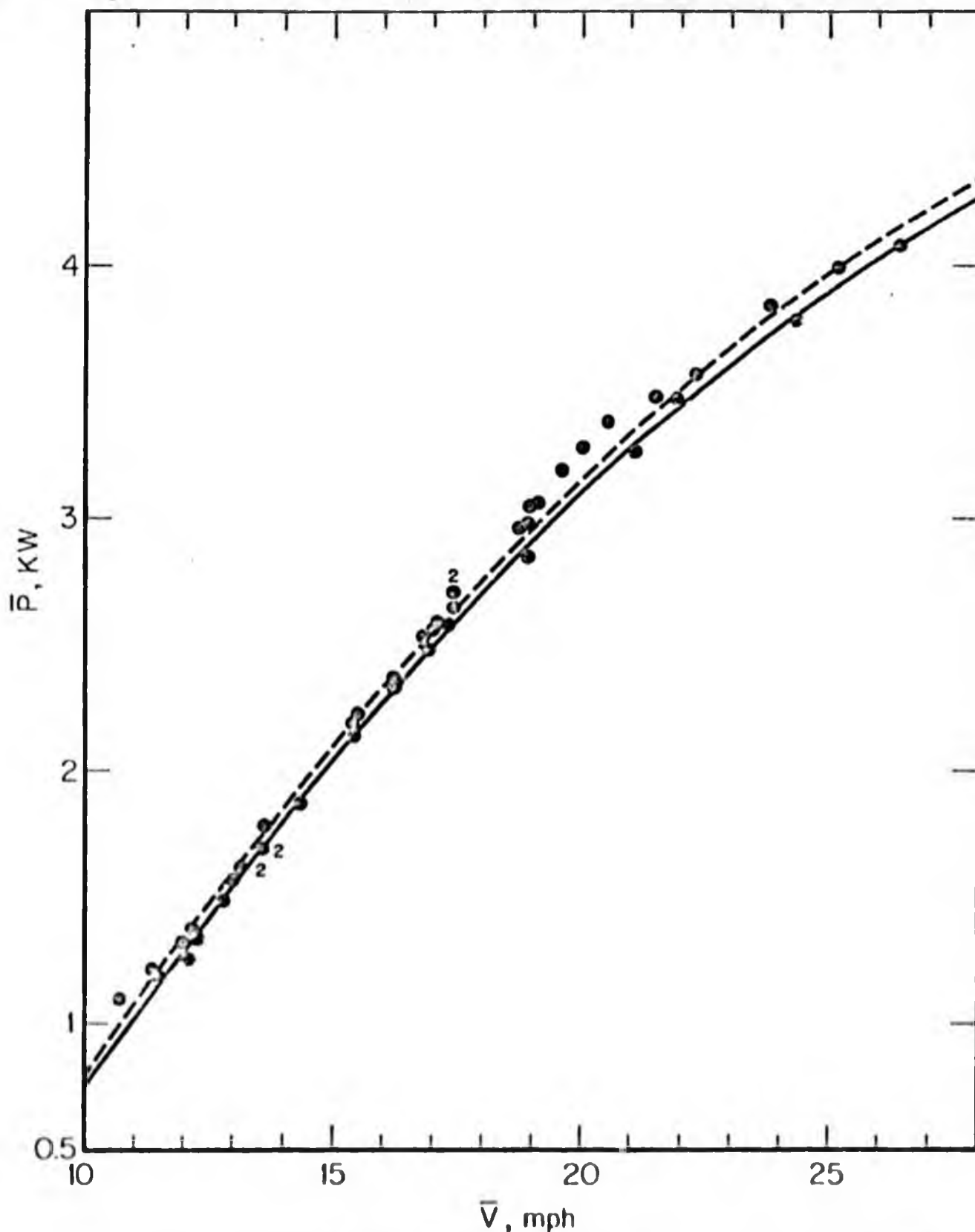


Figure 16: Mean power from an Electro WVG50 (6 KW at 33 mph) Windmill for measured and analytically-predicted duration curves. (Points from measured winds; dashed curve best fit to them. The 2 on graph means duplicate points. Solid curve is quadratic polynomial calculated from F3.)

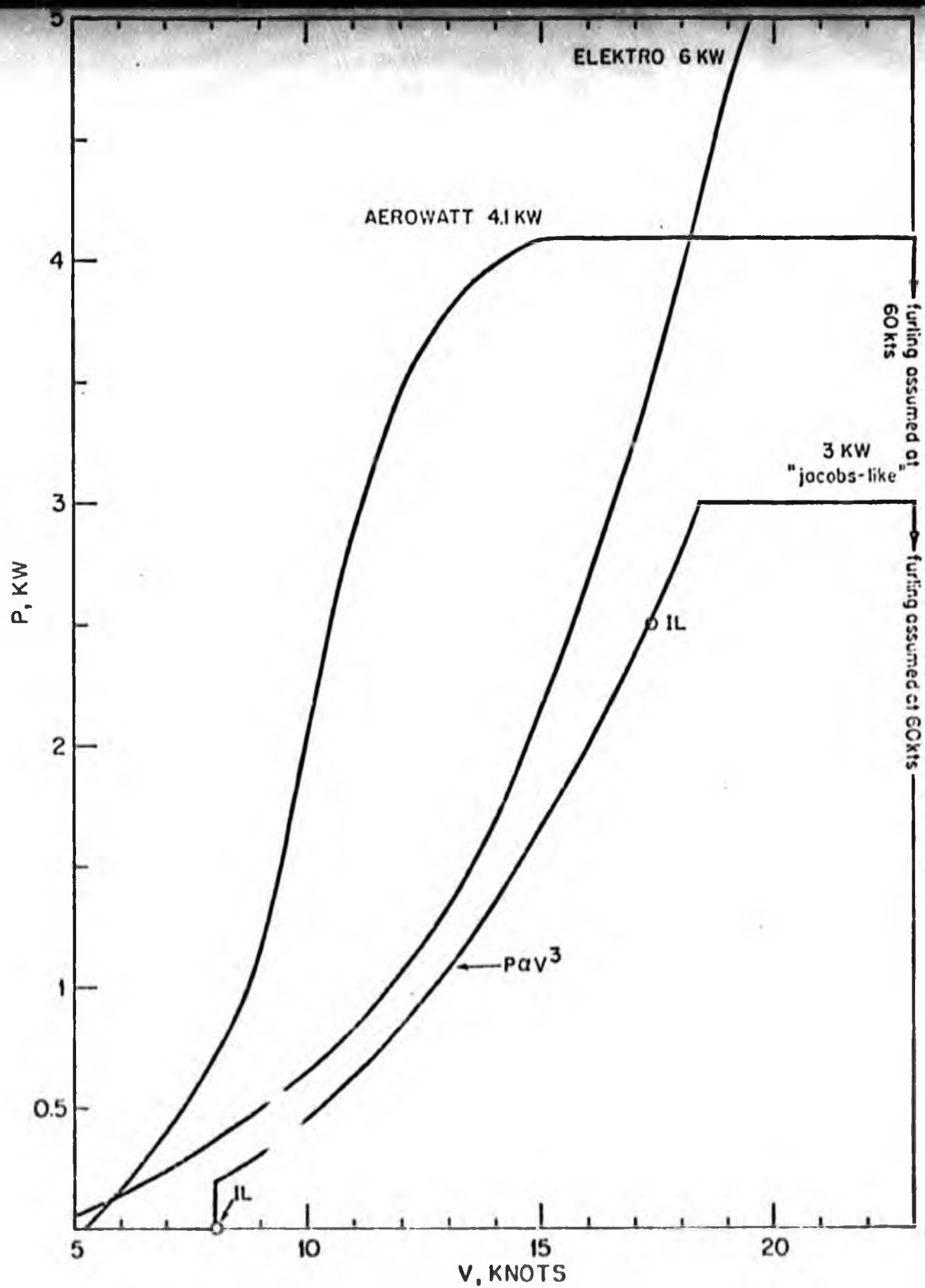


Figure 17: Power characteristics for Aerowatt 4.1 KW, Elektro 6 KW, and Jacobs-like 3 KW windmills.

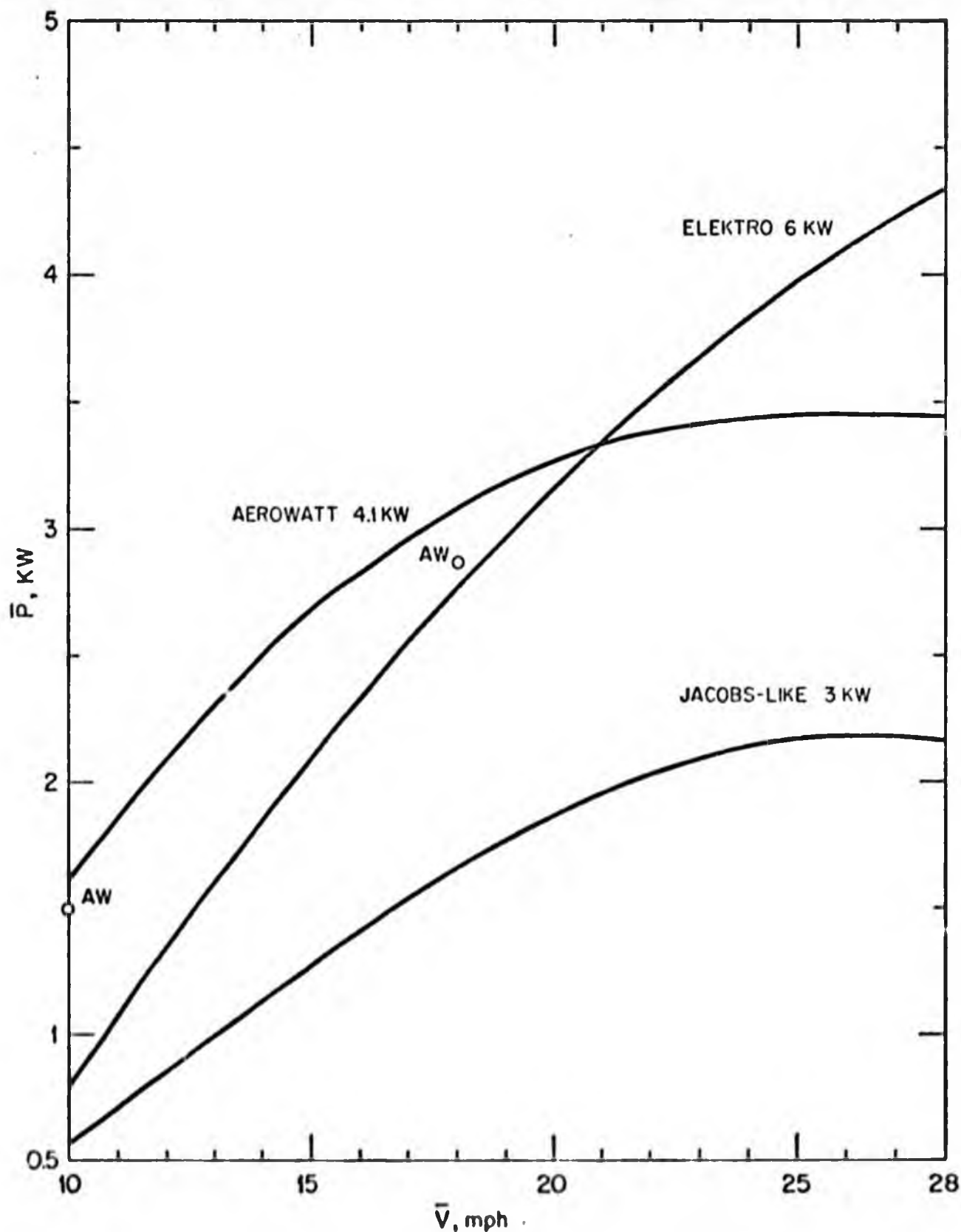


Figure 18: Average power vs. average wind speed for three small windmills in Alaskan wind regimen. (All from bent fit to polynomials, each based on 46 long-term duration curves. Points marked AW from Aerowatt literature.)

Aerowatt 4.1 KW machine in use, in Norway; and we have no details.

A Jacobs-like 3 KW WECS. The Jacobs 1 to 10 KW machines (thousands of units) have a long history of very successful operation, with high reliability and energy yields. Our studies and Jacob's substantiated claims (1974) indicate that these machines are probably the most successful electricity-producing small windmills ever produced in quantity. It is regrettable that the 1930-1957 units are no longer manufactured, and are only available as rebuilt items. Jacobs may produce newer designs and hardware in late 1976 (6 to 10 KW?).

Jacobs, to the best of our knowledge, never published a formal power characteristic curve. We deduced such a curve from Frenkiel's (1964) Iliat data. We call our characteristic, shown in Figure 17, the Jacobs-like 3 KW; and of course M. Jacobs is not responsible for any of the conclusions drawn from our curves.

The $\bar{P}$ vs $\bar{V}$ curve for the Jacobs-like 3 KW plant is also given in Figure 18. This is based on 46 measured duration curves. This is not in good agreement with Frenkiel's result, for one or more unexplained reasons. However, his machine power characteristic may have been appreciably different than our necessary estimate, especially at low $\bar{V}$ (10-12 mph). He also intentionally limited the maximum power to 2.5 KW. Furthermore, he computed his expression from $\bar{V}$ data spanning only the 10 to 16 mph range.

The reader can draw his own conclusions. A major hindrance in comparisons, for example, between a Jacobs-like 3 KW and an Elektro 6 KW ($\bar{P}$ same at $\bar{V}$ = 15 to 20 mph), is the absence of present cost data for any vintage Jacobs units, or for comparable newly-produced windmills.

Energy Productivity and the Height Effect

Assume an Elektro 6 KW windmill installed at Ugashik on a 40 ft tower. Take $\bar{V}$ there as 12 knots (13.8 mph), from the better known long-term $\bar{V}$ values (and varying quite smoothly along the Alaska Peninsula) at King Salmon (9.9 knots), Port Heiden (12.9 knots) and Cold Bay (15.1 knots). The airline distances from Ugashik to those places are, respectively, 80, 60 and 263 statute miles.

We then estimated the energy power and energy productivity at 40 feet, the oil-savings equivalent, and also the effects of variation in tower height between 30 and 100 feet (see Table 15). A major assumption was that only one-half of the energy yield of the windmill was useable. This assumption is based on our knowledge of Alaskan bush energy habits and wind patterns, and the experience of other workers. For instance, the wind-derived voltage might often be less than the battery bank voltage, or the batteries might be fully charged, with no load to use the wind energy. Also, considerable energy might be lost due to windmill shut-down (for safety) during sustained gales.

There are other assumptions, which may be questionable for the long term, including such things as 1975 prices for typical towers and constant oil costs of 75¢/gal at Ugashik. Nevertheless, it appears that tower heights in the 40 to 60 feet are most cost-effective. In this range the yearly oil-equivalent of the useful energy is 20 to 24 drums (53 gal, not 42 gal drums), with an energy cost savings of \$800 to \$940/year. The improvement in average power, relative to that at 40 feet, is 18% at 60 feet and 26% at 70 feet. However, the accompanying savings in oil and costs at these heights are not great. Thus, the cost of tall towers appear to off-set the increased energy yield obtained, as others have noted. Hence, for the Ugashik area, we would question the worth of tower heights above 60 feet.

TABLE 15

ESTIMATED ENERGY PRODUCTIVITY (10 years) OF AN ELEKTRO 6 KW WINDMILL
AT UGASHIK, ALASKA, FOR VARIOUS HEIGHTS WITH SOME RELATED COSTS

height/ft	$\bar{V}$, mph (N-1,4)	$\bar{P}$, KW (N-2)	$\frac{10 \text{ year}}{\bar{E}} \times 10^5$ kwh (N-2)	$\bar{E}/2 =$ Drums of Oil (N-3)	$\frac{10 \text{ year}}{\Delta \bar{E}} \times 10^4$ kwh (N-4)	Oil Equiv. Savings in \$ (N-5)	Tower Cost \$ (N-6)	h. increase Savings (or drums) (N-4)
30	1.29	1.58	1.384	176	-1.93	6996	990 (645)	-724 (-18d)
40	13.8	1.80	1.577	201	0	7990	1260 (800)	0
50	14.5	1.98	1.734	221	1.57	8785	1560 (1000)	495 (12d)
60	15.1	2.12	1.857	237	280	9421	1935 (1250)	756 (19d)
70	15.7	2.26	1.980	253	4.03	10057	2470 (1600)	857 (22d)
100	17.0	2.54	2.225	284	6.48	11289	?	-

- Notes:
- N1. For mean $p = 0.23$ in V vs h relation; equations (3).
 - N2. From Figure 16, before battery bank.
 - N3. Assumes 1/2 of windmill productivity is usable, and alternate energy source generator yields 7.4 kwh/gal; then 10^5 kwh = 255 drums oil.
 - N4. With reference to $h = 40$ ft value.
 - N5. As for N-3, with constant 10 year cost of 75c/gal or \$39.75/drum, delivered (questionable long term assumption).
 - N6. Delivered at Ugashik, including cost of footings, with no provisions for labor or interest; (price fob Seattle).

Engineering Design Factors

Power Coefficient and Efficiency: The power coefficient C_p , as we use it, is the ratio of the actual windmill power output to the power in the wind. The efficiency of an actual single disc windmill, as we define it, is the power output of the actual mill relative to an idealized windmill. The latter is limited, through the Betz (1966) formulation, to the extraction of 59.3% of the power of the wind.

Cut-in Speeds and Calms: The energy (power x time) productivity versus the costs determine the utility of a windmill system. Important factors include the starting or cut-in wind speed, the wind speed required to reach rated power, and of course, the mechanical integrity. The time of power generation is as important as the power rating. While our wind survey results reveal many desirable locations for windmills in Alaska, design innovations should be directed toward decreasing the wind speed necessary for attaining the rated power of the generator, compatible with mechanical integrity. In our opinion, emphasis should be placed on blade design, reliable speed controls, reduction of the generator power overrating, and the cost and weight of the generator. The French Aerowatt windmill (full rating reached at 17 mph for their 4 KW machine) and the NASA/Lewis-Plum Brook projected 100 KW windmill (full rating at 18 mph) show considerable promise in this respect.

Productivity Curves: Productivity is best estimated by combining the machine power versus wind speed curve with the wind velocity duration curve. In this way, one can generate productivity curves like those in Figures 18 and 19.

One aspect of curves such as those shown in Figure 19 is that wind machine output characteristic curves are almost always given

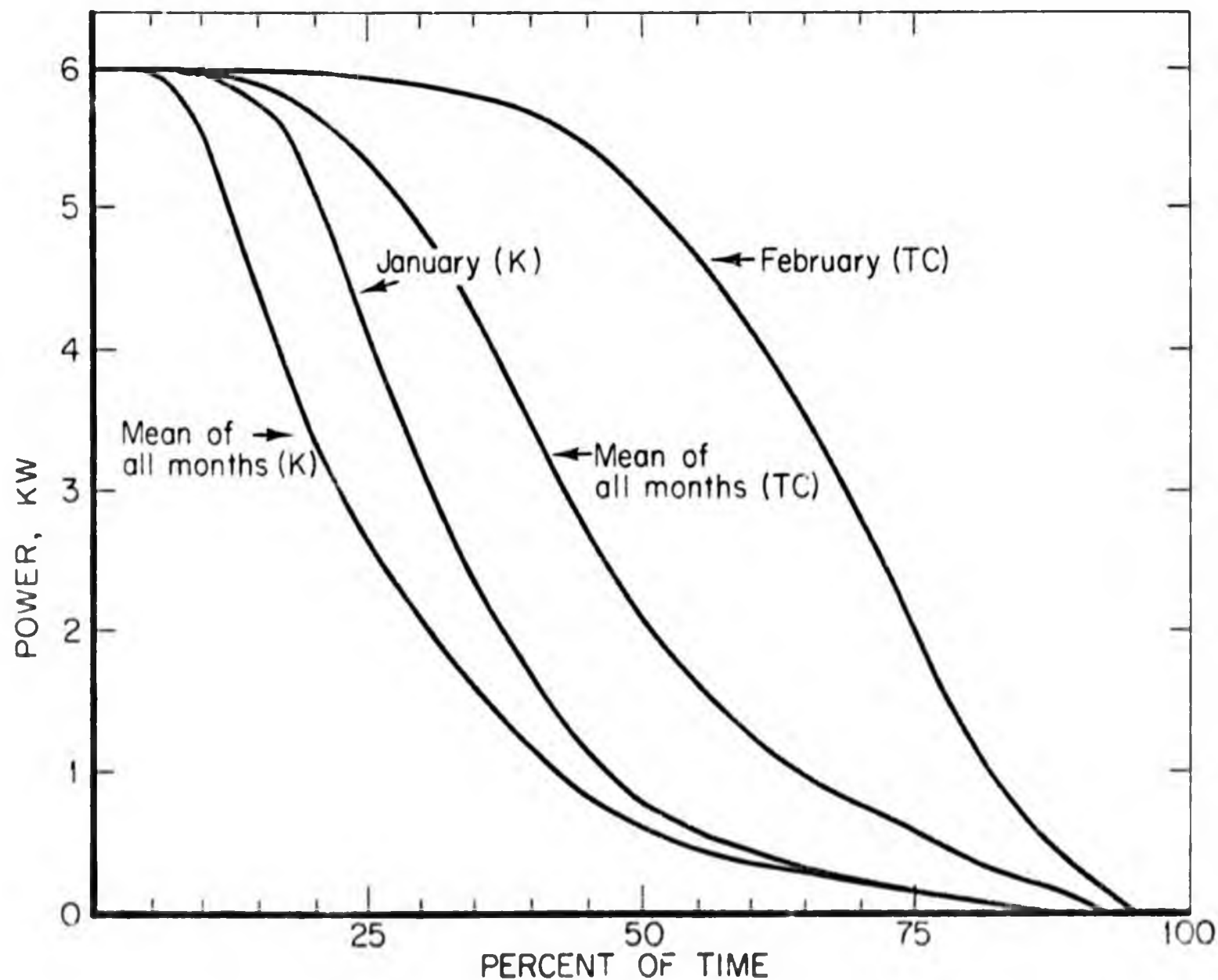


Figure 19: Monthly Power Productivity at Kotzebue (K) and Tin City (TC), Alaska, from a 6 kW Rated Windmill (areas under the curves give the energy produced each month or year).

in terms of power, not voltage, output. In the absence of such published voltage versus wind speed curves, it can be concluded that for resistive loads the voltage quickly drops below acceptable levels for lighting and other loads requiring voltage regulation, as wind speed drops. Furthermore, as in the case of wind-charged battery banks, the generator output is insufficient for battery charging, unless elaborate switching is used. In such cases, a considerable part of the total energy is available only if diverted to low-level energy reservoirs, such as hot water tanks.

Icing Problems and Blade Coating: The icing problem relates to tower integrity, blade strength (survival), and possible mechanical damage to the generator assembly through vibration. Putnam's (1948) experience with the large wind machine on Grandpa's Knob (Vermont) seemed to indicate that the best de-icing technique was to run (cautiously) the windmill during icing conditions, as blade flexure usually shed the ice. Putnam said:

"Although ice several inches thick was observed on the stationary structure several times, the maximum thickness observed on the rotating stainless-steel turbine blades was about 1/2 inch thick on the leading edge. As this skin of ice began to peel off, the unit would begin to run rough and was usually shut down for this reason."

Experience suggests that major icing problems are also caused by the unequal thawing of blades that accumulated ice during shut-down periods. A start-up under these conditions results in excessive vibration which can destroy the main bearings very quickly.

Some information has been gained from interviews with users or observers of windmills in Alaska. At barrow, for example, icing problems

were not encountered, and the most serious operational problem was charge limiting, and destructive overcharging of the batteries. In the Alaskan interior (Livengood), packed snow behind the blades acted as a brake, but blade icing was negligible.

Location, of course, is important. Australian mills were said to have iced up in tests in Australian mountains, but they encountered little trouble in Antarctica. It is said that Swiss mills used in the Alps do not ice up.

Usually blade protection from normal weather is obtained from paints, such as urethane. The French Aerowatt Company offers fluoro-carbon coatings as a protection against heavy icing. We had also advocated this approach to the problem, but later indicated that teflon coatings are most probably not worthwhile (Wentink, 1976).

DC Versus AC Rural Systems and Inverters

We recognize that modern windmill systems are often engineered to yield controlled frequency AC over large power and wind speed ranges. However, in view of our experience in rural Alaska, it appears that DC outputs may still have a considerable role, especially where the wind-derived power is generated close to the user. DC is advantageous because:

- (a) DC-AC inverters are expensive, and increase the capital investment in wind-powered systems by 30 to 70%.
- (b) Incandescent lights, motors, heaters (for water, fish smoking, etc.) work well on DC.
- (c) DC motors offer some advantages over AC motors, such as increased tolerance to changing line voltage, in variable

speed control, and in starting characteristics. Also, there are numerous inexpensive DC motors on the surplus market, especially in the 28 volt DC range.

- (d) Batteries, when used in an energy reservoir, can supply large short-term loads, which are usually well beyond the safe surge capability time of many inverters.

Inverters used with battery bank storage in small WECS should include refinements, such as those available in the Soleq and modified Topaz units. The efficiency is often good (80 to 90%) at higher loads, but poor under light loads or on idle. For instance, 3-KW rated inverters often have a no-applied-load power consumption of about 200 watts (5 KWh/day). This can be significant during long calms. However, a load sensor, such as that in the Soleq unit, switches off the main inverter circuit on the DC side when there is no AC load; and power drain of the load sensor is negligible. Voltage controls to protect the battery bank and the inverter at low and high DC levels are also available and should be installed.

WECS Foundation Requirements

The foundation footings for towers need special attention in Alaska, due to break-up (thawing) and soil fluctuation conditions. Tower vibration can also be a problem, in addition to high mechanical loads experienced during icing conditions or gales.

Environmental Impact

Currently, we do not foresee any major environmental problems associated with the use of wind power plants. However, there are two

potential problem areas that should be checked, involving the movements of migratory birds and possible disturbances in navigational radio aids.

Possible Bird Kills: The possibility of large bird kills by windmills during annual migrations should be further evaluated. However, shutdowns during these rather brief and predictable migration periods could be utilized for maintenance and repair, and this possibility does not appear to be a serious problem, with proper checks and planning.

Communications Interference: The reflection and diversion of radio waves from navigational aids by windmills could be troublesome near airports, runway approaches and repeater stations. All-metal blades, such as those on the Grumman Windstream 25 propeller (25 ft or 7.6 m disc diameter, 2 ft or 61 cm blade chord), could be potent reflectors and modulators and/or erroneous redirectors of navigational signals in critical locations. Even the wooden blades of the Elektro 6 KW (16.5 ft or 5 m disc, 6 in or 15 cm chord), if coated with metallic paint could be sources of reradiation. This effect would be accentuated by oscillations of the windmill in response to variation in wind direction.

Generator noise could also be a problem. All of these effects need further evaluation.

Weather Modification: Although the question of detrimental weather modification by large windmill farms has been raised repeatedly, the effects do not seem to be of serious concern.

Even though we were to install five 1 megawatt-rated mills per square mile at Cold Bay, where wind conditions limit the power extraction to about 3 megawatts/mile², both atmospheric horizontal mixing and

energy replenishment from the upper layers should quickly smooth out any energy unbalance. Also, of course, there is no particular need to crowd the machines in most areas that are candidates for windmill farms.

Mechanical Risk and Liability: A propeller fragment in free flight could cause serious damage. The Smith-Putnam windmill threw a 65-foot, 8-ton metal blade 750 feet, which landed in one piece on its tip (Putnam, 1948). When our Ugashik windmill was destroyed in 1975, the 8-foot wood blades were completely fragmented before they struck the ground. There was no wooden debris at the tower base, and fragments were found over a radius of 1/4 mile. No property or personal damage occurred in these cases, but the implications are obvious.

WIND POWER APPLICATIONS

Wind Versus Fossil Fuel-Generated Power

Wentink (1976) has recently published a cost analysis of a small windpower installation at Ugashik, Alaska, including a 6 KW maximum rated windmill with controls, tower, small battery bank (25 KWh capacity at 50% discharge limit), and a 4 KW DC-AC inverter yielding 60 cycle/115V AC. Today, this plant could be delivered to Ugashik at a cost of approximately \$10,000. Assuming free labor, and no interest payments, the installation cost would be about \$1,670/KW.

These costs may seem excessive when first compared with the \$450/KW installed capacity of large fossil or nuclear utility plants, and the target of \$500/installed KW for projected new and larger windmills. If these costs are compared to those of diesel fuel-generated kilowatts in rural Alaska, however, wind power-generated electricity may be competitive over longer production periods.

Economic viability of a WECS is based on the energy cost in \$/KWh, not the installed power cost in \$/KW. If we apply the AVEC system-wide factor of 7.4 KWh/gal of fuel to Ugashik (where there is no central utility), and consider the present cost of fuel delivered to Ugashik (70¢/gal), the fuel production cost of electricity would be 9.5¢/KWh. The actual sale price by AVEC (elsewhere) is currently 22¢ to 12¢/KWh (Table 16).

If we derate the windmill system further because of wind conditions, so that the average system productivity is only 2 KW, power output would be 1460 KWh/month or 17520 KWh/year. Corresponding costs for electricity

TABLE 16
(Spring 1975)

RECENT RATES FOR ELECTRICAL ENERGY IN ALASKA

<u>Location</u>	<u>Monthly use KWh range</u>	<u>Residential cost, ¢/KWh</u>	
Boston Area (September '74)	First 15	12.9	\$1.94 monthly min.
	Next 35	5.6	
	Next 50	3.5	
	Next 150	3.2	
	Next 200	2.9	
	Next 500	1.5	
Fairbanks (GVEA, 1975) ^a	First 150	8.0	\$10 monthly min. (Rates out of city slightly higher)
	Next 550	3.9	
	Next 800	2.2	
	Over 1500	1.9	
Nome (1974)	Flat Rate	15.	
Kotzebue (1974)	First 50	21.5	
	Next 50	12.5	
	Next 400	11.0	
	Over 500	10.5	
AVEC ^b (same for all 47 villages 1974)	First 75	20. ^c	\$15 monthly min.
	Next 225	15.	
	Next 700	12.	
	Over 1000	9.	
Bethel (1975)	First 50	12.	\$5 monthly min.
	Next 200	10.	
	Over 250	7.5	
Cold Bay (1975)	First 50	11.5	\$10 monthly min.
	Next 650	9.5	
	Over 700	7.5	

a: Golden Valley Electric Association

b: Alaska Village Electric Cooperative

c: For 1975 a 2 to 3¢ /KWh fuel surcharge is in effect.
Surcharges are also present in most of the other rates.

derived from oil would be \$139/month or \$1664/year (at 9.5¢/KWh). Using actual AVEC customer prices to purchase 1460 KWh/month, we estimate consumer costs of \$204/month and \$2449/year.

So, for users presently using electricity at only 9.5¢/KWh, the small windmill system would establish a ratio of \$9864/\$1664/year, which would require 5.9 years to pay off through fuel oil savings. However, a typical "AVEC customer" could anticipate an earlier payoff in only 4.0 years.

We cannot assume that the cost of fuel oil in rural Alaska will remain at 70¢/gal (recall our earlier comments on current village fuel costs up to \$2.15/gal). The control of domestic crude oil prices will make wind power even more attractive. The actual savings from the use of wind power will depend on variations in wind conditions and logistics. Although the initial cost of wind power plants will remain higher than those for diesel power plants for the foreseeable future, the soaring costs of fuel oil will permit rapid (4 to 6 years) payback of capital costs of wind plants through savings on fossil fuel costs alone.

Industrial Applications

One possible use of large scale wind power could be the production of electricity for processing other chemically-reactive materials or the production of reactive materials (e.g., compressors or hydrogen, respectively). Thus, wind could either drive pumps to transport hydrogen, or release hydrogen from water.

Ammonia Production: Consider one of the present methods for ammonia (NH_3) production. Purified natural gas (CH_4) is reacted with steam in

a catalytic reformer to eventually yield carbon monoxide (CO) and H₂.

The overall reaction (some steps omitted) is:



Further processing, requiring compressors and other energy using steps, produces the reaction:



For WECS applications we would propose using H₂ from water and N₂ from the air.

The economics of scale dictate that modern NH₃ plants must operate at output levels above 600 tons NH₃/day; many plants actually produce above 1000 tons/day. We think that the case for smaller fertilizer plants (100 tons/day or less) should be re-examined, when the user is nearby and when wind and water are used rather than natural gas.

A 1 MW rated (installed capacity) WECS in a suitable wind regime (50% power productivity) could generate enough hydrogen to produce 1.7 tons of NH₃/day. Thus, an ammonia plant of 100 tons/day capability (admittedly a small plant) would require a windmill complex of at least 59 MW for the necessary H₂ production. The capital cost (without interest, etc.) at \$500/installed KW would be about \$30,000,000, which is the same order of magnitude as the cost of a large modern transport aircraft.

At \$100/ton of NH₃ and 300 days/year of plant operation, more than 10 years of production would be required to return the capital investment of the WECS. At present, this is economically unattractive. However, there are several other factors that need to be considered:

(1) the plant lifetime, (2) the need for fertilizer, (3) the price the market will bear in 1980-90, (4) the availability of natural gas and (5) the cost of gas if available. Also, the cost of the reformer in present NH_3 plants which use natural gas is large, and these troublesome units are often plagued with excessive down time. These reformers break down the natural gas (CH_4) to yield CO and H_2 and also consume significant gas to heat the reformer chambers and to produce steam. We have no firm information on the initial and maintenance costs for reformers, but we estimate that reformers may account for nearly 30% of total plant costs.

The long-term cost of natural gas is not clear. For estimating purposes, we note that the cost of CH_4 for a 100 ton/day NH_3 plant at \$1/Mcf would be near \$3,200/day (at ideal conversion), or \$948,000 for a 300-day operating year. Hence, replacing natural gas with water as a raw material would amount to a savings of about a million dollars each year which could be applied to the amortization of WECS costs.

Urea and Methanol Production: The production of urea and methanol require a carbon source, such as coal. Consider the Alaska Peninsula region, where coal and wind power are available, and where ice-free harbors exist. This coal could be combined locally with electrolytic hydrogen and then ammonia to yield urea (H_2NCONH_2) or methanol (CH_3OH), which are readily shippable chemicals.

In the case of methanol, there are two possible routes that deserve consideration. The first route would be to power the plant machinery with windmills, to produce so-called process gas (COH_2) from the reaction:



In further reaction, to produce:



In this case there would be excess CO which could be burned later (perhaps yielding undesirable side products other than methanol). An alternate route would be to react the process gas with a stoichiometric amount of H₂ from wind-powered electrolysis units, as in the properly-catalyzed reaction:



Mining: The Alaskan mining industry is expected to grow during the next decade. The Lost River (Seward Peninsula) fluorite-tungsten-tin mine shows promise for future development, and the Seward Peninsula may also contain economically-important copper deposits. Tin City is already known for its wind potential. (The long-term yearly average wind speed at Tin City is 17.1 mph.)

Wind power could be exploited by the mining industry in several ways, including power (lighting, machine power, the generation of compressed air -- an attractive energy storage device), possible ore reduction with electrolytic hydrogen, and metal refining by electroplating. Windmills delivered to remote sites by helicopter might be economic at interior localities in the early phases of exploration development.

Agriculture

Alaska has relatively little agriculture due to high costs, late planting dates, low soil temperatures, and early frost, even though much of Alaska is blessed with long days during the summer growing season.

We do not think wind-derived electricity is best used for soil warming on a large scale. However, there seems to be real merit in

combining thermal spring water with wind-generated electricity for greenhouse operations. For example, greenhouses above the Arctic Circle near Nome could supply year-round green vegetables to Seward Peninsula consumers, and export products to other Alaskan communities.

Refrigeration

Another important Alaskan windmill application could be wind-powered refrigeration units. The preservation of meat and other foods is a major problem in many communities where harvesting occurs during warm weather. The Alaskan summers are long and warm, and sometimes hot, even above the Arctic Circle. Adequately-insulated wind-powered refrigerators would not require much, if any, electrical energy storage if frozen brine cold storage techniques were used.

ALASKAN AGRICULTURE AND THE ENERGY PROBLEM

Logistics

The primary energy source for modern agricultural food production remains the sun; however, man has learned that he can increase productivity of his food crops by modifying the plants' environment for maximum capture of sunlight. This environment modification is largely dependent upon the use of fossil fuels to supply the required technological materials such as machinery, plastics, pesticides and petroleum for heating, farming, drying, processing and transportation.

Work specialization, decrease of the agrarian society, better balanced nutrition, movement to northern climates and an increased consumption of products contributing to a quality of living all play a significant role in an increasing energy intensive food and fibre production, processing and distribution system.

Alaska, one-fifth the size of the 48 conterminous states, produces a relatively small amount of the agricultural products consumed by its own population. Alaska has large acreages of land suitable for potential agricultural production (cropland, rangeland and forest) (A.P.C., 1974). Many plants are well-adapted to Alaska's climates. During the Alaskan growing season, there are more hours of sunshine than during a comparable calendar period in the more southern latitudes (Dinkel, et al., 1976). The long summer days contribute to larger, tastier and more tender vegetables. Grains are often higher in protein content. In some cases, yields are even greater than in the best agricultural areas of the United States.

Increasing Alaskan and world population will inevitably require utilization of northern areas and development of new methods for food production in these northern areas. Development of various natural resources (particularly in the petroleum industry) indicate future social and economic development of Alaska. Also, the Native Land Claims Settlement, the Rural Development Act of 1972, and the continuing industrialization of Alaska's cities will stimulate development of the State. The world situation that puts agricultural products on the world market will certainly create expanding demand for United States agricultural products and inhibit the development of a United States surplus.

Alaska is at the end of the nation's food system and would suffer the most direct and immediate impact from natural disasters such as prolonged droughts, floods, virulent disease among plants and animals, extreme climatic change and unpredictable weather in the continental United States.

Fuel price increases will undoubtedly have a great effect on the cost of foods shipped to Alaska and on the cost of producing these foods in the more southern latitudes. It is not a wise use of the nation's Alaska produced petroleum to ship it to southern latitudes to produce foods that will later be shipped back to Alaska if we can produce the foods here for a nearly similar energy use on the farm. Alaskan food production will save the 9-15% energy consumption required to transport the oil to the southern agricultural areas and also save the energy now required to ship the foods to Alaska.

Much of the energy required to produce the intensively cultured crops in Alaska is in the form of heat requirements. This energy is

used to heat greenhouses and animal shelters, to warm soils, and to dry livestock feed. The wise use of Alaska's wind, geothermal, hydroelectric and waste heat energy sources for agricultural production in Alaska will reduce the nation's use of fossil fuels. This Alaska production will also increase the nation's agricultural land base which is rapidly dwindling in the southern states.

Controlled Environment Systems

Although vegetables are grown during the relatively short summer growing season in many rural areas and communities, only a very small portion of the summer crop can be preserved for consumption during the other months of the year. The high cost of fuel and electricity has prohibited large-scale greenhouse operations, and hydroponic gardening has not yet been attempted in the rural areas for the same reasons.

Controlled environment experiments at the University of Arizona's Environmental Research Laboratory, and the Phyto-Engineering Laboratory of the Agricultural Research Service at Beltsville, Maryland, have demonstrated that certain plants are capable of growing up to 10 to 50 times faster under controlled environments than by conventional growing means, and that the yields in tons per acre can be greatly increased.

Accelerated growth rates and vastly increased yields per unit acre are being developed through the use of higher CO₂ levels, controlled humidity and temperature, artificial lighting and the supply of the proper nutrients through automatic systems.

Hydroponically-grown and sub-irrigation grown lettuce, tomatoes and cucumbers already bring premium prices because of their quality and

year-round availability. The yields of such premium produce would be greater under ideal controlled environment conditions. Premium hydroponically-grown tomatoes are now being grown and marketed in Anchorage, with considerable success, by Mosesian Farms.

Recent experiments conducted by Donald H. Dinkel of the Institute of Agricultural Science, University of Alaska, on the Fairbanks campus, have shown that controlled environment facilities have excellent potential for producing year-round salad vegetable crops in northern Alaska (Dinkel, 1974).

Thermal springs are uniquely valuable energy sources for controlled environment experiments, as they can provide hot water, warm and permafrost-free ground, and small amounts of electricity from a common energy source, at very little expense.

Open Plot and Controlled Environment Gardening on Geothermally-Heated Ground

Some Alaskan thermal springs are surrounded by rather large areas of warm ground, which remain frost-free throughout the year. Perennially warm ground around Manley, Chena and Pilgrim Springs has been used for vegetable crop gardening since the arrival of the first white settlers. The Pilgrim garden plots produced vegetables in commercial quantities for miners during the Nome gold rush period; and the Manley Hot Springs commercial vegetable crops have continued from the early 1900's to the present day ... as exemplified by Mr. Charles Dart's presently successful greenhouse operation (to be described in more detail in the next section).

Warm frost-free soil is of great potential value in the arctic environment and should be utilized in a total energy applications system. A soil temperature survey, similar to that conducted by N. Biggar (1973) at Chena Hot Springs (Figure 20), can determine those areas which are optimum for vegetable crops.

Controlled environment enclosures could be located on selected plots of hot ground, adjacent to thermal springs, and require no other source of heat to maintain adequate soil and ambient air temperatures.

Growing seasons could be lengthened and plant maturation time could be accelerated through the use of garden plots which are heated by hot springs water circulated through networks of plastic pipe, buried at shallow depths in the soil.

ISOTHERMAL MAP of the CHENA HOT SPRINGS AREA, ALASKA

- Ground temperature stations
- Isotherms, (°C)
dashed where approximated
- 9 Thermal spring
- Thermal pools and streams
- === Private roads

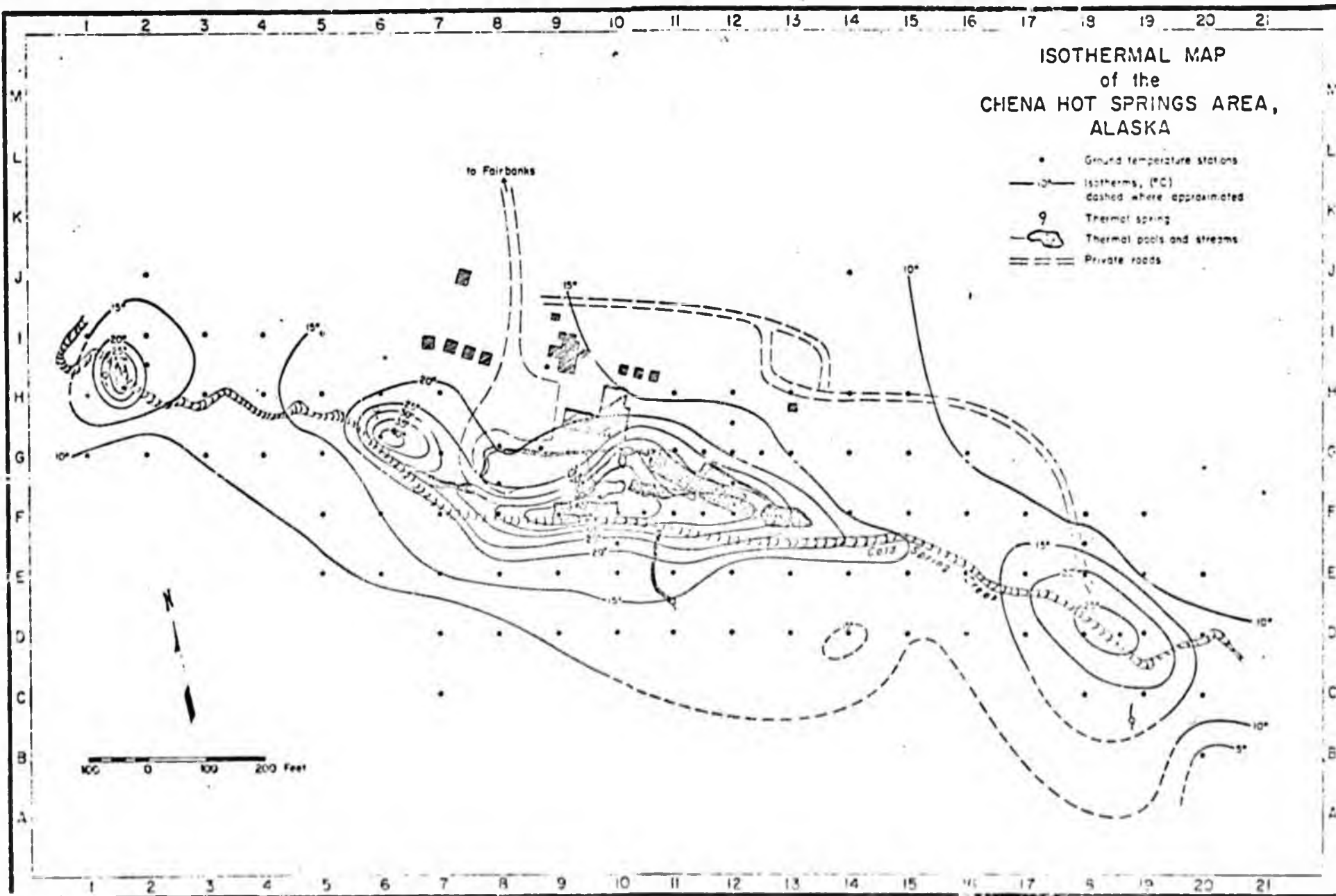


Figure 20: Isothermal map of soil temperatures in the Chena Hot Springs area (Biggar, 1973).

FISHERIES AND AQUACULTURE

Opportunities for Aquaculture

Salmonid fishes offer the greatest promise for tangible benefits from aquaculture in Alaska when biological, technological, economic, and institutional problems are taken into account. The list of salmonids suited for aquaculture includes salmon, trout, char and grayling. However, ocean ranching of Pacific salmon will most likely afford the greatest potential for an economically-viable aquaculture industry.

Catch records reveal that Pacific salmon have declined precipitously in Alaska. For many years Alaska contributed about two-thirds of the total harvest of North American salmon, but Alaska's contribution is now less than one-half of the total (Figure 21). Catches in the Pacific Northwest and Canada have not declined even though environmental changes wrought by man have had adverse effects on natural stocks. These adverse effects have been compensated to a large extent by hatcheries, spawning channels and other aquaculture systems which today produce 450 million or more juvenile salmon for release into marine nursery waters.

Salmon Ocean Ranching

The potential gain in efficiency of ocean ranching over natural reproduction can be illustrated by a hypothetical example where chum salmon are released into the ocean as unfed fry. The probable fates of progeny from a pair of chum adults spawning naturally and spawned artificially in a hatchery are compared below:

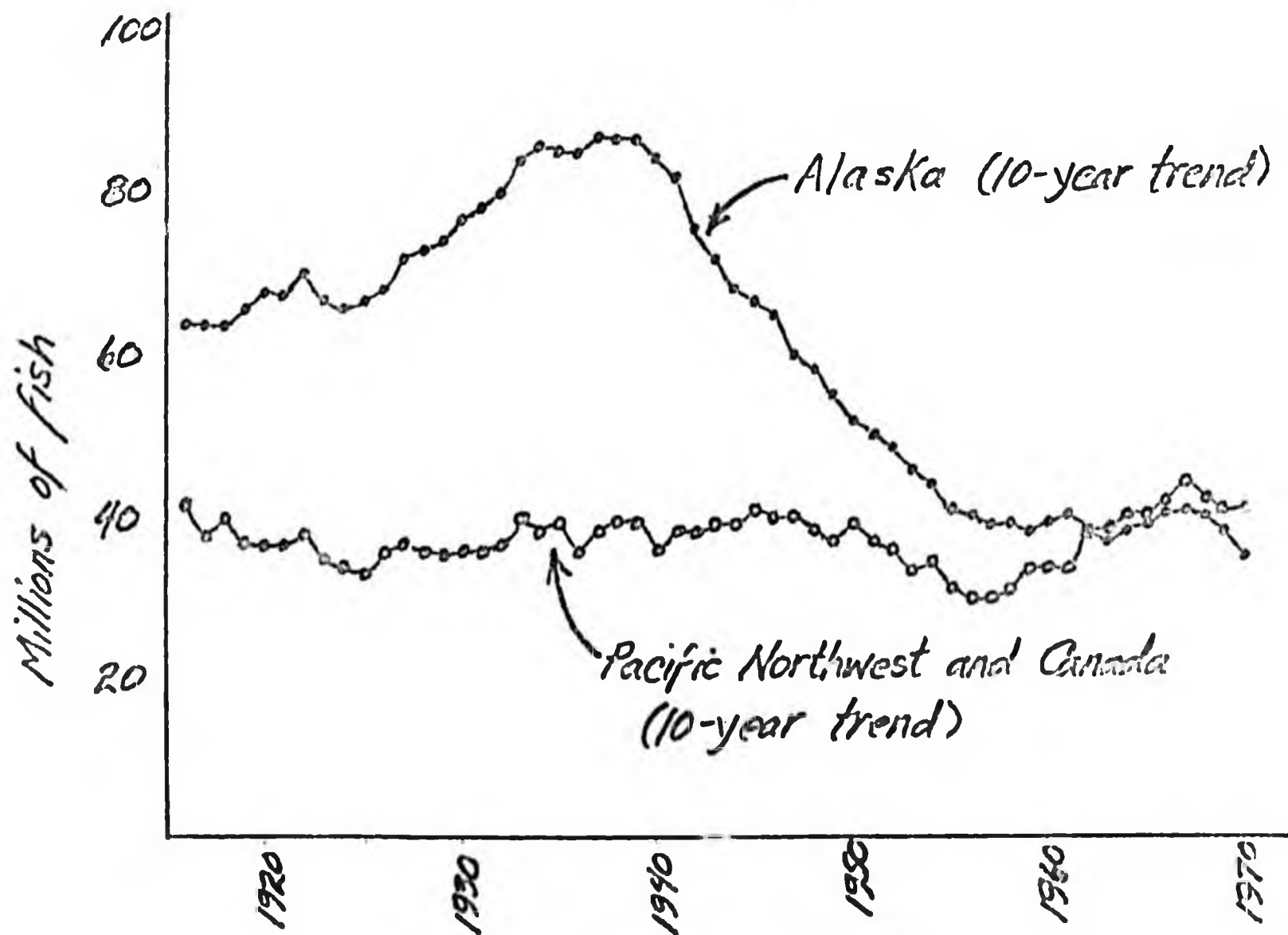


Figure 21: Trends of harvest of Pacific salmon on the Pacific Coast of North America.

Natural spawning

2 spawners

↓

3,000 eggs

↓

(10% survival)

↓

300 fry

↓

(2% survival)

↓

6 adults

(2 spawners)

(4 harvested)

Hatchery

2 spawners

↓

3,000 eggs

↓

(80% survival)

↓

2,400 fry

↓

(2% survival)

↓

48 adults

(2 spawners)

(46 harvested)

Recent experience with ocean ranching confirms that artificial propagation greatly increases the efficiency of production of salmon. The increase is not always 11-fold, as the example suggests, but it is substantial.

Perhaps the most successful ocean ranching program today is with chum salmon in Japan, where more than 500 million juvenile salmon are released annually and contribute about 10 million adult salmon to the harvest. Efforts are being made in Japan to double this production on Hokkaido Island, and the annual harvest of hatchery chum on Hokkaido has surpassed the harvest of wild chum in Alaska (Figure 22). Ocean ranching of chum and other salmon species is also undergoing rapid growth in the USSR and Canada.

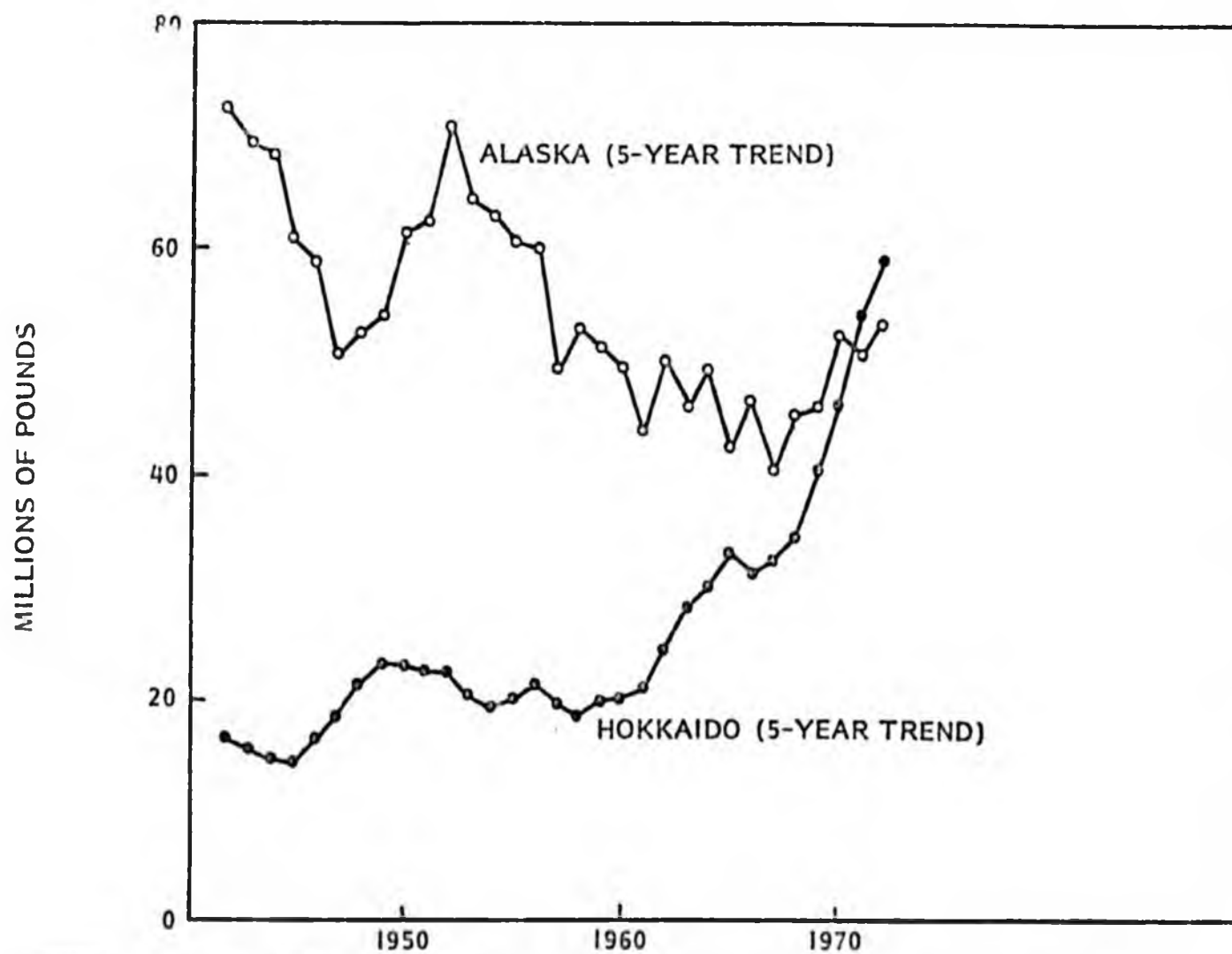


Figure 22: Trend of production of hatchery chum salmon on Hokkaido Island and wild chum salmon in Alaska.

Uses of Warm Water in Ocean Ranching

The operation of facilities in Alaska for salmon ocean ranching is complicated in many cases by severe freezing conditions in winter. Salmon spawn in summer and autumn and the fry emerge in spring when seasonal increases in natural food production occur in nursery waters. Avoidance of freezing requires that water used for incubation systems either must contain adequate heat or heat must be added. The artificial addition of heat requires expensive equipment and facilities, and places a heavy demand on fossil fuels. This can be avoided by using sources of fresh water where temperatures remain naturally above freezing during winter.

Lakes and geothermal springs are attractive sources for hatchery water supplies in Alaska since they are natural reservoirs for warm water in winter. Several hatchery projects now in operation or in planning in Alaska rely on lakes for water in winter. The use of geothermal water sources should also be evaluated.

Use of warm water for salmon ocean ranching can produce these effects:

1. Accelerated early development will contribute to early fry emergence.
2. Early fry emergence may require short-term rearing on artificial diets to insure that the time of release of juvenile salmon coincides with seasonal availability of natural food. (The Japanese follow this practice.)
3. Where juvenile salmon are raised to smolt size before release, early fry emergence should shorten the period of rearing, resulting in the release of smolts at age I (possibly at age 0) rather than at age II or III, which is common for wild fish.

Proposed Program

Two things must be done before potential benefits of geothermal water in salmon ocean ranching can be evaluated in Alaska:

1. Sources of low-grade geothermal water which are suitable for salmon aquaculture need to be inventoried.
2. Feasibility of using geothermal water in ocean ranching needs to be evaluated with five species of Pacific salmon.

Inventor₂ of Geothermal Waters: Promising sources of geothermal water should be identified and cataloged on a state-wide basis. Quantity and quality (temperature, dissolved solids, gas content, etc.) need to be determined. Relatively cold (55°F and lower) geothermal waters of suitable quality might be used directly as a medium for raising salmon. Relatively warm (above 55°F) geothermal water of suitable quality would probably be diluted with colder water, and the availability of cold water would need to be considered. Where relatively warm geothermal water contains dissolved substances which are toxic to salmon, the use of heat exchange systems to warm cold water should be considered. The total volume of water available from a given source for raising salmon should probably be at least 5 cfs (2,250 gpm) for commercial-scale aquaculture.

Feasibility of Using Thermal Waters: The use of geothermal water in salmon ocean ranching should be studied at one or more locations in Alaska with several species of salmon. Two locations are discussed here and should be considered for possible feasibility studies. They are Gulkana springs (near Paxson) in the Copper River drainage and springs in the Fort Glenn area of Umnak Island (in the Aleutian Islands).

Umnak Island is remote and is served once a week by Reeve Aleutian Airlines. The Fort Glenn area possesses a complex of roads and airfields which were constructed in World War II and are still useable. A cattle ranch, with a functional cold storage plant, now operates on the former military reservation. A network of spring-fed streams which individually deliver more than 5 cfs of waterflow, arise from lava beds. The topography of the area lends itself to the construction of low-cost hatchery facilities.

An important feature of Umnak Island is its location near the geographic center of the North Pacific Ocean-Bering Sea nursery ground of salmon from North American and Asian streams and lakes. Pink and chum salmon would be the primary target species on Umnak Island. Sockeye and coho salmon would be secondary target species.

Hatcheries at Gulkana and Umnak springs can be developed with gravity feed water delivery systems. Demand for energy from fossil fuels would be limited to illumination and heating of modest support facilities. Supplementary power for a demonstration hatchery on Umnak could potentially be obtained from wind-driven generators. Hatcheries at both locations could be designed to operate without a full-time attendant.

Total cost of a feasibility study at Gulkana and Umnak springs is estimated to be about \$500,000 for each location. This amount would include construction of facilities and operations for 5 years. The estimated costs are based on:

- Planning and site evaluation	\$ 50,000
- Construction (10 million egg hatchery)	200,000
- Operation (5 years @ \$50,000/yr.)	250,000
Total	\$500,000

A hatchery facility at Gulkana springs would produce mostly sockeye fry to supplement recruitment of wild fry into Summit and Paxson Lakes. The present levels of fry recruitment to these lake nursery areas should first be evaluated to determine if such a project might be warranted.

A demonstration hatchery facility at Gulkana springs might also be used to raise chinook and coho fingerling from Copper River stocks to boost recruitment of these species at selected locations within the Copper River drainage.

A hatchery facility on Umnak Island would produce primarily pink and chum fry for release into the ocean. Some sockeye and/or coho fry might be produced for stocking lakes. A successful demonstration project at one site would most likely lead to larger projects on Umnak, other Aleutian Islands, and the outer Alaska Peninsula by the Aleut Corporation and possibly other fishery interests. The salmon fisheries of the Aleutian area are very depressed (Figure 23), and the emergence of a hatchery program capable of producing 500 million pink and chum fry has the potential of contributing at least \$10 million annually to the economy of this region.

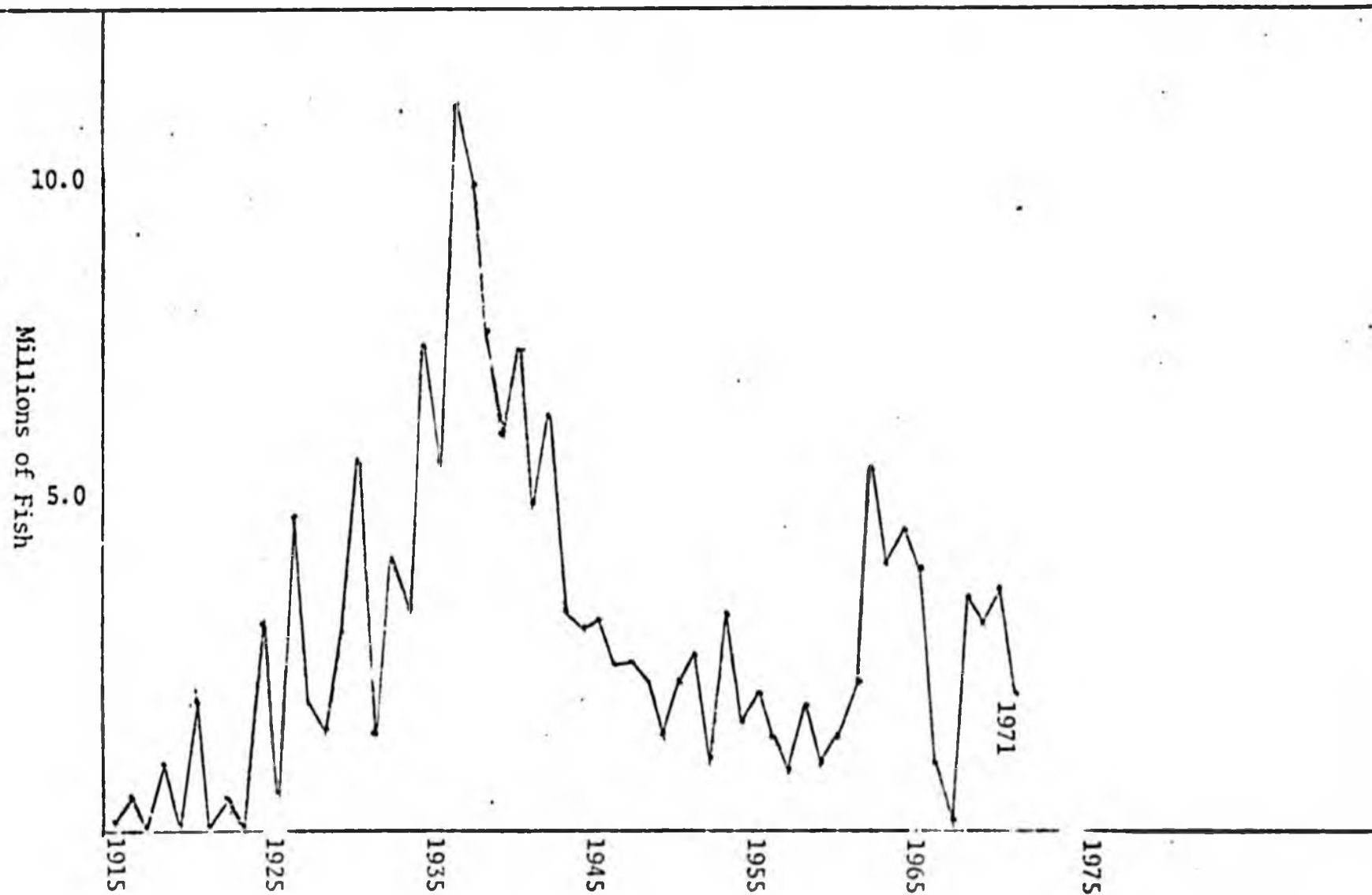


Figure 23: Annual catch of pink salmon in the Alaska Peninsula and Aleutian Island area.

CONCLUSIONS AND RECOMMENDATIONS

Geothermal Potential and Applications

Classification of Geothermal Resources: Although the assessment of Alaska's geothermal resources is in its infancy, the presence of over 40 active volcanoes and many thermal springs suggests that Alaska has geothermal energy resources similar to those which occur in other regions of the world, including:

1. subsurface steam reservoirs
2. subsurface hot water reservoirs (including geopressured reservoirs)
3. thermal springs (surface hot water)
4. subsurface geothermal anomalies (hot-dry rock)
5. volcano-related systems, including hot-dry rock and potential "magma tap" applications
6. deep drill hole applications in areas underlain by a normal geothermal gradient (30°C/kilometer).

Geothermal Resources Applied to Alaskan Needs: Although the generation of electricity has received more public attention than other uses of geothermal energy, there are many non-electrical applications of geothermal resources which may also be important to Alaska, including:

1. space heating and waste disposal
2. aquaculture (including fish hatchery and farming operations)
3. gardening, farming and greenhouse applications
4. melting of snow on roads and airfields
5. manufacturing
6. extraction of valuable heavy metals and salts from brines
7. potable water

Convective Systems: Currently, our optimism toward the geothermal potential of Alaska is based on the Alaskan segment of the circum-Pacific volcanic belt, and the possibilities offered by thermal spring waters in several districts. To date, however, geothermometry studies on thermal spring waters by the U. S. Geological Survey have not yet detected any vapor-dominated reservoir temperatures -- and only two thermal spring systems appear to have reservoir temperatures greater than 180°C -- which is the currently accepted temperature minimum for steam turbine systems utilizing the present technology (see page 47).

Volcano-related Systems: U. S. Geological Survey investigations (Miller and Barnes, in press; Smith and Shaw, 1975) indicate that several silicic volcanic fields, including the Wrangell Mountains, deserve further exploration as potential geothermal targets (see Figure 6 and Table 5). To date, however, no test holes have been drilled in any of these fields, and no heat flow or thermal gradient measurements have been made.

The energy potential of volcanoes is tremendous (Table 6). The amount of energy that is dissipated by uncontrolled and unuseable, worldwide volcanic eruptions each year is of mind-boggling order in terms of today's energy crunch. For example, the 1883 eruption of Krakatoa Volcano released about 10^{25} ergs of energy -- roughly equivalent to the total power consumption in the United States in the year 1970. The energy expended in the 1952 eruption of Kilauea Volcano would have been worth \$350 million if it could have been converted to electricity.

To date, significant geothermal power production has been from the so-called vapor-dominated geothermal reservoirs. If a technology could be developed to extract electricity from magma reservoirs

or from induced steam systems in volcanic piles, huge and previously unobtainable energy resources would become available.

Heat Flow and Thermal Gradient Measurements: High heat flow and/or geothermal gradients are the characteristic signatures of economically-significant geothermal anomalies. Although high heat flow values can be obtained on many active Alaskan volcanoes, published Alaskan heat flow determinations taken from drill holes have not yet exceeded 2.6 hfu (hfu = heat flow units). Based on the worldwide average of 1.5 hfu, and the association of heat flow values of 4 hfu and above with meaningful geothermal anomalies, we have not yet located any geothermal targets in Alaska by means of high heat flow, other than volcanic vents.

This does not mean that there are no zones of high heat flow in Alaska, as no more than 20 reliable heat flow determinations have been extracted from Alaskan drill holes; and considering the vast area of Alaska, little can be concluded from these initial determinations other than the need for more data.

To date there have been no known exploratory geothermal holes drilled in Alaska, other than a shallow (86 ft.) hole drilled in the lava dome (destroyed during the eruption of January 1976) near the summit of Augustine Volcano by the Geophysical Institute, University of Alaska (J. Kienle, et al., unpublished research).

Total Energy Utilization of Thermal Springs: Alaska has a large number of thermal springs which constitute potential energy sources other than geothermal subsurface steam reservoirs. The recent development of hot-water generating systems offers promise for the production of

electricity from thermal spring water (60°C) with outflow water temperatures which are high enough for second-stage energy extraction for space heating and agricultural application.

The exploitation of an energy source which could generate heat and power at less cost and develop the on-site production of vegetables through hydroponic farming and greenhouse operations would increase the economic stability and standard of living of remote resident populations.

The Geophysical Institute is now studying the total energy potential of three thermal springs in northern Alaska as possible sites for energy conversion experiments and pilot plant studies. Priority targets include Manley Hot Springs in the Tolovana District, and Clear Creek, Pilgrim and Serpentine Hot Springs on the Seward Peninsula (see Appendix E).

Rural Geothermal Priorities and the Total Energy Concept

High priority should be given to the development of geothermal resources in rural Alaska, rather than the cities. In addition to the previously-mentioned economic constraints, none of the presently recognized geothermal targets are located in the immediate vicinity of the cities. There are, however, potential geothermal resources which are located in or closely adjacent to villages in the outlying areas. The need is also most acute in the rural areas, and the development of any resource which can reduce the dependence on expensive fossil fuels and/or help establish local industry on any scale would be highly desirable.

Electric Versus Non-Electric Applications

In our discussion of Alaskan economics, we pointed out the difference between Alaskan needs and priorities and those of the other 49 states.

It follows that the utilization and economic potential of geothermal energy resources will be based on special criteria related to Alaskan problems and needs. Although non-electric applications of Alaskan geothermal resources deserve highest priority, it may also be advisable to generate small amounts of electricity in some rural settings. In many areas of rural Alaska, electricity is not continuously available in any form at the present time, and it would not be sensible to develop a geothermal resource exclusively for non-electric applications under such conditions. Secondly, the amount of electricity under consideration ranges from 2 to 250 KW -- quantities which are substantially below the levels considered feasible for large-scale developments in other parts of the nation. Since economic competition with other forms of power generation does not exist in many parts of rural Alaska, it makes good sense to consider generating small quantities of electricity by geothermal means wherever possible.

Sources of State Funding

We have reached a point in time when many rural areas could benefit greatly from geothermal resources, if we begin now to develop a technology which is compatible with environmental considerations and the cultural needs of the people. Capital to invest in such an enterprise may be available from two resources. The Alaska Native Claims Act of 1971 has given the native people the economic leverage to undertake development of geothermal energy. However, these monies are restricted by act of Congress to profit-making ventures by the regional and village corporations; and research and development expenditures on geothermal resources are not permissible. The State of Alaska has oil and gas revenues which could be used to develop geothermal resources in rural areas.

Research and pilot plant experiments must be initiated as soon as possible to insure that the technology is ready when the funds become available.

Present State of Geothermal Research and Development

Development: Currently, geothermal development by the private sector in Alaska has been restricted to hot spring resort activities and one large greenhouse operation at Manley Hot Springs.

Several Alaskan native regional and village corporations have received exploration proposals from private consultants and corporations during the last year, but to our knowledge none of these proposals and/or programs has progressed to the field stage.

Research: To date, most of the research on Alaskan geothermal resources has been done by the U. S. Geological Survey and the Geophysical Institute, University of Alaska. The U. S. Geological Survey's contributions date back to the pioneering work of Waring (1917) on Alaskan thermal springs. More recently (since 1971), the U. S. Geological Survey has been conducting a helicopter-supported assessment of Alaskan geothermal resources, with special attention devoted to the Alaskan volcanoes and thermal springs. Under the direction of T. Miller, this program has concentrated on the geothermometry, chemistry and geologic setting of the mal springs, and the age, petrology and setting of young (Tertiary and Quaternary) volcanic fields. With the exception of a gravity study conducted in the Wrangells, this program has not involved geophysical surveys.

The work done by T. Miller, I. Barnes and R. Smith was essential to the data presented on the energy potential of Alaskan geothermal resources, as recently published in U.S. Geological Survey Circular No. 726, "Assessment of Geothermal Resources of the United States - 1975."

The Regional Geophysics Branch of the U.S. Geological Survey (A. Lachenbruch and J. Sass) has been conducting a "target of opportunity" heat flow program in Alaska by capitalizing on available drill holes, when possible, which were drilled for other purposes. Funding for this program has been minimal, however, and no geothermal holes have been drilled by the U. S. Geological Survey in Alaska.

The Geophysical Institute, University of Alaska, initiated its geothermal program in 1971, with a revision of Waring's map of Alaskan thermal springs (Biggar, 1971). Biggar (1973) conducted a geophysical and geological study of Chena Hot Springs, and Forbes, et al. (1975) located a possible geothermal reservoir beneath Pilgrim Hot Springs with geophysical methods in 1974.

Forbes, et al. (1975) recently completed a feasibility and planning study on the utilization of geothermal energy resources in rural Alaskan communities under the provisions of a contract with the Atomic Energy Commission (AEC); and at present, Forbes, et al. are doing research on fossil versus present thermal gradients in deep drill holes, with the assistance of a research grant from ERDA.

J. Kienle, et al. (Geophysical Institute) are presently conducting an investigation of the magma tap potential of Augustine Volcano, with the aid of an ERDA research grant.

A Proposed Geothermal Research and Development Program

We believe that there is an urgent need for an integrated state, federal and private sector geothermal research and development program in Alaska.

Optimally, this program should be composed of cooperative projects involving the U. S. Geological Survey, the Energy Research and Development Administration, the State of Alaska and the private sector.

In our opinion, the program should reflect the following guidelines:

1. Heat is a precious commodity in the Alaska subarctic and arctic. Although geothermally-generated electricity may not be competitive with that generated by mine-mouth, hydroelectric and natural gas power plants for transmission to major population centers, hot water and vapor-dominated geothermal systems, where available, could improve the standard of living and economic viability of village populations.
2. Thermal springs have great promise as total energy systems in remote Alaskan villages. Applications engineering studies and pilot plants should explore this potential.
3. Volcanoes are confirmed targets. High priority should be given to the development of a technology which will extract useful energy from Alaskan volcanoes.
4. A systematic heat flow and thermal gradient measuring program should be initiated, involving the required cooperation of industry, and a federally-funded cooperative drilling program in Alaska.
5. Vast areas of Alaska are mantled by vegetation, alluvium and permafrost. Remote sensing techniques, including ground conductivity, infrared, gas detection and other methods should be investigated as possible geothermal exploration tools.

Three proposed geothermal research projects, concentrating on total energy utilization of selected Alaskan thermal springs are contained in Appendices E-3, E-4 and E-5.

Wind Power Potential and Applications

Potential: There are large areas of Alaska that appear to be uniquely favorable for wind power applications. The most promising areas are located on the coastal plains in the arctic, northwest (including Seward Peninsula), and southwest (Yukon-Kuskokwim Delta and Bristol Bay areas) regions. These areas experience strong, persistent winds which have their highest potential in winter, when energy requirements are the largest. Wind extremes are probably less in these areas than in coastal areas in Southeast Alaska, the Gulf of Alaska and the Aleutians. These "favorable" areas include many villages and a few small cities which are now totally dependent on fossil fuels.

Generally, interior Alaskan villages are less favorable sites for wind power applications due to a lack of suitable winds in the winter months.

State of Technology: Commercially-available wind power units up to 2 or 3 KW, including conventional storage batteries, are well proved. Initial costs and performance characteristics are fairly well known, but there are differences in opinion on long-term costs, including maintenance and repair.

Large wind power units are not yet readily available, and energy storage problems will become more serious when the larger units become available.

Present federal and industrial research and development programs include the construction of prototype windmills up to 100 KW capacity, and it seems likely that wind power units in this size range may be available within a few years. Longer-term research and development goals envision even larger machines, and it is possible that a 1000 MW prototype may be constructed within a few years. Windmill technology will probably progress more rapidly than energy storage technology for the next several years.

Applications: The wind power potential of Alaska is high. The annual power potential averaged for Alaska is of the order of 3400 MW, assuming that 1/1000 of the available kinetic energy in the first 1100 meters (3600 ft.) of the atmosphere could be extracted. The wind power potential of most coastal areas is assured; in the interior, however, the potential is low and variable with location.

The best and most immediate application of windmills would be in the electrification of many small communities, especially in coastal Alaska. Fuel oil conservation and an improvement in the quality of life are implicit to this application. Windmills (individual or clustered) in the 10 to 50 KW range would have considerable impact in the villages. A major problem in windmill utilization in rural Alaska is that those who could profit most, in a social sense, can least afford the capital investment. Demonstration projects are clearly needed; state and federal agencies should support and initiate early tests and demonstrations to educate potential users.

Longer-term applications will depend on the availability of large wind machines, producing 100 KW-rated (or above) output. The first Alaskan users would probably be privately-owned central utilities.

in intermediate-size communities (1000 or so population), and the seafood canning industry. The industrial production of methanol, ammonia and urea with windmill-produced power is feasible, but at present it is uneconomical. The economics of mass-produced large wind machines will be better understood in the near future.

While windmills rated at 100 KW or above offer the economy of scale, more emphasis should be placed on the development of reliable units rated in the 10- to 30-KW range, especially for rural applications. Logistics considerations, installation problems, and the need for redundancy indicate that the "windmill farm" (WEGS complex) concept is superior to that based on one large unit, at least in Alaska.

We expect engineering improvements in wind-generating units to be ahead of those in energy storage systems, for many years. Therefore, we recommend the early study and field demonstration of hybrid (wind-oil) energy systems, using existing small and medium (up to few hundred KW) diesel-fueled generators that are fairly common in Alaskan communities. Emphasis in these hybrid systems must be on automatic and reliable switching.

Our wind surveys are necessarily incomplete, and none of the locations considered from existing data have been surveyed at specific sites selected for wind power purposes. Yearly mean wind speeds range from about 18.3 to 7.0 knots (excepting several interior Alaska locations known for lack of wind). Topographic shielding is often present where the lower means prevail.

A useful numerical factor arising from our analysis of Alaskan wind data is the power factor (pf) which describes the potential use of the maximum installed power capability. While our surveys confirm the

generally-held view that Alaska locations can be very windy, the power factors of available windmills dictate careful site selection and the use of tall towers (cost permitting). Only machines like the very expensive Aerowatt seem to have merit at average wind speeds near 10 mph ($pf=0.39$); others have pf of 0.13 to 0.19 at that $\bar{V}$. At $\bar{V} = 20$ mph the computed pf of the Aerowatt, Elektro and Jacobs-like windmills treated in this report are 0.80, 0.53 and 0.62, respectively.

An Alaskan test center should be established to run various WECS in the same weather regime, to confirm these calculations and determine mechanical integrity under subarctic and arctic conditions. We recommend Cold Bay or Ft. Greely for this purpose.

Many small cities and villages are promising candidates for windmills, in terms of winds and need. For initial large-scale test installations, we recommend Nelson Lagoon, Cold Bay and Kotzebue. These were selected because of wind conditions, diversity of climate, relative ease of access for freight and personnel, and the degree of local interest.

A major windmill design effort should be made to minimize the wind speed necessary for achievement of the generator-rated output, and on the reduction of the weight and size of the generator (to avoid overrating). Heavy emphasis also should be placed on automatic controls for this purpose. Designers should specify the voltage output of their wind systems versus wind speed, as well as power output, and decisions on energy storage devices (active loads, batteries, heat sinks, etc.).

Gusting may cause windmill blade problems that are more severe in Alaska than in lower latitude locations. Generator braking due

to ice build-up behind the blades may actually be a greater problem than blade-icing. Slow speed operation during icing, or careful thawing of iced blades before start-up, are important procedures. However, much more study in different parts of Alaska needs to be done to better define these problems.

The cycle of Alaskan winds is usually in phase with the cyclic power requirements of Alaskan communities. Thus, the strongest winds occur during the colder and darker months. This is the reverse of the situation encountered with northern hydroelectric power sources. In that case, water flow is often minimal in the winter and early spring, before snow melting and river thawing.

For many Alaskan coastal sites the average decrease in the mean wind speed from the maximum monthly mean to the minimum monthly mean is about 30%. Because of the exponential velocity dependence of the power output of a windmill, this 30% amounts to a factor of 2 to 3 decrease in the average monthly power output of an idealized windmill. Factors of this order must be considered in setting the maximum power rating of a windmill (for winter use) or in estimating the summer (in coastal Alaska) yield of a windmill and storage system designed for winter loads. Cold Bay is a favorable exception to the large swing (16% versus 30% above).

Electricity: There are several possible levels of wind power application in Alaska which depend largely on the level of technology and the relative costs of the wind generators.

1. Presently available small capacity wind generators are suitable for some remote area applications when energy and power requirements are small. This might include single windmill units for very small loads or groups of units, where requirements are on the order of 10 to 20 KW.
2. The prospect that windmills up to about 100 KW in size may be available soon is of particular interest for many remote areas in Alaska which have power requirements in the 50 to several hundred KW range. It is not difficult to visualize a ready market for several hundred wind generators in the 50 to 100 KW range -- when proved machines become available at reasonable cost.
3. The application of wind power to the larger power systems will not be significant until generators in the 1000 KW size range and larger become available.
4. The State's electric utility systems offer some unusual opportunities for testing the wind power applications. Integration of windmills with other types of power generators in an electric system could avoid all energy storage problems during no-wind periods; any energy produced from windmills in such a system would provide a direct fuel savings. The very high fuel cost for remote cities and villages in Alaska suggests potential benefits from wind power applications would be very large.

Wind Power Demonstration Projects

Preliminary proposals for wind power demonstrations at selected Alaskan sites (Umnak Island, Cold Bay, Kotzebue and Nelson Lagoon) are contained in Appendix F.

Institutional Considerations

The Alaska State Energy Office and Statewide Coordination of Geothermal Activities: In coordination with the federal and private efforts in the geothermal and wind power field, the Alaska State Energy Office hopes to aggressively pursue worthwhile energy research, development and demonstration projects in areas of concern to Alaska. The wind power and geothermal research and development requirements and applications addressed in this report will receive very high priority. There has not been a traditional coordinating point in the State of Alaska for geothermal and wind power affairs and activities. The Alaska Energy Office is a logical vehicle for the state-wide administrative coordination of geothermal and wind affairs. This office could also improve liaison between state and federal agencies. The Alaska Energy Office should also serve as the state center for the dissemination of geothermal and wind power information.

State of Alaska Geological and Geophysical Survey: The State of Alaska Geological and Geophysical Survey should become increasingly involved in state geothermal affairs and be assigned an active role in state geothermal research and development activities.

State Versus Federal Funding: To date, the State of Alaska's investment in geothermal and wind power resources has been confined to work by the Geophysical Institute; participation of the Alaska Energy Office in the

recent Geothermal and Wind Resources Planning Conference; and the assignment of cognizance for geothermal affairs to the State Geological and Geophysical Survey. As of March 1976, federal agencies have contributed more than \$500,000 to geothermal and wind power research in Alaska; and to date, no State of Alaska funds have been appropriated for research and development in either of these areas.

Considering socio-economic needs and the importance of alternate energy sources in Alaska, the State of Alaska should initiate a funded geothermal and wind power program as soon as possible and develop incentives to attract the private sector.

Possible ERDA-State of Alaska Memorandum of Understanding: The Energy Research and Development Administration has been empowered to negotiate and finalize "Memoranda of Understanding" with state governments for cooperative energy programs. We recommend that the State of Alaska negotiate and sign such a memorandum of understanding with ERDA in the fields of geothermal and wind power research and development, involving a possible matching fund agreement.

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APPENDIX A

Program for the

Alaska Geothermal and Wind Resources Planning Conference

ALASKA GEOTHERMAL AND WIND RESOURCES PLANNING CONFERENCE

Anchorage Westward Hotel
July 8 & 9, 1975

Program Chairman: Dr. Robert B. Forbes

Convenor: Dr. William Ogle

Tuesday - July 8, 1975

MORNING SESSION

8:30 - 8:35	Welcome & Opening Remarks	Dr. William Ogle Anchorage, Alaska
8:35 - 8:40	Introduction of Lieutenant Governor Lowell Thomas, Jr.	Mr. William C. McConkey Director Alaska State Energy Office
8:40 - 9:00	Greetings from State of Alaska	Honorable Lowell Thomas, Jr. Lieutenant Governor State of Alaska
9:00 - 9:40	Alaskan Energy Economics (5-minute discussion period)	Dr. Arlon R. Tussing Chief Economist United State Senate Committee on the Interior and Insular Affairs
9:45 - 10:25	Geothermal Resources of Alaska --- A Status Report	Dr. Thomas Miller Geologist Branch of Alaskan Geology U.S. Geological Survey
10:30 - 10:45	Coffee Break	
10:45 - 11:25	Wind Resources of Alaska --- A Status Report (5-minute discussion period)	Dr. Tunis Wentink Professor of Physics Geophysical Institute University of Alaska
11:30 - 12:00	Geothermal & Wind Resources as Applied to Alaskan Needs	Dr. William Ogle Anchorage, Alaska
12:00 - 1:30	Lunch	

AFTERNOON SESSION

1:30 - 2:10	The U.S. Geological Survey Geothermal Program (5-minute discussion period)	Dr. L.J. Patrick Muffler Coordinator Geothermal Research Program U.S. Geological Survey

AFTERNOON SESSION (Cont'd.)

2:15 - 2:55	Agricultural Applications of Geothermal Resources	Dr. Don Dinkel Professor of Agronomy Institute of Agricultural Science, University of Alaska
3:00 - 3:15	Coffee Break	
3:15 - 3:45	Possible Utilization of Thermal Waters in Salmon Rearing Operations	<u>Part 1:</u> Dr. William McNeil Auke Bay Fisheries Laboratory National Marine Fisheries Service
3:45 - 4:15		<u>Part 2:</u> Mr. Joe Wallis Hatchery Superintendent Firelake Hatchery Service Department of Fish & Game State of Alaska
	(5-minute discussion period)	
4:20 - 5:00	Space Heating & Industrial Applications of Geothermal Energy Resources (discussion)	Dr. Jay F. Kunze Manager Geothermal Projects Aerojet Nuclear Company
5:30 - 6:30	Post Session No-Host Cocktails	

Wednesday - July 9, 1975

MORNING SESSION

Convenor: Mr. William C. McConkey, Director
Alaska Energy Office

8:30 - 9:10	The Hickel Report --- Two Years After	Honorable Walter J. Hickel Former U.S. Secretary of the Interior & Governor of the State of Alaska
9:15 - 9:55	The U.S. Geothermal & Wind Resource Research & Development Program & Possible Alaskan Assistance	Dr. Louis Werner Assistant Director for Research Utilization Division of Geothermal Energy Research & Development Administration
10:00 - 10:40	National Science Foundation Geothermal & Wind Resource Program (discussion)	Mr. Ritchie B. Coryell Geothermal Program Manager Advanced Energy Research & Technology Division National Science Foundation

MORNING SESSION (Cont'd.)

10:40 - 12:00 Working Groups Convened by
 Chairmen

12:00 - 1:30 Lunch

AFTERNOON SESSION

1:30 - 5:00 Working Groups Convene in
 Assigned Rooms

5:00 - 7:30 Dinner

EVENING SESSION

7:30 Working Groups Convene in
 Assigned Rooms

WORKING GROUPS

Agriculture	Dr. Don Dinkel Professor of Agronomy Institute of Agricultural Science University of Alaska	Chairman
Electrical Power	Mr. Robert Cross Chief Project Development Division Alaska Power Administration	Chairman
Fisheries & Aquaculture	Dr. William McNeil Auke Bay Fisheries Laboratory National Marine Fisheries Service	Chairman
Geothermal Resource Research & Development	Dr. Robert B. Forbes Professor of Geology Geophysical Institute University of Alaska	Chairman
Space Heating & Industrial Applications	Dr. William Ogle Energy Consultant Anchorage, Alaska	Chairman
Wind Power Development & Applications	Dr. Tunia Wentink Professor of Physics Geophysical Institute University of Alaska	Chairman

APPENDIX B

Attendance List for the

Alaska Geothermal and Wind Resources Planning Conference

ALASKA GEOTHERMAL AND WIND RESOURCES PLANNING CONFERENCE

Anchorage Westward Hotel
July 8 & 9, 1975

Attendance List

Atuk, Richard K.	Bering Straits Native Assn., Nome, AK 99762
Barnes, William	Windlite - Alaska, 4303 Forest, Anchorage, AK
Bewley, Georgia	Geological Asst., Alaska Geological & Geophysical Surveys 3001 Porcupine Drive, Anchorage, AK 99501
Bodnar, Andrew J.	Electrical Engineer, Engineering Div., Directorate of Engineering & Construction, HQ AAC/DEEE, Elmendorf AFB, AK 99506
Boston, Clark D.	Director, Div. of Rural Development Assistance, Pouch B, Juneau, AK 99801
Boucher, H.A. "Red"	H.A. "Red" Boucher & Assoc., 805 W. Third, Anchorage, AK 99501
Boudreau, Barry	Supervisory Physical Scientist, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025
Braasch, Richard, Dr.	Sandia Laboratories, P.O. Box 5800, Albuquerque, NM 87115
Brink, Irvin	Mayor, Village of Akolmiut, Nunapitchuk, AK 99641
Bruce, Jim	Architect, James B. Bruce, A.I.A. Architect, P.O. Box 2376, Anchorage, AK 99510
Brueckner, Hannes	Associate Professor, Queens College of New York and Lamont-Doherty, Geological Observatory, New York, NY 11375
Buness, Everett W.	Director, U.W. Dept. of Commerce, 632 Sixth, Anchorage, AK 99501
Burton, Wayne E., Dr.	Assoc. Prof. of Agricultural Economics, University of Institute of Agricultural Sciences, P.O. Box AE, Palmer, AK 99645
Cameron, Robert B.	Command Environmental Engineer, Directorate of Engineering & Construction, HQ AAC/DEEV, Elmendorf AFB, AK 99506
Carpenter, John	The Aleut Corporation, 833 Gambell Street, Anchorage, AK 99501
Chernikoff, Fred	Alaska Federation of Natives, 670 West Fireweed, Anchorage, AK.

Chiel, Jr., Fred	Deputy Regional Administrator, FEA, Federal Building, Anchorage, AK 99501
Claus, Harold	Asst. Operations Mgr., E.G. & G., Inc., P.O. Box 1912, Las Vegas, NV 98102
Cline, Dave	Wildlife Biologist, U.S. Fish & Wildlife Service, 8th and A, Anchorage, AK 99501
Comiskey, Albert L.	National Weather Service, NOAA, 632 Sixth, Anchorage, AK 99501
Coryell, Ritchie B.	Geothermal Program Mgr., Advanced Energy Research and Technical Division, National Science Foundation, Washington, D.C. 20550
Cross, Robert J.	Chief, Project Development Div., Alaska Power Admin., P.O. Box 50, Juneau, AK 99802
Curtis, Edgar J., P.E.	U.S. Army Corps of Engineers, Elmendorf AFB, Anchorage, AK
Dart, Charles W.	Owner, Manley Hot Springs Greenhouse, Manley Hot Springs, AK 99776
Davis, T. Neil, Dr.	Deputy Director, Geophysical Institute, University of Alaska, Fairbanks, AK 99701
Denslow, Dan	Ambler Air Service, Ambler, AK 99786
DeWitt, Michael, Capt.	AFWL-DE 2, Kirtland Air Force Base, NM 87117
Diershaw, A.	Engineer, Wincom, 4134 Ingra, Anchorage, AK 99510
Dinkel, Donald, Dr.	Professor of Agronomy, Institute of Agricultural Science, University of Alaska, Fairbanks, AK 99701
Doak, Barney R.	Area Mechanical Engineer, Alaska Area Native Health Service, Box 7-741, Anchorage, AK 99503
Dobey, Patrick	Chief Petroleum Geologist, Alaska State Geological and Geophysical Surveys, 3001 Porcupine Drive, Anchorage, AK
Dorris, J. David	Land Systems Planner, Joint F/S, Land Use Planning Commission, 733 W. Fourth Ave., Anchorage, AK 99503
Dowling, Forrest, Dr.	National Coordinator of Geothermal Resources, Office of Rural Research in Chicago, 536 S. Clark Street, Chicago, IL 60605
Drahn, Richard A.	Civil Engineer, Alaska Geological Consultants, 702 W. 32nd, Anchorage, AK 99502

Duke, Kit	Project Planner - Southcentral Region, University of Alaska, P.O. Box 4-2540, Anchorage, AK 99509
Forbes, Robert B., Dr.	Professor of Geology, Geophysical Institute, University of Alaska, Fairbanks, AK 99701
Ford, Michael F.	Development Specialist, State Dept. of Commerce and Economic Development, Pouch E, Juneau, AK 99801
Forrest, Lesh C.	Vice Pres., - Operations, Alaska Geological Consultants, Inc., 702 W. 32nd Ave., Anchorage, AK 99502
Fukuhara, H.	Assistant to Mgr., - Engineering Project, Nissho-Iwai Co., Ltd., 4-5 Akasaka Minato-Ku, 2-Chome, Tokyo, Japan
Galliett, Harold	Civil Engineer, Galliett Engineers, 746 F St., Anchorage, AK 99501
Gerik, Al	3217 Redoubt Ct., Anchorage, AK 99503
Grundy, Scott	Regional Habitat Supervisor, Alaska Dept. of Fish and Game, 1300 College Rd., Fairbanks, AK 99701
Gryc, George	Chief, Branch of Alaskan Geology, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025
Gunnery, Donald A.	Marketing Mgr., Standard Oil Company, P.O. Box 1580, Anchorage, AK 99510
Hablett, Thomas R.	Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, 813 D Street, Anchorage, AK 99501
Hall, Bert	Alaska Liaison, U.S. DHEW, Box 378, Anchorage, AK
Harnish, Charles E.	Hydrologist, U.S. Forest Service, 121 W. Fireweed Lane, Anchorage, AK 99503
Hartman, D.C.	Geologist, Texaco, Inc., P.O. Box 4-1570, Anchorage, AK 99504
Heath, Thomas	Field Engineer, Rural Electrification Administration, Anchorage, AK
Henderson, Wayne	Civil Engineer, RCA, 606 E. Bluff Rd., Anchorage, AK 99504
Hodder, David	Escatech - Calista Corp., 516 Denali, Anchorage AK 99501
Hodson, Loyd M.	General Mgr., Alaska Village Electric Cooperative, 999 E. Tudor Rd., Anchorage, AK 99503
Hoffman, Robert N.	Electrical Engineer, Crews, MacInnes & Hoffman, 4111 Minnesota Dr., Anchorage, AK 99503

Holdsworth, Phil R., P.E.	Commissioner, Federal-State Land Use Planning Commission for Alaska, 326 Fourth St., #1009, Juneau, AK 99801
Hooper, Lennon	Park Planner, National Park Service, 334 W. 5th Ave., Anchorage, AK 99501
House, J.V.	Administrator, Alaska Power Administration, P.O. Box 50, Juneau, AK
Hudson, Bill	Lawrence Livermore Laboratory, Livermore, CA 94550
Hudson, Ted	District Geothermal Supervisor, Portland District, U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA 94025
Huettl, James A.	Project Planner, University of Alaska, P.O. Box 4-2540, Anchorage, AK 99509
Isberg, Howard, P.E.	Chief Engineer and Assistant to General Mgr., Philleo Engineering and Architectural Service, Inc., Box 464, Fairbanks, AK 99701
Janson, Lane E.	Alaska Native Management Report
Jean, Don	Industrial Specialist for Energy Research and Develop- ment FEA, Federal Bldg., Anchorage, AK 99501
Jewell, Edward	Electrical Engineer, BLM, Air Service Operations - Electronics, Anchorage, AK 99510
Johns, Milly	Alaska Center for the Environment, Box 393, Anchorage, AK 99510
Johnson, Gerald W.	Systems and Energy Group, TRW, Inc., One Space Park, Redondo Beach, CA 90278
Johnson, Steven A.	Geological Engineer, Alaska Geological Consultants, Inc., 702 W. 32nd Ave., Anchorage, AK 99504
Kagin, Solomon	President, Real Gas and Electric Co., Inc., P.O. Box A, Guerneville, CA 95446
Kallenberg, Walter B.	Engineer, R & M Consultants, 249 E. 51st St., Anchorage, AK
Kay, Robert	Research Associate, UCLA Geology Dept., Los Angeles, CA 90024
Kay, Suzanne Mahlburg	Post-Doctoral, UCLA Geology Dept. Los Angeles, CA 90024
Kemppel, Roger	Attorney, Municipal Light and Power, City of Anchorage, 1200 E. First Ave., Anchorage, AK 99501
Kern, Edward D.	Marketing Specialist, State Div. of Agriculture, Box 1088, Palmer, AK 99645

Kerr, Donald M., Dr.	Los Alamos Scientific Lab. Los Alamos, NM
Kiech, Maurice C.	4019 Tazlina Ave., Anchorage, AK 99503
Klebesadel, L.J.	Research Agronomist, Agricultural Research Service, USDA, Box AE, Palmer, AK 99645
Klein, Bob	Stratigrapher, Alaska Geological and Geophysical Surveys, 3001 Porcupine Dr., Anchorage, AK 99501
Kreiling, Lee	Operations Mgr., E.G. & G., Inc., 2801 Old Crow Canyon Rd., San Ramon, CA 94526
Kuhn, Adolf	Hydrologic Tech., U.S. Geological Survey - WRD 7010 E. Twelfth, Anchorage, AK 99504
Kunze, Jay F., Dr.	Manager, Geothermal Projects, Aerojet Nuclear Company, Idaho Falls, ID
Kuwada, J.T.	Vice Pres., Rogers Engineering Co., Inc. 111 Pine St., San Francisco, CA 94111
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APPENDIX C

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APPENDIX D

CHEVAK'S CURRENT ENERGY PICTURE:
(Fall, 1975)

A STUDY OF A SOUTHWESTERN ALASKAN ESKIMO VILLAGE
(61°30'N, 165°W)

This especially lucid presentation of the problems of a small Eskimo village near the coastline on the Bering Sea is typical of the situation facing many of Alaska's native peoples. It was written by an unidentified Chevak resident.

CHEVAK'S CURRENT ENERGY PICTURE:

A Study of a Southwestern Alaskan Ekimo Village

When time became a consideration in the changing lifestyle of the subsistence hunters in Southwestern Alaska, energy became a problem. Unlike the days of past, where dog teams consumed renewable resources for their fuel, and the people harvested natural fuels for their energy needs as they migrated to seasonal locations, the present Eskimo villages are normally located in places where both subsistence foods and natural fuels are dwindling, or are extinct. The reasons for the location of permanent settlements in areas devoid of natural support systems is due to time conditions.

When the government gave gifts, it established its schools and services in central locations, and demanded that the villagers cease their seasonal movements. Instead of subterranean houses, the government established framed, above ground dwellings as its standard of housing, and discouraged native efforts to maintain their former ways. The the limited amounts of wood that washed ashore during the summer near the permanent location, limited winter storage. Competition among households for the available fuels occurred, and many families were without fuel for space heating or cooking. Whereas the house buried in the hillside and covered with sod was warm enough without added heat to prevent water from freezing, the above ground houses were exposed to the wind, and freezing conditions. Fuel oil was cheap at that time, and when money became available in the village, the people converted to oil.

The seasonal migration to locations of abundant food was also terminated through permanent settlements. Hunters had to go farther away

from their villages to harvest their foods, more often than in the past, but hunters also had to make money to pay for the imported lumber and heating fuel. The summer was the only period of the year when seasonal work was available, which is also the most important time of the year for the harvest of subsistence foods. The compromise that was struck with technology was the advent of the outboard motor and the framed boat for the summer that allowed quick, and at that time, inexpensive access to food sources and to continuation of summer employment in the village. In that less time was being spent in the harvest of fish, feeding the dog teams during the winter became a burden, and the dogs gave way to the snowmachine that did not require the constant, and year round attention dog teams demand.

From a community self-sufficient on natural fuels and transportation, the coastal Eskimo village became dependent on imports; transportation developed as a limiting factor to the way of life, and energy became the largest single type of imported goods in the village. Although the harvest of foods has possibly diminished in terms of per capita consumption, the average household still depends on 80% of its gross nutrition, and 95% of its protein on local species. It is in the field of energy however where a permanent change has occurred.

The village of Chevak sits 120 air miles west of Bethel, the regional transportation center of that part of Southwestern Alaska drained by the Yukon and Kuskokwim rivers. It receives its goods from the Bureau of Indian Affairs (BIA) annual "Northstar III" ship out of Seattle, and by Wlen Air Alaska, and two barge companies out of Bethel.

Energy in the village is produced totally by imported fuels. The Alaska Village Electrical Cooperative (AVEC) has homogenized electrical

delivery, operating a plant capable of 300 KW prime production. Current consumption in the village is 45-60 KW prime during the summer when the school is closed, and 100-110 KW prime during the winter. The new school, being built by BIA to replace a school that burned in 1972, will demand a 85 KW prime, with a peak of 115 KW when the shop is operational. The BIA subsidizes AVEC, \$700,000 from the BIA's agency Plant Maintenance budget, which allows AVEC to charge its residential users a minimum of \$21/month at 17.1¢/KW average. Bulk users, the school, pay 9.5¢/KW. AVEC currently consumes 45-52,000 gallons of diesel. Its bulk storage capacity has recently been upgraded to 110,000 gallons, in preparation for the opening of the school, which will increase its consumption to 85,000 gallons of diesel. The BIA maintains auxiliary diesel for electrical emergency, but does not have bulk tanks for its diesel supply.

Both the BIA and the village owned store have bulk storage for fuel oil. Space heating the current BIA school requires 35,000 gallons of fuel. The BIA has a 130,000 gallon capacity and presently tops its tanks each year. The new school will demand up to 122,000 gallons of #1 and #2 mixed fuel oil when completed, leaving a surplus of only 8,000 gallons, if the tanks are topped. No new bulk storage tanks are being purchased for the school.

The fixed nature of federal contracting normally guarantees the supply of diesel and fuel oil by the local barge companies and the North Star. It is the problem of the village's growing need for fuels, and the doubt that villages can pay that makes the yearly delivery of enough fuel and gasoline to the village a gamble. The village of Chevak has 45,000 gallons bulk storage capacity for fuel, and 5,000 gallon

capacity for gasoline. Unlike other villages on the coastline, Chevak is well prepared for its needs. But for three years in a row, Chevak ran out of fuel oil because its summer re-supply never arrived or was not enough. In 1973, Black Navigation of St. Michaels sold 20,000 gallons of Chevak's fuel on the Yukon before coming to the village. The village ran out late in February. In 1974, the same situation duplicated itself. Turning toward Bethel's distributors, Chevak fuel was ice locked on the the Yukon in 1975 when the tug pulling the barge burned in late July, and no replacement barge could be located before freeze-up. When the village runs out, the Council borrows fuel from the BIA, which has had, to this time, a surplus. In 1975-76, Chevak's tanks are full, and the BIA will have a surplus, but in 1976, when the re-supply of the village will again remain to chance, and the BIA will require all its fuel, a problem may develop. In villages that have had to fly their fuel in, the amount per drum rises from an average of \$48/55 gallon drum to \$65-75/drum.

Gasoline storage in Chevak is favorable, and the village normally supplies its neighboring villages which do not have bulk gasoline storage. The average cost of a drum is \$50. Gasoline consumption has risen from 12,000 gallons in 1970 to 39,000 gallons in 1975, and the rate of consumption is expected to continue to rise until supply is exhausted within the next two years, the village store's manager declared.

Per capita income in the village of Chevak, located in Wade-Hampton census district, was \$1,300 in 1970. The listing of 24 families in Chevak made in 1975 reveals that 20-40% of the cash income of these families is consumed by imported fuels, well out of line with the natural average.

The statistics of energy in the village do not reveal the entire story, however, for growth in the public sector principally influences the village's way of life, and growth in the public sector is undisciplined, and not coordinated with the village.

Bethel's tug industry is concentrated on oil; freight is secondary. The growth in public facilities dependent upon fuels for energy has outgrown the barge companies' ability to deliver. While public facilities are normally resupplied, the villages become the supply casualties; in 1972, 14 villages ran out of oil; in 1973, 24 villages; in 1974, 36 villages; and in 1975, 39 of Bethel region's 57 villages had fuel oil shortages.

Total energy planning for the community is non-existent and the failure to plan causes an undisciplined demand for more oil, which is duplicated in all other villages. Alternate energy systems do not exist, nor do total energy systems employing waste heat recovery. Federal and State of Alaska agencies to this date have not initiated studies on the utility of these alternate forms of energy involving hydro-electric, geothermal, and aerogenerators in the plan and design of new facilities, or the consolidation of existing energy demand by public facilities.

The BIA's new plant will sit 70 feet from the existing AVEC plant. AVEC's engineers have initiated studies that determined that the majority of the space heating demand of the new facility could be produced by AVEC using water jackets, and a utility to convey the waste heat to the school for distribution. The BIA has not accepted this idea to date. Because BIA subsidizes AVEC, AVEC is committed to selling all of its waste heat to BIA. Even though BIA does not want the waste heat,

AVEC cannot release the heat to other customers. At this time, AVEC believes that 650,000 BTU will be wasted each hour when the plant is operating at full capacity in 1976.

The Chevak store wishes to buy the waste heat. Concerned with fire from its domestic boiler, and consuming 6,000 gallons of fuel in its store/hall, the village determined that it could save money, while reducing the village's total demand for fuel, by converting to waste heat. AVEC will not sell the village the heat until the BIA makes up its mind. The village built a community hall this summer, and wished to place the hall near the store and close to the heat recovery system. BIA personnel informed the village that building the hall on the selected location would present a fire hazard to the new school, and with the waste heat recovery system idling, the village moved the hall across the village, requiring an additional 1,500-2,000 gallons of fuel depending on use, and the necessity of burrowing a new path through the village to roll the drums to the hall.

New housing in the village, sponsored by the Alaska State Housing Authority and the Bureau of Indian Affairs, is well designed, and properly insulated. The houses sit in rows that would make utility hook-ups convenient, and a centralized heating plant economically feasible. However, the houses are located across the village from the AVEC plant, almost 3/8 mile, making waste heat recovery impossible. Villagers now have to roll their drums that distance from the village store, or use gasoline in their snowmachines to accomplish the task.

The village also runs a modified village safe water act facility that drains the local economy. Built in 1974 by the villagers, the

State of Alaska Department of Environmental Conservation awarded the village \$60,000 to finish off the system. Containing a water pump, showers, flush toilets, and a laundromat, the facility would have consumed \$26 to \$34,000 worth of energy along if operated like other VSWF facilities in the State. The annual operating cost for the Emmonak EPA and the State Alukanuk facilities is \$100,000 in which energy accounts for almost \$42,000 of the costs. The villages raise approximately 15% of the annual costs through user fees, with the remainder being subsidized by the State and Federal governments. Realizing the financial burden, The State "educated" Chevak to the energy costs it would face, and informed the village that no budget subsidy could be expected. The village opened the facility only 3 hours a day during the winter of 1975, all day Saturday and Sunday, and kept its electrical and oil costs to \$12,500 gallons of oil, and added a further burden to the village's capacity to remain within its bulk capacity. The new facility is located 1/4 mile from the AVEC facility.

Wind blows constantly in Chevak. The Cape Romanzoff Early Warning Station 26 miles northwest of the village records ambient wind velocities above 15 mph at 70 feet the majority of the year. One individual aware of the Romanzoff readings declared that in his stay at the EW site, only 12 days had less than 15 mph for their average.

The village of Chevak is interested in breaking loose of the oil burden. Aware that shipping costs, supply, and storage are outstripping the village's ability to pay, the Council and the Corporation are seeking technical information on aerogenerators. The Alaska Native Claims Settlement Act deposits yearly funds into the Chevak Corporation, and the Corporation is re-cycling its funds to support the village's fuel

economy, and recognizes the dead end this yearly re-investment means for its only capital, but State and Federal responses to date have been negative.

<u>(1)</u> <u>HOUSEHOLD</u>	<u>INCOME (2)</u> <u>FAMILY INCOME</u>	<u>DRUMS(3)</u> <u>OIL USED</u>	<u>DRUMS</u> <u>GAS USED</u>	<u>TOTAL(4)</u> <u>FUEL COSTS</u>	<u>%</u> <u>OF INCOME</u>
1.	\$2,450	18	4	1,052	42.9%
2.	\$3,000	20	6	1,296	43.2%
3.	\$3,650	19	4	1,136	31.1%
4.	\$2,560	16	4	992	38.8%
5.	\$4,060	15	5	1,000	24.6%
6.	\$2,760	16	4	990	35.9%
7.	\$2,800	14	5	952	34.0%
8.	\$3,340	20	5	1,240	37.1%
9.	\$2,800	14	4	896	32.0%
10.	\$2,360	11	2	640	27.1%
11.	\$4,000	19	6	1,248	31.2%
12.	\$3,560	17	4	1,040	29.2%
13.	\$3,110	10	3	648	20.8%
14.	\$2,760	12	4	800	31.9%
15.	\$3,340	16	5	1,048	31.4%
16.	\$2,380	14	5	952	40.0%
17.	\$2,900	15	6	1,056	36.4%
18.	\$2,460	14	4	912	37.1%
19.	\$3,500	18	5	1,144	32.7%
20.	\$2,670	18	6	1,200	44.9%
21.	\$5,500	21	7	1,400	25.5%
22.	\$3,070	17	5	1,096	35.7%
23.	\$3,600	16	6	1,004	27.9%
24.	\$4,590	20	7	1,352	27.6%

- 1) Chevak has 67 heads of the households; some families have substantial cash incomes.
- 2) Transfer payments and cash income combined.
- 3) Estimate in terms of 55 gallon drums
- 4) Based on summer, 1975 price of fuel in Chevak: \$48/drum #1 heating oil; \$56/drum gasoline.

APPENDIX E-1

PROPOSED USE OF GEOTHERMAL WATER FOR SALMON AQUACULTURE
ON UENAK ISLAND, ALASKA

by

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National Marine Fisheries Service
Auke Bay, Alaska 99821

PROPOSED USE OF GEOTHERMAL WATER
FOR SALMON AQUACULTURE ON
UMNAK ISLAND, ALASKA

Introduction

Several streams on Umnak Island in the Aleutian Islands have been identified as possessing significant potential as hatchery water sources for ocean ranching of salmon (McNeil, 1974). The streams in question drain fairly recent volcanic formations and are believed to have sufficient warmth to remain ice free throughout the winter, although water temperature regimes remain to be determined. If temperature and chemical quality of these streams should prove to be favorable for anadromous salmonid fishes, a successful salmon ocean ranching industry is a distinct possibility for the Aleutians, as well as other areas of Alaska, where geothermal sources of water might be developed for aquaculture at relatively low cost.

This proposal is for an ocean ranching demonstration project, primarily with pink salmon. A successful demonstration of ocean ranching in the Aleutians could lead to a large-scale hatchery program which might ultimately produce several million pounds of salmon annually for harvest.

First year of the program would be devoted to hydrological and biological surveys of several spring-fed streams on Umnak Island to determine their suitability for salmon aquaculture. Should water quality prove to be suitable, the surveys would be followed by construction of a demonstration hatchery capable of producing 8 million juvenile pink salmon annually for release into the ocean as unfed fry. The hatchery would be operated 4 years to demonstrate economic feasibility of ocean ranching using geothermal water on Umnak Island.

Total cost of the 5-year project is estimated to be about \$485,000 plus overhead. Application of the technology for large-scale ocean ranching on Umnak Island would have the potential annually of contributing millions of pounds of high quality animal protein with virtually no expenditure of energy. The major economic benefits would accrue directly to the Aleut Indians who are about to acquire from the Federal Government ownership of land on Umnak Island where the geothermal water sources are located.

Study Area

The study streams are located within the boundaries of the former Fort Glenn military reservation on the east end of Umnak Island (Figure 1). Tulik Volcano (4,100 feet elevation) is the dominant feature of the lava formations where the study streams originate. Several of the streams flow in an easterly direction into the Bering Sea and into Umnak Pass which connects the Bering Sea and the North Pacific Ocean.

Intense upwelling of marine waters along the Aleutian Islands creates conditions which are highly favorable for plankton. As a consequence, salmon from many regions around the rim of the North Pacific Ocean and Bering Sea feed in the area. Thus, marine waters surrounding Umnak Island should be well suited as nursery waters for hatchery-produced fish.

Hydrological Surveys

Temperature recorders would be installed on at least 5 streams and operated one season (August or September - April or May) to evaluate temperature regimes of the study streams. The Aleut Corp. own 5 automatic recording thermographs which might be rented for this work.

There is also a need to acquire qualitative information on stream discharge patterns and quantitative information on chemical water quality. Workers at an existing cattle ranch on Umnak Island might be trained and employed part time to make periodic observations on streamflow and to collect water samples for laboratory analysis.

Biological Surveys

These surveys will be required to catalog the existing fish fauna in the study streams and to estimate the size and species composition of existing stocks of salmon which might be used to supply eggs for hatcheries. Surveys of streams would be required during the August-September spawning period. The existing road system is extensive and crosses most, if not all, of the study streams. A motorized land vehicle could therefore be used for transportation.

Hatchery Design

Construction of a demonstration hatchery would proceed only if it is evident that water quality is suitable. It would be preferable to obtain eggs from a stock of salmon which is native to the hatchery stream, but eggs could be transplanted from nearby Unalaska Island which is known to have pink and chum salmon. Umnak, unfortunately, has never been surveyed at the proper time of year to establish the size of salmon stocks.

A demonstration hatchery would be a simple, inexpensive design which is used primarily by private hatcheries on coastal streams in Oregon and Washington. The design is sometimes called a "shallow-matrix gravel incubator" or "Netarts gravel incubator" after Netarts Bay, Oregon, where the system was first employed in 1968. Hatchery

tanks can be constructed onsite from plywood or prefabricated and shipped to the site. About 500 square feet of level ground is required for each million eggs of installed tank capacity. Water can be delivered to the hatchery site through open canals and distributed from canals to tanks through plastic pipe. Figure 2 shows a schematic diagram of a hatchery layout. The hatchery is not housed, but lids are placed on tanks to shield eggs and alevins (larval salmon) from light, weather, predators, etc.

The Umnak Island study streams have modest gradients and pass through small valleys which are covered by a mantle of top soil. Canals and other excavations can be done with farm machinery.

Pink and chum salmon are easy to trap and spawn artificially. Fish are almost fully mature when they leave salt water, and it is unnecessary to hold adults in captivity for more than one week while they ripen. A weir diverts spawners from the stream into a hatchery discharge canal (Figure 2), and they are sorted and spawned at the site where hatchery tanks are located.

Eggs and alevins require little or no care after the fertilized eggs are placed in tanks. Eggs are placed on screen trays suspended in the water column in tanks during September. Hatching occurs in December, and the alevins drop through the trays to the bottom of a tank which has a shallow layer of gravel or artificial plastic turf for support. The unfed fry emigrate from tanks in the spring and follow the discharge canal to the stream which carries them into the ocean. Pink salmon mature at 2 years of age. Chum salmon mature after 3, 4 or 5 years.

Work Schedule

The work schedule is conceived as follows:

- Year 1 - (a) Complete hydrological and biological surveys.
(b) Select hatchery site and donor stock.
(c) Design hatchery.
- Year 2 - (a) Construct water delivery system for 900 gallons per minute.
(b) Excavate site for hatchery tanks and fish spawning.
(c) Install hatchery tanks.
(d) Construct adult trapping facilities.
(e) Stock hatchery with eggs from donor stock.
- Year 3 - Stock hatchery with eggs from donor stock.
- Year 4 - Stock hatchery with eggs from returning hatchery fish (pink salmon only).
- Year 5 - (a) Stock hatchery with eggs from returning hatchery fish.
(b) Formulate an expanded program, depending on results of demonstration project.

Economic Considerations

Pink salmon have the shortest life cycle (2 years) of all salmon species and are recommended for evaluating the feasibility of ocean ranching on Umnak Island. Chum salmon have a 3- to 5-year life cycle. Sockeye and coho salmon also spawn in the Aleutian area, but these species require a year or longer of freshwater rearing before they go to sea.

Pink salmon have been released from three pilot incubator hatcheries in Alaska since 1972, and six experiments involving up to 1 million

fry per experiment have been evaluated. The number of adults returning to hatcheries has varied between 0.7 and 3.0 percent of the number of fry released, with an average of about 1.5 percent.

A hypothetical projection of production of pink salmon from gravel incubator hatcheries on Umnak Island is given in Table 1. The assumptions are:

1. Egg-to-fry survival = 80 percent.
2. Fry-to-adult survival = 1 percent.
3. Fecundity = 1,600 eggs per female.
4. Amount of water available for hatcheries = 50 c.f.s. on the expectation that several spring-fed streams can be developed for hatchery use.

At this point we can only speculate about our ability to generate returning runs of 2 million adult pink salmon to Umnak Island. This is probably a much higher level of production than Umnak streams have achieved with natural spawning because spawning area is limited.

It is not inconceivable, however, that such a potential exists with hatcheries, since streams entering Makushin Bay, Unalaska Island (50 miles east of Umnak Island), are known to have produced several hundred thousand adult pink salmon.

If a demonstration project should be successful, the ultimate potential for Umnak Island for salmon ocean ranching would probably be determined by the availability of fresh water for artificial recruitment of pink and chum salmon fry. It is assumed that the capacity of marine nursery waters to grow salmon to maturity is not limiting.

Each adult pink salmon returning to a hatchery would generate about \$2.50 of wholesale value as a canned product (1974 prices). There would also be a substantial added value (more than \$1 per female), for surplus roe. Thus, wholesale value of a processed pink salmon should average at least \$3 per fish. Value of chum salmon would be almost three times higher per fish, reflecting their larger size at maturity.

Cost of Project

The project would include two phases. Phase I would take place in the first year and would include hydrological and biological survey work to evaluate the desirability of a demonstration hatchery. Phase II would take place in the 2nd through 5th years to evaluate economic feasibility of an ocean ranching industry on Umnak Island and to establish pink salmon brood stock for expanding the project into a large-scale commercial venture. Expansion into a commercial venture should be the responsibility of the Aleut people working through their regional and village corporations.

The total cost of a 5-year project would be about \$500,000 to \$600,000. This cost may seem low to some reviewers, but keep in mind that this project is not intended for the construction of a permanent edifice. The hatchery would be simple and temporary and would be operated as inexpensively as possible for the purpose of determining feasibility of salmon ocean ranching in the Aleutians with geothermal water.

Reference

McNeil, W. J., 1974, Preliminary analysis of aquaculture potential in the Aleutian Islands, Alaska. U.S. Dept. of Commerce Economic Development Admin. Tech. Assistance Project, Sept. 1974:13p.

APPENDIX E-2

A PROPOSAL FOR ALASKA MUNICIPAL GEOTHERMAL HEATING

by

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A PROPOSAL FOR ALASKA MUNICIPAL GEOTHERMAL HEATING

The use of warm geothermal waters from drilled holes or springs for space heating has proven economic in many regions of the world. The costs vary with the ease of obtaining the hot water, its purity, the distance that it must be piped, and the duty cycle determined by the climate. Following are some examples:

Reykjavik, Iceland: Homes for approximately 100,000 people are heated for about \$4.00/gigacalorie, equivalent to oil for about \$5.60 per barrel. The duty cycle is almost 100%. Wells vary in depth from 2100 feet to 6000 feet and the water is piped from 1/2 mile up to eleven miles. Total system capacity is about 190 gigacalories per hour, equivalent to 135 barrels of oil per hour. Water flow is about 2700 cubic meters per hour (equals about 800,000 gallons/hour).

Husavik, Iceland: Some 2500 people reap the benefits of hot water piped from natural springs 11 miles away. The household is heated about the same as in Reykjavik. Total capacity is about 6 gigacalories per hour with a flow rate of $125 \text{ M}^3/\text{hr}$. The electrical heating equivalent of this is about 7000 kilowatts.

Hungary: Some 4000 apartments and large areas of greenhouses are heated by geothermal wells. The cost is \$3.00 per gigacalorie. Coal heat in the same region is \$11.00 per gigacalorie.

Klamath Falls, Oregon: Some 450 homes are heated by individual wells 200 to 450 feet deep. The costs are competitive with other sources even though the systems are quite inefficient due to the householders desire to independence. The normal well would supply five to ten houses if its entire capacity were used.

Oregon Technical Institute: This institute is entirely heated from its own well drilled to 1715 feet. At 30 cubic meters of water per hour the cost is \$18,000.00 per year, or \$.70 per gigacalorie, corresponding to oil for about \$1.00 per barrel.

Melun, France: There is an apartment complex of 3500 apartments for which all of the utility heat and part of the space heating is provided at costs competitive with \$6.00/barrel oil. The well is 5900 feet deep and supplies 13 to 100 cubic meters per hour of water at 163°F. This is in a region with no geothermal anomaly.

There are many other examples in Japan, Italy and Russia. Depending on the local conditions, the cost of heat runs from a price equal to that which would be obtained if oil were being used, to a factor of ten less, or better.

The Melun experience is of special interest for application in Alaska. A system that is competitive with oil in France should be very attractive in the remoter regions of Alaska where oil costs are very high because of transportation costs. In principle, one should be able to drill almost anywhere in Alaska and reach usable temperatures at depths of 6000 to 7000 feet. While it is in principle feasible to extract that heat even if there is no water present, the techniques for so doing have not yet been developed. Thus one must, at the moment, depend on hitting water at depth. No good data on the prevalence of water at depth are available for Alaska; however, informed geologic guesses would put it above 50%. What little data that are available would also imply that the geothermal temperature gradient in Alaska is a bit above normal, implying that on the average, one would not have to go so deep to obtain usable temperatures.

Thus it appears that over perhaps half or more of the area of Alaska, the question becomes, not whether it is feasible to heat using geothermal waters, but what are the economics involved? In principle, one can drill anywhere and have a roughly 50% chance of obtaining usable hot water. The question of economics will depend upon local conditions.

Obviously appropriate geological studies will improve the likelihood of picking a favorable site. However, the record of geology and geophysics is not good in this field, and one must be careful of being either encouraged or discouraged by judgments from these disciplines. Certainly, where anomalies are being sought, the techniques are more reliable.

The high cost of labor in Alaska would probably run the costs up over those mentioned above, for similar installations. However, one should still be able to produce heat for the equivalent of \$10.00/ barrel of oil or less. This price is much less than the cost of oil in many regions of the state now. The disparity will probably become greater in the future.

While the economic geothermal space heating systems can be of almost any size, there is an effective minimum if one is to not depend on local geothermal anomalies. With present drilling and casing techniques a production hole at 8 1/2" diameter will cost approximately what is given in the following table:^{*}

<u>depth (ft)</u>	<u>cost per foot</u>	<u>cost to depth</u>
2000	\$34.50	\$69,000.00
4000	\$50.00	\$200,000.00
6000	\$61.00	\$366,000.00
8000	\$73.00	\$584,000.00
10000	\$83.00	\$830,000.00

* TWT Method - Geonometrics

These costs will, of course, vary with location and geology. They are estimated assuming reasonable transportation to within 50 miles of the drill site. Thus, if one assumes at 6000' hole, which is reasonable on the average, the hole alone will cost \$366,000.00. If reinjection is necessary, this cost doubles. Obviously, exploratory hole costs are much less. The expected load must therefore be such as to amortize such costs.

To illustrate this point better, let us assume a Melun type system producing 100 cubic meters of water per hour at 80°C (176°F) and assume the dump temperature as 50°C (122°F), thus producing 3 gigacalories of usable heat per hour. We further assume \$2.50/hour running costs (one man). The following table then obtains:

<u>Cost of Installation</u>	<u>cost of money</u>	<u>necessary sale price of heat*</u>	<u>equivalent oil cost</u>
\$2,000,000.	15%	\$12.33/Gcal	\$17.39/bb
\$2,000,000.	6%	\$6.23/Gcal	\$ 8.78/bb
\$ 500,000.	15%	\$3.66/Gcal	\$ 5.16/bb
\$ 500,000.	6%	\$2.13/Gcal	\$ 3.00/bb

* assuming 30 year amortization.

Obviously costs can become even less if the resource is closer to the surface, hence reducing hole costs, or if the water temperature is higher.

The above table illustrates why such installations may be more feasible in Alaska than in the lower 48. There are many places in Alaska where heat, at even the higher prices shown, would be cheaper than the sources now used, with the lower costs much cheaper still.

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 1975. 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

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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.

Phase¹ 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:

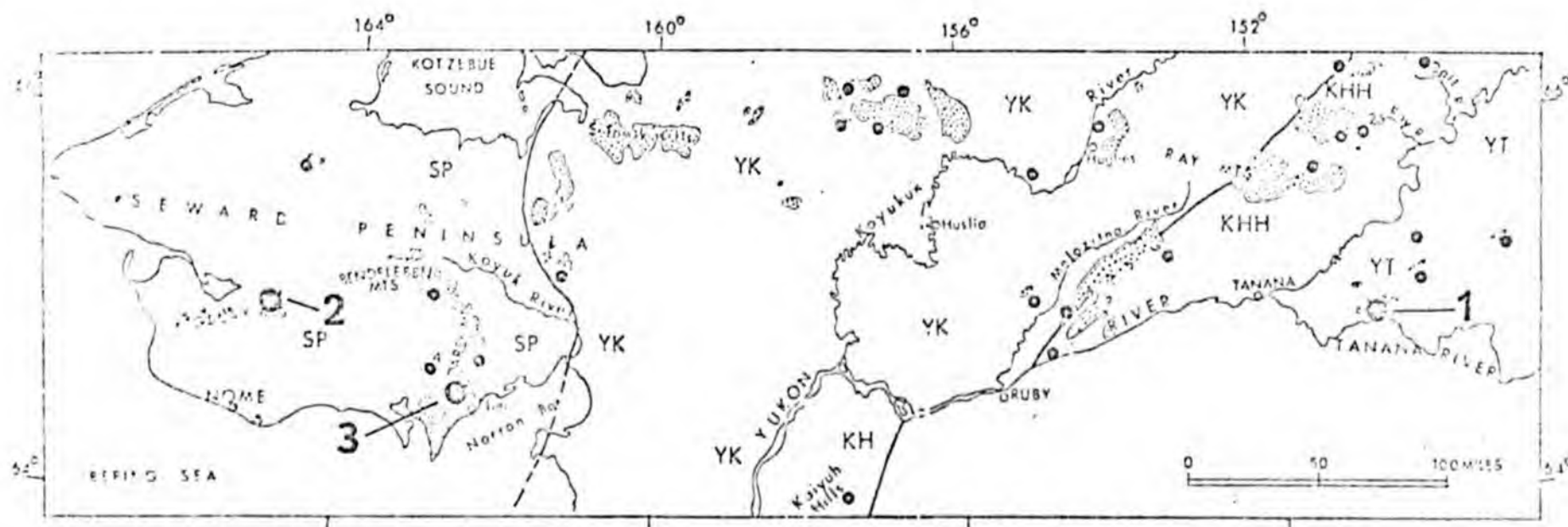
- (1) Manley Hot Springs (90 miles northwest of Fairbanks)
- (2) Pilgrim Springs (40 miles north of Nome)
- (3) Clear Creek Springs (15 miles north of Elim, on the southeastern coast of the Seward Peninsula)

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.



EXPLANATION

- Hot spring
- Granitic pluton
- Contact between geologic provinces



- GEOLOGIC PROVINCE
- SP Seward Peninsula
 - YK Yukon-Koyukuk
 - KH Koyuk Highlands
 - KHH Kokhrines-Hodzana Highlands
 - YT Yukon-Tanana

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.

(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 Hanley 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 Hanley 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 larger-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, CO₂ content (in air), and nutrient supply and chemistry.

Heated Garden Plot Experiments

(D. Dinkel)

There are extensive areas of warm ground adjacent to Banley 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 Banley 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 (1976) 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 alkalis, 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 effect 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 laboratories 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 design 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)

Warm season

- 1) Cucumbers
- 2) Sweetcorn
- 3) Snapbeans
- 4) Tomatoes or Peppers

Cool season

- 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 initiation
 - 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. CO₂ (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)

<u>Component</u>	<u>Pilgrim</u>	<u>Serpentine</u>	
SiO ₂	100.0	100.0	*ppm
Al	0.044	0.033	
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.P. 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 greenhouse) 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-surface 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.

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

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 Miller 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/min 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 defined, 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 conferral 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*
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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.

2. 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 Nukolski) 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 the apparent high bids, not plaintiffs' bids. *Kelly v. Zamarelli*, Sup. Ct. Op. No. 705 (File Nos. 1255, 1256), 486 P.2d 306 (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 be-

coming 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 41.07.010.

(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 (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.

(1) *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 be made more than 25 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) *Right of withdrawal.* In case of an application for a patent or lease covering land 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.

(c) *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 (c) (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.

(g) *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 (d)(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 am II), see 1969 House Journal, p. report on ch. 56, SLA 1970 (CSSB 185 571.

Article 7. Mining Rights.

Section	Section
185. Generally	230. Lien for performance of annual labor
190. Qualifications	235. Lien for annual labor is independent of other liens
195. Mining claims	240. Labor defined by §§ 210—235 of this chapter
200. Changes in locations and amended notices	245. Prospecting sites
205. Mining leasing	250. Tide and submerged lands
210. Annual labor	255. Surface use
215. Notice to co-owners to contribute to cost of annual labor or improvements and forfeiture for failure to contribute	260. [Repealed]
220. Recording the notice to contribute and affidavits	265. Abandonment
225. Lienholder may perform the annual labor	270. Transfers
	275. Recognition of locations
	280. Definitions

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

