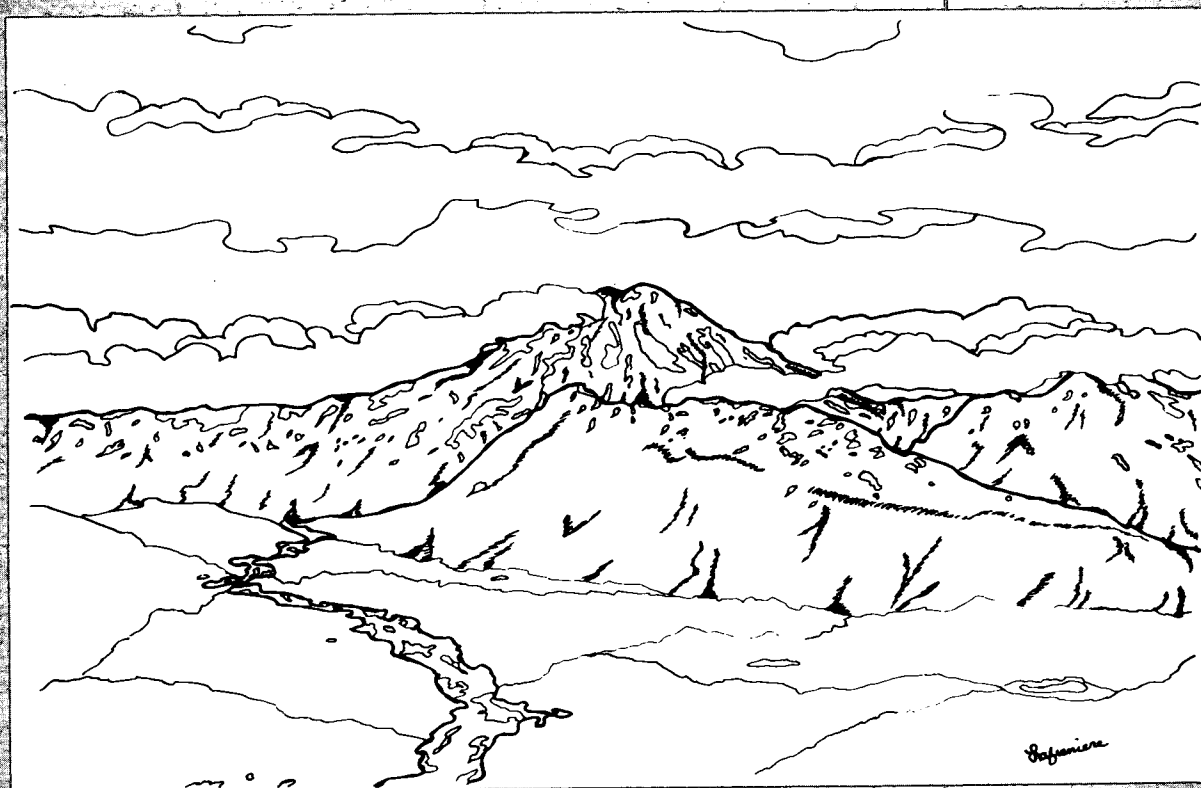


# Geothermal Energy in Alaska: Site Data Base and Development Status

by  
Donald Markle

**MASTER**



OIT Geo-Heat Utilization Center  
Klamath Falls, Oregon

in cooperation with

State of Alaska

Division of Energy and Power Development

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Redoubt volcano in south central Alaska sketched from a photograph  
by R. P. Koeppen.

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GEOTHERMAL ENERGY IN ALASKA:  
SITE DATA BASE AND DEVELOPMENT STATUS

Prepared for

U.S. Department of Energy (USDOE)

San Francisco Operations Office  
Oakland, California

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by

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April, 1979

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## Foreword

Among the most critical of problems facing our nation is energy resources. Though there may be minor disagreement about the specifics, magnitude and solutions to these problems there can be no question about their urgency and of the necessity for immediate action. In an effort to in part resolve these questions by accelerating utilization of one of our renewable resources, the U. S. Department of Energy has developed a program of National and Regional Planning and Operations Research of geothermal energy resources.

The OIT Geo-Heat Utilization Center, under contract to USDOE, has evaluated the geothermal energy resource development potential of the six northwest states of Alaska, Idaho, Montana, Oregon, Washington, and Wyoming. Our goal has been to summarize for this region on a site-specific basis the various factors affecting development including resource data base, geological description, reservoir characteristics, environmental character, lease and development status, institutional factors, economics, population and market, and finally potential for development. This report summarizes the known data base for the state of Alaska.

As so little geothermal resource data is available this then represents a progress report in a young but rapidly developing field of knowledge. The continuation of this project now underway is attempting to complete this core of site information and identify data on new significant sites, provide accurate information and recommendations to policy and decision-makers, and ultimately to assist in evolving more effective regional and national geothermal energy programs.

R. P. Koeppen  
June, 1979

## PREFACE

In November, 1977, a study was initiated by the Oregon Institute of Technology (OIT). The objective of this project was to construct realistic scenarios for the development and commercial use of geothermal resources in the states of Alaska, Idaho, Montana, Oregon, Washington and Wyoming. The OIT study identifies milestones that must be reached to develop geothermal resources for energy planning purposes.

This Alaska Volume, associated with the OIT study, illustrates Alaska's unique aspirations concerning this form of energy. These aspirations have been formed in an environment of institutional infancy, racial melting, cultural change, economic diversity and the frontier spirit.

This Alaska Volume is intended to be a resource manual for future geothermal research and development. After realizing the magnitude of compiling site specific data on all geothermal resources in the state, the decision was made to limit site specific analysis to Alaska's 104 hot springs. It is the opinion of this author that due to technology, social conditions and economic factors, hot springs will be the first geothermal resource developed in Alaska.

This Alaska Volume is intended to be a working paper. Omissions, corrections, and additions should be reported to the Author. Additions to it should investigate not only those easily developed surface manifestations, but also local gradient, hot dry rocks, magma tap and other energy alternatives. Analysis for local gradient applications and drilling operations have been included when interest was shown.

I have called upon, drawn from, cojoled and downright plagiarized an amazing number of people to make this report the best I could produce. Numerous federal, state and private institutions have contributed time and energy to this volume. Private citizens were most helpful when called upon for information. All these people are acknowledged for their participation.

Some people contributed so much that they should be mentioned specifically for their efforts. They are: Dr. Bob Forbes; Dr. Don Turner and Dr. Joyce McBeath of the University of Alaska; Patty Kirkwood and Bill Ogle of Energy Systems, Inc.; Paul Lienau, John Lund, Gene Culver and Chuck Higbee of Oregon Institute of Technology; John Hale, Kyle Weaver and Greg Edblom of the Alaska Division of Energy and Power Development. Each was invaluable in their respective way.

I would like to especially thank Clarissa Quinlan, Director of DEPD, for her guidance and encouragement throughout the project. Also Nancy Knowlton, Gloria McCubben and Peggy Skeers, the secretarial staff at DEPD, for their infinite patience.

Finally, I want to thank my OIT counterparts: Dave McClain, Gordon Bloomquist, Debra Justus, Keith Brown, and Rick James for making many of the mistakes first; and my supervisors, Dr. Don Karr and Robert Koeppen, and special thanks to Colleen Fry for editorial assistance and typing.

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## INTRODUCTION

The extent of Alaska's geothermal resources is enormous. Eighty-eight active and dormant volcanoes are located in Alaska. More than 140 volcanic expressions and millions of acres of recent volcanics are indicative of the State's tremendous geothermal potential, perhaps the largest in the Nation.

One hundred and four separate geothermal spring locations are mentioned in the literature concerning Alaska as well. In the near term, development should occur at these sites. A mission of this study is to document development, the socio-economic and physical data concerning geothermal energy. Data of this nature concerning these springs are presented by regions.

The six regions presented are those of the present Alaska State Planning Activities and those of the Federal State Land Use Commission. The regions were chosen because of socio-economic factors and physical similarities as reflected in this document.

Geographical distribution indicates that Alaska's geothermal springs occur in three different tectonic settings. One association finds hot springs adjacent to Quaternary volcanoes such as the Aleutian Island Arc, the Alaska Peninsula and the Wrangell Mountains. The second geological association finds spring locations near the contact between late Cretaceous or Tertiary granitic plutons and surrounding country rock. Waring suggests that this is due to deep circulating meteoric waters using boundary faulting and fracturing near plutons as a mechanism for a hot water circulation system. Numerous springs of this genesis occur in a broad east-west trending zone in North Central Alaska. Southeast Alaska is the setting for a third zone which appears to be involved in some relationship with transform faulting associated with the submergence of the East Pacific Rise under the North American Continent.

These three settings for the resource, encompass much of the State which present a considerable study area. The incredible physical size of Alaska is almost incomprehensible. Alaska's 586,000 square miles of land is twice the size of Texas and equal to one-fifth of the total area of the United States. There is more coastline here than all the rest of the country combined. The furthest North, East and West points of the nation are here. This vast area can be visualized by transposing a scaled Alaska map over the rest of the United States. If done, Ketchikan in Southeast Alaska would be where Charleston South Carolina is; Barrow, Alaska's northernmost point, would be near Minneapolis Minnesota; while Attu, at the end of the Aleutians would be near Santa Clara California. Alaska's geothermal resources are proportionately as large and located across the great majority of the State.

This vast wilderness is peopled by only 415,000 citizens of which over half live in the vicinity of Anchorage, Alaska's largest city. The incredible size and scant population of the State help foster the extreme social and economic diversity, isolation, and cultural change now found in Alaska. The diversity was exemplified in a recent primary

and state election. The Republican Party Primary was dominated by gubernatorial candidates with significantly different development policies and was decided by a mere 98 votes in over 60,000 counted. Two court battles ensued and months of controversy were associated with this election and this major policy. Diversity is seen between rural and urban interests; between subsistence and cash economies; in the distribution of wealth; and between environmental and developmental philosophies. Trying to appease these conflicting attitudes is a paramount issue in determining the feasibility of any of the geothermal sites that will be presented in this paper.

Isolation has always been part of Alaska. The first overland connection with the Lower 48 was the building of the Alaska Highway during World War II. The vast majority of Alaska is still without road service. High cost air and water transportation coupled with extreme weather conditions continue to make isolation a predominant lifestyle in rural Alaska. Most of Alaska's geothermal resources are located in very remote areas away from population centers, so isolation will be a factor in geothermal development and is documented.

Overcoming the isolation resulting from the vast size and small population of Alaska and providing services that people in most parts of our country take for granted is costly both economically and culturally. Development of geothermal will be as well water, sewer, electricity, doctors, dentists, schools and even basic food commodities are still closer to rare than universal in the bush. The premise being followed today is that these benefits outweigh losses concerning the cultural issue. This report and its updates will focus on cultural heritage as one of the prime considerations in developments in bush Alaska for the near future.

To date, there has been very little development associated with Alaska's geothermal resources despite their potential. This potential is limited by lack of investment capital, lack of demand and lack of knowledge about the resource. Data in this report have been gathered to show historical perspective, legal, institutional, social, economic, and physical factors concerned with geothermal development. Site specific data is documented to integrate possible geothermal development with existing land use, needs and aspirations. cursory site specific data is also gathered because resource used on that basis.

The development of remote geothermal springs in Alaska is dependent upon presenting the facts and opportunities to prospective entrepreneurs. This book is the result of that mission.





Figure 1  
 Circle Hot Springs During the 1940's  
 (Charles Bunnell Collection - University of Alaska)



Figure 2  
 Chena Hot Springs  
 (Ruth Tondoff Collection - University of Alaska)

## HISTORY OF GEOTHERMAL ENERGY IN ALASKA

Indians and Eskimos throughout Alaska constitute the first cycle utilizing geothermal resources. From the Seward Peninsula to the isles of Southeastern Alaska, the Natives were aware of the natural geothermal springs. Kruzgamepa Hot Springs, 50 miles north of Nome, now known as Pilgrim, was utilized for bathing years before the white man arrived. People visiting Chief Shakes Hot Springs, near Wrangell in Southeastern Alaska, still use the wooden cribs placed there by the Tlingit Indians prior to the Russian arrival in Alaska. Some springs held mystical powers, such as Kilo Hot Springs in north central Alaska. The entire Ray Mountains were considered tabu by local Indians; perhaps not because of the stinking seepage from the bowels of the earth, but what better birth to a legend. Although the Indians' early use was in-situ and sporadic, it was nevertheless a precedent that still holds for the vast majority of hot springs in Alaska.

When the Russians began colonizing the Great Land, they followed the Indians example of leaving most springs as they found them. This due to the fact that most of the Russian colonies were not located near geothermal resources, a second precedent that still holds for the vast majority of hamlets and springs. Perhaps another reason for this was the Russians who did use them were the nomadic fur traders of transient flavor and not likely to tarry long in their pursuit of bounty.

After the American purchase, things remained stable for awhile. Gradually the enterprising Americans pried into Alaska's rich treasure trove, in search of rumored El Dorados. As the Fraser River Gold Field in Canada played out, word came of riches in the North; men named Harris and Juneau hit pay dirt in Southeastern Alaska during the 1880's. Then in 1896 Bob Henderson and two partners unearthed the tip of the iceberg known as the Klondike. The impact of the richest placer gold concentration ever found started the second cycle of geothermal development in Alaska.

Alas, all who came to the gold fields did not strike it rich. For every one who made it to Bonanza Creek, ten came late. For every miner, it seemed at least one nefarious character of low esteem came to relieve him of his poke. The scene of much of the debauching associated with gold stampedes took place at the local roadhouses and/or brothels. Enterprising young entrepreneurs who came too late for the mining and had more moral stock than a common thief, but not a lot more, struck it rich by developing the recreational "resource". In areas where there were hot springs, it was a natural location for a roadhouse. If a miner were to follow the mining cycle from the gold fields in the Klondike to Eagle to Nome and Fairbanks, he would have been able to soothe his work-worn bones at Canadian, Circle, Pilgrim, Serpentine and Chena Hot Springs.

In Alaskan History Felix Pedro is noted as the discoverer of the Placer Gold Field at Fairbanks. In 1905, gold prospector Felix Pedro first utilized the Chena Hot Springs for recreational purposes. George Wilson homesteaded the land and commercialized it as a health spa. By 1915, a log bath house was built containing a dressing room, a sweat room, and a bathroom with five wooden clean water tubs and a mud bath tub.



Figure 3  
Geothermal Application Manley Hot Springs Early 1900's  
(Alaska Historical Library)



Figure 4  
Manley Hot Springs in the Height of Development  
(Alaska Historical Library)



The resort complex at Circle was homesteaded by Frank Leach in 1918, but apparently the Springs were used long before that. The installation now consists of a 22-room hotel and 13 cabins, various out-buildings and a large swimming pool, all heated from the springs.

Pilgrim Hot Springs was developed about 1905 on the Seward Peninsula. The resort was frequently visited by parties from Nome and other mining centers in the area. Unfortunately, the roadhouse and saloon burned in 1908 and the resort went into neglect.

At Serpentine Springs to the north of Pilgrim, some remnants of the roadhouse still remain. Nominated for inclusion in the National Historic Register, it was another example of geothermal space heating that Alaskan gold miners developed before the oil age.

In 1900, John Karshner discovered Manley Hot Springs. With the discovery of gold in the Eureka and Tofty areas, Karshner staked his homestead and it quickly became a trading center. Karshner made an agreement with Frank Manley, a man with a past in Texas, and soon a 60-room, 3-story geothermally heated hotel with bar and bath were built. Eventually, swimming pools, stables, chicken coops, hog sty and vegetable gardens all benefited from the utilization of geothermal energy. During the boom years before WWI, numerous small businesses flourished including two newspapers. In the tradition of most early boom developments in Alaska however, a marked decline in the Manley area became apparent after the war. The Hotel burned down and most of the people moved out by the late 1920's.

The hot springs in southeastern Alaska had their own cycle, somewhat along the same boom/bust philosophy, but gold was not necessarily the prime mover of men and materials.

Tradition has it that Tlingit Indians first used Baranof Hot Springs, near Sitka for bathing. History has it that white men appeared at the turn of the century with the establishment of the town of Baranof as a fishing and timbering community. In the late teen and early 20's, a pipeline was laid from the springs to a bath house for use by itinerent fishermen and others. This was done under the auspices of the territory. At the same time, a house of ill repute was established at another of the springs and apparently used the hot water for both bathing and heating purposes. It became common practice for the proprietor of the bordello to levy a toll for those wishing to use the bath or go fishing in the lakes above the springs. The Territory eventually moved the bath house down to sea level by piping the water through a 4" pipe in the 1930's. When the timber and fishing industries moved to more promising areas, the local flavor did as well, leaving behind a sleepy town of reclusive elegance.

Remarkably, many of these boom resorts have hung on and still exist marginally today. Some have benefited from "civilization" arriving. This civilization could be considered the third cycle of geothermal development.

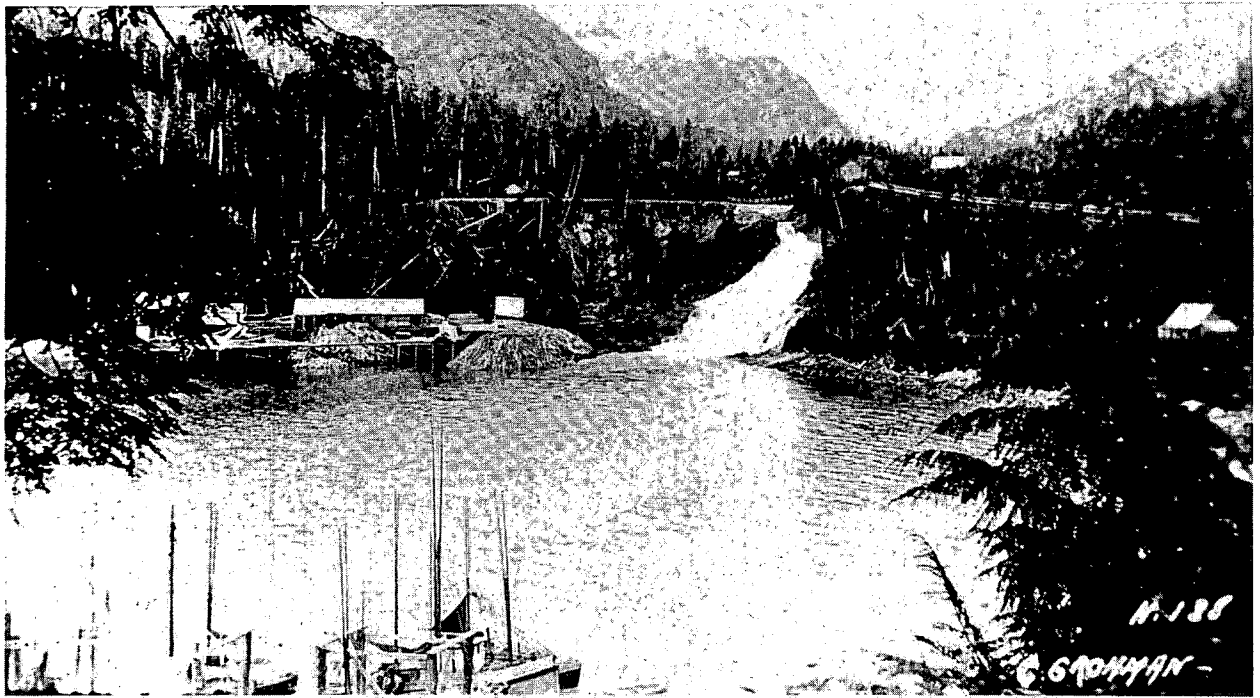


Figure 5  
Baranof Alaska - Early 1900's  
(Alaska Historical Library)



Figure 6  
Sitka Springs Resort - Early 1900's  
(Alaska Historical Library)

Located on Baranof Island in Southeastern, is Sitka or Goddard Hot Springs, whichever you might prefer. It is just 2-1/2 hours by boat south of the old Russian capitol of Sitka. Sitka Springs was, in 1908, a site of fishing shacks of the Sitka Indians. Behind the shacks, water from two of the springs was piped to a two story building containing three bathrooms. The area was called Sanatarium, Alaska. According to reports the Russians had a hospital there at least as early as 1841 where they sent patients suffering with diseases of the skin and constitutional blood disorders. Dr. F. L. Goddard ran the sanatorium during 1908 and the years thereafter. Dr. Goddard is quoted as saying, "As a resort there is no more favored spot on the North Pacific coast". Advertisements about the healing qualities of the springs appeared in many Northwest newspapers and travel manazines. Transportation to the springs from Juneau aboard the Juneau Steamship Company's "Georgian" once a week was but \$12.50. This same steamer took in Tenakee and Baranof Hot Springs because of their medicinal properties. After Goddard left, the springs became a recreational spot for Sitka residents. There are now plans in the offing to build a modern bathing facility by the City of Sitka.

The Pilgrim Hot Springs area on the Seward Peninsula was "civilized" by the Catholic church. After the roadhouse burned in 1908, the property was donated to the Catholic church. The spring area, the Catholic church, and most particularly Sr. Frederick A. Ruppert SJ., became the custodians of some 120 orphans. These orphans came to the church due to a local outbreak of the Spanish influenza epidemic that took over 20,000,000 lives worldwide during WWI. From 1919 to 1942, geothermal energy was used to raise large gardens and provide heating in the buildings. Excess vegetables were brought to Nome and sold in the stores. A dog-propelled rail system was developed to transport materials between the Taylor Road and the Springs - a rather unique technological spin-off of the Pilgrim experiment.

Pilgrim and almost all other Alaskan geothermal developments were consumed in the energies of civilized man's insanity known as world war, technological advances and the widespread discovery and use of oil spread with our martial pursuits and the golden age of geothermal energy ended in Alaska.

Things remained rather quiet on Alaska's geothermal frontier during the cheap oil years of the 1950's and early 60's. Then, certain events revived the resource. On March 13, 1968, oil was discovered at Prudhoe Bay and in the late summer of 1973, there was the Arab oil embargo. The oil discovery and its boom brought people, money and enterprising spirit. The embargo brought favorable economics and sudden realization that the oil age was terminal. Government monies for research and development soon followed. These events, coupled with the mystique of the Last Frontier in this age of drift, has begun a new cycle of development.

At Ophir Hot Springs, near Bethel, owner Mr. Faulkner has installed a 4" line to run the 150 feet between his home and the hot springs. He only uses 1/3 of the springs flow for space heating and the overflow is diverted into a nearby creek. The warm water keeps the creek open in



Arctic Circle Hot Springs resort, a leap or two from the Arctic, is a shocking place for the uninitiated. Hot springs and pool, a magnificent vegetable garden, and a lodge containing all the niceties...all this at a point that is almost at the end of the road, the northernmost point to which one can drive on the North American continent.

Figure 7

Circle Hot Springs in the 1960's  
(Tourism Collection - Alaska Historical Library)

the winter and Mr. Faulkner takes advantage of this by using a low head hydro facility for electrical production. Mr. Faulkner is one of the new renaissance men appearing in Alaska's bush.

On another order of magnitude, the government has become the prime mover of geothermal development in Alaska - something quite unique in American history. In the early 1970's, Tom Miller of the United States Geological Survey did the first specific scientific research concerning geothermal energy in Alaska since Gerald Waring's 1917 water supply survey. At present, the U.S.G.S. geothermal program is continuing under limited budget restraints to assess Alaska's geothermal potential.

The University of Alaska Geophysical Institute has and is conducting research concerning geothermal energy. Dr. Bob Forbes of the Institute, one of the fathers of modern geothermal development in Alaska, is continuing under a mission team study with principle investigator Dr. Don Turner to assess the low temperature geothermal energy resources of Alaska for the Federal Dept. of Energy. Lee Leonard, another member of the Institute, is presently working to establish a geothermal research station at Manley Hot Springs, which will include a low temperature electrical application. The Institute is conducting numerous other scientific investigations that will effect the eventual development of geothermal energy in Alaska, including resource evaluation of the state demonstration project at Pilgrim, Alaska.

Principle investigator, Ms. Pat Kirkwood, et. al, then of the Sierra Pacific Research Corp., recently completed an economic analysis of local gradient utilization for the Dept. of Energy, another illustration of the involvement of the Dept. of Energy in stimulating the development of geothermal. Local consultant, Bill Ogle of Energy Systems, a real heavy weight in Alaska's geothermal world, talks another order of magnitude of development in the future. In an energy starved world, perhaps Alaska's volcanic Aleutian Chain will produce multi-megawatt power for industrial applications. Dr. Ogle and Ms. Kirkwood are funded by D.O.E. to promote geothermal in Alaska.

Dr. Carl Halsey of the U.S. Navy is presently conducting drilling operations at Adak Naval Air Station to determine the potential for geothermal energy there. The installation there and the possible electrical applications being considered make this Alaska's major geothermal project to date.

The State Government has recently become involved in the development of geothermal energy. This can be considered an amazing bit of insight considering the vast fossil fuel reserves in Alaska. The State Division of Energy and Power Development (DEPD) has been working in conjunction with the Dept. of Fish and Game to utilize the geothermal resources on Bell Island for salmon hatcheries. Clarissa Quinlan, Director of D.E.P.D., has also been working directly with this author on the Northwest Regional Planning Support for Development of Geothermal Energy in conjunction with the Oregon Institute of Technology (Dept. of Energy contractor for the project). This planning effort is to determine the economic potential of each of Alaska's geothermal sites.

In a state where geothermal energy is but a stepchild to the largest oil and coal resources in North America, the state legislature last year considered nearly \$1,000,000 worth of appropriations for development of its geothermal energy resources. The bills included roads, drilling and an agricultural experiment station at the Pilgrim Hot Springs and on the Seward Peninsula.

\$245,000 was appropriated by the Legislature for a geothermal demonstration at Pilgrim.

Various private entrepreneurs have plans for everything from hydroponic gardening to ski resorts, utilizing the natural heat from the earth. These independent pioneers will eventually bring geothermal energy utilization back to the Last Frontier. It will be a long bumpy road due to the remoteness of most of our resources, but in many of our remote villages the impetus is already there as they continue to pay the highest per capita energy costs in the country. Large new developments will have to have some commercial utilization in order to overcome the extreme Alaskan capital costs and will have to compete with the populous states in the Lower 48 to get money to develop her resources. It will be a real challenge to not think too big for near term development considering these restraints. However, we Alaskans are just beginning a new cycle in developing geothermal energy, and those of us involved can feel a tremendous momentum building. In a rich land like Alaska where the only limit to its potential is imagination, the real challenge to the long range geothermal development is that we don't think too small.

## HISTORY OF ALASKA LAND

Portions Extracted From Lands for Alaskan Bulletin  
Alaska Department of Natural Resources

### AFTER THE PURCHASE

Getting land for individual Alaskans has been a problem ever since the territory came under American control. Just six days after the Alaska acquisition was officially consummated in 1867, the Secretary of the Interior announced that any attempt to claim land in the 367 million acre territory under U.S. land laws would be considered illegal and that military force might be used "to remove the intruders."

For the next seventeen years there was no form of government in Alaska whatsoever, and it was impossible to claim land for any purposes. Then the Organic Act of 1884 extended the United States mining laws to Alaska, but specifically provided that other land laws of the U.S. should not apply to the District of Alaska.

### AGRICULTURAL SETTLEMENT

In 1890, agricultural settlement was made possible by a special act of Congress which extended a limited form of homestead act to Alaska. This act required homesteaders to pay for surveying, but since no survey baselines existed, and no other provision was made for surveys, no settler was able to acquire title under the act. A few years later another homestead law was passed, comparable in requirements to the national Homestead Act. It increased Alaska homesteads to the standard 160 acres. This act failed to take the Alaska climate and physical conditions into account and resulted in the transfer of relatively little land.

More land was transferred to Alaskans by the Trade and Manufacturing Sites Act passed in 1891. This allowed citizens or corporations to obtain land for business enterprises. It contained many protections against abuses, and allowed a maximum of 80 acres to be claimed.

For many years these two laws plus the mining and mineral laws were the only mechanisms for gaining title to public land in Alaska. Later, at wide intervals, other acts were passed making small tracts of land available for recreational and residential uses, for the leasing of grazing lands, and for the sale of timber and other materials from public lands.

On its last day, March 3, 1915, the Sixty-third Congress passed an act establishing a land grant college in Alaska (The University of Alaska) and reserving two sections out of every township for the support of the territory's schools. These sections were to become available "When the public lands of the Territory of Alaska are surveyed..." but, typically, these surveys remained undone for years.

## FEDERAL WITHDRAWALS

A long series of federal reservations and withdrawals began to take place around this time, with 11 million acres for the Chugach National Forest (now reduced to 4.8 million acres) and 16 million acres for the Tongass National Forest, reserved by President T. R. Roosevelt. By 1952, military withdrawals alone totaled 52 million acres (now reduced to 2.5 million). For the most part none of these reserved lands were open to private entry or settlement. By an executive order in 1906, coal lands were also withdrawn from private location and entry, and no private development was permitted until a special Alaska Coal Leasing Act was passed in 1914.

The Matanuska Colony, an effort by the federal government to relocate depression-stricken farmers to the fertile valley north of Anchorage, gave Alaska nationwide publicity as an agricultural settlement frontier for several years, beginning in 1935. Although the program was of limited scope, it encouraged development of the Matanuska Valley and developed farms for needed food production during World War II.

Japanese occupation of Attu and Kiska in the Aleutians brought worldwide attention to Alaska in 1942. The American defense of Alaska brought thousands of men and the construction of large defense facilities, many of which are still in use. The war also necessitated the construction of the Al-Can Highway, the first road link from the 48 states to Alaska.

Settlement patterns during and since World War II have been in large part urban. The growth of Anchorage and Fairbanks has occurred largely since the mid-1940's.

## STATEHOOD

The effect of federal policies and actions is most clearly demonstrated by the pattern of land ownership that existed when the Statehood Act was passed in 1958. In that year, 99.8 percent of the land was still owned by the federal government. Only a little over a half million acres had passed into private ownership. Lands withdrawn by various federal agencies for permanent public ownership covered 92 million acres, more than a quarter of the state, while the rest was under the jurisdiction of the Bureau of Land Management. This meant that nearly half of all the land owned by the U.S. Government was in Alaska. In 1966, the state contained 11 percent of all national forest reserves, 31 percent of all national park lands, 64 percent of all unappropriated public lands, 70 percent of all lands managed by the Fish and Wildlife Service, and over 85 percent of all lands under the jurisdiction of the Bureau of Indian Affairs.

## EFFECT OF PRE-STATEHOOD POLICIES

The Statehood Act, passed in 1958, marked the beginning of a dramatic shift in these land ownership patterns. First, it entitled the state to select a total of 103.35 of the 367 million acres of land in Alaska. These selections were to be of two kinds. The first, general land grants, entitled the state to select up to 102.55 million acres of



unreserved federal land by January, 1984. The second, community land grants, allowed the state to select 400,000 acres from the national forests and another 400,000 from the public domain lands to meet community needs. Following statehood, Alaskans were faced with decisions of where and when to make these selections.

In passing the Statehood Act, Congress cited economic independence and the need to open Alaska to economic development as the primary purposes for large Alaska land grants. The Alaska Constitution, speaks of both conservation and development as key factors in managing and disposing of land, with the dominant theme being development.

### EARLY LAND SELECTIONS

The state's initial land selections were small and carefully calculated, largely due to the young state's precarious financial position. Land selection was expensive. The federal government charging 2 cents an acre for fire protection of state lands and each selected acre reducing the state share of federal highway funds. This was costing the state \$15,000 a year for each 23,040 acre township selected, at a time when the total state budget was less than \$100 million. The state simply could not afford to select the whole 103.35 million acres.

By 1968, the state had selected about 26 million acres of its statehood entitlement. Most of these lands were chosen for their immediate potential to bolster the Alaska economy and their proximity to existing transportation routes: the Prudhoe Bay selection was the most successful of these choices. Another early selection, made for a different reason, was 1.5 million acres in the Wood River-Tikchik Lake system. This area was under consideration as a national park, and the state selected it both for public recreational use and to prevent a single-purpose federal designation. It is now a state park.

### THE QUESTION OF NATIVE CLAIMS

Late in the 1960's, the long simmering question of Native land claims started a process which was to dramatically affect the patterns of land ownership in Alaska. The Organic Act of 1884 recognized the Native's right of occupation. The Act said "that the Indians or other persons... shall not be disturbed in the possession of any lands actually in their use or occupation or now claimed by them," but reserved the method for Native's gaining title to this land for "future legislation by Congress."

Native leaders, first prompted by the state selections of Native hunting grounds near Minto in the mid-1960's, asserted Native claims to large areas of the state. Acting to protect Native land rights, Secretary of the Interior Stuart Udall froze "final action" on federal land transactions (including state selections) in 1966. In 1968, oil was discovered on the North Slope and the need for an oil pipeline right-of-way provided impetus for the settlement of Native claims.

The issue of the Native claims in Alaska was cleared with the passage of the Alaska Native Claims Settlement Act (ANCSA) on December 18, 1971.

This Act, the result of a tremendous struggle by Natives and their supporters, created Alaska Native village and regional corporations and gave them nearly one billion dollars and the right to select 44 million acres of land.

The Alaska Native Allotment Act of 1906 allowed individual Natives to claim and receive restricted title of up to 160 acres of land which they had used and occupied for residential or subsistence purposes. Before the mid-1960's, this law was little used, but with the rise in interest in land ownership associated with the Native Claims movement, several thousand claims have since been filed. Legal problems have slowed processing, and only a small percentage of the allotment applications have been granted. The Settlement Act repealed the Allotment Act, except for pending applications.

#### FEDERAL PUBLIC INTEREST LANDS - (d)(2)

Section 17(d)(2) of the Settlement Act allowed the Secretary of the Interior to withdraw up to 80 million acres for further study leading to classification as national parks, wildlife refuges, forests, and wild and scenic rivers. The act also directed the withdrawal of substantial areas (ultimately totalling some 116 million acres) to form a pool from which the natives were to choose their lands.

A month after the passage of the Settlement Act, the state filed selections of some 77 million acres of land before the creation of the Native and federal pools. The Department of the Interior refused to allow these selections, and, in September, 1972, the litigation initiated by the state was resolved by a settlement affirming state selection of 41 million acres.

The state's next selection in 1973-4 was 2.5 million acres, primarily selected for mineral potential. After the expiration of some Native selection rights in late 1976, the state selected 3.6 million acres, following an extensive evaluation and public review process. (See fig. 8)

The completion of state land selection is now blocked until Congress acts to resolve the (d)(2) issue; to decide which of the withdrawn lands will be put into federal management systems.

In order to protect the state interests, in May, 1978, after widespread public review, Alaska identified 41 million acres of "state interest areas," and requested that they be conveyed to the state by Congress as part of the final (d)(2) legislation.

#### CONCLUSION

The effect of all of this activity is that while there is a huge amount of land in Alaska, some of the land best suited for private use and residences will not come into the hands of the state government for disposal. Homesteaders, through the years, took some of the best home-site land. Then the University and schools were granted 100,000 acres each, followed by the million acre mental health land grant. Following statehood, the state selected only a limited amount of land. In 1964,

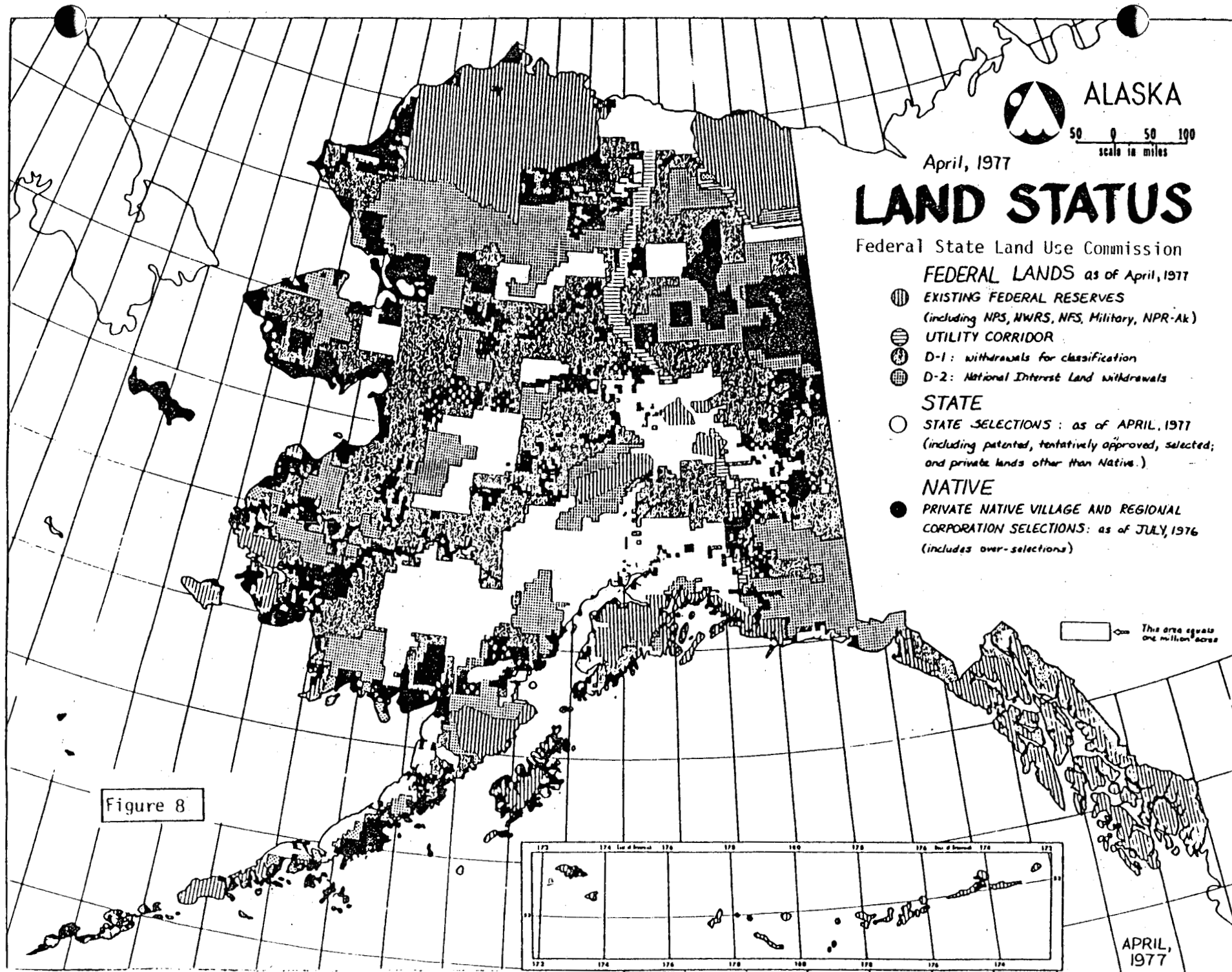




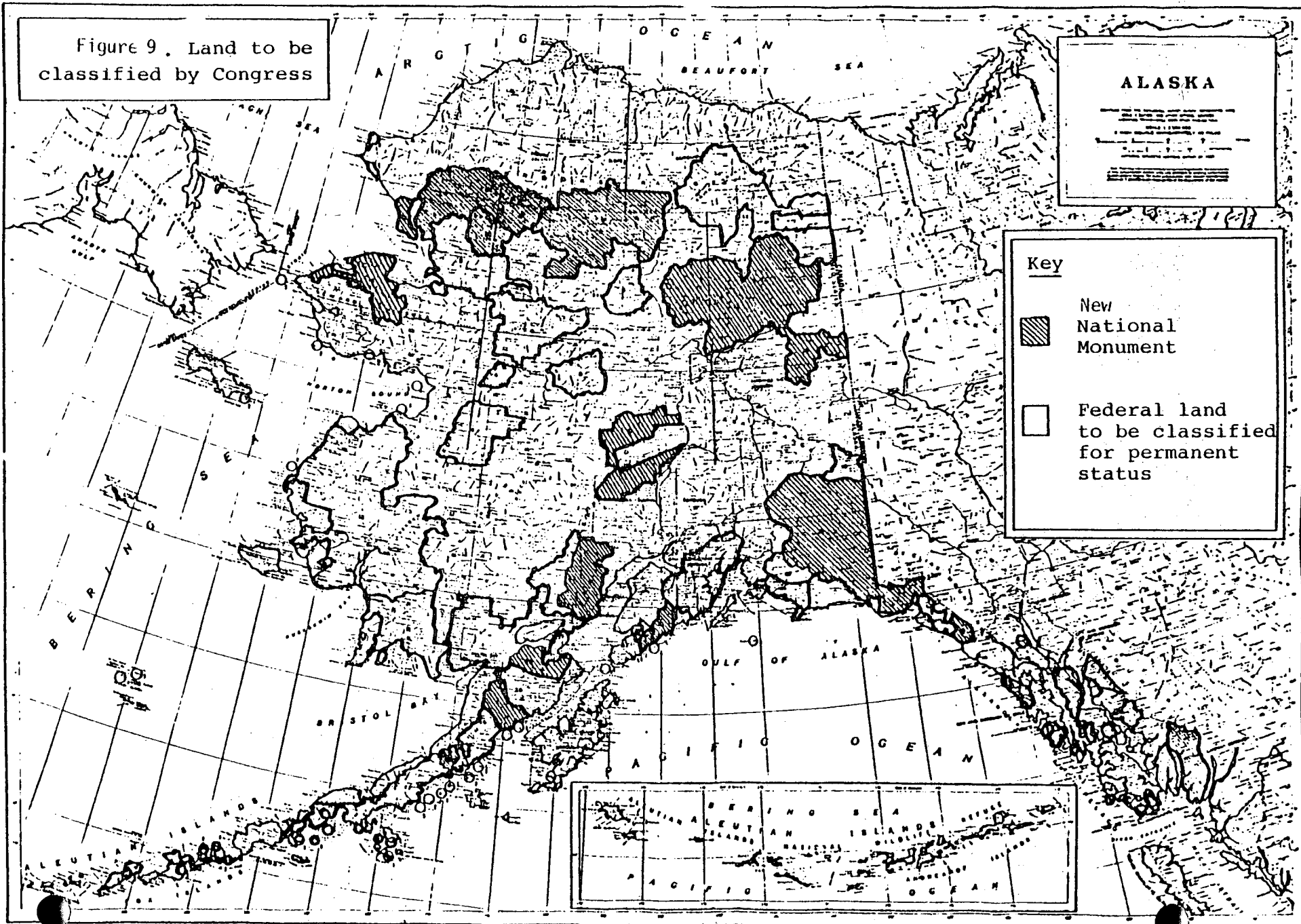
Figure 9. Land to be  
classified by Congress

# ALASKA

## Key

 New  
National  
Monument

 Federal land  
to be classified  
for permanent  
status



state legislation allowed the boroughs to select 10% of the state land within their boundaries. Native village corporations were entitled to select state land in order to complete the total of 44 million acres allowed the Native corporations. The federal government further reduced the state selection pool by (d)(2) and other withdrawals.

Thus, although the state owns much land which will meet many individual needs, the opportunity for state land to move into private ownership is limited by the fact that the state does not and will never own many prime areas in Alaska.

#### STATUS OF LAND IN ALASKA

The status of land, especially Alaskan lands, is constantly changing. In most states, the free market has affected the pattern of land ownership; but in Alaska, land ownership patterns were the result of a century-long process of a single land owner, the United States Government, divesting itself of some of its land. (See figure 9 and 10.)

When the provisions of the Alaska Statehood and the Alaska Native Claims Settlement Acts are fulfilled, the land in Alaska will be roughly divided 60% federal, 28% state, and 12% native entities. Land in private (non-native) ownership can be expected to increase as State and Native corporation holdings enter the open market. (Lands for Alaskans)

#### FEDERAL GOVERNMENT LANDS






Of the 220 million acres which the federal government is likely to retain in Alaska, about 72 million acres were already been designated as National Forests, National Parks, Wildlife Refuges, and Petroleum Reserves, prior to the December 1, 1978, designation of 56 million acres as New National Monuments. These previous designations include the Tongass and Chugach National Forests (21 million acres); Mt. McKinley National Park, and Katmai and Glacier Bay National Monuments (7.6 million acres); wildlife refuges (20 million acres); and the National Petroleum Reserve-Alaska formerly Naval Petroleum Reserve No. 4 on the North Slope (23 million acres) (McConkey, 1977).

With the exception of the relatively small amount of land controlled by other federal agencies (such as the Department of Defense which now controls 2.5 million acres), most of the remaining federal land serves as a pool from which future State and present Native selections, and federal reservations, will and have been made. (McConkey, 1977)

#### STATE LANDS

Territorial trust grants plus the generous statehood grants ensure the State of Alaska title to 104.55 million acres: an area larger than the State of California. Although the State has selected over 72 million acres of its statehood entitlement, only 21 million acres have been patented (final title) by the Federal government. These patented lands, plus the 15 million acres which have been tentatively approved for patent, comprise the 36 million acres which the state now manages. These lands may now be offered under numerous disposal programs. (Lands for Alaskans)

Figure 10 Composite map of  
geothermal resources and  
lands awaiting Congressional  
action.

- Proposed action lands 
- Wild and scenic rivers 
- Geothermal areas 
- Hot springs 
- Volcanoes 



Alaska was also entitled to University and Mental Health land grants up to 400 thousand acres at the time of statehood as well as another 400 thousand acres from the U.S. National Forest for community development and recreation. (Lands for Alaskans) Alaska also gained title to substantial submerged offshore lands to the limits of the territorial sea and submerged lands along navigable inland lakes and rivers. These lands, however, are subject to adjudication. (DEPD Personal Communications)

At one time the lands bordering navigable waters were seemingly insignificant. However, the Statehood Act specified that the State of Alaska shall receive title to all navigable rivers. At the time of this statement there were only a few rivers designated in court cases as having been accepted as historical commercial usage streams. According to recent court cases in other states, however, the term "navigable rivers" is being defined to be any stream on which commerce took place. Current studies of historical records and reports show that most of the streams in the State of Alaska have been used for fur trapping or gold prospecting. This may be defined as commerce, thus raising serious semantic difficulties as to the navigability of most of the streams that are in Alaska. (State Department of Natural Resource Communications)

As it presently stands, this matter must be resolved before total Native land entitlements can be conveyed. If the State has already gained title under the navigatable river provisions, the Natives will have to obtain alternate selections if they selected stream bottoms. This will also effect the timing of the statehood selections in that they will not be resolved until the Native land claims have been transferred to the Natives. Since the Natives have priority to land selections according to the Statehood and the Native Claims Settlement Acts, a real Catch 22 may be developing and may require court action.

Another twist in the land controversy is that the BLM has transferred title to the State in areas that include navigable waters. These areas were charged against the State's 100 plus million acre entitlement. This may have been done in error since the beds in navigable rivers were specifically granted to the State outright at the moment of statehood.

The State has a land transfer program available for municipal governments. Until these State selections and problems are settled, the question of State land available within the municipal boundaries for their use remains open. Most of the land that will go to the municipalities is very well suited for private use, and it is expected that it will be made available by the boroughs for intensive settlement and development. It is obvious that legal questions such as this have far reaching effects when the amount of land acreage in question is so large.

#### TRUST LANDS

Until June, 1978, more than one million acres of state land was specially designated as "trust lands," held to support the State mental health program, the public schools, and the University of Alaska. The management of these lands was restricted by law.

This year the Legislature created trust funds to replace the mental health and school trust lands. This will allow these lands to be selected by municipalities or disposed of by the State. The act will also require a significant portion of the former mental health land close to population centers be designated for private uses.

### NATIVE CORPORATIONS

By the terms of the Alaska Native Claims Settlement Act, Native corporations at both the regional and village level received the right to select and obtain title to 44 million acres of federal land in Alaska in settlement of their aboriginal claims. The land selected, as defined by the Act, is mainly in the vicinity of Native villages, which are largely located along major rivers or on the coast.

The Act granted a cash settlement of 962 million dollars as well as the selection of nearly 44 million of the acres of federal lands in Alaska. 13 Regional Corporations and 212 Village Corporations were set up to make land selections. 12 of the Alaska Regional Corporations were to receive the subsurface estate of their associated village corporation lands as well as surface and subsurface estates to their own selections. This will effect geothermal potential in that if under a village selection geothermal potential exists and BLM transfers the surface rights to that village, the actual subsurface manifestations will be under the control of the regional corporations. (ANCSA)

Because of initial uncertainty about exact entitlements, many Native corporations "over-selected," or exercised their option on more land than will be finally allowed. The reasoning behind this overselection was the Natives would not be able to obtain title to existing patented mining claims, and the BLM is uncertain as to how much of this kind of land is within the Native selected lands. (Jess Johnson Personal Communications) Over 80 million acres have been selected, of which a total of 44 million will be conveyed. (McConkey, 1977) This substantial overselection has further added to the uncertainty of land status within the State. The Federal government has granted patent (final title) for only 7 million acres to date, December 1, 1978. (BLM Communications)

When the Native corporations finally receive title, the supply of private land in Alaska will increase substantially. Some Native land is now being leased for development and may be sold for residential use.

### STATE SELECTIONS

In order to receive the remainder of its Statehood land, the land has to be transferred by 1984. (Statehood Act) The State is seeking to speed the conveyance process through Congressional action as part of the (d)(2) legislative process. The language to accomplish this has been drafted by the State for Congress and if adopted will increase the amount of land under state management almost threefold. (Lands for Alaskans)

The location of State lands will determine how useful they are to be for private purposes. A recent Federal-State Land Use Planning Commission



study found that only about ten percent (10%) of the usable, accessible land near the two (2) large Alaska regional centers is State general grant land. Between 68 and 82 percent of this land is already in private hands. This is a reasonable assessment of community land status in Alaska. For future selection there is some land available in certain areas of Southeast, such as Petersburg, Wrangell and Juneau; but almost no land is presently available in the Sitka area. It appears that community needs will not substantially effect State selections. This fact will allow the State to use its selections for such resources as Geothermal Energy.

#### MUNICIPAL LANDS

In 1963, the Legislature passed the Mandatory Borough Act, with the intention of granting land to the municipalities on the same basis land was given to the State upon statehood; to establish an economic base. The Act allowed municipalities to select ten percent (10%) of the vacant and unappropriated state general grant land within their boundaries. Disputes over the handling of these lands led to litigation, which was settled by an act passed in 1978, which allocated 860,000 acres to the existing boroughs. (Lands for Alaskans)

#### (D-2)

In response to Section 17(d)(2) of the Alaska Native Claims Settlement Act, numerous proposals for the creation of new conservation units in Alaska have been advanced. In May, 1978, the U.S. House of Representatives passed a bill (H.R. 39) which would set aside 123 million acres of Federal Land for new or extended parks or refuges. Less than half of this area is made up of lands included in the original (d)(2) withdrawals put forth by Interior Secretary Morton in 1973. The U.S. Senate considered the bill during the 1978 Legislative session, as well. Senator Gravel of Alaska, killed the legislation in the Energy Committee after deciding the Senate compromise version of H.R. 39 did not meet his view of Alaska's needs. This action of Senator Gravel's caused much political turmoil in both Alaska and Washington, D.C.; and only time will tell how Alaska will fare regarding (d)(2). The 1994 Congress is to reconsider this question.

It is obvious that there is a great deal of uncertainty in regard to energy potential under (d)(2) proposals. Not only geothermal sites, but many of the coal reserves, hydroelectric locations and certain uranium potentials are also being considered for inclusion into the National Parks System and Wildlife Refuges. Many of the important transportation and transmission corridors are being considered for classification as well. Hopefully, the legislation that Congress will consider this next year concerning (d)(2), will seriously address these potential energy resources.

The lack of action on the (d)(2) issue by the U.S. Senate and the expiration of the (d)(2) withdrawal prompted Interior Secretary Cecil D. Andrus to withdraw, for three years, substantial portions of land in Alaska which have been under consideration for inclusion in the National Conservation Systems (See Appendix C for background and administrative

options). This action took place November 16, 1978, when the Secretary announced withdrawal of 110 million acres under terms set forth under Section 204(E) of the Federal Land Policy Management Act (FLPMA), an emergency powers law. The withdrawal included all composite boundaries included in the Carter Administration's recommendations; the House-passed H.R. 39, the Senate Energy Committee version of H.R. 39, and some other land which was not specified. Portions of 13 rivers were included in withdrawals by PLO #5654.

This action and others by the Department of Interior prompted Alaska Governor Hammond to bring suit against the United States. The basis of the case was a 9 million acre overlap of State selected land and interior withdrawals. It is generally thought that this suit was used as a part of the States (d)(2) bargaining position and a hedge against the President involving the Antiquities Act (Anchorage Times) Appendix D gives the State input concerning geothermal Energy and Secretary Andrus' and President Carters' Emergency Powers Options.

December 1, 1978, President Carter did invoke the Antiquities Act to designate 56 million acres of Federal land as 17 new national monuments. These units were originally portions of the Carter Administration's (d)(2) proposal. President Carter's proclamation covers 13 units to be administered by the National Park Service, two (2) units to be managed by the Fish and Wildlife Service and two (2) National Forests to be administered by the National Forest Services.

The monuments proclaimed by the President are: Aniakchak NM (350,000 acres); Bering Land Bridge NM (2.6 million acres); Cape Krusenstern NM (560,000 acres); Denali NM (enlargement of Mount McKinley National Park, 3.9 million acres); Gates of the Arctic NM (8.2 million acres); Glacier Bay NM (enlargement 550,000 acres); Katmai NM (enlargement 1.4 million acres); Kenai Fjords NM (570,000 acres); Kobuk Valley NM (1.7 million acres); Lake Clark NM (2.5 million acres); Yukon-Charley NM (1.7 million acres); Yukon Flats NM (10.6 million acres); Becharof NM (1.2 million acres); Admiralty Island (Forest Service, 1.1 million acres); Misty Fjords (Forest Service, 2.2 million acres). (December 1, 1978, Memo, Secretary of Interior)

#### PRIVATE LAND

Private land in Alaska, excluding land held by Native corporations, is estimated to be over one million acres. Much of this land passed into private hands through the Federal Homestead Acts and the land disposal programs of the State, boroughs or communities. Native allotments, filed prior to the Settlement Act, put more land into private hands. Most private lands are located along Alaska's road network. Compared to other categories of land, it is highly accessible and constitutes some of the prime development and settlement land in the state. (Lands for Alaskans)

#### KEY DATES

Key land issue dates concerning land determination in Alaska start with December 18, 1978, which was the expiration deadline to resolve the

(d)(2) issue. During 1979 Further Legislation Concerning (d)(2) will be considered. In 1981 the Expiration of the Organic Act withdrawals of 110 million acres of Federal Land in Alaska will obtain considerable attention. These are the lands the Secretary of Interior decided to protect after the (d)(2) compromise failed in the 1978 Congress. In 1984, the State of Alaska must have made all of their land selections. In 1991, all the entitlements to the Native claims must be transferred and at that time they will be liable for the taxation on their properties unless some compromise is reached in the Senate of the United States. As these milestones are reached, hopefully the land situation in the State will begin to resolve itself.

At this time the only lands that could possibly be developed for geothermal resources are held either in the private sector, by the Forest Service in Southeast Alaska, Federal (d)(1) lands, patented Native lands, or patented State lands. Much of these lands are comprised by Administrative and regulatory restrictions. Unrestrictive State lands do have geothermal potential but there has been some questioning of regulations written to permit the leasing of these lands for geothermal development.

#### STATE LAND POLICY

##### (Lands for Alaskans)

The present state policy of Alaskan land management is found in Chapter 181, SLA 1978, the culmination of an effort by Governor Jay S. Hammond, the Legislature and the Federal-State Land Use Planning Commission. The provisions of this Act, signed into law July 18, 1978, are based on Article VIII, Section 1 of the State Constitution: "...the state (is) to encourage the settlement if its land and the development of its resources by making them available for maximum use and development consistent with the public interest." The Land Policy Act implements this Constitutional mandate by setting specific policies. The legislation recognizes the special importance of making land available for Alaskans, and sets criteria for the disposal and retention of state land.

The key policy points of Chapter 181, SLA, 1978, are: The state should "plan and manage state-owned land to establish a balanced combination of land available for both public and private purposes." This determination will be made through the Division of Land's inventory, planning and classification process.

"In allocating land for private use and public retention, the requirements of future generations shall be considered. To this end, a supply of state land of a variety of types and locations shall be reserved to provide an opportunity for future decisions."

"Involvement of municipalities and local residents is essential in the decision making process."

## PUBLIC INTEREST IN MAKING LAND AVAILABLE FOR PRIVATE USE

1. "Private land use rights are integral to the material well being of the people of Alaska and our society."
2. "The primary public interest in conveying rights to state land surface to private parties is to make them available...for direct use in areas classified as suitable..."
3. Year-round settlement should be guided "to areas where public services already exist, or can be extended with reasonable economy, or where development of a viable economic base is probable."
4. In classifying land for private use and settlement, adequate provision should be made "for public open space which is accessible to communities so that natural areas are easily reached..." "Special care shall be taken to preserve access to public water and to retain state ownership of sufficient lands which combine high value for recreation and other public purposes with accessibility to settled areas."
5. "State land which is located beyond the range of existing schools and other necessary public services, or which is located where development of sources of employment is improbable, may be made available for seasonal recreational purposes or for low density settlement, with sufficient separation between residences so that public services will not be necessary or expected."

### Public interest in retaining state land in public ownership:

1. "to make them available on a sustained-yield basis for a variety of beneficial uses including subsistence, energy development, aquaculture, forestry, grazing, sport hunting and fishing, hiking, snowmobiling, skiing, and other activities of a type which can be generally made available to more people and conducted more successfully if the land is in public rather than private ownership;"
2. "to facilitate mining and mineral leasing...;"
3. "to protect critical wildlife habitats and areas of special scenic, recreational, scientific, or other environmental concern;"
4. "to restrict development in hazardous locations...;"
5. "to guide the location of settlement and development to minimize public costs and maximize social and economic benefits."

### IMPLEMENTING THE LAND POLICY ACT

To implement the Land Policy Act the Division of Lands must inventory all state land and water, their resources and other values. These inventories, which are to be kept up to date, are to be used to develop regional or area land use plans which will guide the management of state owned lands.

The Act set guidelines for these plans, and thus for all uses (including disposal to private ownership) of state land. Some of these guidelines are: to encourage principles of multiple use and sustained yield; to give priority in planning and classification in areas of potential settlement and critical environmental concern; to consider land under other ownership; to plan for compatible surface and mineral land use; and to provide for meaningful participation in the planning process by local governments, state and federal agencies, adjacent landowners, and the general public.

To meet the goal of putting state land into private hands, the Act orders the Division of Lands to designate by November 1, 1978, 30,000 acres of state land for disposal under either the homesite or open-to entry programs. This land will be part of the 50,000 acres which will be made available during fiscal year 1979 (July 1, 1978, to July 1, 1979). After this first year, the Legislature will annually decide on the amount of land to be offered. This offering has been made.

#### LAND CLASSIFICATION SYSTEM

This state land policy is reflected by a land classification system, which was the step following the inventory and land planning processes. Upon selection by the state, land is inventoried for its resources, and a land management plan is prepared. The plan then recommends classification of the land into one of the existing 16 classification categories. There are currently eight retention categories. They are: Watershed, Public Recreation, Reserved Use, Grazing, Material, Mineral, Timber and Resource Management. All of these are multiple-use categories which allow both dominant and non-conflicting uses.

There are also eight disposal categories. They are: Homesite, Agricultural, Commercial, Industrial, Private Recreation, Residential, Utility and Open to Entry. Land will be selected for future disposal programs from these categories.

#### EXECUTIVE POLICY

In 1976, Governor Jay Hammond summarized his state policies on land disposal: "First, I am committed to orderly management and disposal of lands. This goal can only be met if state land programs address defined and justly arrived at objectives. New programs or alterations to old ones should clearly identify such objectives and be targeted to them.

"Second, any land disposal program should be integrated into an overall Alaska land management framework which acknowledges other landowners and the dynamic and transitional nature of land allocations. Efficient and thoughtful land use planning which coordinates well with other landowners must guide state land disposal.

"Third, public participation must be a major ingredient in all state land programs. Thus, local governments will play a major role in any program I support.

"Fourth, I will be opposed to speculation wherever it exceeds the bounds of fair investment; wherever it inflates land prices beyond present land use values or creates scarcity through price alone. I will not hesitate to fight such unwarranted price inflation."

#### LAND FOR ALASKANS

The Legislature, by the passage of Chapter 181, SLA 1978, directed the designation of 30,000 acres of land to be made available for Homesite and Open-to-entry programs. Additionally, the Act required the designation of 25% of the former mental health land located inside eligible boroughs for disposal. Borough selection would be permitted only if the borough submitted a plan that would satisfy private needs for land within the borough.

Portions of areas designated for disposal have only tentative approval. Conditional sales of this land may be made until the state received patent to the land from the Federal Government. Areas affecting geothermal energy are included in these disposal plans (Lands for Alaskans).

The November 7th state election results indicated that the Beirne Land initiative passed by a substantial margin. This initiative had been placed on the November ballot by the referendum method. The aim of the initiative is to transfer 30 million acres of state land to the people of Alaska by 1983. The land will be transferred to private citizens on a preferential basis with long tenured Alaskan citizens receiving up to 160 acres free with a decreasing amount of land available to people with less than 10 years of residency.

There is a court challenge to the constitutionality of this initiative and it appears that any transfers under the law will be in the future after the matter is resolved in the courts. Large segments of land will transfer to private lands regardless of the outcome, but this plan would be most ambitious. State Supreme Court ruled the initiative invalid April 16, 1979. The Legislature and administration have both submitted plans for the Legislature to dispose of up to 500,000 acres of land over the next five years.

#### STATE LAND PROGRAMS

In 1978 and 1979, the State of Alaska will make at least 130,000 acres of land available for private use throughout the state by a variety of disposal programs. Over 80,000 acres are scheduled for disposal to private users in 1978, and a minimum of 50,000 acres are committed for disposal in 1979.

#### CRITERIA FOR PROGRAM SELECTION

The new state land policy act sets standards for the decision on which of the available programs the state will use. The criteria are:

1. State costs of the sale should be covered, and the public should get a fair return from the sale of public lands. To do this,

conveyances to private parties should be at fair market value, unless otherwise authorized by statute.

2. Sale or lease programs should be used for land readily accessible to a major community or which, because of location, is of relatively high value. Sale programs are generally preferred, but lease programs should be used where special land use controls are required, where the use is temporary, in a commercial situation where a leasehold is advantageous to the lessee, where a unique location is involved, or where current demand for the land is high but it appears that in the future the land may become more valuable for public use.
3. A system of cabin permits may be used in remote locations where survey and conveyance is impractical.
4. Limited or conditional title may be granted when in the best interests of the state. This may include the sale of agricultural interest only, retention of development rights, or retention of scenic or other easements.

The act also allows school and university land to be made available for disposal, in accordance with the laws regulating those lands.

#### FAIR MARKET VALUE

Fair market value is defined as the price at which a willing seller and a willing buyer will trade. The best way to determine it is by examining the history of similar sales, making adjustments for qualities like accessibility, soil types, steepness, timber, scenic values, etc. This is difficult for state land, as this is the first time that most has been on the market. The Division of Lands has a staff of appraisers who will make fair market price determinations.

#### HOMESITE ENTRY PROGRAM

The Homesite Program was enacted by the Legislature in 1977 and amended in 1978. The program allows residents of the state who have lived in Alaska three years or longer to secure title to parcels up to five acres in size. Requirements are: they must 1) occupy the land for 21 months within the first three years after entry; 2) build a habitable, permanent, single-family dwelling on the land within five years of entry; and 3) pay for the survey of the land. Residents who have lived in Alaska twenty years or longer need to reside on the land for only five months to meet the occupancy requirement. A \$10 application fee is required with an affidavit confirming the applicant's length of Alaska residency. A person may acquire only one homesite from the state.

The first disposal of Homesite Entry land was held in the spring of 1978 in the areas of Tok, Delta Junction, Rex-Nenana and Central. There were over 1,200 applications for the 192 parcels of land. Applications were reviewed on the basis of length of residency. The successful applicants had lived in Alaska between 7 and 37 years.

The Legislature has directed that 30,000 acres of state land be designated for disposal in fiscal year 1979, under combination of Homesite Entry and Open-to-Entry programs.

#### OPEN-TO-ENTRY

This program started in 1968, but was suspended in 1973, due to program abuses and administrative difficulties. It has been revised and reopened in the fall of 1978.

The OTE program allows one-year Alaska residents to file on specially designated, subdivided land. The application fee is \$10, and if more than one application is filed for the same parcel within a filing period not to exceed 60 days, the award is made by lot. After the filing period, applications are filled on a first-come, first-served basis. A successful applicant gets a five-year lease at a cost of no less than \$100 per year, which may be renewed once. The state will convey title to the land if the parcel is surveyed and the fair market price is paid before the end of the second lease period. The value is determined as of time of entry.

Most OTE land is suitable for recreational uses.

#### AGRICULTURAL SALES

In an effort to protect Alaska's limited agricultural land base, and to encourage the development of agriculture, the 1976 Legislature provided that 650,000 acres of state land are to be designated for agricultural use by 1979. This land may be used only for agricultural purposes, and will be sold at fair market value at either public auction or by lottery. If new state agricultural land is offered, adjacent farmers may be entitled to a preference to purchase it at auction. A farm conservation plan must be submitted by the purchaser.

The state held its first agricultural rights sale in April of 1978, auctioning 5,300 acres in the Tanana Loop area. In July, 2,900 acres in Homer were auctioned and in August, 60,000 acres in Delta Junction were sold by lottery.

#### SALE BY AUCTION AND LOTTERY

The state has been selling land at public outcry auctions since 1959. Lands are normally sold for no less than their fair market value. This process brings the most money to the state, but has the disadvantage of excluding some potential buyers by possibly raising the sale price far above their ability to pay.

This year the Legislature, in Chapter 176, SLA 1978, approved lotteries as a new method of land disposal. Under this method, potential purchasers apply for land and a drawing is held, with the winner having the right to buy the land at the fixed price, rather than bidding against others. The Division of Lands has the option to dispose of lands at a price which may be less than their appraised value if lands suitable for private ownership are scarce in the particular area. Development re-



quirements may be imposed, and purchasers must have lived in Alaska for at least three years. Lotteries will provide an opportunity for people of all income levels to own land. A lottery winner must wait eight years to participate in another lottery.

#### LAND DISCOUNTS

Alaska residents are eligible for price discounts on state sales of land for residential use, under a program passed by the Legislature in 1978. Each year of residency allows a discount of 5%, up to 50% of the sale price. The maximum discount is \$25,000.

The discount may be applied to sales by auction or lottery, negotiated sales or the purchase of open-to-entry land. It may be applied to the purchase price only, and not to the cost of survey, appraisal, platting, etc. A person may use his or her land discount only once. To be eligible, a person must be at least 18 years old; maintain a residence in Alaska; be a registered voter; not have claimed residency in another state within 12 months of the sale; have been physically present in Alaska for the 12 months prior to the sale (except for brief periods, military service, education or training, or other good cause); and, show his or her intent to make Alaska a permanent residence.

It can be seen that the most dramatic change in land ownership and status in the Nations history is now taking place in Alaska. The 367 million acres of land, its resource, and unspoiled beauty will rightfully continue as the topic of controversy in Alaska for the remainder of this century.



## LEGAL

### Introduction

In order to protect the environment, the rights of the citizenry and to generate revenue, the local, state and federal governments have enacted a myriad of laws pertaining to geothermal energy and its development. Some of these laws were not enacted to specifically affect geothermal energy. Others are specific, such as the Federal Geothermal Steam Act. This summary touches on the statutes and regulations that effect potential development in Alaska.

### Definition

The first obstacle to be surmounted is the definition of geothermal energy. The Federal definition is: 1) all products of geothermal processes, embracing indigenous steam, hot water and hot brines; 2) steam and other gases, hot water and hot brines resulting from water, gas or other fluids artificially introduced into geothermal formations; 3) heat or other associated energy found in geothermal formations; or 4) any by-product derived from geothermal formations. (Geothermal Steam Act of 1970 (30 United States Code Sec. 1001: 84 Stat. 1566).)

Alaska law combines this definition with the California definition, "...geothermal resources shall mean 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, such 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, but excluding oil, hydrocarbon gas or other hydrocarbon substances." (California Public Res. Code, Section 6903 (West Supple., 1976).)

The Alaska definition is: "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." (Alaska Statutes, Section AS.5.38.05.181.)

Since about the turn of the century, it has been the policy of the Federal government to retain the rights to hot and medical springs on federal lands in Alaska, as evidenced by Public Land Orders 399, 614, Executive Order 1883 (dated March 28, 1911), Executive Orders 5106 and 5389, Public Water Reserve No. 107 and the Department of Interior Circular #1066. These are all reaffirmations designating how much and which federal lands would retain rights to springs, hot or otherwise.

The above actions retained federal rights to all but a few hot springs in Alaska. Utilization of geothermal water could be obtained by lease prior to the Geothermal Steam Act under CFR, Title 43, Section 2311.3, Hot Springs Leasing, and these development rights are grandfather rights that supercede the Geothermal Act.

## The Federal Geothermal Steam Act - Portions Extracted, McClain, 1979

In 1970, the United States Congress passed the Geothermal Steam and Associated Geothermal Resources Act. This Act is the exclusive means of acquiring the right to explore and develop geothermal resources underlying federal lands and on lands subject to a reservation of these resources. The geothermal resources are disposed of through a system of privately held leases. The structure of this Act and the legal framework of the leases closely parallel the Mineral Leasing Act of 1920 governing oil, gas and minerals used for energy and fertilizer. )30 USC 181 et. seq., also 30 USC 351, 358.)

The Secretary of Interior, through the offices of the Bureau of Land Management (BLM), is authorized to issue leases for geothermal resources on public lands. The Bureau of Land Management regulations concerning geothermal resources are found under Chapter 2, Title 43, Code of Federal Regulations Section 3200. The minimum lease size is 640 acres, and the maximum is 2,560 acres within an area of six square miles. Departures from the compact area and minimum size restriction are allowed with the approval of the BLM. Additionally, there is a limit to the acreage that any one citizen, association, corporation or governmental unit can hold, own, control, or have direct interest in, federal geothermal leases in any one state. Code of Federal Regulations Section 3203.2 States: Any one entity must limit its maximum holdings to 20,480 acres. This provision is intended to limit the amount of potential resource areas that any one concern can hold or control. In this manner, it was the intent of Congress to prevent large energy companies from controlling the future development of a competitive form of energy and to encourage smaller interests to become involved in the development of this resource.

All federal lands open to geothermal leasing fall under two general classifications. Land in a "Known Geothermal Resource Area" (KGRA) requires competitive bidding to acquire the lease rights. Other land is classified as "Potential Geothermal Resource Areas" (PGRA) and may be leased by the first qualified person applying for a lease. (30 USC 1020) A KGRA occurs when geology, discoveries and competitive interest and overlapping applications for leases suggest geothermal resources are present and appear to be a recoverable investment. The U.S. Geological Survey classifies lands as KGRA. Also, see USGS Circular 647.

Special provisions are made in the Act to limit the amount of surface area which can be developed and controlled by the leasee. The leasee may use only "the necessary amount of surface area required for his operation" (CFR 3200.0-8.). Geothermal development is specifically prohibited by the Act from interfering with or endangering the operation of other interests on the same land. In the same respect, other leases cannot interfere with or endanger the operation of the geothermal lease. (CFR 3200.0-8)

The primary term of a federal geothermal lease is ten years. Within this period, the leasee must "prove" his lease by diligent drilling operations. A continuation of leases without commercial production cannot exceed 40 years. (CFR 3202.1-3)

From the Federal Government's point of view, revenue raising is secondary to the development of the resource. An annual rental of at least one dollar per acre and a royalty of not less than 10% nor more than 15% of the gross value of energy derived and sold is required by law. The Secretary of Interior can waive these payments in the interest of a successful operation. Furthermore, the Act recognized that royalty must also be paid on valuable by-products. The Secretary of Interior is given wide discretionary powers on placing a value on the by-products (CFR 3205.3).

A bond of \$10,000 must be maintained; it's return is conditional on the compliance with all terms of the lease. An additional \$5,000 bond for indemnification for all damages which result from the lease operation must also be posted by the leasee. (CFR 3206.1)

Land specifically excluded from the operation of the Federal Geothermal Steam Act are national parks, national recreation areas, fish hatcheries, wildlife refuges, wildlife management areas and Indian lands. The most notable example of this potential problem area is the Birds of Prey Natural Area Idaho. Geothermal leases are not issued in the buffer study area of the natural area and leases that are in the general area have specified stipulations within the lease which protect nesting sites and restrict activity in the area. This provision of the Act is of major interest for the development of geothermal resources of Alaska. Major geothermal areas of the state are located near, or within these specifically excluded areas. Past performance indicates that no geothermal development will occur under a federal lease whose exploration and development is adjacent to areas that will be liable for major environmental restrictions.

The potential for environmental conflict between geothermal development in adjacent areas and specifically excluded areas is greatest in close proximity to wildlife refuges and wildlife management areas. Well drilling, testing and maintenance present local noise pollution problems. Depending on the location of the geothermal field and associated utilization facilities with respect to a wildlife area, noise pollution control could become a major factor in the application of land use regulations within individual lease contracts.

The development of a geothermal resource involves a major change in land intensity. Increased noise pollution, sulphur dioxide emissions, and general human activity will affect adjacent wildlife areas. Adoption of mitigating measures during various stages of development can solve most of the environmental problems associated with geothermal development. Future regulatory activities will undoubtedly focus on developing the geothermal resource compatible with the present land use rather than prohibiting it entirely.

In 1979, it is probable that a geothermal omnibus bill be considered by the Congress of the United States. (See Appendix F) It is intended that many of the unnecessary impediments to the Geothermal Steam Act of 1970 will be eliminated and a more development oriented bill will be forthcoming.

## State of Alaska Policy

State geothermal lands would be leased under Alaska State Statutes Title 38. The terms of this leasing procedure are outlined in Title 11, Chapters 82, 84 and 88 of the Alaska Administrative Code (AAC), mineral leasing procedures. The State Geothermal Resources Act of 1971 designates the Department of Natural Resources (DNR) as the leasing agent for State lands.

To date, comprehensive leasing regulations for geothermal energy have not been written. It is probable that present regulations will be reconsidered by the Department of Natural Resources in 1979. It is felt that certain amendments to the State Geothermal Act will be forthcoming as a result of this regulation producing procedure.

Provisions of the State Steam Act are designed to be much the same as those on Federal Lands. The U.S. Geological Survey, or State Geologist can ask the commissioner (DNR) to designate the State Lands Known or Potential Geothermal Resource Areas (K&PGRA). Each lease must be for more than 640 acres and less than 2,560 acres. The maximum any one person can acquire at this time (December, 1978) is 25,600 acres. If the area is remote, it is implied that smaller tracts can be leased.

The state will collect a 10-15% royalty on gross revenue, exclusive of charges made or incurred with respect to transmission or sale of geothermal energy at point of delivery. A 2-10% royalty will be imposed for extraction of minerals. A minimum of \$1.00 per acre annual rental toll be collected on leased land. After discovery, the minimum payment will be \$2.00 per acre. It should also be noted that the State may fix royalties for private consumption. (AS.5.38.05.181)

The primary term of lease is 10 years. If the resource is developed, the lease can be extended to 40 years. Preferential rights can extend for 99 years. Provisions for similar wilderness restrictions that are found in the Federal Geothermal Steam Act exist for State Lands (ASS 38.05.181).

## Reservation Doctrine

Congress elected to leave the issue of reservation of geothermal resources to judicial interpretation. The Geothermal Steam Act of 1970 directed the Federal Justice Department to institute litigation to quiet title of geothermal resources that have mineral estates reserved to the United States. (84 Stat. 1573, Sec. 21(b).)

A very important case resulted in the United States vs. Union Oil of California. The basis of the suit was the claim by the United States that Section 9 of the Stock Raising Homestead Act of 1916 reserved to the U.S. all geothermal steam and geothermal resources. Section 9 provided for reservation of "all coal and other minerals". The District Court rejected this claim. (United States vs. Union Oil of California, 369F, Supp. 1289, ND, Calif. 1973.) However, the U.S. Circuit Court of Appeal held that geothermal resources were energy. As an energy resource, it was reserved under the stock raising and homestead act. (Case reversed, 549F, 2nd. 1271 (1977).)

The results of the court decision indicate that when the surface and mineral estates are severed, geothermal rights are retained by the mineral estate. Therefore, homestead grants without a mineral reservation to the federal government, and patented mining claims, include any geothermal resources. The United States Supreme Court denied review of this case in the fall of 1977. This 1977 ruling is therefore upheld.

The argument that geothermal resources are energy resources, reservable as part of the mineral estate, was further strengthened in the case of Geothermal Kinetics vs. Union Oil of California. (#7514, Superior Court Sonoma County, California). This decision held that the surface owner was not entitled to the energy which the water carries, but the water itself. Water is essential for the productive use of the land. Minerals are considered valuable for their indigenous properties and independent of the land title. The core of this case was who owned the energy in the severed estate, when the surface estate owned the water rights. The court found that the energy belonged to the mineral estate.

These cases have far reaching effects in Alaska. In the provision of the Alaska Statehood Act (ASA) of 1958, and the Alaska Native Claims Settlement Act (ANCSA) of December 18, 1971, the mineral, and thus, geothermal resources are to be transferred to the patentee by the United States. Therefore, appropriate State and Native leasing entities are those persons who will issue prospective leases. If title is only tentatively approved, the prospective leasee would have to obtain a letter of concurrence from the future land holder, as well as follow all the procedures outlined in CFR, Title 43, Section 3200. When the title is transferred in such a case, the title would be subject to all provisions transactions, including the lease, but the new landlord would receive any and all fees.

It should also be noted that the mineral and geothermal estate of village selections under the ANCSA remains under the control of the Regional Native Corporation. (Alaska Native Claims Settlement Act, 1972.)

### Exploration

The beginning of any development associated with the harnessing of geothermal energy is the exploration effort. This is also the beginning of the legal maze. If the developer has reason to believe there is a geothermal resource on federally owned lands, he will have to obtain a "Casual Use Permit" from the U.S. Geological Survey, Title 30, Chapter 11, Code of Federal Regulations, and file a notice of intent with BLM as prescribed in CFR Title 43, Public Lands 3209-5d, GRO #1, to do any exploration. If the title has passed from BLM to another Federal agency, then the permit must be processed at the new agency and then processed at the BLM. If the land is in the State domain, then the developer will have to obtain a miscellaneous land use permit as prescribed in the Alaska Administrative Code, Title 11, Chapter 96. If the land is held by the Native Regional or Village Corporation, an exploration agreement must be made with that entity. Individual Indian and private ownership is the same.

If the land is on an Indian Reservation, the procedure is to go to the Tribal Council first. The Indians then take the request to the Bureau of Indian Affairs. All these aforementioned permits pertain to surface entry only.

If a substantial geothermal resources is indicated, further exploration might be advisable. Federal prospecting permits are issued by the U.S. Geological Survey. This would allow seismic operations. Separate exploration drilling permits would also have to be obtained from the U.S. Geological Survey. All of these procedures are outlined in CFR Title 30, Chapter 11.

State regulations for exploration and drilling are detailed by Alaska Administrative Code, Title 11, Section 94. This includes separate permits for exploration and drilling operations. These permits are issued through the State Department of Natural Resources.

#### Production of Water

As the exploration effort goes into the production phase of development and the developer starts drilling production wells, there is the possible applicability of water laws. Geothermal operations frequently are producers of water. This brings the producer into possible confrontation with Federal and State water laws.

The use of water in the Western United States is generally controlled by the States. The Supreme Court has held that Federal legislation (the Desert Land Act of 1877, as amended 43 USC, 321, et. seq. 1965), has "effected a severance of all waters upon the public domain from the land itself", (California-Oregon Power Co. vs. Beaver Portland Cement Co., 295 U.S. 142, (1935)). In 1955, this definition was narrowed to "public lands" by the court.

The case of U.S. vs. Winters finally sums these thoughts up. The Winters doctrine is the word on the water rights on Federal reservations. It concludes that the states control their water, except for Winters doctrine rights relating to Federal reservations, (parks, forests, Indian reservations, etc.), (26 Montana Law Review 154).

This gave the notion that severance on Federal "reservations" did not occur. If so, Executive Order 5389, which withdrew "every smallest legal subdivision of the Public Land Surveys ...containing a hot spring or a spring, the waters of which possess curative properties" would maintain that those waters would be governed by Federal, not state laws.

The Department of Interior has suggested that this Executive Order was not limited to hot springs created solely by the force of Nature. "The development of these hot spring systems by drilling wells on the public lands would be within the purview of the Executive Order of July 7, 1930". (M-36625, Memo - Ed Fisher, Acting Solicitor, Dept. of Interior, to Director, BLM, August 28, 1971). At this time, (December, 1978) this opinion has neither been resisted or enforced.



These laws may become important if direct use applications are ever given a legal minimum temperature definition.

When in Alaska, regulation of water resources has been left to the State, the regulations for drilling and water rights are covered in Title 46, of the State Statutes. These are now being revised. All the well logs and inventory compliances are regulated under Title 41 of the Alaska State Statutes. These are administrated by the Department of Natural Resources, Water Resources and Minerals Division, respectively.

### Production Environmental

Currently, there are debates and turf battles over regulatory supremacy of the overlapping jurisdiction of many Federal and State agencies.

In Idaho this issue was brought to a head in Andrew V. Click 97 Idaho 791; 554 p.2 969 (1974), The Supreme Court of Idaho. The court's conclusion was that the Idaho Dredge Mining Act was within the regulatory jurisdiction of the State. The case dealt with the collision between State and Federal legislation. If there is a collision, then the Federal legislation would preempt the State legislation by reason of the supremacy clause. However, State regulation, which is more stringent than that under the Federal legislation, is not the type of conflicting legislation described by the supremacy standard.

When considering a right granted by the Federal legislation, State regulation which renders it impossible to exercise that right would be in conflict with the supremacy clause. For example, if the State allowed drilling of geothermal wells near a National Park with a geyser and that geyser was jeopardized by that drilling it could be stopped. This could affect State owned land near the boundaries to the numerous national reserves in Alaska.

On the Federal level, numerous environmental laws affect geothermal resources.

The water and air standards are the chief environmental laws affecting geothermal energy. The Safe Drinking Water Act is concerned with protection of ground water, among other things. Developers should make themselves fully aware of the provisions of the Act and its related permitting and regulations before going into production. The Environmental Protection Agency (EPA) and State Environmental Conservation are the entities involved. Normally the State is the agency in these matters. However in the case of water law, Alaska does not have delegation of the 402 NPDES permit program under the Clean Water Act. Such permits may be associated with water and energy withdrawal rights and permits.

The Clean Air Act of 1977 will also affect the developer. It is not clear whether NAAQS Air Standards will be applicable to geothermal development. If they are, there have been no standards set for hydrogen sulfide and mercury, which could present problems. More likely, new source performance standards is the applicable program. EPA has produced a document outlining the probable federal environmental program for geothermal energy.

The authority for Alaska's environmental regulations is found in Title 46 of the Alaska Statutes -- Water, Air and Environmental Conservation. Title 18 of the Alaska Administrative Code sets forth the following regulations which may pertain to geothermal development: Chapter 50, Air Quality Control; Chapter 60, Solid Waste Management; Chapter 70, Water Quality Standards; and Chapter 72, Waste Water Disposal.

Along these same lines, on the State level are State Department of Fish and Game statutes, Section 16, concerned with the protection of fish and game. These regulations outline the parameters in disturbance of habitats related to development.

Other considerations which may have a serious impact in Alaska are the Coastal Zone Management Acts. At this time, there is no clear-cut definition of powers authorized, but as regulations are adopted, they shall be examined. The Federal Coastal Zone Management Act, which only speaks to general energy development, would probably have little affect on geothermal development. The State Act, however, which does have regulations, guidelines and standards, could have an affect. In so far as none of the regulations apply directly to geothermal development, some of the habitat standards and district plans could affect placement of facilities.

The U.S. Code, Title 30, Mineral Lands and Mining, Chapter 24, Geothermal Energy Research Development and Demonstration is designed to coordinate and manage projects concerning geothermal development, loan guarantees, environmental protection, etc.

Section 174 of Internal Revenue Code allows for R&D deductions. Also, under current tax laws, there are options to deduct intangible drilling costs for geothermal drilling, there is also a depletion deduction allowed. (See Appendix E)

The Federal Organic Act of 1879 (43 USC 31) allows land classifications by USGS, CFR, Title 30, Chapter 11. The Federal Land Policy and Management Act of 1976, P.L. 94-579, 209(A), 90 Stat. 2757, requires the Secretary of Interior to reserve all minerals in all future conveyances of lands. A major exception provides that the Secretary may convey mineral interests owned by the United States to present or proposed non-federal surface owners if he finds: 1) there are no known mineral rights in the land, or, 2) that the reservation of the mineral rights in the U.S. is interfering with or precluding appropriate non-mineral development of the land and that such development is a more beneficial use than the mineral development.

There are also Alaskan local government laws and regulations. The powers they are authorized are summarized in Alaska State Statutes, Title 29. There are three classes of cities and three classes of boroughs in the State. In addition, there is a Home Rule provision. They each have different regulatory powers and parameters and can only be cataloged individually.

On the North Slope, five (5) Eskimo villages banded together to form the North Slope Borough in 1972. Alaska's local government structure is unique in the U.S. It's constitutional draftsman wanted to avoid the pitfalls of country government--primarily lack of revenue, and created locally based but state type institutions that could bring self-government and services to the vast, sparsely populated expanses of the state. Thus was created the borough system, "to provide the maximum local self government with a minimum of local government units, and to prevent duplication of tax-levying jurisdictions. A liberal construction shall be given to the powers of local government units" (Alaska Constitution, Article X, at §1). The entire state was to be divided into boroughs and cities only (Sec. 2), in order to avoid the patchwork of special service districts generally overlapping counties and cities, filling service gaps and creating a multiplicity of taxing jurisdictions. Subsequent legislation fleshed out the procedures for borough creation (Borough Act of 1961, Alaska Stat. 29 (Sess. Laws of Alaska, Ch. 146 (1961)); Mandatory Borough Act of 1963 (Sess. Laws of Alaska, Ch. 52 (1963).)

As of 1976, there were nine (9) boroughs in Alaska. In many instances, their boundaries coincided with those of 12 regional corporations organized by Alaskan Natives under the terms of the 1971 Federal legislation. In particular, the North Slope Borough represents the Arctic Slope Native Association and its regional corporation. It is noteworthy that the Arctic Slope Natives possessed such a high degree of organizational ability and independence, that they were able to successfully pursue the creation of the North Slope Borough. Immediate and persistent legal challenges were met and rebuffed by the Natives. (Mobil Oil Corp. vs. Local Boundary Commission, Civ. No. 72-834 (Alaska Superior Court, Filed 3/28/72) and Gulf Oil Corp. vs. North Slope Borough, Civ. Nos. 73-794, et. al., (Alaska Superior Court, 1973).) In addition, the will and ability of the new Borough to levy tax ~~on~~ (on an advalorem basis) oil Company property on state leases within their jurisdiction is of importance to the future of geothermal resources in Alaska.

But, if the borough tax situation is interesting, it pales by comparison with the numerous levies enacted by the State of Alaska. First of all, there is a severance tax of 12.25% of gross value for oil and 10% on gas (Alaska Stat. Sec. 43.55.011-016 et. seq. (1977 Alaska Sess. Laws, Ch. 136).) There is also a "Mining License Tax" of from 3-7% of gross value and a \$200 per 20 acre or fraction thereof tax on mining claims (Alaska Stat. Sec. 43.65.010 and 29.53.030, respectively). There is a State ad valorem tax of 2.5% on all exploration, production and pipeline properties (Alaska Stat. Sec. 43.56.101 et. seq.). This latter tax is presently assessed against the oil industry only, and for 1978 amounted to \$136 million.

An additional \$26 million was paid to local (borough and city) governmental units (Minerals and Materials (Aug., 1978, DOI) at p. 42). The political vulnerability of resource developers is demonstrated by the severance tax increase from 8.3% to 12.25% only last year. Defeated, for the moment, was an increase to 14.5%. Also of note, is a two-year-only (1976 and 1977) tax on the oil reserves of Prudhoe Bay, with a credit against later severance taxes.

A great deal of geothermal energy development might prompt the State Legislature to ask the developing industry to contribute to the States development at a more substantial pace.

## ECONOMICS

Finding alternative energy sources to replace fossil fuels is a goal that appeals to the people of Alaska. Rural electric rates are expensive, as high as 74¢/kw hour (DEPD). Fuel oil in remote villages can run as high as \$3.00 per gallon (DEPD). This expense coupled with the chance of shortages resulting from logistical problems makes a site specific resource such as geothermal energy a popular alternative.

\*Geothermal energy will, of course, have to compete economically with other forms of energy. Pricing for a specific geothermal resource with specific commercial users can be broken into four major categories:

1. The capital investment to develop the resource;
2. The cost of delivering the resource to the user or users;
3. The cost of maintaining the system for its economic life, and
4. The savings or cost benefit realized from utilizing the resource.

### Capital Investment To Develop The Resource

In the development of a geothermal resource there are extremes in drilling cost related to geographic location, type of drill rig required, existing drilling conditions, well depth required to encounter the resource, and the probability that a resource will be found with sufficient temperature and flow to be usable. Some resources seem to yield a production well with every drilling; others require several drillings to obtain a single production well. Therefore, the probability of encountering the resource is a major factor and the price of energy would vary greatly depending on whether the supplier or the user bears this risk.

A number of users demand an uninterruptable source of energy. This requires 100% redundancy which could nearly double the capital investment required. Typically, the supplier would like 100% utilization of the resource on a continuing basis, while the user merely wants to satisfy his existing energy requirements as they occur. This dilemma results in a resource developed to supply peak demand with an average usage rate that may be as low as 10% of the resource available. Some compromise here seems inevitable. The supplier might consider several users whose seasonal demands occur at different times in order to better utilize the resource. The user should consider paying a premium if he expects a dedicated resource to supply peak demand with a low average rate of consumption. In many instances, conventional fuels are used in parallel with the geothermal resource to provide peaking. It goes without saying that many utilities hesitate to offer energy during peak demand periods if these periods occur at the same time that their regular clients consume maximum energy. Therefore, it is suggested that any peaking system utilize conventional fuel that can be stored on site, such as oil, propane or coal.

### Cost of Delivering The Resource

Well head pumping costs vary greatly, depending upon the resource. Some geothermal resources have artesian flow in excess of 1,000 gal/min.

Others with a high static water level require very little pumping. Still others have either low static levels or severe drawdown in production which drastically increases pumping costs.

Transmission lines require costly expansion joints and insulation is necessary to avoid heat loss. Transmission lines placed in concrete conduit have a high initial cost, however, such a system increases the life of the transmission line and lowers maintenance and replacement costs. Uninsulated pipe is less expensive but loses considerable energy as distance increases. Costs of transmission lines vary from \$10 to \$80/ft (See Appendix A). Therefore, the distance from the well head to the user and the type of transmission line installed is another major cost factor. In this regard, if the well owner provides the transmission line, the temperature of the resource would be measured at the point of delivery. If, on the other hand, the user designs and pays for the transmission line, temperature should be measured at the well head. This method would encourage the design of optimum transmission lines, depending on the temperature of the resource vs. the temperature required by the user.

#### Costs of Maintaining The System

Water quality greatly influences maintenance costs. Water which is excellent quality (low in chemical content and dissolved solids) can be pumped directly through the system. As water quality deteriorates, maintenance and replacement costs increase, more elaborate heat exchangers are required, and efficiency drops.

#### Savings Or Cost Benefit Realized From Utilizing The Resource

The annual savings resulting from the application of direct use geothermal resources is largely dependent on the amount of energy available and the amount of energy extracted in the conversion system. The amount of energy available is related to the temperature and production rate or flow rate of the resource. Many wells yield only sufficient flow to heat a small residence and are rarely economically feasible. Conventional hot water heating systems typically supply temperatures of 200°F (93°C) to 210°F (99°C) and have a Delta T (change in temperature, or heat extracted) of 20°F (11°C). Many of these systems are overdesigned and could function with 180°F (82°C) and 160°F (71°C) return temperatures. Assume geothermal water is supplied to such a system at 210°F (99°C) with a 10°F (6°C) approach temperature in a plate heat exchanger. The user could probably obtain a 40°F Delta T (22°C Delta T) in the heating system. Compare this to a supply of 190°F (88°C) water with 10°F (6°C) approach temperature in the heat exchanger. The user could only obtain a 20°F Delta T (11°C Delta T) which would increase the flow required and consequently the pumping costs. A supply of 170°F (77°C) would be useless without expensive retrofit costs in the heating system. \*(Higbee 1978)

The savings to the user is based upon the equivalent energy costs for other forms of fuel in the area. Costs for alternative fuels along the rail belt where energy is cheapest in Alaska is as follows:

## Energy Costs

$$\text{Energy Cost} = \frac{(\text{Fuel Price} + \text{Transport}) + \text{Conversion}}{\text{Efficiency}} + (\text{Operations \& Maintenance})$$

Efficiency:    Coal-----70%  
                 Natural Gas-----80%  
                 Oil #2-----75%  
                 Oil #6-----75%  
                 Solid Waste-----70%

## Summary (Capital Report #6)

### Dollars per Million BTU

	<u>1978</u>	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
	\$	\$	\$	\$	\$	\$
Coal (by rail from Healy)	4.40	4.472	4.683	4.945	5.272	5.682
Natural Gas (from Kenai)	5.33	5.753	7.118	9.031	11.733	15.567
Oil #2 (from Kenai)	4.35	4.856	5.766	6.971	8.579	10.267
Oil #6	4.25	4.573	5.381	6.455	7.884	9.786
Solid Waste	3.958	4.002	4.167	4.406	4.756	5.266

## Applicability To Rural Alaska

The demography of Alaska has an important influence on the energy usage in the state. Half to two-thirds of the 400,000 people live in the "Rail Belt" between Anchorage and Fairbanks. The rest are scattered across an area that would stretch from coast to coast of the Lower 48.

Because of these characteristics, transportation systems are quite limited. Most areas are accessible only by small plane, boat, snow machine, dog sled, or foot. One of the results is extremely high fuel costs, a barrel of oil costing over \$100 in many towns.

Rural Alaskans living in towns of under 300 have serious restrictions concerning financial resources. It is quite unlikely that a village will be doing much geothermal exploration and drilling. Therefore, these Alaskans use will probably be limited to simple development of natural hot springs without Government help. There are nearly 80 located Alaskan hot springs and an additional 22 reported thermal sites to work with at this time.

With the low ambient temperature in Alaska and relatively low temperature of the majority of thermal springs, the resource is quite suitable for non-electrical applications. Utilization already includes recreational bathing, space and water heating, and agriculture (greenhouses and planting in areas heated by subsurface geothermal water). Expansion of these uses would reduce dependence on imported fuels and provide a local source of foods that might not otherwise be available to the community.

Present interest also includes aquaculture and reindeer husbandry, drying and refrigeration facilities and possibility for solid waste and sewage treatment. Space heating has and will continue to be a major application for this resource.

Home Space Heating Rules (Department of Energy Rules of Thumb) for direct heat utilization.

Example: In a modern, well-insulated, 1800 ft<sup>2</sup> home the minimum outside design temperature is assumed at -10°F and the desired inside temperature is 70°F. The DD for the locale is 4500 DD. A fluid temperature drop (Delta T) of 15°F is assumed and the heating system is to be over-designed by 25%.

Problem: Determine the maximum and annual heat loads, the delivered heat requirement assuming a 25% overdesign, and the required geothermal fluid flow rate.

For an average sized home:

Maximum Heat Load = 500 (T1-T2 min) BTU/hr.

T1=desired inside temperature

T2 min.=minimum outside design temperature

Annual Heat Load = 12000 x DD BTU/yr.

\*\*DD = annual Fahrenheit heating degree days

Example: Average sized house

T1=70°F

T2= -10°F

D.D. = 4,500 Degree day F

Maximum Heat Load = (70 - (-10)) x 500

= 80 x 500 = 40,000 BTU/hr.

Annual Heat Load = Annual Heating Load (1)

HLA = 12,000 (DD)

(1) Best Energy Efficient Home Requires

12,000 Btu/DD Annually

12,000 x 4,500 = 5.4 x 10<sup>7</sup> BTU/yr.

Minimum economic water temperature for space heating is approximately 130°F. For winter design assume that the temperature drop across the heating system is no greater than 20°F and an outlet air temperature from the system is not less than 100°F. Heat delivered by the water (H) is:

H = 500 (Delta T)(Q) BTU/hr.

Delta T = Temperature Drop (°F)

Q = Flow (gal/min)



Example: For the home above, assume:

Only 15°F drop in water temperature and 25% over design of the heating system. What is the maximum required water flow?

$$\begin{aligned} H &= 1.25 \text{ max. heating load} \\ W &= H/500 (\text{Delta } T) \\ H &= 40,000 \times 1.25 = 50,000 \text{ BTU/hr.} \\ \text{Delta } T &= 15^\circ\text{F} \end{aligned}$$

$$H = 50,000$$

$$Q = \frac{H}{500 (\text{Delta } T)} = \frac{50,000}{500 (15)} = 6 \frac{2}{3} \text{ gal/min.}$$

An average home is defined to have 1800 ft.<sup>2</sup> with modern construction and be well insulated

Degree Days for a specific area (state) can be obtained by ordering the July, "Climatological Data". Publication from:

Environmental Data Service  
National Oceanic and Atmospheric Administration  
National Climate Center  
Asheville, North Carolina 28801

### Geothermal Space Heating Technology

Since geothermal space heating has a low annual operation cost and the fuel cost (i.e. BTU's in the water) can be considered "free" or at least low, attention needs to be focused on capital costs. Unfortunately, geothermal space heating, whether used on an individual basis or in heating district, has a high initial cost and is so capital intensive that development is frequently precluded. These costs are reflected in the initial cost of drilling and casing a well followed by the installation of heat exchangers, piping, valves and instrumentation.

### Geothermal Exploration and Drilling

A number of years ago at Pilgrim Hot Springs, Alaska there was the need to elevate the geothermal hot water to a level of 15 to 18 feet above the surface of the ground to transfer the heat into the nearby church. The church officials apparently decided to merely hand-drill a pipe about 8 feet into the ground. With the temperature and pressure from the geothermal water, it was possible to obtain a flow from eight feet below the surface of the water to the desired fifteen to twenty feet above the level of the geothermal reservoir. This simple, yet appropriate, technology of merely tamping the pipe into the ground shows what a little ingenuity can do to develop an energy resource.

The expense of this type of development is limited to the costs of the delivery system, which can be purchased at a plumbing store in Anchorage, Fairbanks or Juneau. Expense for transport of this system can run 30¢ per lb. for remote villages however, and even higher for remote sites with no landing strip.

If an end user is found, drilling might be used to enhance a resource to meet the energy demand of the user. It is quite reasonable to expect that some exploration of the resource takes place before any drilling begins to determine the suitability of the resource and the best location of the drilling rig to find the reservoir.

Exploration costs are quite high in Alaska. These costs could run as high as ten times the costs of those in the lower 48. Some rules of thumb for costs of Remote Industry Quality Geophysical Methods are:

Gravity surveys cost	\$ 400/day
Infra Red Survey Cost	400/day
Resistivity survey cost	3,000/day
Active seismic survey cost	5 - 10,000/day
Magnetometer survey 100 <sup>2</sup> miles	10,000
Geochemical survey cost	400/day
Geological survey	400/day

A proposed geothermal project and its budget are presented here as an example. The project would be located at Pilgrim Hot Springs on the Seward Peninsula. This is intended to be an articulated example and not a cookbook methodology for exploration work in Alaska. Each site will require different exploration methods. This outline is to site an exploration drill rig in a semi-explored area. The methods are to minimize cost at the expense of Quality. Portable equipment is being considered rather than Industry Type Exploration.

#### PILGRIM SPRINGS GEOTHERMAL PROJECT

##### Proposed Project Outline (Prepared by R.B. Forbes)

##### 1. Aerial photography and infra-red imagery:

Recurrent low level (1,000 ft) (305 m) color aerial photographs of snow melt patterns following onset of winter snowfall, and spring breakup. Melt patterns to be used as a guide for temperature survey grid. Request to be forwarded to Air Force for infra-red imagery of Pilgrim springs area.

##### 2. Thermal grid survey:

Downhole temperature survey, utilizing augers. Holes to be drilled at pre-determined grid survey locations. Temperature gradient data to be supplemented by water table measurements and soil and water sampling. Temperature data to be plotted on isothermal maps of the area.

##### 3. Magnetometer survey:

Airborne magnetometer survey at elevations of 500 and 1,000 feet (152 and 305 m) above terrain, supplemented by surface survey.

Survey to be based on flight and traverse lines with 250 feet (76 m) separation.

4. Water temperature and chemistry:

Spring water temperatures to be determined at points of upwelling and in subsurface aquifers with thermal probes. Water samples to be obtained from subsurface and surface, and comparative chemistry used for determining mixing ratios with local groundwater table and revised deep reservoir temperatures based on geothermometry.

5. Gravity profiles:

Gravity profiles along selected traverse lines in conjunction with magnetometer profiling. Data to be used in determining subsurface geology along with seismic profiles.

6. Seismic survey:

Seismic refraction and reflection profiling with improved equipment and geophone spacing. Emphasis on selection of deep drilling site.

7. Preliminary test holes:

Three relatively shallow test holes, about 150 feet (46 m) to be drilled at sites selected on the basis of geophysical data. These holes could be drilled with cable tool rig, with aim of determining depth and thickness of hot water aquifers, plus flow rates and temperature of saline water in subsurface channel sands.

8. Resistivity survey:

Resistivity survey to determine subsurface geometry of sand and gravel aquifers containing saline spring water.

9. Deep test hole:

Deep test hole (400 to 600 feet)(122 to 183 meters) with casing and blow out preventer to be drilled at site believed to be above thermal spring conduit system and/or shallow subsurface reservoir.

### Exploration Budget

Salaries:

2 Geologist I, 5 mos. @ \$2,000/mo.	\$ 20,000
1 Geologic Consultant, 1 mo. @ \$4,400/mo.	4,400
1 Secretary, 1 mo. @ \$1,300/mo.	1,300
Drafting & photographic work, 1 mo. @ \$2,200/mo.	2,200
1 Field Assistant, 3 mos. @ \$1,000/mo.	3,000
TOTAL:	<u>\$ 31,900</u>

Transportation & Per Diem:

Personnel air fares	\$ 1,800
Supervision	900
Field per diem & camp expenses	16,800
280 man days @ \$60/day	
Local air charters	2,000
TOTAL:	<u>\$ 21,500</u>

Materials & Supplies:

Camp & expendable items	\$ 1,000
Explosives	5,000
TOTAL:	<u>\$ 6,000</u>

Services:

Computer time & programming	\$ 3,000
Xeroxing, packaging, etc.	400
Telephone, postage	600
Water analysis	4,000
TOTAL:	<u>\$ 8,000</u>

Equipment Rental:

Power auger and bits	\$ 1,100
TOTAL:	<u>\$ 1,100</u>

Contractual:

Airborne magnetometry contract	\$ 10,000
TOTAL:	<u>\$ 10,000</u>

	SUBTOTAL:	<u>\$ 77,500</u>
If continued (+ overhead @ 100%)		

\$155,000

PRELIMINARY TEST

DRILLING COSTS  
3-150' WELLS  
SHALLOW TESTS

Rig Costs (1) @ \$2,000/day for 6 days	\$12,000
Supervisor @ \$26/hr. for 48 hrs.	1,248
Living expenses @ \$60/day/man	<u>1,440</u>
TOTAL:	<u>\$14,688</u>

The drilling equipment that is used for a geothermal well is somewhat similar to the equipment that is used for an oil and gas well. Never-

theless, there is one major concern with respect to drilling that is different than with oil and gas, and that is in the utilization of drilling mud. While drilling mud is acceptable for an oil and gas well, it can be a problem with a geothermal well in that it may cement the fractures and plug off the geothermal resource. Sometimes salt is used instead of mud to control the geothermal pressure. Also, it is important to take very careful temperature measurements when logging, a less essential procedure in an oil and gas effort.

The drilling plans for the holes necessary for a demonstration space heating project are given in a report by R.C. Stoker. Stoker identifies the drilling materials for the (1) casing, (2) drill bits, (3) casing equipment, (4) drill tools, (5) drill rod, and (6) tubing.

The costs of drilling an exploration hole at Pilgrim Hot Springs are listed in the following cost breakdown. This is once again an ideal site specific situation without downtime, logistics problem and a myriad of other expenses that cannot be calculated. It is hoped that the estimated costs of this 1,000 ft. (305 m) hole can be a base for calculating exploration costs.

#### Drilling Cost Breakdown

These costs are rough estimates courtesy of Dale Spanogle at Hamilton Drilling Company in Anchorage. This drilling company is the only company with experience in geothermal drilling in Alaska. They did the exploratory drilling for the Navy's geothermal study at Adak, Alaska.

Costs are for a rotary core drill (the type used for mineral exploration), which has depth limit of about 3,000 feet (914 m). The hole is to be a narrow one for exploration rather than production, with an outer diameter at the top of 3-1/2 inches and a bottom OD of 2 inches. The hole is to be cased for the entire depth. It is estimated that this drilling may take up to thirty days, thus costs given in this breakdown are for that duration.

Logging costs are courtesy of Floyd Bettis at Schlumberger in Anchorage. Costs assume one month of logging. In reality, a much shorter logging period is anticipated since it would probably be of little use to attempt to log at depths of ground level to 200 feet (61 m). The logging crew and equipment can be called in when needed and may only be needed up to 20 days. Thus, costs cited here are hopefully an upper limit. If one was working on a limited budget adjustments could be made concerning logging as well as drilling requirements.

## DRILLING COSTS

Rig Cost (1).	@ \$2,000/day	30 days	\$ 60,000
Mobilization & Demobilization (2)			48,000
Mobilization related Activities			10,000
Supervisor	@ \$26/hr	390 hrs.	10,140
Living Expenses	@ \$60/day/man	120 man days	7,200
Blowout Prevention			12,000
Track Vehicle Rental	@ \$4,000/mo/ Vehicle	2 vehicles one month	8,000

## LOGGING COSTS

Equipment rental And Crew	\$ 16,820
Transportation (2 Herc Trips)	20,000
	<hr/>
Total cost of drilling and logging:	\$192,160
Contingency @ 20%	38,432
	<hr/>
TOTAL ESTIMATED COST:	\$230,592

### Geothermal Piping

Both at Chena Hot Springs, Alaska and Boise, Idaho, geothermal piping systems have used wood. A number of other materials (black steel, CPVC, PVC, cartina and asbestos cement) have been analyzed for costs by I.A. Engen (Figure 12). Also, an Alaska firm, Energy Systems, Inc., will soon publish cost versus MBTU versus diameter for ten mile long pipe installations. John Beebee is the author of that paper.

His conclusions from his study are attached in Appendix A including costs for hot water pipelines. It is John's estimate that Alaskan pipelines cost three times that of the lower 48.

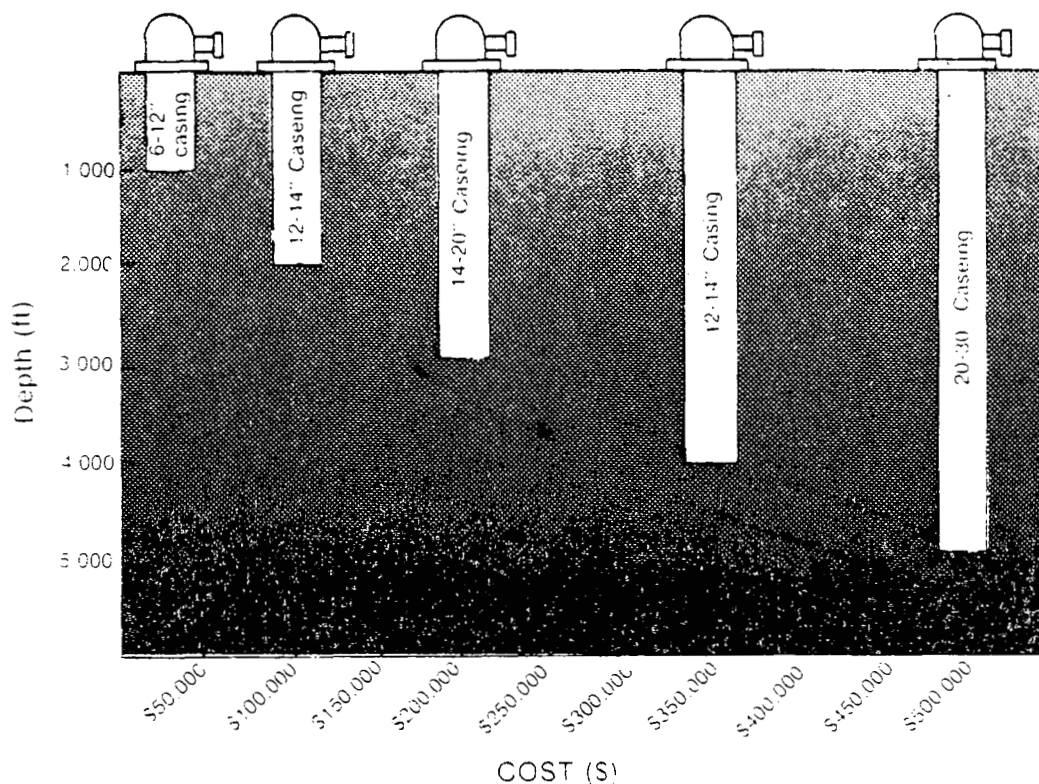
## ECONOMIC RULES

### FOR PRODUCTION DRILLING

(Department of Energy Rules of Thumb)  
(Alaska costs roughly 3 times these)

The graph below shows the approximate relationship between depth and well cost

Figure 11



To determine annual project costs of the well and other capital expenditures should be summed. An acceptable project life and time value of money (interest rate) should be chosen. The annual capital amortization rate  $R$  is given by:

$$R = P \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where:

$R$  = Annual Cost

$P$  = Present Project Value

$i$  = interest rate (annual)

$n$  = life of project (years)

The cost of energy from a geothermal system is determined by the cost of the system and its operation, and the rate of heat delivery from the system. The following nomograph relates these factors. It should be noted that this nomograph is constructed assuming a 100% on stream factor and a 50% efficiency of heat extraction. Actual heat cost should be determined after adjusting these on stream factors and efficiencies.

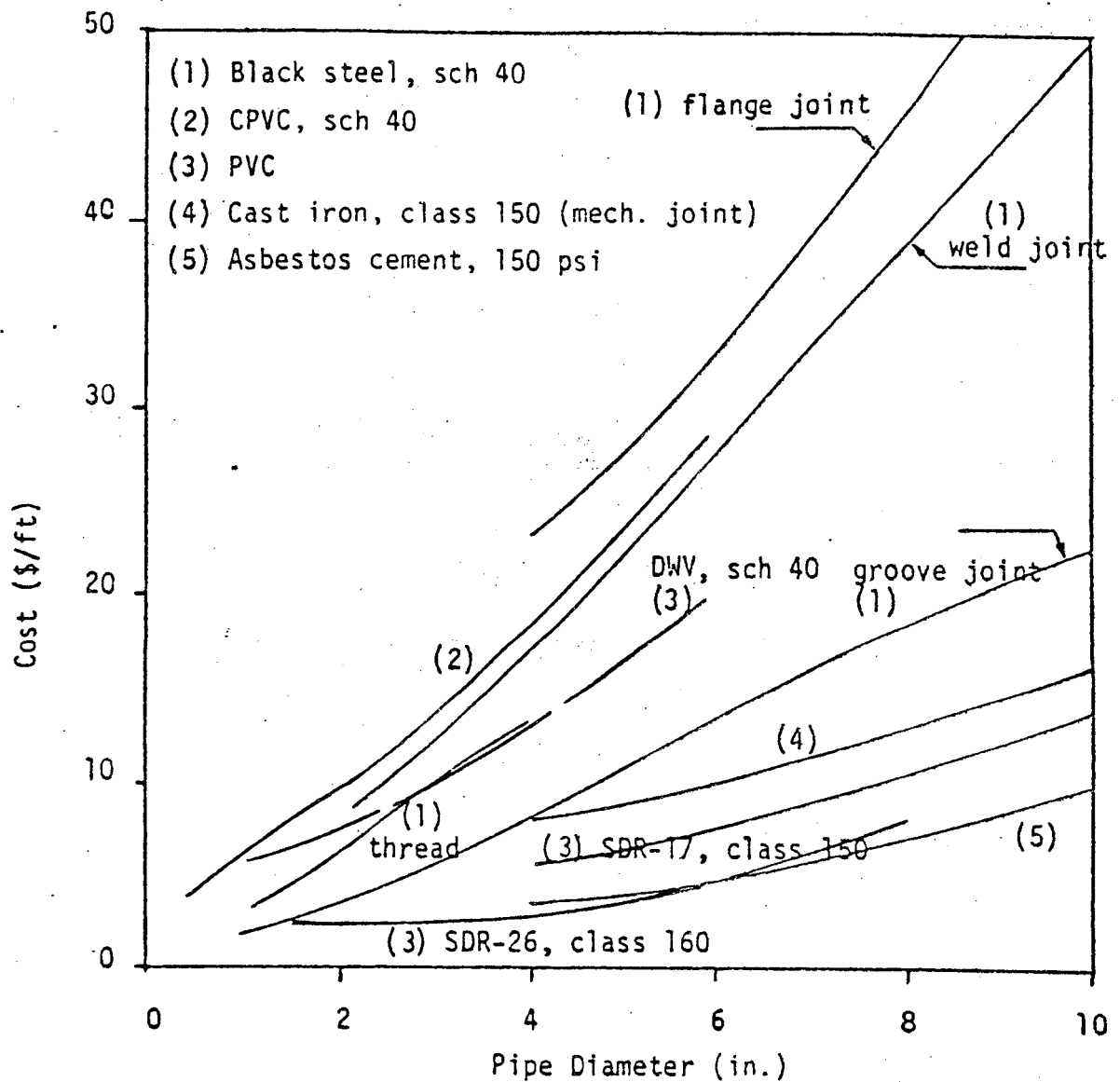


FIGURE 12

### Pipe Installation Costs

(Add \$3/yd<sup>3</sup> for burial service - trench and backfill.)

Source: I.A. Engen, "Residential Space Heating Costs: Geothermal vs Conventional Systems," p. 31.

Alaskan costs are estimated to be three times these for remote areas.



There are several piping materials that can be used to transport the geothermal waters. One is transite, which is a trade name for the asbestos cement manufactured by Johns-Manville. Another piping material is the standard carbon steel piping. Also, polyvinyl chloride, PVC piping, is used up to about 120°F (49°C). Above 129°F (49°C), the temperature and the pressure will be too great to permit utilizing PVC material. As far as availability of PVC piping is concerned, it is sold in retail outlets everywhere. PVCC special pipe material is good to about 180°F (82°C).

Other geothermal piping includes steel and cast iron; however, experience in Alaska and elsewhere has shown that some iron type piping materials are "eaten up very rapidly as a result of electrolytic action that occurs within the pipe." Another hazard is mineral deposits, although these can be minimized by using pipe with a shiny, polished inside surface. A build-up of calcium carbonate, for example, can occur to such an extent that pipe will eventually be plugged. For projects requiring a considerable amount of piping, piping manufacturers will actually design the system and provide cost estimates.

The gallons per minute flow from a well is a function of the inside diameter of the casing. The production flow rate versus well casing diameter is given in Figure 13.

#### Heat Exchangers

In order to transfer the geothermal heat into the air within a building it is not necessary to purchase fancy and expensive equipment. At Circle Hot Springs in Alaska, 30 foot long coils of pipe about five feet high are housed in a room about six feet by thirty feet. The geothermal water warms the pipe and the surrounding air which is blown with a fan to the areas of use.

Another type (water to air) heat exchanger is the well known cast iron radiator so familiar a few years ago. Today steel pipe heating elements, with fins added to increase the transfer of heat to the air, are in frequent use.

Also, heat exchangers may be used down in the geothermal hole (called down hole heat exchangers) in order to prevent direct contact of geothermal waters with the plumbing system, thereby eliminating geothermal corrosion of the system.

The introduction of gas bearing geothermal fluids directly into a home should be discouraged because the release of a noxious gas could be dangerous. The hairpin down hole heat exchangers used in Klamath Falls, Oregon provides a closed system operation resulting in a very clean geothermal system. See Figure 15.

#### The Heat Pump\*

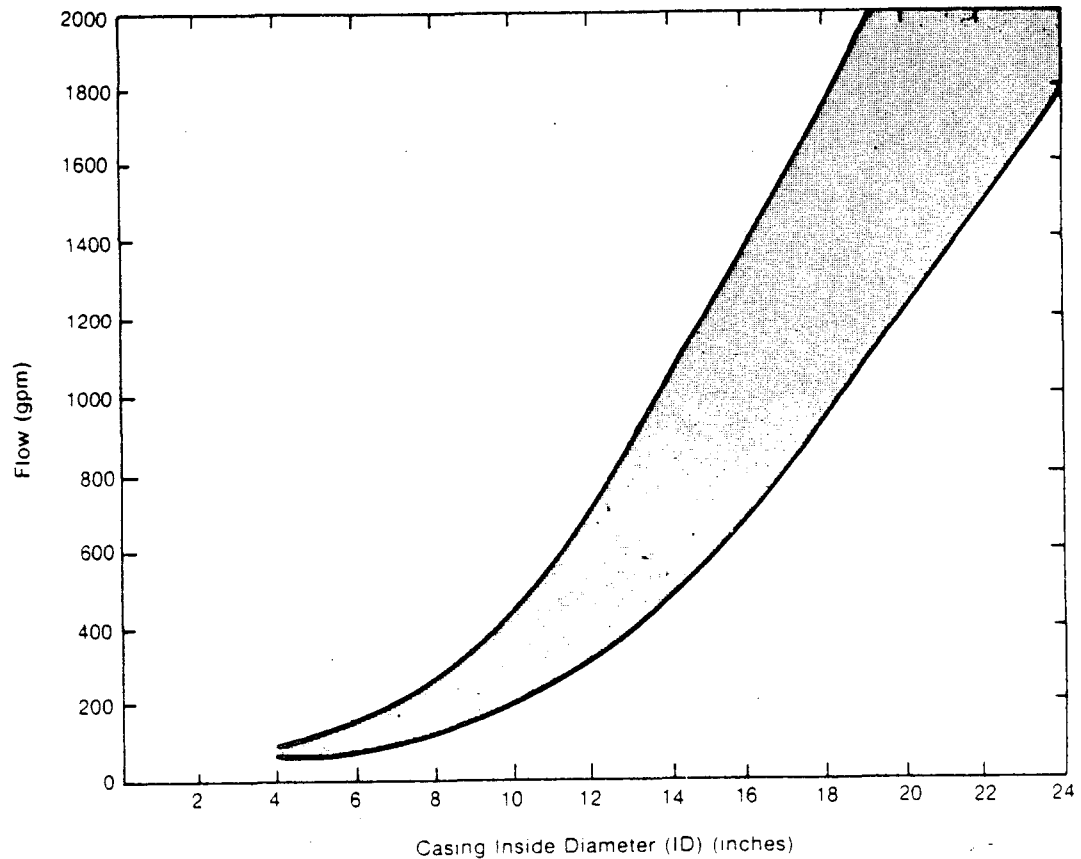
\*Slight modification has been made to a part of an EG & G Idaho, Inc. report entitled "Heat Pumps Primer for Use with Low Temperature Geothermal Resources", by J.G. Keller, November 16, 1977.

(Department of Energy Rules of Thumb)

## RESOURCE DELIVERY RULES

Figure 13

Caseing Size Vs Achievable Flow



Assuming that an adequate resource is available, the graph above shows the relationship between casing ID and produceable flows.

Availability of geothermal water in a given area may be indicated by hot springs, geysers, fumaroles, or existing hot wells. Additional information can be gained by contacting:

The United States Geological Survey (USGS)

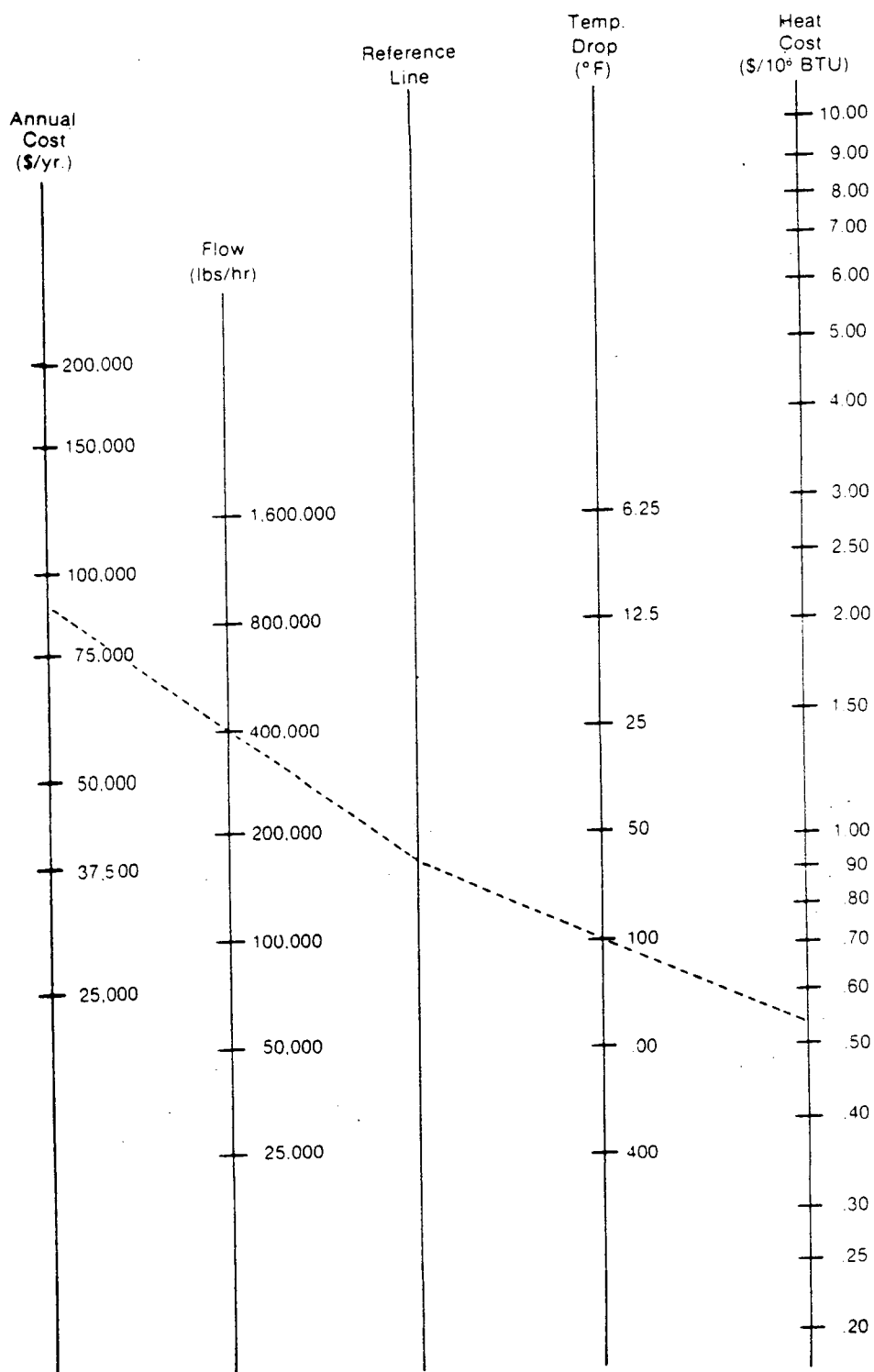
State Bureau of Geology

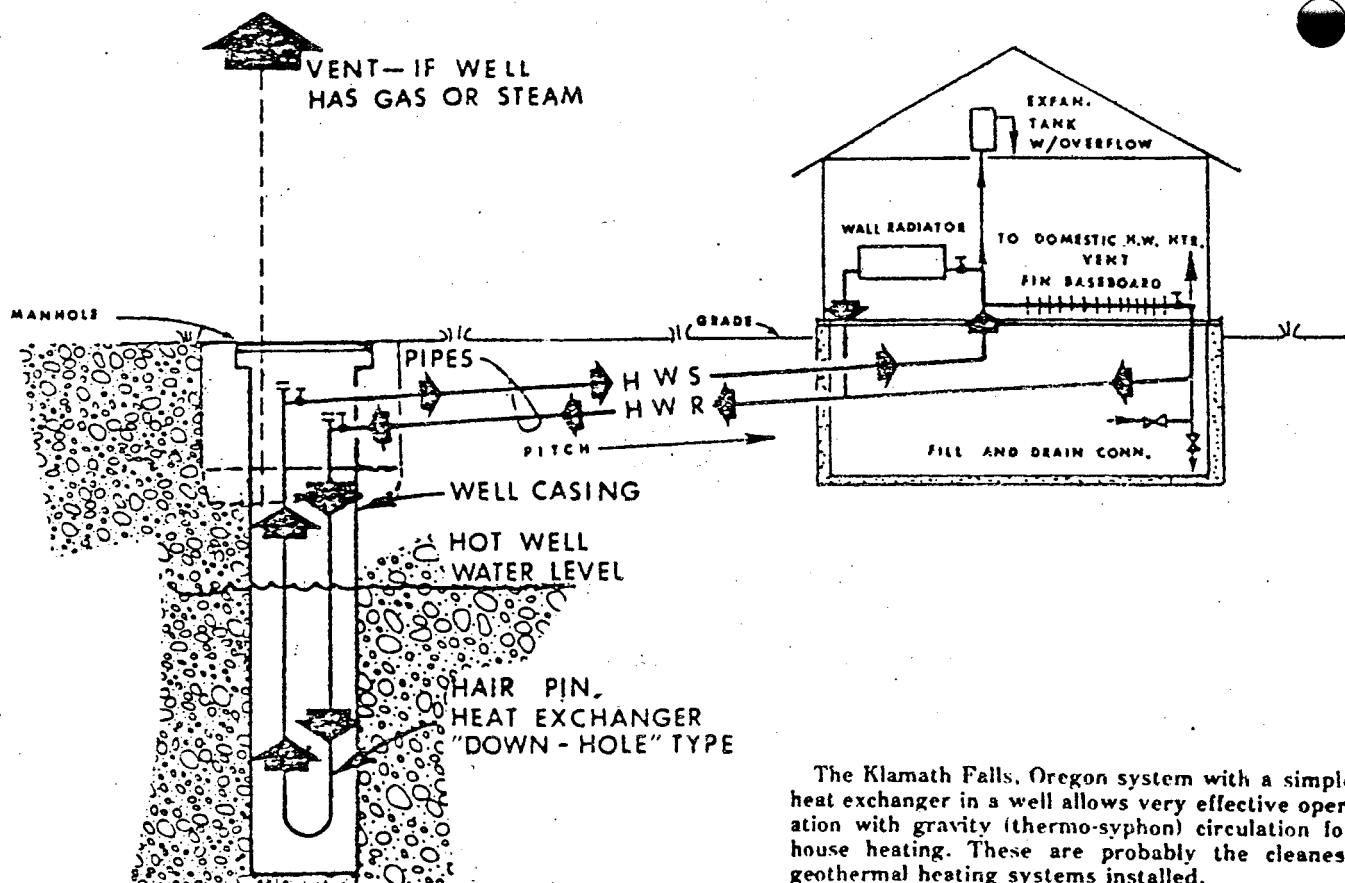
State Water Resources Department

State Bureau of Mines

## GEOHERMAL ENERGY COST NOMOGRAPH

Figure 14





The Klamath Falls, Oregon system with a simple heat exchanger in a well allows very effective operation with gravity (thermo-syphon) circulation for house heating. These are probably the cleanest geothermal heating systems installed.

FIGURE 15

### The Klamath Falls Geothermal Space Heating System

Source: Edward F. Wehlage, The Basics of Applied Geothermal Engineering, p. 164; Original Source: ISGE Transactions, vol. 1, no. 1.

In a residential forced air heating system, hot air in the temperature range of 100 to 140°F (38 to 60°C) is added to the room air to maintain the desired indoor temperature. Absorbing heat from a low temperature geothermal source of 60 to 90°F (16 to 32°C) and transferring heat to provide 100 to 140°F (38 to 60°C) air temperatures might seem impossible when the principle of heat flow from high to low temperature is considered. As implied by the name, heat pumps are to transfer or pump heat from a low temperature to a higher temperature medium. The principle is identical to the operation of a refrigerator, where heat is removed (pumped) from the colder interior of the refrigerator and given off to the surrounding room air. A second fluid is used inside the "heat pump machine," to absorb heat from the geothermal water and transfer this heat to a surrounding space. This secondary fluid is the key to the ability of a heat pump to transfer heat from low temperature sources.

The secondary or working fluid, frequently freon 12 or freon 22, is called a refrigerant. When heat is absorbed by a refrigerant, it undergoes a change of state from a liquid to a gas, much the same as water changes to steam when heated. This change occurs at a constant temperature (the boiling point). The refrigerant will give off heat in the reverse process as it changes from a gas back to a liquid state. If a warm refrigerant while in a gas state is brought into a cool room, the refrigerant will cool and condense, transferring heat and raising the temperature of the room.

Pressure is another property important to understanding the operation of a heat pump. A change in pressure of a refrigerant can lower or raise the boiling temperature. For example, high pressure in a household pressure cooker allows the temperature of water to exceed 212°F (100°C) at sea level atmospheric pressure, however, water will boil at only 198°F (92°C) atop a 14,000 foot (4,267 m) Alaska mountain where the atmospheric pressure is below normal. By manipulating the pressure, the refrigerant under reduced pressure can absorb heat from a low temperature source and change to a gas, and at a high pressure, the heat of the refrigerant can be given to a higher temperature substance while changing back to a liquid. Thus, a heat pump refrigerant can absorb heat and become vaporized from a low temperature geothermal source and transfer this heat to the higher temperature room air by condensing to a liquid.

A schematic diagram illustrates these processes with the various stages numbered and described in Figure 16.

The process is continued as heat is removed from the low temperature geothermal water and transferred to the higher temperature room air. Return air ducts collect cool room air while supply air ducts provide the heated air to the room in much the same manner as a conventional forced air heating system only in the heat pump case, the condenser coil replaces the fire box. Geothermal water from a spring or well is piped to the evaporator. The cooler geothermal water leaving the evaporator is then discharged. The heat pump schematic in Figure 16 is termed a water-to-air heat pump as it uses water as the heat source and air as the delivery medium.

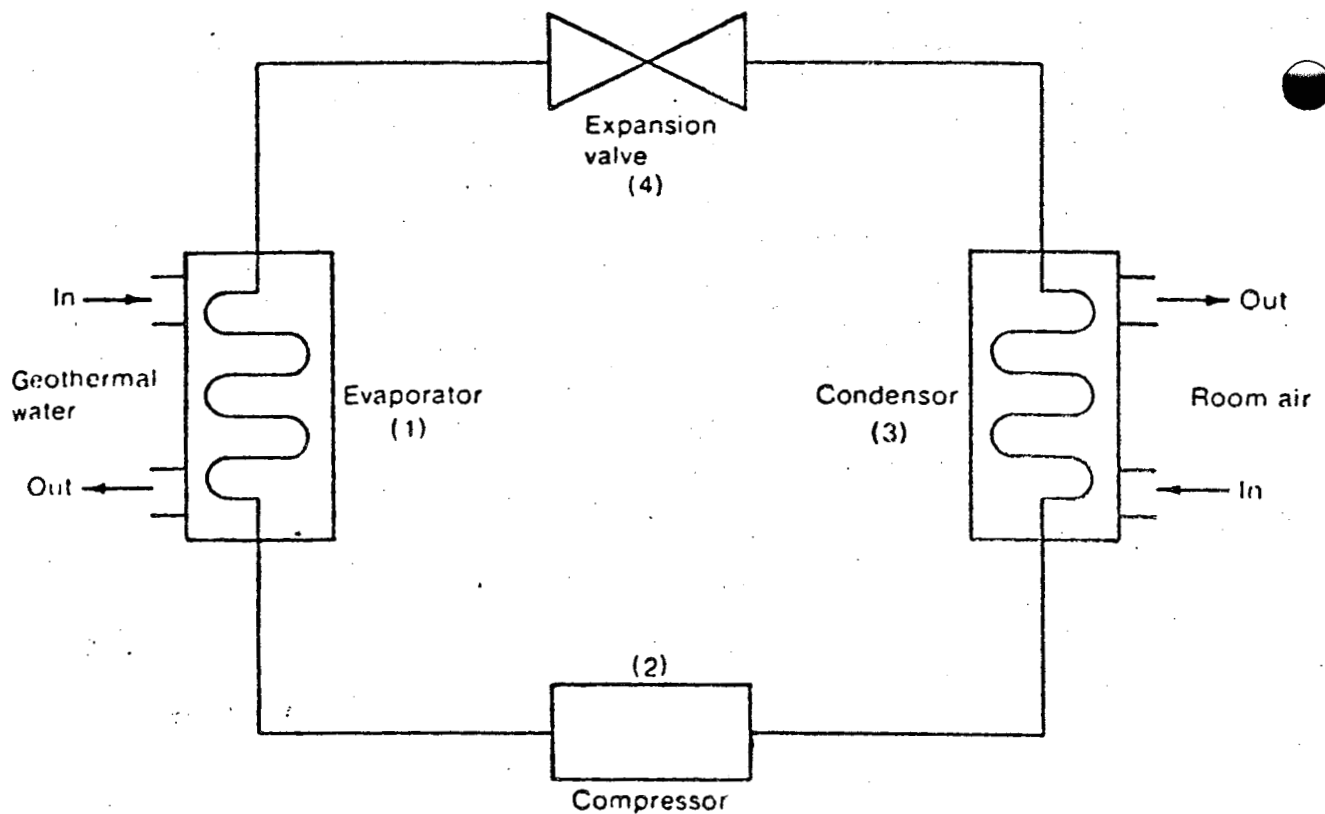


FIGURE 16

### Heat Pump Schematic

1. The refrigerant enters the evaporator at low temperature and pressure as a liquid. In the evaporator, low temperature geothermal water transfers heat to the refrigerant which becomes vaporized. The refrigerant is capable of vaporizing at this low temperature because of the low pressure.
2. The refrigerant enters the compressor as a gas at low temperature and pressure. As a result of compression, the refrigerant leaves at high temperature and pressure.
3. The refrigerant enters the condensor as a gas at high temperature and pressure. Heat is given up to the room as the refrigerant condenses to a liquid at high pressure. The refrigerant is capable of condensing at high temperatures because of the high pressure.
4. The refrigerant enters the expansion valve as a liquid at high pressure and low temperature. As the pressure is reduced, its boiling point decreases and part of the refrigerant is vaporized cooling the remaining liquid.

Sources: J.G. Keller, "Heat Pumps: Primer for Use With Low Temperature Geothermal Resources," p. 5.

A requirement for a heat pump is electrical energy to circulate and compress the refrigerant. But for each electrical energy unit used, two, three, or more equivalent units of heat energy are transferred from the source. The efficiency of the heat pump is the ratio of these two energies and is called the coefficient of performance (COP). It is given by the formula:

$$\text{COP} = \frac{\text{Quantity of heat energy delivered}}{\text{Quantity of energy supplied to operate the device}}$$

The key to understanding the operation of a heat pump is to remember that it takes heat to change a liquid (the working fluid) into a gas with no change in (boiling) temperature for a given pressure. Also, heat is released as the gas returns to the liquid state at a constant temperature and pressure. With a change in pressure this boiling temperature changes; therefore, it is necessary to obtain a working fluid that has the desired boiling temperatures versus pressure properties. With a pump, it is possible to (a) control the pressure of the fluid which in turn controls the boiling temperature and (b) move the fluid from the location where heat is extracted to a location where the heat is utilized (e.g. a home or building) or discharged (e.g. outside a refrigerator).

Kunze and Forsgren have analyzed the economics of the heat pump as a device to assist in geothermal district space heating using 55°F (13°C); 80°F (27°C); 130°F (54°C) and 180°F (82°C) geothermal waters. Whether or not a system is economical depends upon a number of variables such as climate, BTU requirement and price of competing energy. Kunze and Forsgren concluded that pumping costs are less than 20% of the total costs.

#### Technology Summary Documents

More detail on geothermal technology, including design procedures for house heating, hydraulics and pumping instrumentation and the mechanical/electrical aspects of geothermal hardware, is given in a book entitled The Basics of Applied Geothermal by Edward F. Wehlage, published by Geothermal Information Services, 318 Cherrywood Street, West Covina, California 91791.

For a recent publication on technology, the 748 page transactions of the annual meeting of the Geothermal Resources Council held in Hilo, Hawaii of July 25-27, 1978, are available from P.O. Box 98, Davis, California 95616.

Last but not least are the costs for development in Alaska. The cost index for construction in Anchorage is 1.8 times the average for the lower 48. This figure can easily jump to ten times on remote locations.

#### Economic Comparisons:

Hopefully the price breakdowns will be examples that can be followed when planning for site specific analysis.

The important criteria though is whether geothermal is competitive with other forms of energy. Clifton Stine of the Mechanical Design Branch of the Aircraft Armament Division System Development Department for the Energy Program Management, Naval Weapons Center, China Lake, conducted a technical/economic comparison of alternate energy systems at Naval Air Station/Adak. The following summary indicates the feasibility of geothermal energy in remote areas in Alaska.

#### SUMMARY

This study was conducted to provide a preliminary evaluation on the use of geothermal resources at Adak, Alaska, to provide power and heat for the Naval installation at that location. Surface exploration indicates that a good potential exists for usable resources in the vicinity of the Navy complex. However, an expensive drilling operation will be required to actually define the geothermal system and its associated fluids. The questions answered by this study are: "If a good geothermal system exists, how do the costs compare to existing fossil fuel systems and other alternate energy systems that might be employed? Hence, are the geothermal resources at Adak worth developing?

A 25-MW power level was assumed for electricity and heat. This provides for projected facilities growth as proposed radar and communications systems are added. The systems considered by this study were:

1. A geothermal system to provide 25 MW of electric power for both utility electricity and heat.
2. A geothermal system to provide 15 MW of electricity with heating accomplished using geothermal fluids.
3. A nuclear system to provide 25 MW of electric power for both utility electricity and heat.
4. A wind power system with pumped hydrostorage to provide 25 MW of electric power for utility electricity and heat.
5. A tidal system at Finger Bay to provide 25 MW of electric power for utility electricity and heat.
6. A proposed modern fossil fuel system to provide 15 MW of electricity with heating accomplished as at present, with JP-5 jet fuel.
7. The present fossil fuel system which provides 15 MW of electrical power with JP-5 fuel used for heating. This is considered the baseline.

An economic comparison is given in Table 1 with the undiscounted and discounted cost and time (in years) to complete. The numbers are preliminary at this point, but they show further exploration and development of the geothermal resource is attractive.



TABLE 1. Uninflated Costs of Alternative Energy Systems for Adak, Alaska

System	Undiscounted cost \$ x 10 <sup>6</sup>	Present worth 10% discount \$ x 10 <sup>6</sup>	Years to completion
25 MW geothermal total electric	18.33	13.8	3
15 MW geothermal/ space heating	20.97	14.52	5
25 MW nuclear total electric	61.82	33.90	8+
Wind/pump storage	116.52	60.89	8+
unacceptable because of earthquake activity			
Tidal			
15 MW fossil fuel	81.90	37.87	5-7
Baseline (main- tain existing facilities)	68.75	26.19	0

### Geothermal Incentives

This past year the Federal Government passed legislation to give the same tax advantages to geothermal drilling as oil drilling for intangible development costs. These advantages along with the Alternate Energy Tax credits, of the National Energy Plan, give both credits and deductions on Federal Income and Corporate taxes. The credits offer 30% of the costs of Alternate Energy Systems on and up to \$2,000 worth the expense to the developer. See Appendix E for detailed tax information.

The State of Alaska offers a tax credit for energy conservation measures that would allow up to \$200 tax credit for geothermal applications.

Aside from these tax incentives there are programs on the Federal level to allow for geothermal development cost sharing and grants. Program opportunity notices and program research and development announcements are methods to obtain funds from the Federal Government. Recently an Appropriate Technology Grants program was announced. These programs are periodically announced by the U.S. Department of Energy. The funds vary

from cost sharing of larger projects and grants for exploration costs, to total funding individual with ideas that are appropriate to the area.

Technical assistance is also available from the Oregon Institute of Technology Geo-Heat Utilization Center through a Federal Department of Energy Program. Up to 100 hours of free to the user time is available under this program for engineering expertise.

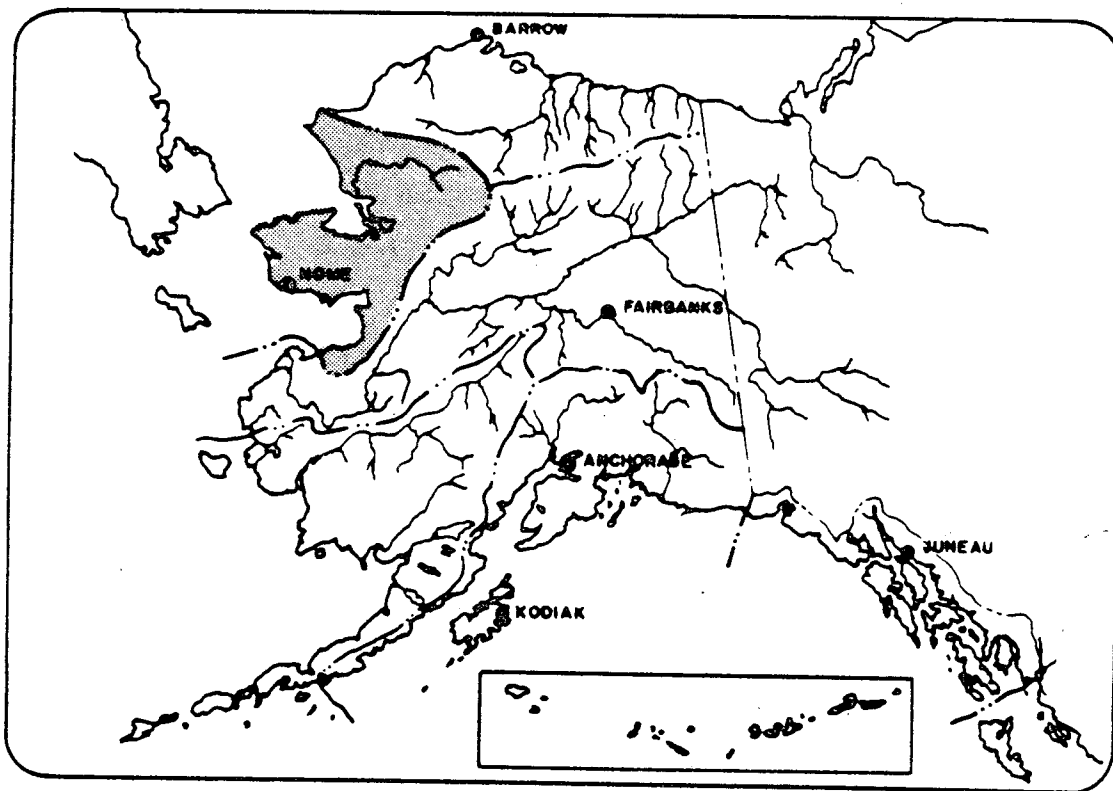
The state of Alaska has an alternate energy revolving loan fund. Up to \$10,000 can be borrowed from the Division of Economic Development Department of Commerce for up to 20 years at 8% interest. This money is loaned for the installation of alternate energy devices and systems. To date money has not been appropriated for this fund.

The state also has an office of Appropriate Technology in the Governor's Office. To date money has not been appropriated but it is likely that grants will be made through this program in the next few years.

During the last legislative session the state passed a bill establishing the renewable Resource Fund. This establishes a corporation that will receive 5% of the state royalties from the permanent fund to develop the states renewable resources. Geothermal applications to renewable resource development should qualify for loans and grants from this program. Quite a bit of money will come available when this fund becomes operational this coming year. An estimated 300 million dollars will be put into this fund over the next 15 years.



## Northwest Region



## NORTHWEST REGION

The Seward Peninsula is bounded by Norton Sound to the south, the Bering Straits to the west and Kotzebue Sound to the north. Permafrost is continuous throughout the peninsula, but is not as thick as in more northern areas. The climate is mostly transitional, which becomes continental as one travels east.

The population is low and scattered with Nome as the only major population center. Only a few intra-regional roads exist. Winter trails are extensive, including a major portion of the Iditarod trail. Summer surface transportation depends heavily on the river and the sea. This area is a remote and barren land. It has mineral wealth and is peopled by rugged men and women capable of handling the hostile environment. Eighty-five percent are native.

### Climate

Long severe winters are characteristic of the climate of the Northwest Region. Summers are cool, windy and often wet along the coast. Interior sections are relatively warm with increasing rainfall as summer progresses. Summer fahrenheit temperatures generally range from the low 30's to low 50's (0 to 10°C). In the interior peninsula, 50 miles (80 km) from the coast, the temperatures reach the high 60's (15°C). In the winter, coastal temperatures range from -5 to 20°F (-15 to -7°C). In the interior they range from -20 to -5°F (-30 to -15°C). The annual precipitation averages less than 20" (51 cm). Most of the precipitation occurs as rain in late summer and early fall.

Winds average 10 to 15 knots year round. Calm periods occur five to fifteen percent of the time at most locations.

General weather conditions in northwest Alaska require pilots to be constantly alert. In addition to wind, pilots must also deal with reduced visibility from fog, rain, snow and white-out conditions. Weather systems frequently form in areas where no weather observations are available to aid the pilots. The Brooks Range, to the north, is the only natural barrier that reduces penetration of arctic storms into the area.

The growing season and number of growing degree days are not adequate for extensive agriculture, but certain garden crops, flowers, trees and shrubbery grow quite well at some of the inland locations.

The solar radiation change this far north is spectacular. For 120 days, the sun never dips more than 12 degrees below the horizon in summer, and in the winters, there are days that the sun doesn't peak above the horizon north of the Arctic Circle.

Soil temperature near the surface run from 15 to 26°F (-9 to -3°C) in the summer. There is a time lag between temperatures near the surface and those deeper in the soil. In some instances, the coldest air temperature occurs in February, but the coldest ground temperature, 22 feet down, may not be until July or September. This suggests the problem of freezing pipes, even in the summer.

Lakes and rivers are important transportation links. The length of time that vehicular traffic can normally travel on the ice would be late October to the middle of May for the interior. Along the coast, the season would be shorter. There is a two week break-up period that normally is attached to the end of the spring season, as well as a two-week freeze up period in the fall.

There is almost always a temperature inversion in Alaska's arctic. In the winter, when ground temperatures are the coldest, the inversions are most persistent. Air pollution has not been a problem, and probably won't be except under special circumstances; those being temperature inversion limiting vertical escape, land forms that limit horizontal escape, little or no wind, and polluting source. Wind and source so far has limited pollution in this area.

There are other weather conditions that one should be aware of: white-outs and blizzards can send one into a state of vertigo. Snow blindness can disable a person on a bright winter's day; wind chill factor can drain body heat in a matter of minutes if one is not prepared for the harsh environment.

#### Marine Environment

The environment is heavily influence by ice, which covers the region most of the year. The ice itself, particularly its substance, and other marine influences, such as tidal motion and coastal water depths which affect ice formations and scour, profoundly affect the regions fauna and flora. There is a persistent northward-moving ocean current that moderates the marine environment. It delivers warm, low salinity water diluted by the Yukon fresh water into the Bering Straits. There are considerable marine mammal populations, and limited commercial fisheries exist in both Norton and Kotzebue Sounds.

Ice formation begins in October and the permanent polar ice pack edge begins to move counter-clockwise, generally toward Siberia. The ice reaches its maximum southern exposure by the Ides of March. By early summer, the Bering Sea is essentially free of ice. The Bering Straits are clear by late June.

Yukon sediments are distributed northward by currents. Sea waves average approximately five feet, and tides run in the neighborhood of three to five feet (1 meter).

#### Topography

The extensive uplands of the peninsula consist of broad, covered hills and flat divides that are 500 to 2,000 feet (152 to 610 meters) high. These uplands are indented by sharp, v-shaped valleys, isolated groups of rugged, glaciated mountains 20 to 60 miles (32 to 96 km) long and 10 miles (16 km) wide with summits 2,500 to 4,700 feet (762 to 1,433 m) high, and coastal lowlands and interior basins.

Drainage includes many small rivers with sluggish, meandering lower courses. Some of these build deltas into the heads of protected bays.

The interior basin is drained through narrow canyons across intervening uplands.

The lowlands have many thaw lakes, and there are several rock basin and morainal lakes in the glaciated Bendelebem and Kegluvik Mountains. Lakes fill several large shallow volcanic craters in the northern part of the peninsula and several depressions between lava flows in the central uplands. There are no glaciers on the peninsula.

The northwest coast of the peninsula consists of lagoons and barrier islands. No large rivers empty into the sea in this area. There are no real harbors on the north coast.

### Geology

Scientists do not entirely agree on the geologic history of the Northwest Region, but the basic framework of the area has been developed (Holmes, 1975).

In Paleozoic time, a broad sedimentary trough, known as the Brooks Range geosyncline existed in the approximate location of the present range and coastal plain. It was bordered on the north by the high arctic platform and on the south by the Yukon shelf. The sediments that vent into the geosyncline come from the arctic platform.

During Triassic time, sedimentation continued from the north, but the site of the present Brooks Range stabilized and limestones were formed. During mid-Jurassic time, mountain building began, which eventually resulted in the formation of the topography of today. Uplift was initiated in the southern part of the Brooks Range geosyncline. Though there was no emergent land mass yet in the Brooks Range, there was a positive stable feature in the location of the Baird Mountains. In the Yukon-Koyukuk Basin, south of the Brooks Range, volcanic activity began.

By Cretaceous time, the Brooks Range was a dominant land mass. During this time, the influence of sedimentation from the arctic platform ceased, as it subsided or rifted from northern Alaska. In late Cretaceous time, the Brooks and DeLong Mountains were intensely deformed and the present east-west fold trends established.

Thrust faults in the Lisburne Hills from late Cretaceous to early Tertiary were probably connected to a thrust zone in the eastern Seward Peninsula and western Yukon-Koyukuk Provinces. This thrusting was probably related to an eastward drift of the Siberian plate. A marine connection between the Pacific and Arctic Basins on the eastern side of the Seward Peninsula was closed.

Diabase and granite intrusions were emplaced in the Seward Peninsula during early Cretaceous time. In mid-Cretaceous time, eroded volcanic debris filled small troughs between volcanic uplands. Granitic plutons intruded the western and central parts of a belt from the Seward Peninsula to the Kobuk Valley. The thermal springs in the area are associated with these plutons. Faulting and thrusting continued as the Seward Peninsula was forced east by the Siberian plate.

In early Tertiary time, there was a strong uplift of the Brooks Range. During Tertiary and Quaternary time, several periods of active volcanism produced flows and debris. Flows and craters are found in northern and eastern Seward Peninsula, Buckland River Lowlands, and near St. Michael.

During Pleistocene time, the glaciers periodically inundated the area and exposed the so-called Bering Land Bridge. At present, the western half of the Seward Peninsula is principally underlain by Ordovician to Silurian limestone, slate and schist, Pre-Silurian crystalline limestone, schist and gneiss, intrusive granitic rocks in the Kigluack Mountains and western tip of the peninsula. Paleozoic phyllite and slate are found in the northwest, and Quaternary basalt and Mississippian limestone to the west.

In the eastern part of the Seward Peninsula, the northern margin is principally characterized by Paleozoic phyllite and slate and the Devil Mountain area is underlain by Quaternary basalts. A few Mesozoic basic extrusives and granitic intrusives are also found. To the south, bedrock includes basaltic lava flows and basaltic andesites in the Imuruk Lake region, intruding paleozoic schist and gneiss. To the east, more volcanics.

The southeast part of the Peninsula consists of the same rocks, but the dominant types are metamorphosed sedimentary. The main outcrops of intrusive rocks are in the Darby and Bendeleben Mountains.

Permafrost and erosion are primary geologic phenomena to be considered in developing this area. These efforts have far reaching impact on man's occupancy. Earthquakes and volcanism are insignificant. Thermokarst topography is common, as are ice wedge polygons to the landscape. Braided streams, pingos, frost mounds, soilification and garlands are also common where there is permafrost. Engineering limitations associated with permafrost are not the same for every rock type or sediment, but in all cases they are important.

Erosion can be a major problem where the insulating tundra is torn away from the frozen ground. There is a long time period needed to establish the tundra. For this reason it is virtually impossible for nature to stop erosion once it begins.

#### Mineral Resources

Mineral resources have greatly influenced the region's settlement pattern and economics. It all started in 1898, when three Scandinavian prospectors struck gold on Anvil Creek, a short distance from Nome. In two years, 12,000 people lived in Nome. Mining activities have steadily declined to the present from the big rush of 1900, but interest is presently being shown in offshore gold and mineral reserves on the peninsula. Minerals mined so far include: gold, silver copper, iron, zinc, lead, manganese, tin, beryllium, antimony, bismuth, mercury, and molybdenum. Gold by far, has been the most sought after mineral with close to six million ounces taken so far. A major mine now exists at Lost River, northeast of Nome, but is not currently in operation.



Asbestos, jade, talc, graphite, fluorite, mica, garnet, limestone, barite, phosphate and gravel have all been found in quantities that have potential economic value.

#### Petroleum

The presence of oil and gas appear to be most favorable in the basin that contains sediments of Cenozoic age. The Selawik Basin north, and Norton Sound south of the Peninsula are most promising. Lease sales for offshore are being considered in the 1980's.

#### Water

The presence of water, especially ground water, is greatly altered by severe climate and permafrost. Most precipitation runs off the land to the drainage systems as surface water. Permafrost prevents the downward and lateral movement of water. Water and sewage disposal are major problems in the arctic because of this.

#### Terrestrial Vegetation

In the Northwest Region, the vegetation is varied and includes moist tundra, alpine tundra, wet tundra, upland spruce hardwood forest, bottom land, spruce-poplar forest, lowland spruce hardwood forest, high brush and low brush muskeg. Transition zones are common between these plant communities.

#### Terrestrial Animals

Dall sheep live in alpine tundra, moose, wolves, wolverines, weasles, bear, caribou and, recently, reindeer have a more varied habitat. Fur bearers have always been a part of the subsistence lifestyle of the north. Musk oxen have been planted in certain areas.

One hundred-twenty terrestrial and aquatic species have been recorded in this area. Peregrine falcons and Eskimo curlews are endangered species that are near. The north peninsula is a major migratory bird nesting area.

Sea mammals abound along the coastal waters, including walrus, four species of seals, ten species of whales and polar bear.

#### Utilization of Biotic Resources

Subsistence: Marine mammals are the mainstay of coastal and island peoples. On the peninsula, moose is very important as are ptarmigan, grouse, snow owls, porcupines and hares. Salmon has been a mainstay, as well as other fish, with salmon providing up to 40% of the diet.

Commercial: Fur trapping is decreasing and fisheries are increasing. Fishing has been sporadic due to a lack of processors and buyers and inadequate tendering services for collecting fish from fishermen. Reindeer production is once again on the rise. At this time 16.9 million acres are leased for grazing.

As game rich areas are overhunted and the population of the biotic community decreases, recreational hunting and fishing activities are shifted to more remote, inaccessible regions. The impact of new restricted hunting zones resulting from the recent Antiquities Act withdrawals will seriously effect the commerce associated with sport hunting and fishing.

### History

Northwest Alaska may prove to be the cradle of civilization in the Western Hemisphere. About 40,000 years ago, man lived on the Asian side of the Bering Sea. From there, it is postulated that he entered North America over the "Land Bridge" along the edge of the ice sheets.

Early estimates of population from historic times have varied greatly. Anthropologists currently estimate between 2,000 and 2,400 persons lived on the Seward Peninsula during the 1800's (Ray, 1964).

The inhabitants spoke two dialects of Inupiat. South coast natives spoke Unalit, St. Lawrence group spoke Yupik. The general native settlements in the region were coastal and riverway, depending on food and shelter.

The white man's entrance in this area followed this sequence: first, came the explorationists, then the Russian whalers, trappers and traders, American whalers, trappers and fur pirates. In the 1870's, serious scientific investigation started and in the 1890's, the educators and missionaries came. The gold stampede and the merchants arrived at the turn of the century, forming the largest influx of population to date. The population declined until World War I; after the War it stabilized and has remained about the same.

The area from Cape Lisburne to the Yukon has a population of only 10,000 people today. The population density for the entire Northwest region is approximately one person per 6.8 square miles.

### Economy

Although western civiliation has changed the pattern of Eskimo life considerably, most Natives in the Northwest still remain economically and culturally oriented to the same subsistence resources that supplied their culture prior to contact with the western world. Except for Nome and a few mining camps, every settlement in the region is located according to the availability of game, fish or fuel.

Northwest Alaska Native Association, and Bering Straits Native Corporation are investing Native dollars to establish industries in the area while maintaining the cultural heritage. Fishing, building trades and mineral exploration have been prime targets.

### Employment

At present, the cash income of the region is based on government spending (services, public assistance and public works), tourism,

mineral exploration and export of locally produced goods. Government is by far the most important primary source of income and its base in the regional economy is growing. The level of economic activity in the region is low, as reflected in the high unemployment rates and low per capita income. Non-Natives dominate the cash economy though comprising only 15% of the population. Unemployment averages 16.9%.

### Transportation

Transportation in Northwest Alaska is perhaps the most undeveloped in the nation. Except for a few miles of traditional roads, overland transportation is limited to snowmachines during the winter. Lacking adequate seaport terminals and transfer facilities for cargo, residents of the region seasonally pay high prices at the shallow ports of Kotzebue and Nome. Air transportation is the bottom line in transportation.

### Communications

A new network of earth stations was initiated in 1975 as part of a statewide program. These stations provide a toll telephone circuit and a channel for emergency and medical use for eight of the more remote communities. There are three newspapers and two radio stations, in Kotzebue and Nome.

### GEO THERMAL

Northwest Alaska has numerous hot spring locations within the region. Pilgrim, Serpentine, Inmachuk, Lava Creek, Kwiniak, Kachanik, Clear Creek, Granite, Kiana, South, Souby, Hawk, and Purcell.

The occurrence of most of these hot springs are spacially associated with contacts between granite plutons and the surrounding country rock. The occurrence of hot springs appears to be independent of the age, composition or magmatic history of the pluton. Most of the analyzed hot springs appear to have chemical and isotopic compositions indicating that they were derived from deeply circulatory meteoric waters (Miller, 1973). Recent volcanic zones are also found on the Seward Peninsula. In the northeast portion of the Peninsula several volcanic expressions are noted in the Cape Espenberg area. The Imuruk Basin volcanoes occupy the central region of the Peninsula. The Selawik Basin has been inundated with recent volcanoes as well. The Imuruk Basin has had eruptions less than 10,000 years ago.

The local gradient potential of the sedimentary basins of Norton Sound and the Selawik Basin hold promise for geothermal production. The local gradient of the Kotzebue area of the Selawik Basin is 40°C per kilometer which is above the world norm (Forbes, 1976).

Serpentine P.G.R.A. contains a hot springs by the same name.

SERPENTINE HOT SPRINGS, ALASKA

KATEEL RIVER MERIDIAN, (Unsurveyed)

T. 5 N., R. 28 W.  
T. 6 N., R. 28 W., S/2  
T. 5 N., R. 29 W., E/2  
T. 6 N., R. 29 W., SE/4

Containing 68,965 acres, more or less

Pilgrim K.G.R.A. contains 25 square miles of unfrozen ground and the Hot Springs.

PILGRIM SPRINGS, ALASKA

KATEEL RIVER MERIDIAN (Unsurveyed)

Tps. 4 & 5 S, Rgs. 30 & 31 W.

Containing 91,572 acres, more or less

The Imuruk Basin contains the Quaternary volcanic cones Dryas, Andromeda, Cassiope, Camille, Rhododendron, Blueberry, Gosling and Lost Jim. Inmachuk Hot Springs is also located here.

IMURUK BASIN, ALASKA

KATEEL RIVER MERIDIAN, (Unsurveyed)

Tps. 1 & 2 N., R. 20 W., W/2  
T. 3 N., R. 20 W.,  
    Secs. 4 to 9  
    Secs. 16 to 22  
    Secs. 27 to 33  
T. 4 N., R. 20 W., W/2  
Tps. 1 to 6 N., Rgs. 21 and 22 W.  
Tps. 1 to 4 N., Rgs. 23 to 25 W.  
T. 5 N., R. 23 W.,  
    Secs. 1 to 3  
    Secs. 10 to 15  
    Secs. 22 to 27  
    Secs. 31 to 36  
T. 6 N., R. 23 W., E/2  
T. 5 N., R. 24 W.,  
    Secs. 34 to 36

Containing 619,543 acres, more or less

The Darby Mountain P.G.R.A. contains Kwinink, Kachavik and Clear Creek Hot Springs.

DARBY MOUNTAINS, ALASKA

KATEEL RIVER MERIDIAN, (Unsurveyed)

Tps. 7 & 8 S., Rgs. 17 to 21 W.

Containing 229,670 acres, more or less

Granite Mountain P.G.R.A. contains one reported hot spring.

GRANITE MOUNTAIN, ALASKA

KATEEL RIVER MERIDIAN, (Unsurveyed)

T. 1 N., R. 12 W., SW/4

T. 1 N., R. 13 W., SE/4

T. 1 S., R. 12 W., W/2

T. 1 S., R. 13 W., E/2

Containing 34,287 acres, more or less

The Selawik River P.G.R.A. contains Hawk, Purcell and Souby Hot Springs. South Hot Springs is located just to the south of the P.G.R.A.

SELAWIK RIVER, ALASKA

KATEEL RIVER MERIDIAN, (Unsurveyed)

Tps. 10,11,12, & 13 N., Rgs. 6,7,8,9, & 10 E.

Containing 457,655 acres, more or less



NORTHWEST REGION  
SITE DATA SUMMARIES





## PILGRIM HOT SPRINGS

Pilgrim Hot Springs is located on the Seward Peninsula approximately 42 miles (68 km) northeast of Nome. Access is by air to a small landing strip or by track vehicle. The Nome-Taylor road is 7 miles (11 km) east of Pilgrim.

Pilgrim Springs is in the wide flat valley of the Pilgrim river 1/3 miles (1/2 km) south of its banks.

The Valley is mantled by alluvial fill. The larger springs and associated seeps emerge from channel sands and silts in an abandoned loop of the Pilgrim river. However, other seeps and patches of warm ground occur in the adjacent area (perhaps old meanders).

This spring system is the site of a proposed exploration effort being conducted by the State of Alaska, Division of Energy and Power Development. The 1978 Legislature appropriated \$245,000 for this effort. D.E.P.D. has requested additional funding from the Federal Department of Energy to complete an exploratory effort and develop a demonstration project at the spring site.

The project will be conducted on ground owned by the Catholic Church and leased to Pilgrim Hot Springs Limited. The project will follow the following outline.

### PILGRIM SPRINGS GEOTHERMAL PROJECT

#### Proposed Project Outline (Prepared by R.B. Forbes)

#### 1. Aerial photography and infra-red imagery:

Recurrent low level (1,000 ft.(305 m)) color aerial photographs of snow melt patterns following onset of winter snowfall, and spring breakup. Melt patterns to be used as a guide for temperature survey grid. Request to be forwarded to Air Force for infra-red imagery of Pilgrim Springs area.

#### 2. Thermal grid survey:

Downhole temperature survey, utilizing augers. Holes to be drilled at pre-determined grid survey locations. Temperature gradient data to be supplemented by water table measurements and soil and water sampling. Temperature data to be plotted on isothermal maps of the area.

#### 3. Magnetometer survey:

Airborne magnetometer survey at elevations of 500 and 1,000 feet (152 and 305 m) above terrain, supplemented by surface survey. Survey to be based on flight and traverse lines with 250 feet separation.

4. Water temperature and chemistry:

Spring water temperatures to be determined at points of upwelling and in subsurface aquifers with thermal probes. Water samples to be obtained from subsurface and surface, and comparative chemistry used for determining mixing ratios with local groundwater table and revised deep reservoir temperatures based on geothermometry.

5. Seismic survey:

Seismic refraction and reflection profiling to supplement previous work. Emphasis on selection of deep drilling sites.

6. Test holes:

Three relatively shallow production test holes (about 150 feet (46 m)) to be drilled at sites selected on the basis of geophysical data. These holes would be drilled with aim of determining depth and thickness of hot water aquifers, plus flow rates and temperature of saline water in subsurface channel sands.

7. Resistivity survey:

Resistivity survey to determine subsurface geometry of sand and gravel aquifers containing saline spring water.

DEVELOPMENT PROJECT

The specific purpose for doing a demonstration project is to determine and develop a commercial production potential for vegetable and fruits in remote sites using geothermally-heated soils.

The intent is to establish an experimental station in the Arctic utilizing geothermal heat for food production. Ten acres (4 hectares) would be leased in the Pilgrim Hot Springs area. A 4,000 square foot (372 m<sup>2</sup>) greenhouse would be constructed. Development of food fodder and ornamental plots would be undertaken.

The models would be to develop a totally integrated horticultural production system and to determine the production costs of such a system for the Arctic area. This involves projection from seedlings to greenhouse production, the use of the greenhouse to provide seedling plants for outdoor production, soil heating in the outdoors, the use of row covers and plastic mulches, and normal field production integrating the new technologies that have been developed and experimentation with new techniques.

A non-profit agricultural experimental corporation could be set up that could generate as much as \$100,000 of the annual operating budget after the first year from crops produces here according to agricultural experts.

## SITE DATA SUMMARY

### SITE: PILGRIM HOT SPRINGS

#### ..Physical Reservoir Data

##### ..Temperature °C

Water: 17° to 45°C

Bottom: 27° to 80°C (Forbes, 1975)

Subsurface:

Measured 80°C, but probably higher - up to 150°C (White)

##### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

$6 \times 10^{15}$  cal./year

##### ..Type of Overlaying Rock: See Below

##### ..Estimated Depth to Top of Reservoir (meters):

608' (185 m) CAP rock top 205' (59 m) (Forbes, 1975)

#### ..Site Land Status

##### ..Total Acres: 22,400

Federal Acres: 22,080

State Acres: 319.96

##### ..Total Acres Leased: Ø

#### ..Geothermal Development Status:

None to date. No leasing planned on Federal or Indian lands at this time.

#### ..Local and State Attitude Toward Geothermal Development:

C.J. Phillips, lessee and manager of the Pilgrim Hot Springs is authentically interested in development. He has said he would like to promote electrical production as well as the cascading usages of geothermal waters. He envisions a town here. Local legislators are enthusiastic as are Nome residents to the electrical development. Natives appear interested in agricultural development. Drilling money appropriated

#### ..Land Use and Population:

There are no year-round residents.

## SITE LOCATION AND PHYSICAL DESCRIPTION

### SITE: PILGRIM HOT SPRINGS

..Latitude: 65° 06'N

..Longitude: 164° 55'W

..Rectilinear" Beldeleben, Quad A-6, T4S, R31W, Sect. 36

..County: Unorganized Borough

..Adjacent Counties:

..Topography:

Springs located on an abandoned meander of the Pilgrim River. Pilgrim Valley is mantled by alluvial fill. PC mountains exposed 4 miles north. CR intrusive 3 miles to south and east. Marshy with some subsidence to north toward springs. (Sapping)

..Present Land Use:

Used for recreation and summer gardening.

..Future Land Use Plans:

The State appropriated monies for an exploration effort at Pilgrim. DOE is considering a bill to establish an agricultural station at the springs. This will be under the direction of the University of Alaska. There has been interest in the development of a fish hatchery, along with a reindeer research center. More recreatino facilities are planned. When technology comes on line the Nome Power facility has shown considerable interest in electric power.

..Aesthetics:

Very attractive, no permafrost, wilderness setting.

..Historical/Archaeological Significance:

Eskimo Name: Kruzgamepa. Gold mining resort for Nome gold stampede. Vegetables grown. Catholic mission school for natives closed 1942. It was an orphanage. Used for space heating. 107 orphans. (Phillips - personal contact).

## ..Comments and Critical Issues:

Proposed wildlife refuge on (d)(2) lands to North. It is located in an undeveloped area which is always a critical issue to environmentalists within the State of Alaska. Land status not very clear as the Natives have overselected and have not received the patent to any land yet. Bering Straits Native Corporation has not signed easement agreement WITH DOI, and are in litigation over proposed easements. BLM will not transfer lands until a decision is made. This should be late 1980.

Status of Church vs. Phillips vs. States Rights to be determined before well is drilled.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: PILGRIM HOT SPRINGS

## ..Geologic Description:

Quaternary alluvium covers much of the valley of the Pilgrim River. In the Kilgluaik Mountains to the south and Hen and Chickens Mountains to the north of the area, bedrock consists of various metamorphic rocks of Precambrian age. Medium to fine gravel biotite granite of cretaceous age is intruded locally into the metamorphic rocks. The Kilgluaik Fault, down thrown to the north, trends east near the northern edge of the mountains. Numerous north trending faults are mapped, one of which is projected under the Valley fill 1.5 miles (2.4 km) east of the Hot Springs (McFadden, 1971).

The hot waters of the spring system appear to be contained in several abandoned stream sand channels in the vicinity. Temperatures of 70°C and 3 foot (2.7 m) depths have been recorded here.

## ..Geophysical Summary:

Steffano and Associates of Anchorage have conducted cursory resistivity in the area. Forbes of the U. of A. has conducted a seismic refraction and geomagnetic profile, across the spring site. (Forbes, 1975) A work plan including air borne magnetometer of seismic, gravity and resistivity is now being considered to aid in determining the best site for drilling an exploratory well in the area.

## ..Geologic Hazards:

The saturated sands could harbor foundation problems. There is a 25 square mile (65 km<sup>2</sup>) area free of permafrost but other lands in the area do have permafrost problems.

## RESERVOIR CHARACTERISTICS

SITE: PILGRIM HOT SPRINGS

..Reservoir Temperature: 150°C might be greater (White, 1975).

..Subsurface: 150°C

..Geochemical:

SiO <sub>2</sub> :	137	100	(White, 1975)
Na-K-Ca:	146		

..Total Dissolved Solids:

Greater than recorded. Estimate by factor of 1/3 due to ground water mixing.

..Fluid Chemistry:

SiO <sub>2</sub>	100
Al <sup>2</sup>	0.04
Fe	---
Ca	530
Mg	1.4
Na	1450
K	61
Li	4.0
NH <sub>3</sub>	---
HCO <sub>3</sub>	30.1
CO <sub>3</sub>	---
SO <sub>3</sub>	24
Cl <sup>4</sup>	3346
F	4.7
Br	---
B	2.4
pH	6.75
Temp. °C	55

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.6 x 10<sup>18</sup> cal. (White, 1975)

..Subsurface Area of Reservoir:

1.5 km<sup>2</sup>  
Volume: 2.75 km<sup>3</sup>

LAND OWNERSHIP AND LEASING

SITE: PILGRIM HOT SPRINGS

..Land Ownership

..Total Acres: 24,400

Federal Acres: 22,080

State: Ø

Private: 319.96

..Land Leased

Total Acres: 24,400

Federal: 22,080

State: Ø

Private: 319.96

..Tentative Lease Sale Dates: None Planned. Private: 10 acres, 7/78.

..Summary of Leasing Status and Needs:

None at this time. Not likely to be any lease until land is patented by Natives.

GEOHERMAL DEVELOPMENT STATUS

SITE: PILGRIM HOT SPRINGS

..Present Development Status:

Used as private resort and garden.

..Projected or Planned Development:

Battelle NW has shown interest in initiating a reindeer research center using the geothermal water for the benefit of the calving season and protection against the elements. Native Corporation has recently shown interest in the development of their selected lands for agricultural development. \$245,000 was appropriated by the State Legislature to complete an exploratory drilling operation at the spring during FY, 1978. Matching money has been requested of the Federal Department of Energy to develop an agricultural experiment station. The experiment station will operate over a 15 year period and will be a show case for Northern Geothermal Technology.

## INSTITUTIONAL CONSIDERATIONS

SITE: PILGRIM HOT SPRINGS

### ..Institutional Requirements:

The 319 acres (129 hectares) held by C.J. Phillips has no requirements on land itself as he has rights to the geothermal springs. Federal Lands: In order for any lease to be let a statement of consensus must be submitted by village or regional corporation depending on who is to receive title of the now federal lands. Part 3200, Geothermal Resource Leasing, CFR Title 43.

### ..Agency and Public Attitudes:

Designated by BLM as area of ecological concern in their (d)(1) Classification.

Native Corporations are profit making entities by definition. Accordingly, they have been receptive to development. C.J. Phillips, proprietor of springs, is very excited over the prospect of development. This is active participation by the BIA.

### ..Status of Requirements (i.e., EIA/EIS Requirements):

It is probable that surrounding lands will be Native. At this time, no EIS have been filed, but the lands have been assessed under the (d)(1) study by the Federal-State Land Use Commission.

State funds have been approved. Initial studies have been started on a work plan. Federal assistance has been requested.

## ENVIRONMENTAL FACTORS

SITE: PILGRIM HOT SPRINGS

### ..CLIMATE (From Teller - Approx.)

..Prevailing Winds: East

..Precipitation (Annual):

14.5" (36.8 cm), including 50" (127 cm) snow.

..Average Temperature:

Minimum: -9 to 10°F (-23 to -12°C) in winter

Maximum: 37 to 57°F (2.8 to 13.8°C) in summer (Selkregg)



..Degree Days (Annual): 15,000

..AIR QUALITY: No known pollutants .

..WATER QUALITY: No known pollutants in area

Mean annual runoff: 2 cubic ft./per./sec. per square mile.

..NOISE: No human induced;

..BIOLOGICAL

..Dominant Flora:

Moist tundra, cottonwood, berries, lowland hardwood forests.

..Dominant Fauna: Moose, grizzly bear

#### TRANSPORTATION AND UTILITIES

SITE: PILGRIM HOT SPRINGS

..Utility or Energy Transmission Corridors and Facilities:

Nome City power lines. Distance from the site is approximately 65 miles (105 km).

..Transportation Corridors or Facilities:

Nome to Taylor road. Distance from the site is approximately 7 miles (11 km). Access to right-of-way easement (subject to litigation) has been approved. Senate Bill #384 is now being debated to appropriate monies to build spur and upgrade road to Nome.

#### POPULATION

SITE: PILGRIM HOT SPRINGS

..General Description of Population:

There are presently no year round residents at Pilgrim Hot Springs. The greater Nome area (50 miles (80 km) to the south) has a population of 7,000 people. With 2,535 people within the city limits. The labor force of Nome and nearby rural villages ranging from Stebbins to Shishmaref include a large supply of skilled, semi-skilled and unskilled people available for work. (Nome Profile)

..Present Land Use:

The Pilgrim area is presently used for agriculture on a small scale commercial basis during the summer. The market is Nome.

Nome's economy is mainly that of a government/transportation center. The mining industry is still active in the area however.

..Future Land Use:

Possible development of the offshore oil potential should take place in the next decade. Mineral production seems likely as metal prices skyrocket.

Renewable resources such as agriculture are being considered for future development, especially in the Pilgrim Springs area.

SITE: Serpentine

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 65° 51' N; 164° 42' W

QUADRANGLE: Bendeleben, T6N, R29W, KRM

BARRIER: BLM discouraging use

RECOMMENDATION: Possible resort area

DESCRIPTION:

Located in the northwest portion of the Seward Peninsula, Serpentine Springs is within the Serpentine Hot Springs P.G.R.A., 68,965 acres (27,910 hectares). The springs lie in the small valley of the Serpentine River, perhaps 20' (60 m) from the creek (Ogle, 1976).

There are springs in two main areas, about .5 miles (800 m) apart on Hot Springs Creek. Discharge at the eastern spring is estimated at about 35 gal./min. (132 l/m), with temperature measured at 77°C (Miller, 1973). Bill Ogle visited the springs in 1976 and measured the temperature at what is thought to be the eastern spring at 68°C with a flow rate of 26.5 gpm (98 l/m).

The host rock is biotite granite, which is part of the Serpentine hot springs pluton about 1.0 miles (1.6 km) from the faulted contact with the country rock which is Precambrian metasiltite and related rocks (Sainsbury and others, 1969).

Analysis suggests a reservoir temperature of 140°C. The SiO<sub>2</sub> temperature is 132°C; Na-K-Ca is 161°C (White, 1975). Estimated energy content is  $.2 \times 10^{18}$  calories, which is speculative (White, 1975). Chemical analysis for the springs is:

SiO <sub>2</sub>	90
Al <sup>2</sup>	0.06
Fe	.01
Ca	75
Mg	0.35
Na	800
K	41
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	57
CO <sub>3</sub>	1.3
SO <sub>3</sub>	1.0
Cl <sup>4</sup>	1450
F	6.0
Br	4.9
B	2.9
pH	---
Temp. °C	77

#### SOCIO-ECONOMIC:

The land in the area is under management of the BLM. About one-third of the land area is being considered for possible inclusion into the proposed Chukchi-Imuruk National Park under Section (d)(2) of the Alaska Native Claims Settlement Act. The other two-thirds, including the spring, is classified as national interest lands, or (d)(1) classification under the same act. This would allow eventual development.

The area has a history of use. A three bedroom cabin and small bath house are built near the spring, but abandoned. Water temperature in the bath house is adjusted by mixing the spring water with water from the river. A small airstrip accommodates visitors to the springs.

The BLM is currently discouraging use of the abandoned cabin and the spring under current programs. The potential use of this spring is dependent upon a change of philosophy at the BLM.

The springs would apparently support approximately a 10 kw generator and be an ideal physical test site (Ogle, 1976). There is no apparent user in the area, however. A potential for a resort exists since there is already an airstrip for access.

The nearest population center would be Kotzebue, northeast about 100 air miles (160 km) across Kotzebue Sound.

The springs have been placed on the historical sites register.

#### ENVIRONMENT:

The nearest climate station is Shishmaref, on the coast to the north. The precipitation there averages 8" (20 cm) with 33" (84 cm) of snow. The average summer temperatures range from 33 to 54°F (0 to 12°C); winter averages -12 to 7°F (-24 to -14°C). Extremes of -48 and 78°F (-44 and 26°C) have been recorded.

The heating degree days average about 15,500 annually.

Mean annual runoff averages about 1 cu.ft./sec./sq.mi. in this area of Alaska.

The flora is generally moist tundra. Concentrations of grizzly bear and moose have been noted in the area (Selkregg, 1976).

The area around the springs generally has occurrences of permafrost. The immediate spring area, however, does not.

KEY CONTACT: BLM, Fairbanks

REFERENCE:

Miller, 1973 Chemical Study of Hot Springs  
Northwest Regional Profiles  
Ogle, Visit to Hot Springs, 1976  
Waring, 1917 Springs Study

SITE: Inmachuk Hot Spring

LATITUDE AND LONGITUDE: 65° 53'N 163° 12'W

RESOURCE: Waring, 1917

QUADRANGLE: Bendeleben, T6N, R21W, KRM Approx.

BARRIER: Included in area of Bering Land Bridge National Monument

RECOMMENDATION: Exploration

DESCRIPTION: (Waring, 1917)

No actual scientific data has been gathered concerning the springs, but the temperature of the water has been estimated to be less than 100°F (38°C). It issues from crystalline limestone and forms a shallow stream 3 to 4 feet (.9 to 1.2 m) wide) (Waring 1917).

#### SOCIO-ECONOMIC:

Located within the Imuruk Lake PGRA.

The setting of the springs is in the Fairhaven mining district, 20 miles (32 km) south of Deering. There is a road to the mining district and a tractor trail that probably goes to the spring.

The mining district produced gold, silver, copper, iron, zinc, lead and manganese. The claim staking was widespread. A total of 527,000 oz. of gold was mined, largely from the Inmachuk River, Penmel River and Candle Creek area. Some mining continues today.

Because of the temperature of the spring and its assumed association with a zone of minor faulting, It can be assumed that the potential for development would be restricted to local recreational.

There are three classifications of land owners in the area. The village of Deering has selected lands along the Inmachuk River; there are mineral leases and patent holders; and there are Federal (d)(1) lands. All three types of lands located with the Imuruk Basin - PGRA.

December 1, 1978, President Carter designated the Bering Land Bridge National Monument to the west of the springs. The presence of such a unit has proven to be an impediment to large scale development in Alaska.

#### ENVIRONMENT:

The area has a similar climate to that of Candle to the east. The mean annual temperature is probably about 20°F (-7°C). Summer averages 42 to 69°F (6 to 21°C). Winter is -24 to -1°F (-31 to -17°C). Precipitation is 17.3" (44 cm), including 56" (142 cm) of

snow. The area has considerable permafrost and in the neighborhood of 70 frost free days. Mean annual runoff is 1.2 c.f./sec./mile<sup>2</sup>.

The area has a dominant moist tundra flora. There are some moose in the area, but game is rather scarce.

Thermokarst erosion and tundra damage would be major concerns in area.

REFERENCE:

Waring, G.A. "Mineral Springs of Alaska" U.S.G.S. Water Supply Paper #492.

Moffit, F. "The Fairhaven Gold Placers, Seward Peninsula, Alaska". U.S.G.S. Survey Bulletin #247, pl.3, 1905.

Northwest Regional Profile

SITE: Imuruk Lake

RESOURCE: Recent Volcanic Field

LATITUDE & LONGITUDE: 65° 30' N; 163° 15' W

BARRIER: Bendeleben Quadrangle - No end user

RECOMMENDATION: None

#### DESCRIPTION:

The Imuruk Lake area is underlain by metamorphic rocks of Paleozoic age, granite rocks of probable late Jurassic or early Cretaceous age and sediments and lava flows of late Cenozoic age. There are five volcanic formations in the area. The Kugurk Volcanics, Imuruk, Gosling, Camille and Lost Jim in chronological order. The Lost Jim flows were emplaced within the last few thousand years. Most of the volcanic rocks have compositions near the boundary between basalt and andesite. Volcanic eruptions in the Imuruk Lake area probably have been spaced at intervals of five to ten thousand years throughout most of Cenozoic time. There are seven major volcanic vents. These are listed on the regional map. (Hopkins)

#### SOCIO-ECONOMIC:

The Imuruk Lake area, until recently, has been one of the geologically least explored parts of the Seward Peninsula. There is difficult terrain to negotiate and a lack of promising mineral resources. The existence of large expanses of nearly flat terrain on some of the younger lava flows led, to a brief consideration of the possibility of locating a military airfield there in the 1940's. There also was the construction of the Fairhaven Ditch, associated with mining activities. This has been the extent of human activities in the area.

Because of the extreme remoteness and the lack of any transportation to the Basin, there is little chance of any development in the area, resource wise. The land in question is classified (d)(2) under ANCSA and will probably be included in Chuckchi-Imuruk National Reserve, which will preclude any development in the future. This is also the area of the Denbigh Flint complex, the oldest well known human culture site in northwestern Alaska.

#### ENVIRONMENT:

(Extracted from the Northwest Regional Profile).

There is considerable permafrost in the area; when measure, it was only 70' deep though. The climate throughout the area is typical of the Seward Peninsula. The summer averages 42 to 69°F (5.5 to 20.5°C). Winter ranged from -24 to 1°F (-31 to -18°C). Precipitation is probably between 7 to 8 inches (17 to 20 cm) annually. More than 50% of the annual precipitation occurs during a well defined rainy season extending from July through September.



The basic vegetation throughout is tundra. Small thickets of alders are present in a few mountain valleys and in the younger lava flows. Grizzly bears, wolverines, foxes, and wolves, as well as their prey, live in the area.

Imuruk Lake has several species of fish and mollusks.

REFERENCE:

Hopkins, D.M. "Geology of the Imuruk Lake Area, Seward Peninsula, Alaska".  
Northwest Regional Profile

SITE: Lava Creek

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 65° 13' N; 162° 54' W

QUADRANGLE: Bendeleben, T35, R21W, KRM

BARRIER: Remote Location

RECOMMENDATION: None

#### DESCRIPTION:

This spring is not located within a PGRA. There is one principle spring on the east side of Lava Creek, about 30 meters above valley floor. It has a strong flow, noticeable H<sub>2</sub>S odor. The spring is almost on the contact between late Cretaceous quartz monzonite of the Bendeleben pluton and magmatic zone of Precambrian age. Biotite sample from Bendeleben pluton has yielded K: Ar age of 79.8MY (plus or minus) 2.4 million years (Miller and others, 1972). Parts of floor of Lava Creek underlain by basalt of Quaternary age.

SiO <sub>2</sub>	70
Al	---
Fe	---
Ca	2
Mg	0.025
Na	75
K	1.4
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	100
CO <sub>3</sub>	---
SO <sub>4</sub>	---
Cl	8
F	9
Br	1
B	0.8
pH	9.1
Temp. °C	---

#### SOCIO-ECONOMIC:

This spring is located 25 miles (40 km) northeast of the village of Council (pop. about 50). There is no access other than helicopter or all-terrain vehicles in summer, dog sled in winter. Because of the remoteness of this spring, there appears to be no prospects for development at this time.

The area appears to have a high potential for mineralization, but no metals province has been designated for the area, although mines

have been located some 70 miles (113 km) to the west. The land in and around the springs have been either selected by the village of Council under ANCSA or remain as Federal (d)(1) public interest lands. This has not been designated P.G.R.A. by U.S.G.S.

#### ENVIRONMENT:

Extracted from the Northwest Regional Profile.

Permafrost is continuous throughout the region, but is not as thick as in more northern areas. The climate is transitional, the summer average temperatures run from 38 to 64°F (3.3 to 17.7°C). Average winter temperatures run from -9 to 15°F. Council has recorded a low of -45°F (-40°C) and a high of 86°F (30°C). Precipitation averages 14 inches (36 cm) with 46 inches (117 cm) of snow. There are 14,700 heating degree days and approximately 77 frost free days. Mean annual runoff is 1.2 cu. ft./sec./mi.<sup>2</sup>.

The dominant flora is moist tundra and the dominant fauna is moose and grizzly bear, which have a low population density. Major ecological concerns would be thermokarst erosion and damage to tundra, which takes many seasons to regenerate.

#### REFERENCE:

Miller, T.P.; Barnes, F.; and Patton, W.W., Jr. "Geologic Settings and Chemical Characteristics of Hot Springs in Central and Western Alaska". USGS Open File Report, 1971.

Northwest Regional Profile

SITE: Kwiniuk (Battleship)

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 64° 42' N; 162° 28' W

QUADRANGLE: Solomon, T8N, R21W, KRM

BARRIER: Remote location

RECOMMENDATION: Small scale space heating subsistences

DESCRIPTION:

Located 9 miles (14 km) northwest of the village of Elim near the boundary of the Darby mountain P.G.R.A., 229,670 acres (92,947 hectares). Two neighboring hot spring localities have been reported with distinctly sulfurated waters near the Kwiniuk River (Waring, 1917). One principle spring about 100 feet (161 km) north of Kwiniuk River has an estimated temperature of between 40 to 50°C (Miller, 1973). Chemical analysis is:

SiO <sub>2</sub>	45
Al	---
Fe	---
Ca	130
Mg	0.1
Na	500
K	9
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	10.2
CO <sub>3</sub>	---
SO <sub>3</sub>	---
Cl <sup>4</sup>	912
F	5.8
Br	4.0
B	1.0
pH	7.3
Temp. °C	---

The spring is in the Darby Pluton, about 2 miles (3.2 km) from country rock, and on or near conspicuous linaments in pluton contacts. Darby Pluton is late Cretaceous in age (Miller, 1973). The country rock is chiefly Precambrian volcanic and metamorphic rocks. The structural trend is northeast arcing to the west at the northend of the fault system.

SOCIO-ECONOMIC:

The spring is located within the Norton Bay Native Reservation. Any development would have to be approved by Local Tribal Council

The Elim Village Corporation and then by the Bureau of Indian Affairs representative agency the Norton Sound Health Corporation. Presently the springs are located in a rather remote portion of the reservation. They can be reached by river boat along the Kwiniuk River system. There is no utilization at this time. There are placer mining operations within the area.

The nearest logistics center would be Elim, a village of 220 people. Elim's economy is chiefly subsistence with some timber and fishing industry.

The unique individualistic character of the native people in this area would make a remote cottage industry application a reasonable use of the spring.

#### ENVIRONMENT:

The nearest climatological recording station is Golovin. The average summer temperature ranges from 38 to 64°F (3 to 18°C); winter -9 to 15°F (-23 to -9°C). Extremes of -45 and 86°F (-43 to 30°C) have been recorded. The average yearly precipitation is just 14" (36 cm) which includes 46" (116 cm) of snow. Mean annual runoff is 1 ft.<sup>3</sup>/sec./mi.<sup>2</sup>. The annual heating degree days is approximately 14,800.

The dominant flora is high bush tundra. The spring area is a range for Musk Oxen as well as Grizzly bears. Other mammals inhabit the area but are not considered abundant. The Kwiniuk River is a major anadromous fish stream as well.

There is one environmental hazard concerning the permafrost in the area. Related erosional and flood problems are possibilities.

KEY CONTACT: Village Council, Elim

#### REFERENCE:

Miller, 1973  
Waring, 1917  
Northwest Profile

SITE: Kachauik (Battleship)

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 64° 48' N; 162° 55' W

QUADRANGLE: Solomon, D-2, T9S, R18W, KRM

BARRIER: Remote location, low temperature

RECOMMENDATION:

DESCRIPTION:

Located 20 miles (30 km) north of Golovin within the Darby Mountain P.G.R.A., 229,670 acres. One spring on east side of east fork Chiff Creek on a small bedrock terrace about 25 meters above the creek. There is an odor and the spring has a temperature of 17°C. The chemical analysis is :

SiO <sub>2</sub>	---
Al	---
Fe	---
Ca	14
Mg	0.2
Na	111
K	1.1
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	40
CO <sub>3</sub>	10
SO <sub>3</sub>	16
Cl <sup>4</sup>	122
F	---
Br	---
B	0.6
pH	8.97
Temp. °C	17

The spring is in granodiorite of the Kachauik Pluton near its contact with Precambrian Schistose Marble. The Granodiorite is of probable Cretaceous age (Miller, 1973). The structural trend is NE/SW.

SOCIO-ECONOMIC:

The nearest population center is the village of Golovin, 20 miles (30 km) to the south. The village has a population of 119 people. There is a Fish Co-op processor in the village. The springs however appear to be across the divide from Golovin on the North side of Mt. Kachauik. Access to this remote area would have to be by air.

The land in this portion of the P.G.R.A. is under the stewardship of the B.L.M. The land classification is (d)(1) under provisions of the Alaska Native Claims Settlement Act. This could allow eventual development.

#### ENVIRONMENT:

The nearest climatological recording station is Golovin. The summer temperatures range from 38 to 64°F (3 to 18°C); winter -9 to 15°F (-23° to -9°C). Extremes of -45 and 86°F (-43 to 30°C) have been recorded. The average yearly precipitation is just 14" (36 cm) which included 46" (116 cm) of snow. Mean annual runoff in the spring area is 1 ft.<sup>3</sup>/sec./mi.<sup>2</sup>. The annual heating degree days is approximately 14,800 (Selkregg, 1976).

The dominant flora in the area is upland spruce hardwood. There is a major anadromous fish stream in the area. The grizzly bear is one of the dominant land mammals. The area is also a musk ox range.

The terrain around the Darby mountains has discontinuous to continuous permafrost.

KEY CONTACT: BLM, Fairbanks

#### REFERENCE:

Miller, 1973  
Northwest Profile  
Community Energy Survey  
U.S.G.S.

## CLEAR CREEK

Clear Creek Hot Springs is located 15 miles (24 km) north of the village of Elim on the Seward Peninsula. The hot springs has always drawn attention because of the suspected high flow rate of the spring. Potential for binary electrical utilization as well as space heating, and cascading uses such as greenhouses has been established.

The major obstacle to development at this time is the fact that there is no road to the springs. The economics of transporting the hot waters or electricity from the springs to Elim seem to be impractical according to economic projections by Sandia Laboratory. Public opinion in the area and the state remains rather optimistic in future development of the spring however and perhaps the road will be developed.

The present energy needs of the village of Elim is supplied by an Alaska Village Electric Company Utility System consisting of two 50 kw diesel generators. The peak load has been estimated at 67 kw. This source is supplemented by wood for space heating. There have been times when the fuel oil supply runs short because of severe weather or transportation problems.

The village of Elim is located within the Norton Bay Native Reservation. The hot springs themselves are located on Bureau of Land Management lands, about 5 miles north of the reservation boundary. The elected leader of the village has suggested moving some of the inhabitants of the village to the hot springs. With this in mind a possible land swap of some of the reservation lands for the hot springs area might be a practical land title/easement settlement.

The hot springs themselves consist of three springs, close to the tributary of Clear Creek, and on the west side of the creek. The southern, and largest, spring is just below the edge of a round top hill west of the stream, perhaps 250' (76 m) above the valley floor. A second spring, almost as large, is just north of the tributary. The third spring, perhaps 200 yards (183 m) up the side valley from the second, has a very small flow.

The temperature measurement of the south spring was 147.9°F (64.4°C) with a flow rate of 115 gallons per minute (435 l/m). The north spring measured 138.8°F (59.7°C) and a flow rate of 90 gallons per minute (363 l/m).

The electrical potential of the north spring utilizing the experimental Sandia binary generator is 20 to 30 kw. The Sandia machine needs fresh water which could be supplied by a creek nearby, but one which may freeze in the winter. The combination of the two springs could probably furnish heat and a minimal amount of electricity to twenty to thirty homes.

The geology of the area shows that the springs are in quartz monzonite of the Darby pluton. Less than 400 meters from the contact with Devonian limestone. The pluton/limestone contact is inferred to be a major fault traveling N18°E. This suggests that the springs are the



result of a deep circulating meteoric system that allows rainwater to percolate to considerable depth then travel up the fault to flow out at the surface spring manifestation. No reservoir analysis has been conducted to date.

The economics, logistics, and lack of reservoir knowledge combine to discourage any production drilling so all planning revolves around use of the spring.

The Norton Bay Native Reservation has considerable wood resources. A sawmill was once operated at Elim. The mill has potential for full-time operation cutting lumber, pilings, etc. Entire northwest Alaska could benefit from the timber materials produced there. In New Zealand, a lumber mill uses geothermal energy to power its entire operation. If such an application was to be used at Clear Creek on a small scale cascading uses should also be considered. In rural Alaska it is important to utilize the complete potential of any geothermal energy source.

There are going to be major hurdles to jump in getting the potential usages into production. The reservation has an elaborate channel of approval that includes approval by the Village Council, the Elim Village Corporation and then the Regional Representative of the Bureau of Indian Affairs Norton Sound Health Corporation for any project right-of-ways, leases or land swaps. These in turn will have to be negotiated with the B.L.M. which should take a number of years under present understaffing and policies that are in effect. Funding must also be arranged for the road and the facility itself. For these reasons the development scenario is speculative and the time line would reflect the slow progress expected.

## SITE DATA SUMMARY

SITE: CLEAR CREEK

### ..Physical Reservoir Data

#### ..Temperature °C

Surface: 67°C

Subsurface: 125°C

#### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

$2 \times 10^{18}$  (White 1975)

#### ..Type of Overlying Rock: Quartz Monzonite

#### ..Estimated Depth to Top of Reservoir (meters): 2

### ..Site Land Status

#### ..Total acres P.G.R.A.: 229,670

#### ..Geothermal Development Status: None

#### ..Local and State Attitude Toward Geothermal Development:

State Energy Office and Fish and Game have expressed interest in project as well as University. The few villagers that have heard of the project seem impressed.

#### ..Land Use and Population:

Elim Indian Reservation

Village of Elim - Population - 170

#### ..Comments and Critical Issues:

Endorsement of project by Tanana Chief Conference mandatory under reservation status. It has to be shown that development will not disrupt idealized lifestyle as prescribed by residents and that it is desired by Elim residents themselves. The actual springs are located on BLM lands rather than the Native reservation lands. A road must be built to the springs.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: CLEAR CREEK

..Latitude: 64° 51' N

..Longitude: 162° 18' N

..Rectilinear: T8S, R18W, KRM

..Topography:

NE/SW trending mountain system glaciated interlain by bed-rock geology exposed in N/S trending Darby batholith to the northwest. Dendritic drainage system flowing NE to end of mountains.

..Present Land Use: Area has some small scale lumber development.

..Future Land Use Plans:

Possible electrical production as well as cascading usage. Relocate portion of village at hot springs.

..Aesthetics:

Forested area of considerable appeal. Much more aesthetic than the present day setting of the village of Elim.

..Historical/Archaeological Significance:

The village of Elim which is 15 miles (24 km) from the springs 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. Apparently the Elim people paid little attention to the Clear Creek Springs, although remnants of hunting camps can be found in the area.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: CLEAR CREEK

..Geologic Description:

The springs are in quartz monzonite of the Darby pluton less than 400 m (.25 mi.) from the contact with Devonian Limestone, the pluton and limestone contact is lateral to a major fault trending N18°E (Miller, 1972).

The general area east of the springs is interlayered alluvium. The structural trend is exposed by the faulting and mountains which run north and south in the pluton area.

..Geophysical Summary: None to date

..Geologic Hazards: Permafrost conditions.

## RESERVOIR CHARACTERISTICS

SITE: CLEAR CREEK

### ..Reservoir Temperature

..Surface: 67°C (White, 1975)

..Subsurface: 125°C

### ..Geochemical

SiO<sub>2</sub>: 119 (White, 1975)

Na-K-Ca: 83

..Flow Rates: 211 gal/min (800 lpm) 1 spring (Ogle, 1976).

### ..Total Dissolved Solids:

SiO <sub>2</sub>	---
Al	---
Fe	---
Ca	5.6
Mg	0.06
Na	54
K	1.4
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	34
CO <sub>3</sub>	34
SO <sub>3</sub>	25
Cl <sup>4</sup>	4.9
F	---
Br	---
B	0.2
pH	9.43
Temp. °C	67

### ..Estimated Non-Electric Energy Potential (MBtuh 30 years):

2 x 10<sup>18</sup> cal. (White, 1975)

### ..Subsurface Area of Reservoir:

1.5 km<sup>2</sup> (White, 1975)

1.5 km thick

2.25 km<sup>3</sup> volume

## LAND OWNERSHIP AND LEASING

SITE: CLEAR CREEK

### ..Land Ownership:

..Total Acres: 229,670

Federal Acres: 191,670 (BLM)  
Indian Reservation: 38,000

..Summary of Leasing Status and Needs: Must go through BIA

## GEOHERMAL DEVELOPMENT STATUS

SITE: CLEAR CREEK

### ..Present Development Status:

There is no utilization of the Elim Spring at this time.

### ..Projected or Planned Development:

Calculations show that a 50 kw binary generating system could be driven by 400 per gal/min inflow of Clear Creek Springs water (Forbes, 1976).

1. Installation of a 50 kw binary generating system.
2. Possible development of a new community at Elim with the following geothermal utilizations:
  - A. Generation of electricity;
  - B. Space heating;
  - C. Controlled agriculture environment;
  - D. Salmon hatchery operations;
  - E. Timber processing for use in cottage trades, etc.

A combination of the flow of the two springs could furnish a minimal electrical output and space heating for twenty to thirty homes (Ogle).

## INSTITUTIONAL CONSIDERATIONS

SITE: CLEAR CREEK

### ..Institutional Requirements:

The governing body for development is the Norton Sound Health Corporation who have been given trusteeship of the Elim Reservation. Tribal conference must approve plan then the Norton Sound Health Corporation would have to approve. The administration of provisions of Steam Act would be administered by the Bureau of

Indian Affairs through the Norton Sound Health Corporation. The springs themselves are on BLM (d)(1) lands. A suggestion could be made that certain lands be swapped so the springs would be on the reservation.

..Agency and Public Attitudes:

Natives have shown interest in development. The proposal for development was submitted at the state sponsored Geothermal Wind Conference. Lincoln Moore, Mayor of Elim, suggested relocating some of the residents.

..Status of Requirements (i.e., EIA/EIS Requirements):

No action yet.

ENVIRONMENTAL FACTORS

SITE: CLEAR CREEK

..CLIMATE (Extracted from Northwest Regional Profile)

..Prevailing Winds: N/NE 14 kts (26 kph)

..Precipitation (Annual):

18.9" (48 cm) including 40" (101 cm) of snow (Selkregg, 1975).

..Average Temperature:

Summer: 42 to 61°F (5 to 16°C)  
Winter: -6 to 9°F (-21 to 13°C)  
Minimum: -49°F (-45°C)  
Maximum: 87°F (31°C)

..Degree Days (Annual): 14,000

..WATER QUALITY: Mean annual runoff 1 cu.ft./sec./sq.mi.

..NOISE: None

..BIOLOGICAL

..Dominant Flora: Upland spruce - hardwood forest

..Dominant Fauna:

Major anadromous fish streams, some waterfowl and moose.

## TRANSPORTATION AND UTILITIES

SITE: CLEAR CREEK

### ..Utility or Energy Transmission Corridors and Facilities

None. Access and right-of-way agreement between Native and BLM has been reached under A.N.C.S.A.

### ..Transportation Corridors or Facilities:

Logging trails. New road planned in the area.

## POPULATION

SITE: CLEAR CREEK

### ..General Description of Population:

Elim, the nearest population center, is 15 miles (24 km) south of the springs. Elim has an entire Native population of 170. The average income for the village was \$500 to \$1000 per person in 1975 (Ray, 1975).

### ..Economics:

#### ..Present Land Use:

The general character of the village and people is that of subsistent culture revolving around fishing.

#### ..Future Land Use:

The Elim Mountain has a harvestable timber reserve of 36,000 acres (14,569 hectares) with 176,000 acres (71,227 hectares) forested. The Elim Reservation total volume is 81.5 million board feet of spruce. The region has stable mature forests, with slow regeneration (130 years).

A small sawmill has operated at Elim. A logical operation utilizing the forest products for cottage trades could be started. It could allow as much as 250 acres (101 hectares) of harvest per year (Regional Profile).

SITE: Granite Mountain (Sweepstakes)

RESOURCE: Hot Springs (Geothermal File)

LATITUDE & LONGITUDE: 65° 22'N 161° 15'W

QUADRANGLE: Candle B-5, T01S, R13W, Sec. 25, CRM

BARRIER: Remote

RECOMMENDATION: Local Agriculture

DESCRIPTION:

The springs are located within the 34,287 acres (13,875 hectares) Granite Mountain P.G.R.A. The springs are located on a tributary of Sweepstakes Creek near Granite Mountain. Sweepstakes Creek enters Koyuk River about 35 miles (56 km) above the mouth (Waring, 1917).

There are several hot springs issuing on Spring Creek. No estimate of flow has been recorded. Spring temperature is 49°C, reservoir temperature estimates are 130°C. Stored heat estimate is  $.67 \times 10^{18}$  cal (White 1975). Most rock is Nepheline syenite stock near granite pluton. Springwater chemical analysis Li .04 NA 51 K 1.3 MG .04 CA 2.00 CL 9.30 SiO<sub>2</sub> 75.00 SO<sub>4</sub> 62.00 HCO<sub>3</sub> 45.70 PH 10.14 (Geothermal File).

The land around Granite Mountain is located in an area of plutonism. Cretaceous granitic rocks form the Granite Mountain pluton. The country rock in the immediate area of the volcanic flows are volcanic elastic rocks of Jurassic and Cretaceous age.

SOCIO-ECONOMIC:

The nearest population to these remote springs is Hardrock which is a mining location 75 miles (24 km) to the south. There is a landing strip a few miles to the north in the vicinity of the springs. The nearest population center is Nome.

The majority of the KGRA is located on State of Alaska selections under terms of the Statehood Act. There is a reindeer permit registered to Henry Archie of Koyuk village for the area. The Corps of Engineers has a federal facility withdrawal in the area. The Bering Straits Native Corporation has applied for a historical site designation of the old cemetery. They have also conducted business transactions in the area (BLM).

The remoteness of this site would require that any use be small scale and subsistence oriented.



#### ENVIRONMENT:

There are no climatological recording stations near the springs site. Estimated summer temperatures range from 40 to 60°F (4 to 16°C). Winter -10 to 5°F (-23 to -15°C). Precipitation should average about 10" (25 cm). Heating degree days average about 15,000.

The dominant flora is that of alpine tundra above timberline. Below timberline, high brush and moist tundra. Moose, grizzly bear, caribou and numerous fur bearing animals inhabit the area.

#### KEY CONTACTS:

State Department of Natural Resources  
Bristol Bay Native Association

#### REFERENCES:

Geothermal File  
Miller, 1973  
Northwest Regional File  
U.S.G.S. Map I-492 & I-287

SITE: Kiana

RESOURCE: Reported Hot Springs (Kirkwood, Personal Interview)

LATITUDE & LONGITUDE: 66° 58' N; 160° 25' W

QUADRANGLE: Baird Mountains, T21N, R8W, KRM

BARRIER: No data

RECOMMENDATION: Exploration

DESCRIPTION:

The area is not part of a P.G.R.A. This reported hot spring system is not substantiated by observation. It is located within 3 miles (4.8 km) of the confluence of Jack and Klary Creek.

The country rock in this area is divided by a north-south trending fault system in the Klery Creek valley. Late Devonian limestones, sandstone and shale predominate to the west of the fault and Precambrian to Devonian aged rocks chiefly limestone, dolomite, schist and phyllite outcrop to the east of the fault. Quaternary alluvium covers the valley floors of both creeks. There is a Cretaceous pluton outcrop to the east side of the fault in the Killovishuk Mountains.

SOCIO-ECONOMIC:

The land in the area has been selected by the Kiana Village Corporation under the Alaska Native Claims Settlement Act. Possible mineral claims exist in the area. This reported system is located very near Klery village. This village is in use at the confluence of Klery Creek and Squirrel Creek. A 5 mile (8 km) gravel road connects the village with Squirrel Creek and the air strip.

Kiana village (population 314) is located 8 miles (13 km) from the landing. Presently, the annual fuel load is 60,000 gallons of oil and 18,000 gallons of gas. The village has a 650 kw diesel generator (Energy Survey).

The economy of the area is basically subsistence oriented. Placer mining operations are the reason Klery village was founded.

The demand for fresh vegetables in this area is extremely high with little supply. Agricultural utilization of the springs would be a likely candidate for future use.

ENVIRONMENT:

The nearest climatological recording station is Noorvik, 30 miles (48 km) to the southeast. The summer temperatures average 42 to 68°F (5 to 20°C); winter ranges from -16 to 1°F (-25 to -17°C). Extremes of -54 and 87°F (-48 and 31°C) have been recorded. Precipitation averages 16.2" (41 cm) with 60" (152 cm) snow.

The vegetation in the area grades from moist tundra in the lowlands to upland spruce hardwood forests along the mountain slopes. This area has a high concentration of moose and is an intensive use area by grizzly bear during the fall seasons. Caribou are also found here. Squirrel Creek is a major anadromous fish stream. The marshes in the area provide a low density waterfowl nesting area.

This area is underlain by discontinuous to continuous permafrost.

KEY CONTACTS:

Vince Shurek, Kiana Alaska  
Patricia Kirkwood, Energy Systems

REFERENCE: Northwest Profiles

SITE: South

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 66° 09' N; 157° 07' W

QUADRANGLE: Shungnak, T10N, R6E, KRM

BARRIER: Remote

RECOMMENDATION:

DESCRIPTION:

South Hot Springs is located within the Selawik River P.G.R.A., 457,655 acres (185,213 hectares). Several Hot Springs are scattered about a west-facing timbered slope 60 to 120 meters above the south-flowing tributary to Hawk River. Temperatures are estimated at 50°C (Miller, 1973).

Chemical Analysis of the spring water is:

SiO <sub>2</sub>	65
Al <sup>2</sup>	0.1
Fe	0.01
Ca	5.9
Mg	.01
Na	83
K	2.1
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	---
CO <sub>3</sub>	---
SO <sub>4</sub>	122
Cl <sup>4</sup>	6
F	---
Br	---
B	---
pH	---
Temp. °C	---

The chemical indications for the subsurface reservoir give a best estimate of 120°C. The estimate for total stored heat is  $.59 \times 10^{18}$  cal. (Geotherm).

The springs are in late Cretaceous quartz monzonite of Wheeler Creek pluton within 400 meters of contact with lower Cretaceous andesite (Miller, 1970). The springs are approximately on conspicuous lineament trending N80°W (Paxton and others, 1968).

#### SOCIO-ECONOMIC:

The land in the area of the springs has been selected by the NANA Regional Corporation. There are (d)(1) lands located within the P.G.R.A. as well. The nearest village is Kobuk, 52 miles (84 km) north.

The site is in the Yukon River watershed. The drainage in the area is that of the Yukon River. There are large expanses of muskeg to the south barring practical access. Helicopter access is the only practical means of entry.

Mineral deposits are located in the area.

The entire area appears to have been withdrawn by Interior Secretary Andrus under terms of the Federal Land Management Policy Act. P.L.O. 5653.

#### ENVIRONMENT:

The nearest climatological recording station is Kobuk many miles to the North. From this source it can be extrapolated that summer temperatures range from 40 to 70°F (4 to 21°C) and in winter -24 to 0°F (-31 to -18°C). Extremes of -70 and 90°F (-56 and 32°C) could be expected. Precipitation is in the neighborhood of 20" (49 cm). Heating degree days average about 16,000. The mean annual runoff equals approximately 1 ft./sec./mi.<sup>2</sup>.

The dominant flora is bottom land spruce and poplar forest in the low lands. The higher elevations are dominated by hardwood spruce forests. The land is noted for caribou and grizzly bear. The marshes are part of a high density waterfowl range (Selkregg, 1976).

#### KEY CONTACT:

NANA Regional Corporation  
Tom Miller, U.S.G.S.

#### REFERENCE:

- Miller, 1973  
Northwest Regional Profile  
Geothermal File

SITE: Souby (Davidson)

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 66° 22' N; 159° 44' W

QUADRANGLE: Shungnak, T11N, R10E, KRM

BARRIER: Remote

RECOMMENDATION: Reconnaissance Exploration

DESCRIPTION:

Located within the Selawik River P.G.R.A., 457,655 acres (185,213 hectares). Numerous springs are located on both sides of a head-water stream of the Selawik River. Large open meadows as much as 400 meters long by 180 meters wide. This is one of the largest areas of apparent thawed ground of any hot springs in western Alaska. The temperatures are estimated at 50° to 60°C. No chemical analysis is available (Miller, 1973).

The springs are in lower Cretaceous andesitic near a conspicuous N70°W trending lineament and about 2.5 km (1.5 m) north of the quartz monzonite of the Wheeler Creek pluton (Patton and others 1968, Miller, 1970).

The system may be a deep circulating system in which meteoric waters percolate to considerable depth, and when heated, return to the surface as hot springs.

SOCIO-ECONOMIC:

The land status of the spring is subject to change. The area has been selected by the NANA Regional Corporation. The corporation has overselected however, and it is not clear as to whether they will choose this land or not. If NANA chooses not to acquire this land it will remain (d)(1), National Interest Lands under the Alaska Native Claims Settlement Act. The area appears to be withdrawn for further environmental review by P.L.O. 5653.

The nearest population center is Kobuk, 38 miles (61 km) to the north. Kotzebue to the northwest is the nearest regional population center.

The springs appear too near the headwaters across numerous cascades to allow river boat access.

The area has located mineral deposits.

ENVIRONMENT:

The nearest climatological recording station is Kobuk many miles to the north. From this source it can be expected that summer temper-

atures range from 40 to 70°F (4 to 21°C) and in winter -24 to 0°F (-31 to -18°C). Extremes of -70 and 90°F (-56 and 32°C) could be expected. Precipitation is in the neighborhood of 20' (49 cm). Heating degree days average about 16,000. The mean annual runoff approximates 1 ft.<sup>3</sup>/sec./mi.<sup>2</sup>.

The dominant flora is hardwood spruce forests. There are significant caribou, moose and grizzly bear occurrences in the area. The marshes to the north area is underlain by continuous permafrost.

KEY CONTACT:

NANA Regional Corporation  
Tom Miller, U.S.G.S.

REFERENCE:

Miller, 1973  
Northwest Regional Profile

SITE: Hawk

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 66° 14' N; 157° 35' W

QUADRANGLE: Shungnak, T10N, R6E KRM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Selawik River P.G.R.A., 457,655 acres (185,213 hectares). At least one hot spring is on the east bank of Hawk River on the south side of the Purcell mountains. The spring is at the south end of a clearing 25 meters by 60 meters in tall timber and flows directly into the Hawk River. Temperature is estimated at 50°C (Miller, 1973).

The spring is in the alluvial valley of Hawk River, and bedrock is concealed. On the basis of map position, bedrock is probably hornfelsic andesite of early Cretaceous age. The spring lies about 400 meters south of the mid-Cretaceous monzonite of the Hawk River pluton and very close to an east-west fault that cuts the pluton (Miller, 1970).

SOCIO-ECONOMIC:

The land status in the area is not completely understood. The PGRA was partially selected by the NANA Regional Corporation. The unselected land has therefore reverted to (d)(1) National Interest Land under terms of the Native Claims Settlement Act. P.L.O. 5653 withdrew this area for further environmental study.

The nearest population center is Kobuk, 50 miles (80 km) to the north northwest. Kotzebue is the nearest large village many miles further west on the coast.

The Hawk River appears to be navigatable by river boat.

ENVIRONMENT: (Extracted from Northwest Regional Profile)

The nearest climatological recording station is Kobuk many miles to the north. From this source it can be extrapolated that summer temperatures range from 40 to 70°F (4 to 21°C) and in winter -24 to 0°F (-31 to -18°C). Extremes of -70 and 90°F (-56 and 32°C) could be expected. Precipitation is in the neighborhood of 20" (49 cm). Heating degree days average<sub>2</sub> about 16,000. The mean annual runoff approximates 1 ft.<sup>3</sup>/sec./mi.<sup>2</sup>.

The dominant flora is bottom land spruce and poplar forest in the lower elevations. The higher elevations are dominated by hardwood



spruce forest. The land is noted for caribou and grizzly bear as well as moose. The marshes are part of a high density waterfowl range (Selkregg, 1976).

The area is underlain by continuous permafrost.

KEY CONTACT:

NANA Regional Corporation  
Tom Miller, U.S.G.S.

REFERENCE:

Miller, 1973  
Northwest Regional Profile  
Geotherm File

SITE: Purcell Mountains

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 66° 23' N; 157° 32' W

QUADRANGLE: Shungnak, T11N, R6E, KRM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

The springs are located within Selawik River P.G.R.A., 457,655 acres (185,213 hectares). The spring is on the north bank of an unnamed north-flow tributary to Shinilikrok Creek about 5 miles (8 km) northwest of Purcell Mountain. Small flow, temperature estimated at 15 to -20°C. No chemical analysis available (Miller, 1973).

The spring is in late Cretaceous hyperabyssal volcanic complex composed of tuffs, flows, and intrusive rock (Patton and others, 1968). Spring is about .25 miles (400 m) from contact with lower Cretaceous andesite and near contact with granites pluton (Miller, 1970). The host rock is quartz latite.

SOCIO-ECONOMIC:

The land in the area of the springs has been selected by the NANA Regional Corporation. There are (d)(1) lands located within the P.G.R.A. as well. These lands have been withdrawn for further environmental study under P.L.O. 5653. The nearest village is Kobuk about 44 miles (71 km) north northwest.

The drainage in the spring vicinity is that of the Selawik River. River access may be possible during the summer. Helicopter access is most practical however as there is no airstrip.

The remote nature of the springs makes any development rather unlikely. Some cottage trades might develop around the springs however since the Natives of this region tend to live in remote areas.

ENVIRONMENT: (Extracted from Northwest Regional Profile)

The nearest climatological station is Kobuk. Summer temperatures there are 42 to 69°F (6 to 21°C); winter -24 to 1°F (-37 to -17°C). Extremes of -68 and 90°F (-56 to 32°C) have been recorded. Precipitation equals 17.3' (44 cm) including 56" (143 cm) of snow. The annual heating degree<sub>2</sub> days equal 16,060. The mean annual runoff equals 1 ft.<sup>3</sup>/sec./mi.<sup>2</sup>.

The dominant flora is bottomland spruce and poplar forest in the low lands. The higher elevations are dominated by hardwood spruce forests. The area is noted for caribou and grizzly bear range. There are high density waterfowl ranges in the low swampy rivers of the Selewik River Basin. Some endangered Falcon species exist here.

There is also continuous permafrost in the general region.

KEY CONTACT: NANA Regional Corporation

REFERENCE:

Geotherm File  
Miller, 1973  
Northwest Regional Profile

## KOTZEBUE

Kotzebue is a community of 2,500 residents 25 miles north of the Arctic Circle on Baldwin Peninsula. The town borders on Kotzebue Sound facing the Chukchi Sea and Russia to the West.

All residences and buildings are heated by fuel oil, with a disproportionate percentage of family income spent on residential heating. The community is experiencing difficulties with its sewage system due to permafrost and freeze-up problems. Heating with fuel oil is proving very expensive. Several community projects, including a swimming pool, public washing and bathing facility, hydroponic gardens, salmon ranching and canning enterprises, are forestalled by the high costs of fossil fuel. Geothermal energy might help bridge the economic gap. This therefore makes Kotzebue one of the prime prospects in Alaska for utilization of geothermal resources.

Economic studies have not been conducted here to determine the potential for geothermal energy. However, the town of Nome, located 200 miles (320 km) to the south, was one of six sites studied in Alaska for local gradient geothermal applications. The economics of both sites should be somewhat similar on a town by town basis. The cost benefit discussion indicated that "Nome combines several features that make it the most attractive site studied for a high-visibility demonstration of geothermal potential. Although the geothermal system is not clearly superior, it is cost-competitive during later stages of system life. Adding other services and applications should further enhance the total benefits of the geothermal system. Nome is sufficiently populous to support these additional uses and to provide a labor base should industrial uses prove economically feasible (Furguhar, 1977).

The system design for Nome would have a capital investment of \$32,063,000. Its size and extent would be roughly equivalent to a similar heating district in Kotzebue.

Kotzebue would have certain advantages over Nome in that there is a proven resource in a sedimentary section. The local gradient is above normal in the Kotzebue basin and there is already a well drilled and plugged 14 miles south of town.

An economic analysis will probably be undertaken in the next year to determine the economics of an integrated heating system. The actual development of a system could take about four years to complete as outlined in the development scenario.

Kotzebue has a growing population of 2,500 presently. It is the economic, logistic and cultural hub of the Selawick Basin. Presently the energy demands are over 1,200,000 gallons of fuel oil per year. The costs of this oil is 56¢ per gallon. The average annual heating degree days are 16,206. These facts combine to force the people of this region to pay a disproportionate portion of their income toward energy needs.

Combine this type of energy economics with a subsistence culture and the results are disastrous. Escalation of demands and costs will only serve

to improve geothermal space heating attractiveness. Geothermally enhanced new industry would also help in the transition to a cash economy for those residents who wish to make the change.

Evidence from the Nimiak Pt. #1 well drilled by Standard Oil indicates that a potential resource does exist. The well was drilled to 6,311 feet and had a bottom hole temperature of 162°F (72°C). The geothermal gradient is 40°C/km. A foundation test was conducted on the sandstones and conglomerates in the 3755-3537 foot interval. A column of clear saltwater, muddy saltwater and drilling fluid rose 2,190 feet in the hole (top 1,190 feet drilling fluid; next 823 feet muddy saltwater; bottom 177 feet clear saltwater).

The test conclusively showed that the zone was producing saltwater. The temperature was 107°F (42°C). Other sands and conglomerates at greater depths might also be wet and potential producers of hot salt water if tested. This well compared to the Cape Espenberg well on the Seward Peninsula indicates that the producing member is continuous in the region.

The potential users are not limited to a heating district. Possible salmon ranching, canning, hydroponic gardening, swimming pool, public laundry and bathing facilities could also be uses of a geothermal resource.

The related scenario is based on the most optimistic critical path. Assuming that the economic studies to be conducted in the next year were attractive, the rest of the scenario should be a self-fulfilling prophecy.

Kotzebue is applying for a P.R.D.A. (Turned down).

## SITE DATA SUMMARY

SITE: KOTZEBUE

### ..Physical Reservoir Data

#### ..Temperature °C:

Subsurface: 162°F (72°C)

### ..Site Land Status:

..Total Acres: 16,960 (Private)

### ..Geothermal Development Status: None

### ..Local and State Attitude Toward Geothermal Development:

The Geophysical Institute of the University of Alaska, Pacific Research Corporation, Standard Oil of California, The City of Kotzebue, NANA Regional Corporation, and Kikiktagruk Inupiat Village Corporations have all requested support for a proposal engineering and economic study of potential geothermal energy utilization for Kotzebue.

### ..Land Use and Population:

Kotzebue has and desires to remain characterized as a small rural community in Alaska. The land use is designed for readily available subsistent resources, easy intra-community travel and interpersonal familiarity. The town is the cultural and governmental center for northwest Alaska (Kotzebue development plan).

### ..Comments and Critical Issues:

Capital financing for exploration could be a major barrier.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: KOTZEBUE

..Latitude: 66° 51' N

..Longitude: 162° 38' W

..Rectilinear: T17N, R18W KRM

..County: Unorganized Borough

..Topography:

Kotzebue is located on the Baldwin Peninsula. This spit extends into Kotzebue Sound. The spit is a flat tundra with numerous lakes.

..Present Land Use:

This town is the urban hub of this part of Northwest Alaska. The village provides logistical support for the Northwest and West slope regions of Alaska. Kotzebue is flanked by two possible petroleum provinces.

..Future Land Use Plans:

The present planning effort in Kotzebue is to maintain the present rural yet urban center for this part of the state. Population is expected to increase to approximately 3,500 people. Increased commercial, residential, and public land use areas have been designated for the expected expansion. Residential is naturally getting the lion's share of land designation (Kotzebue Development Plan).

..Aesthetics:

Kotzebue is considered a showcase for rural development.

..Historical/Archaeological Significance:

The Kotzebue area has been one of the Inupiat Eskimo cultural centers for years. Most of the archeological sites however are across the bay to the north near Talikoot.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: KOTZEBUE

..Geologic Description:

The Baldwin Peninsula and Kotzebue Sound are part of a large Tertiary basin known as the Selewik Basin. The Basin is considered a moderate potential petroleum basin. The Nimink Pt. #1 well was drilled to 6,311 feet and had a bottom hole temperature of 162°F (72°C). Crystalline basement rocks were penetrated approximately 5,960 feet (1817 m), including schists and phyllites. The schists are overlain by a basal basalt unit which is about 30 feet thick. The Tertiary section is dominated by sandstones with subordinate conglomerate, siltstones and claystones a thin bed of low grade coal was intersected at 2,720 feet (829 m). Conglomerate beds increase in frequency with depth in the section. The geothermal gradient is 40°C/km.

A formation test was conducted on the sandstone and conglomerates in the 3,755-3,537 feet (7,145 to 1,078 meters) interval. No oil

or gas was produced, but a column of clear saltwater, muddy saltwater and drilled fluid rose 2,190 feet (668 m) in the hole (Top 1,190 feet (363 m) drilling fluid; next 823 feet (251 m) muddy saltwater, bottom 177 feet (54 m) clear saltwater). At this depth the temperature was 107°F (42°C).

..Geophysical Summary:

Well logs, lithologic samples and flow test data were all taken in this well. Seismic records have been recorded by Standard Oil Company.

..Geologic Hazards:

Erosion and structural stability problems associated with permafrost.

RESERVOIR CHARACTERISTICS

SITE: KOTZEBUE

..Reservoir Temperature

..Surface: No surface expression

..Subsurface: Thermal gradient of 40°C/km

..Geochemical

SiO<sub>2</sub>: Not available

..Flow Rates: N/A

..pH: N/A

..Total Dissolved Solids: N/A

..Fluid Chemistry: N/A

..Subsurface Area of Reservoir:

Indications are that the subsurface formations are continuous across the entire Kotzebue Sound area. The Cape Espenberg #1 log shows the same saltwater producing formation on the Seward Peninsula.



## LAND OWNERSHIP AND LEASING

SITE: KOTZEBUE

### ..Land Ownership:

The land on the Peninsula has been selected by Kotzebue Village Corporation under terms of the Alaska Native Claims Settlement Act. Private lands are located in the city limits. NANA Regional Corporation is the logical contact.

## GEOHERMAL DEVELOPMENT STATUS

SITE: KOTZEBUE

### ..Present Development Status:

None to date. A proposal has been submitted to the Department of Energy concerning economic and social studies related to geothermal development at Kotzebue. This project was durned down.

### ..Projected or Planned Development:

If economic studies indicate that it is feasible, a city wide heating district will be formed utilizing a local gradient heating district and using the hot water in the city sewer system.

## INSTITUTIONAL CONSIDERATIONS

SITE: KOTZEBUE

### ..Institutional Requirements:

Negotiations and permits to reopen Nimink Pt. #1 well has to be implemented. Easements for distribution system must be obtained from appropriate City, Native, State and Federal government agencies. Environmental Impact Statement will have to be written if the system crosses Federal or State lands. Facilities permit will have to be obtained from State for construction of heating district.

### ..Agency and Public Attitudes:

Economic evaluation needs to be completed before agencies and public attitudes will be favorable. Funding for such an endeavor will have to come from State or Federal sources. A proposal for such a study submitted to D.O.E. was not funded.

### ..Status of Requirements (i.e., EIA/EIS Requirements):

Initiation of new study has not begun at this time.

## ENVIRONMENTAL FACTORS

SITE: KOTZEBUE

### ..CLIMATE: (Northwest Regional Profile)

..Prevailing Winds: ESE 11 kts

..Precipitation (Annual):

8.9" (23 cm) including 47" (119 cm) of snow.

..Average Temperature:

Minimum: -52°F (-47°C)

Maximum: 85°F (29°C)

..Degree Days (Annual): 16,200

..GEOLOGIC FACTORS: Permafrost to 200 feet (61 meters)

..WATER QUALITY: Shores are icebound 8 months per year.

### ..BIOLOGICAL

..Dominant Flora: Moist Tundra

..Dominant Fauna:

Caribou, Moose, Furbearing animals, Fish, Whales, and Seals are abundant here.

## TRANSPORTATION AND UTILITIES

SITE: KOTZEBUE

### ..Utility or Energy Transmission Corridors and Facilities:

Fuel oil is the primary fuel in Kotzebue. Fuel must be barged from Seattle during summer months, and in service shortages flown in from Anchorage. The lack of deep-water port facility necessitates the lighterage of goods from the barges 15 miles (24 km) from shore.

1,200,000 gallons of fuel oil is consumed yearly costing .56¢ per gallon. Storage facilities are capable of holding 1,685,000 gallons.

Kotzebue Electric has a demand of 3,420 kw with a 1,568 peak demand. 491,000 gallons of gasoline are used as well (Rural Electric Survey).

### ..Transportation Corridors or Facilities:

Barge, Arctic Lighterage, and Wien Airlines

## POPULATION

SITE: KOTZEBUE

### ..General Description of Population:

There are about 2,500 people in Kotzebue of which about 75% are Native (Eskimo). The population of the Kotzebue Subregion is 5,000 (Selkregg, 1976).

Kotzebue is the core of a network of regional economic and administrative activities. Kotzebue is an urban magnet; steadily drawing immigrants from the surrounding villages (ASHA, 1971).

### ..Economics:

#### ..Present Land Use:

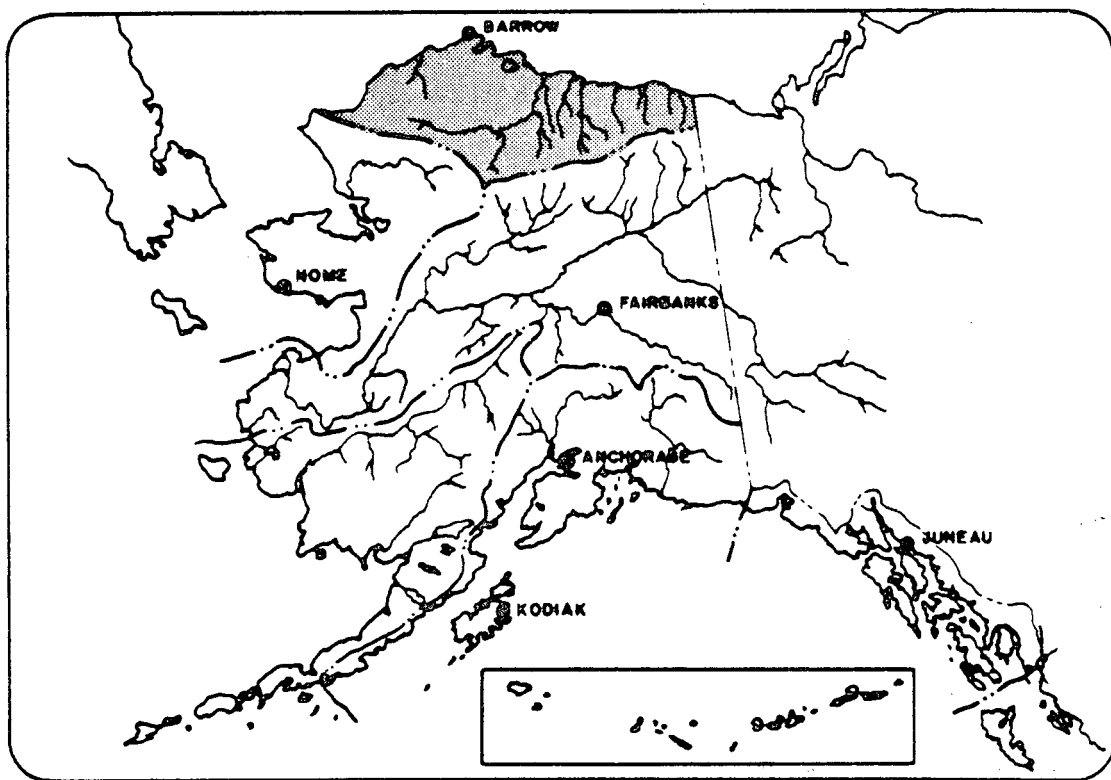
The local economy is equally based on subsistent and cash flow economics. Hunting, fishing, and gathering account for a substantial part of most families' food supplies.

Commercial fishing for chum salmon for export provides seasonal employment. Activities related to the Alaska Native Claims Settlement Act and government are the chief employers. Construction services and trades expand with the population as does tourism.

#### ..Future Land Use:

HUD plans on building 57 new housing units. The University of Alaska plans expansion and a new pioneer home is planned. Oil exploration continues in the region awaiting O.C.S. leases in the next decade. If oil is discovered, a significant change would take place in the local economy (Rural Electric Survey).

## Arctic Region



## ARCTIC REGION

(Portions Extracted from the Arctic Regional Profile)

### Introduction

The Arctic Region encompasses the drainage of all rivers flowing north from the divide of the Brooks Range. The total area is somewhat over 50 million acres. The north slope plain dominates the region with its numerous lakes.

### Climate

The Arctic weather sharply contrasts with weather in other parts of Alaska. The temperatures are cold and strong winds blow persistently over the North Slope. The Arctic and Beaufort Sea have a modifying effect on coastal temperatures. On the southern extremity of the region, the Brooks Range affects both temperatures and precipitation.

Surface winds are relatively strong along the coast, but weaken and become variable further inland. Calm conditions are recorded at Barrow only 1% of the time. Coastal wind speeds of 30-50 knots are common during the winter months. These winds can cause severe white-out conditions and chill factors.

The Arctic Region receives most of its heat energy during the summer months. The decrease in heat energy is dramatic in the fall. From September to the end of December, both maximum and minimum temperatures drop rapidly. A slight warming trend occurs in most of the region in January, with temperatures reaching their lowest in February. In February, temperature minimums range from about -35 to -20°F (-37 to -29°C). In July, highs range from 40 to 60°F.

Annual precipitation levels for the Arctic are generally low. Heaviest amounts occur in the highest elevations of the Brooks Range, where amounts vary from 40 or more inches (102 cm) in the eastern glacial area, to about 10 inches (25 cm) in parts of the Central Range.

The Coastal and Foothill precipitation ranges from 7" (18 cm) to less than 5" (13 cm). Most precipitation occurs during summer as rain. Average annual snowfall amount ranges from an estimated 100" (254 cm) on the eastern Brooks Range, to only 12" (30 cm) along the northwest coast. Terrain has major influence on precipitation patterns.

The sun rises at Barrow at 1:06 AM on May 10th and does not set again until August 2nd at 11:51 PM. There are 118 days without darkness. The sun sets in Barrow at 12:50 PM on November 16th and does not rise again until January 24th at 11:51 AM. The sun does not rise for 67 days. The angle of incidence of the sun is low throughout even the summer season.

Heating degree days range from 17,000 to more than 20,000 along the Arctic coast. The entire Arctic region is layers of permafrost, some as deep as 2,500 feet (762 m) in the deep sediments along the Arctic coast. Soil temperatures range from -17°F (-27°C) in March to 32°F (0°C) at different recording sites.

There is almost always a temperature inversion in the Alaskan Arctic. Air pollution has not been a major problem, though, because of the winds and lack of source.

### Marine Environment

The North Alaska Arctic Ocean is divided into two seas: the Beaufort to the east; and Chukchi west of Point Barrow. The Chukchi is quite shallow, with depths less than 100 m, extending several hundred kilometers offshore. Relatively warm Bering Sea waters enter the Chukchi through the Bering Straits, influencing the ice sheet and currents.

The Beaufort Sea has a narrow continental shelf between 30 to 60 miles (48 to 96 km), where depths are less than 200 m. deep.

The single most important factor in the marine environment is the sea ice. Its seasonal formation, movement, and degradation influence both physical and biological aspects of the environment.

West of Barrow, north and east flowing currents in the Chukchi Sea tend to keep the winter sea ice moving and prevent tight ice occupation of the nearshore environment. In contrast, the Beaufort Sea currents force the ice shoreward and produce a great expanse of relatively tight, shorepack ice in winter. The Beaufort ice is multiyear pack and is present at least nine or ten months. In the Chukchi, the ice is a one year formation and stays seven to eight months. Because of this pack ice, the shipping to and from the North Slope is confined to a few weeks late in the summer.

### Topography

The Arctic region includes all areas drained by streams flowing from the north side of the Brooks Range. It encompasses the northern half of the Brooks Range, and DeLong Mountains, the southern foothills, the northern foothills and Arctic coastal plain and shelf (Wahrhaltig, 1965).

The Arctic mountains section includes the Brooks Range and DeLong Mountains. Their peaks are mainly the result of glacial carving of folded, faulted sedimentary rocks. The peaks are 4,000 to 4,900 feet (1,200 to 1,250 meters) high. No lakes or glaciers exist here.

The central and eastern sections of the Brooks Range consist of rugged, glaciated, east-trending ridges with summits rising to heights of 7,000 to 8,000 feet (2,100 to 2,400 meters). The easterly trend is due to differential weathering of belts of hard and soft sedimentary rocks. On the north boundary the foothills are abrupt with steep mountain fronts. Major rivers flow north from this section of the range and there are surprisingly few glacial lakes.

North of the mountain front, the Southern Foothills vary in height from 1,200 to 3,500 feet (350 to 1,050 meters) with local relief as high as 2,500 feet (750 meters). These hills are characterized by irregular buttes, knobs, mesas, east-trending ridges and intervening rolling tundra plains. The Northern Foothills rise from about 600 feet (180 meters) at their north to 1,200 feet (350 meters) in the south and

consist of broad, east-trending rifhrd eiyh lovs1 mesa-like mountains.

Most streams cross the foothills in north trending courses and are characterized by braided courses. The Colville River, however, follows structure to the east some 220 miles (350 km) along the boundary of the northern and southern foothills. There are no glaciers in the foothills.

The Arctic plain is a smooth surface rising gently from the shores of the Chukchi and Beaufort Seas to a maximum height of 600 feet (180 meters) at its southern boundary. This plain is west of the Colville River and is essentially flat except for occasional rises and a section of active and stabilized sand dunes that trend east-northeast with relief of 40 feet (12 meters). East of the Colville, the White Hills produce scattered low relief above the plains.

Because of the flat terrain and the continuous occurrences of permafrost, drainage on the coastal plain is very poor, and marshes and lakes occur in most low areas. West of the Colville, rivers meander sluggishly in valleys 50 to 300 feet (15 to 90 meters) deep. To the east, streams are braided.

In the western part of the plain, there are northwest trending thaw lakes that make up over 50% of the surface area. These lakes range from a few yards long to 20 miles (30 km).

### Geology

The most recent theory on the Arctic geologic history states that during Paleozoic through Triassic time, the Arctic region was under water. It consisted of a stable shelf bordered by a continental landmass to the north. The Arctic Alaska Basin was to the south and extended as far south as central Alaska. The shield to the north contributed sediments to the basins.

The shield rifted from the present Arctic Slope in Mesozoic Time. The Alaska landmass drifted southwest, pivoted and formed the Arctic Ocean basin. At the same time, uplift of the Brooks Range began. This created a new sediment source that still operates today. Regional structure exerted depositional control in the area, including the rising of the Brooks Range, the Colville Basin, a structural high in the north called the Barrow Arch and the continental margin.

The Colville Basin received sediments and Brooks Range uplift continued displacing the sea northward.

The Mesozoic volcanics were eroded away and the underlying Paleozoic limestone/quantzites were exposed. This resulted in a different composition of rocks in the Northern Foothills than those of the older Southern Foothills.

The Barrow Arch to the north remained a stable high with a gentle dip. It received only muds and silts which pinched out against the slope of the arch. These traps are the basis of the Prudhoe and Barrow oil and gas fields.

During Mesozoic and early Cretaceous periods, the Brooks Range and Southern Foothills underwent intense folding and faulting, with localized metamorphosis. The northern foothills were also gently folded, thus explaining the northward decrease in complexity, relief and age.

The Brooks Range consists chiefly of Paleozoic limestones, sandstones, shales, and their metamorphic pairs. In the southern foothills, rocks are not as affected by metamorphism. The rocks are mainly Mesozoic sandstone, conglomerate, limestone ridges and separated by low areas of shale. In the northern foothills, the open folds formed ridges and mesas underlain by sedimentary rocks.

Drift of the Siberian-Chukchi landmass to the southeast has apparently caused the present sinuosity of the Brooks Range. The forces distorted the mountain chain from its earlier trend. In Tertiary time, uplift and erosion continued. Pleistocene glaciers buried all but the highest peaks and their subsequent deposits are found throughout the range. Streams deposited the debris into even the coastal plain.

Subsidence of the northern part of the region caused several transgressions of the sea across the North Slope. In recent time, the seas retreated to their present level, followed by minor coastal subsidence or sea level rise, forming drowned estuaries on the west coast.

#### Mineral Resources

Four metal deposits, lode or placer, have been reported in Northern Alaska. No major placer deposits that appear at all promising have been located. The general character of the bedrock is not favorable for extensive concentrations.

Limited metallic minerals have been reported on a tributary of the Pitmegea River and the Mount Kelly areas. Other areas have been reported, but not confirmed.

Coal in large quantities is found over a great expanse of the Arctic. It is inferred that some 58,000 square miles of land has coal underlying it. This is perhaps one of the world's largest coal bearing formations, and stretches across most of Northern Alaska.

The petroleum potential has been proven by the discovery of the Prudhoe Bay field on a grand scale in 1968. Oil was discovered much earlier at other Arctic sites not so famous. Besides the 11+ billion barrels of proven oil reserves, considerable potential exists for more discoveries in other onshore and offshore areas.

Oil shale, phosphates, tin, copper, iron, manganese and perhaps lead have been inferred in the region.

#### Erosion

Erosion takes peculiar avenues in the Arctic because of permafrost. As water comes in contact with ice-cemented sediments, heat transfer causes



the ice to melt whenever covering vegetation is stripped. This process can result in serious course changes in rivers and environmental considerations for construction.

In building, proper planning must consider possible erosion because of a loss of permafrost. Because of the time it takes to revegetate in the Arctic, the erosion process is very difficult to stop once started.

### Water

Eighty percent of the land area in the Arctic drains into the Beaufort Sea. The largest drainage is that of the Colville River, which drains about 24,000 acres (9,712 hectares). All rivers are in the zone of continuous permafrost and they are frozen seven or eight months a year.

Freshwater lakes in the Arctic fall into two main categories: thaw lakes and glacial lakes. Thaw lakes cover 50-75% of the total coastal plain, as well as significant areas in the foothills. Glacial lakes are widely scattered and occupy shallow basins. These lakes are usually deep and clear. Lakes less than 6 to 8 feet (2 to 2.5 m) deep freeze solid during the winter.

There are wide fluctuations in runoff because of permafrost and freezing. There is little or no groundwater to reduce these fluctuations.

Mean annual runoff in the Arctic is lowest near the coast and increases somewhat in the foothills and mountains to the south. Peak runoffs are from late May to early July. During late winter months, even large rivers flow so slowly that mean annual low monthly runoff is calculated at 0. Mean annual runoff<sub>2</sub> for the region goes from 0.5 on the coast to as high as 2 ft.<sup>3</sup>/sec./mi.<sup>2</sup>.

Water from surface sources in the Arctic are generally of acceptable chemical quality. The concentrations of total dissolved solids in streams typically increase from its headwaters to its mouth. The TDS range from 30 to 1072 mg/l, but are generally less than 120 mg/l. Lakes normally have less TDS.

Ground water is limited because of permafrost, however, there is potential throughout the year from unfrozen areas near large perennial rivers and beneath large lakes.

Water resources are critical to community development in the Arctic. Most communities get their water by hauling it from nearby lakes and streams in summer and by chopping holes through the ice in deep lakes and melting snow in winter.

Sewage disposal is also a major health problem because of the lack of water. Solid wastes are preserved in the Arctic because of the extreme cold not allowing enzyme actions.

### Terrestrial Vegetation

Terrestrial vegetation in the Arctic region is principally tundra. Tundra is the rolling, treeless plain of Arctic regions throughout the world. This tundra includes all biotic communities above timberline in both arctic and alpine regions.

Generally, the tundra of the Arctic resembles grassland species. Composition of the vegetation varies according to moisture, slope and other such factors. There are three types of tundra: wet, moist and alpine. Moist tundra occupies some 26.5 million acres of the Arctic and by far is the major biotic community.

### Aquatic Vegetation

The Arctic marine environment consists of three vegetation types: microscopic photoplankton, emergent grasses and sedges, and algae growing in shallow water. Sunlight, temperature, and chemical nutrients control growth of the flora. Snow, ice and dissolved materials absorb sunlight and add to the severe physical hardships of the Arctic environment. Carbon dioxide, a necessary gas for plants, is also dissolved in the Arctic winter.

Occasionally, submergent plants grow in protected lagoons. Only in a few locations, such as near Wainwright and in Peard Bay, do kelp beds occur.

### Terrestrial Animals

Moose are confined mostly to high bush areas, especially the Colville and Cannery River drainages. Grizzly bear are also concentrated in these drainages. Carnivores such as wolves, wolverine, lynx, and fox all follow the same pattern of ranging near the drainage systems. Two main caribou herds range over the entire North Slope. Major calving areas are located south of Wainwright and in the Arctic Wildlife Refuge, near the Canadian border. Dall mountain sheep are located in the Brooks Range and Alaska's polar bear concentration is located along the Arctic coast.

A number of birds are closely related to the high bush community. Several species of sparrow, warbles and the ever-present raven inhabit the North Slope. The ptarmigan is abundant as well. The diversity of this winged community depends upon the invertebrates (mosquitoes) that are abundant in the summer.

Two endangered species of Arctic birds exist here, the Arctic peregrine falcon and Eskimo curlew. The Arctic region is also one of the major nesting areas for the migratory waterfowl of North America.

### Aquatic Animals

The aquatic habitat hosts fauna from microscopic zooplankton to whales. Ice is the prevailing condition in the marine environment. Marine mammal and fish species congregate near the edge of the pack ice.

Fish such as sculpin, cod, flatfish, char, salmon, whitefish, grayling, burbot, and pike all inhabit fresh and salt waters in the north. Marine mammals are abundant. Polar bears, seals, walrus, whales and porpoise species are found here and are important to the subsistence communities.

Endangered species include the Angayukaksurak char, the sperm, grey, right and bowhead whales.

### Subsistence

People of the Arctic live closely to the biotic communities. Leaves and shoots of many spring plants are a rich source of vitamins and minerals. Roots and berries are part of the subsistence diet. Grasses are dried for smoking. Driftwood is used in tool making. Wood in general is used for fuel.

Man has always depended on the wildlife of the region for survival and commerce. Caribou is the major food source. Hares, ptarmigan, owls, waterfowl and their eggs are all part of the subsistence diet.

Fur-bearing animals lend their skins to the human communities for clothing and shelter. Musk oxen may be a future commercial resource because of the unique underfur called qiviut, which can be spun into yarn for sweaters.

The fish and marine mammal resources have also been a major source of food and even religious significance. Whales, seals, walrus, salmon, and char are extensively used for food, clothing and tools. A small commercial fishery has been established along the Colville River system to supply the needs of the Arctic peoples. Special provisions in the State and Federal conservation laws permit the continuation of subsistence taking of game by natives.

### History

Archeological evidence from northern and western Alaska strongly suggests that the initial population of the New World was the result of two distinct movements of people. Sometime between 30-40 thousand years ago, populations crossed the Bering Land Bridge and followed an open corridor between the continental ice sheets to the great plains. Subsequently, in the period following before the final subsidence of the land bridge called beringia 10,000 years ago, the hunters were followed by other groups more specifically adapted to the Arctic way of life. These later migrations have their roots in Japanese and Siberian ancestry. These paleo-Eskimos formed the basis of the present Eskimo cultures.

Williams and Stoltman (1965) noted that "no massive migration of peoples need be postulated, but only a gradual filling up of the country in response to the natural processes that can be reasonably inferred to have been operative". The history of these paleo-Eskimos has since been buried beneath timeless snows. Some settlements have been found. Among the most famous is the Kogok site near Utkiavik (Barrow); the Birnik site near Barrow; Nunagiak near Atanik and the Ipiutak site near Point Hope.

There were many stages to early development. This development can be interpreted as adjustments of man and society to his environment. Traditionally, the Alaskan Arctic supported two basic patterns of environmental adjustment. The initial paleo-Eskimo inhabitants subsisted by hunting large herbivores, and during the Bianik phase, a sea mammal hunting cultural change occurred. This separated the peoples of the land (Nunamiut) from those of the sea (Taremiut). These distinctions generally separate the peoples of the region today. The Nunamiut developed around the caribou subsistence while the Taremiut grew around the whaling culture that exists today.

These groups formed the Inupiat people and present day culture developed from the interaction of these peoples. Trading fairs helped maintain the identity and cohesiveness of the Inupiat.

When Vitus Bering and Alexi Chirikof arrived in Alaska in 1741, there may have been as many as 40,000 Eskimos there. It has been estimated that as many as 20,000 Inupiat were a part of these Eskimo peoples. The Russian influence in Arctic Alaska was almost non-existent. The white influence finally arrived in 1848 with the whalers and their systematic harvest methods.

The first white explorers were John Franklin and C.F. Geesay (1826), who came looking for the Northwest Passage. It wasn't until 1903 that Roald Amundsen sailed the Gjøra through the passage, however. These early passage searchings proved the catalyst for extensive exploration and the whaling interest in the region. The disappearance of Franklin's 1845 expedition set off a twelve year search that mapped the main routes to the Arctic. Reward money for information on Franklin prompted whalers to migrate northward in search of whales. In 1848, the whaler "Superior" of American registration, sailed through the Bering Straits to the Arctic Ocean and reported a good catch of whales, thus opening the Arctic waters to commercial whaling.

In 1879, the introduction of steam-powered whaling ships allowed the whalers to winter in the McKenzie River delta. Baleen was the product most sought and this technological advance enhanced the chances of obtaining this product. At \$5 per pound in 1905, this was quite an impetus as were the oils obtained in whaling.

After American purchase, the whalers were still the main contact in the region with the Inupiat people. Between 1848 and 1885, three thousand American ships and 90,000 men entered the Arctic. In 1886, Charles Brown established the Cape Smythe Whaling and Trading Company. The sum of this activity with whites was generally adverse to Inupiat peoples.

Disease, alcohol and diminished food resources are still problems facing the Eskimo populations today. Sheldon Jackson, in the 1890's, began helping the Eskimos rebuild their culture and economy. The introduction of reindeer came in this time frame. The Inupiat were essentially hunters, not herders, however, and the enterprise lost out to whites, and regulations.

In the 1920's, the world fashions demanded furs. This produced a period of relative wealth for trappers until the Depression. The Depression ended the fur trade, and this was compounded by an exodus of Nunanuit Eskimos to the coast from the Brooks Range because of diminished caribou herds. This put the Inupiat peoples' culture back into the subsistence mold of generations before.

The 1936, government began showing serious concern for the native peoples of the region. The Indian Reorganization Act mandating village councils and indigenous industry was passed. This process may not have been culturally acceptable or successful at times, but it was persistent and is now beginning to bear fruits. Tuberculosis vaccination and modern drug programs have been significant advances.

In early 1900's, Erik Leffingwell led a U.S. Geological Survey expedition to evaluate the geology of the Arctic. With native information about oil seeps, Leffingwell identified possible oil structures. This sparked governmental and explorative activity in the region. The commitment to explore in earnest began in the 1944-55 exploration phase.

World War II marks the start of significant change in the Alaskan Arctic. Three primary factors have dominated the Arctic since then. Resurgence of Inupiat dignity, an increased role of Federal and State government in the economy, and discovery of rich exportable resources, especially oil and gas.

The war brought to light the strategic importance of Alaska to post-war politics. A resulting defense program created the White Alice early warning system and its economic impact in the area.

The Indian Claims Commission Act of 1946 began the process of Native claims settlement by allowing the Natives to sue the government over aboriginal claims. A momentum was established that turned toward accumulation and assimilation. The Statehood Act and subsequent state land selections brought the whole issue to the forefront. Federal land freezes, oil discoveries, studies, presidential and congressional action finally produced the Native Claims Settlement Act of 1971.

A new era has begun in the Arctic. A regional government has been established -- the North Slope Borough (1972). There is a road to the slope and the trans-Alaska pipeline is complete and pumping oil south, bringing money to the region and state. State land selections have been assured. Native Claims have been selected. Native capital is available for development, large mineral and oil and gas reserves have been discovered and exploration continues. State and federal monies are also beginning to become available for development here, and would-be energy users see the Arctic as a valuable source of fuel.

The issues of the future will center around the environmental vs. developmental trade-offs and the cultural aspirations of the Inupiat people. These issues will be affecting people's ways of life and will become increasingly significant as time passes.

## Population

In 1970, the population of the Arctic was 3,451. Approximately 93% of the region's population lived in communities scattered along the Arctic Ocean with Anaktuvuk Pass the one significant exception. Alaskan natives made up 85% of the region's population. The remaining 15% was white. The population is young in character.

With the exploitation at Prudhoe Bay, significant white populations have been influencing the region. Prudhoe Bay, at peak population, was the fourth largest population center in Alaska.

## Economy

The Arctic region is a combination of subsistence, monetary and barter economics. The oil industry and government are the leading employers. Construction, tourism and related trades, commerce, transportation, communication, and services all work together to form the network of the emerging cash economy. The severe weather conditions affect all these economic areas. Barrow is the economic, as well as governmental, headquarters for the region.

## Present Land Utilization

With the passage of the Native Claims Settlement Act, the picture of land status in Alaska became very murky. Over-selection by the natives and conflicts with state and federal withdrawals will be contested over the next decade or two.

The Federal Petroleum Reserve and Arctic National Wildlife Refuge take up huge portions of the central and eastern North Slope. Oil exploration is now underway by Husky Oil Company in the petroleum reserve at this time. The State of Alaska has patent to the lands around Prudhoe Bay and is committed to the environmentally acceptable exploitation of the resource there. Major state selections have been applied for in the Point Barrow area, and Point Hope area, largely because of mineral deposits, predominantly coal. Major native selections are in the Point Hope-Point Barrow regions and south of Prudhoe Bay. The Brooks Range has been suggested for the location of national parks and wildlife refuges under (d)(2) legislation. Major utility corridors withdrawals exist as well along the TAPS route.

President Carter established some national monuments in the Brooks Range December of 1978 (See Appendix D).

## Transportation

Transportation modes in the Arctic are perhaps the most underdeveloped in the nation. The residents depend almost exclusively on air transportation for inter-village and inter-regional passenger and freight movement, with the exception of the haul road to Prudhoe Bay. A system of historic winter trails exists, but is only used occasionally.

Commercial transportation in the Arctic Ocean depends completely on ice conditions. The ocean is only open during August and September and commercial service by sea is restricted to these days. Offroad rollagons, snowmachines and hovercraft move the goods about the North Slope.

#### Communications

The civilian communications system is presently switching from the complex military system developed for the NORAD early warning system to satellite communications. There is local telephone service which has improved considerably in the last years because of the satellite program and the communications set up during the pipeline construction.

Radio and television have limited applications, as do newspapers.

#### Geothermal Potential

The Arctic region has only two PGRA's as designated by the U.S. Geological Survey. They are Sadlerochit and Shublik.

##### SADLEROCHIT SPRING, ALASKA

UMIAT MERIDIAN, (Unsurveyed)

T. 3 N., R. 31 E., N/2  
T. 3 N., R. 32 E., NW/4  
T. 4 N., R. 31 E., S/2  
T. 4 N., R. 32 E., SW/4

Containing 34,004 acres (13,760 hectares) more or less

(All within Arctic National Wildlife Range)

##### SHUBLIK SPRINGS, ALASKA

UMIAT MERIDIAN, (Unsurveyed)

T. 1 N., R. 24 E., N/2  
T. 1 N., R. 25 E., N/2  
T. 2 N., R. 24 E., S/2  
T. 2 N., R. 25 E., S/2

Containing 45,894 acres (18,576 hectares), more or less

(Mostly within Arctic National Wildlife Range)

These springs were designated PGRAs because of hot waters issuing from the springs which remain unfrozen throughout the winter. Numerous other springs that remain open have been reported to the U.S. Geological Survey Water Conservation Division. These springs have not been con-

sidered for their geothermal potential, but should be mentioned since they do remain unfrozen in the permafrost environment.

\*A distinctive feature of most of the springs on the North Slope is the luxuriant growth of vegetation, both aquatic and riparian, much of which stays a bright green even in winter. Willow growth is thick near many springs, and at some of the springs are stands of balsam poplar up to 40 feet (12 meters) tall.

Some of the springs that flow from alluvial deposits are surrounded in winter by bare gravel which makes them relatively easy to spot from the air. There is apparently enough heat in the water and in the ground to melt any snow that falls there.

The discharge measurements of spring systems were made at a point downstream so as to integrate the flow of all upstream springs. Samples for chemical analysis were taken at a single representative orifice that could be readily identified and resampled. Temperature and dissolved oxygen measurements of each spring were made as close to the discharge point as possible.

#### Sagavanirktok River System Springs (Sloan, 1976)

Many springs occur in tributary basins of the Sagavanirktok River along the northern edge of the Brooks Range. A general description of these springs is given in Childers and others, 1973.

Echooka springs at the edge of the mountains supply the largest icing in the Sagavanirktok drainage basin, one of the largest icings in Alaska. Echooka springs were discharging about 100 ft.<sup>3</sup>/s (2.83 m<sup>3</sup>/s) in May, 1973.

In winter months discharge from springs in the Saviukviayak River, Flood Creek, and in Ivishak River drainages near the mountain front (Fig. 21) coalesces to form a large and conspicuous icing near their confluence. Cumulative discharge from these springs in May, 1973, amounted to nearly 370 ft.<sup>3</sup>/s (10.5 m<sup>3</sup>/s). Measurement of these same springs in April, 1975 indicated a total discharge of about 200 ft.<sup>3</sup>/s (5.7 m<sup>3</sup>/s). This wide difference in flow was probably the result of early snowmelt runoff in 1973. Use of the 1975 data (Table 2) gives a more conservative figure for minimum spring discharge.

The Saviukviayak tributary has a drainage basin of about 32 mi.<sup>2</sup> (83 km<sup>2</sup>) and had a spring-flow discharge in April of 45 ft.<sup>3</sup>/s (1.3 m<sup>3</sup>/s). If this value is a representative figure for minimum ground-water discharge in the basin, it would be equivalent to an annual basin yield of about 1.6 feet (0.5 m) of water over the entire basin, assuming that the ground-water basin coincides with the surface-water basin. This assumption is probably not valid because the adjacent Flood Creek basin (drainage area 80 mi.<sup>2</sup> (207 km<sup>2</sup>)) had a spring flow discharge of 53.6 ft.<sup>3</sup>/s (1.5 m<sup>3</sup>/s) in April, 1975. This is equivalent to an annual basin yield of about 0.8 feet (0.2 m) of water. If this is combined with the adjacent Saviukviayak tributary basin, a yield of about 1.0 feet (0.3 m) of water for the two basins results. Estimated



average annual precipitation for the area is between 1.5 and 3 feet (0.5 and 1.0 m). Thus it can be seen that ground-water discharge is a very significant part of the hydrologic regime of this part of Alaska.

No single spring orifice in the Sagavanirktok drainage system discharges a very large volume of water. Instead, numerous springs discharge at or near the valley bottoms from exposed bedrock or stream-channel alluvium. In some places, springs such as the Ivishak hillside spring and some springs in Flood Creek valley issue from steep banks several tens of feet above the adjacent stream.

\*(Extracted from Sloan 1975)

#### Canning River System Springs (Sloan, 1976)

The cumulative discharge of springs in the Canning River and its tributaries is probably greater than in any other river system on the North Slope in Alaska. Shublik Spring, which discharges about 24 ft.<sup>3</sup>/s (0.68 m<sup>3</sup>/s) on the southwest end of Copleston Mountain, emerges from two main orifices and descends in a channel about 300 feet (90 m) in half a mile to the point where it plunges at least 40 feet (12 m) into the Canning River.

#### Red Hill Spring (Sloan, 1976)

Red Hill spring at the west end of the Sadlerochit Mountains is one of the few known hot springs on the Arctic Slope. Water temperature at the main orifice was 32.8°C in April, 1975, and 29.3°C in August. Gases bubble to the surface in the orifice pool, and there is a strong odor of hydrogen sulfide at the spring. Lavender and cream-colored algae coat the rocks and bottom of the pool. The water has a slightly bluish, turbid appearance. The spring water flows across and through a rubble slope for about 300 feet (90 m) to join the spring-fed headwaters of the Tamayariak River. The headwater stream contains an unidentified suspended "precipitate"<sup>3</sup> and appears black. Discharge in the stream was measured at 0.85 ft.<sup>3</sup>/s (0.02 m<sup>3</sup>/s) in April, 1975. Water quality was sampled at the spring orifice.

#### Konakut River Springs (Sloan, 1976)

The largest icing known in Alaska occurs in the lower distributary reaches of the Kongakut River. This fan-shaped icing develops from several large springs that emerge from an alluvial fan surface. In November, 1975, a combined discharge of 88.4 ft.<sup>3</sup>/s (2.5 m<sup>3</sup>/s) was measured in two channels at the head of the icing, and another channel was flowing at an estimated 15 ft.<sup>3</sup>/s (0.42 m<sup>3</sup>/s). In April, 1975, a flow of 37 ft.<sup>3</sup>/s (1.05 m<sup>3</sup>/s) was measured in a single channel near the head of the icing. Freshwater from the springs overflows sea ice in the lagoon behind Icy Reef and extends the icing laterally for at least 10 miles (16 km) along the coast. The size of the icing as delineated on Landsat I imagery is estimated to be about 50 mi.<sup>2</sup> (130 km<sup>2</sup>).

Some springs, such as those that feed the Kongakut, Canning, Okerokovik, and Halahula icings near the proposed Arctic Gas pipeline route, emerge

from alluvial deposits and have no apparent relationship to any bedrock outcrops or structure. Furthermore, there is no apparent geomorphic setting such as a channel constriction or change of slope to explain the location of the springs. Thus the question is raised whether these springs have their source in buried bedrock at or near the places where they emerge.

#### Okpilak Hot Springs (Sloan, 1976)

This hot springs is located near the base of Mt. Michleson and has a temperature of 47.5°C.

#### Water Quality of Springs (Sloan, 1976)

The springs are, with few exceptions, remarkably uniform in their water quality (Arctic Section). The water is of excellent quality for almost any use. The water is clear and turbidity is very low; pH ranges from 6.7 to 8.2. Dissolved-oxygen concentration is high, generally near saturation. For those springs in which discharge can be isolated from general runoff, such as the Sadlerochit and Shublik Springs, discharge and temperature seem to remain nearly constant. The water is a dilute calcium bicarbonate type, and dissolved-solids concentrations range from 130 to 225 mg/L.

Red Hill spring is the principal exception to the above generalities. Its thermal waters are a sodium bicarbonate type, high in both chloride and sulfate. (The water in Sadlerochit Spring contains more sulfate than most other springs in the study area.)

Because their flow regime is relatively stable compared to streamflow, the springs support a varied and abundant flora and fauna. The springs are a source of water for overwintering for fish, including Arctic char.

The local temperature gradient of the sedimentary section north of the Brooks Range, in the Prudhoe area, is higher than the world norm (A.A.P.G. Map, 1976). Oil and gas production in the same area make near term use uneconomical.

There are eighteen hot wells in the arctic regime. Most of these are located in the Prudhoe Bay area.

TABLE II

Dissolved chemical constituents and physical parameters for springs, eastern Arctic Slope  
(all constituents reported in mg/L unless otherwise specified)(Sloan, 1976).

Map Number.	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>		
Station Name	Lupine Spring	Saviukviayak R. West Spr.	Saviukviayak Trib. Spring	Flood Creek Spring		
Latitude	68°51'45"	68°54'10"	68°56'20"	68°58'40"		
Longitude	148°12'20"	148°05'10"	147°58'45"	147°51'30"		
Date	05-09-73	05-05-73	05-10-73	04-20-75	05-10-73	04-20-75
Time	---	---	---	10:00	---	14:15
Discharge (ft. <sup>3</sup> /s)	1.5	89.	54.	45.	83.	54.
Silica	3.7	4.8	4.6	4.8	6.3	5.3
Iron ( )	30.	60.	50.	---	30.	---
Manganese ( )	0.0	0.0	10.	---	0.	---
Calcium	51.	40.	39.	52.*	38.	52.*
Magnesium	7.7	9.2	7.3	---	8.8	---
Sodium	0.4	0.7	0.3	0.8	0.4	0.3
Potassium	0.1	0.1	0.1	0.5	0.1	0.5
Bicarbonate	177.	155.	137.	145.	136.	131.
Carbonate	0.0	0.0	0.0	---	0.	---
Alkalinity, total (CaCO <sub>3</sub> )	145.	127.	112.	---	112.	---
Sulfate	12.	8.5	12.	9.1	14.	11.
Chloride	2.8	0.7	0.5	0.9	1.3	0.9
Fluoride	0.3	0.5	0.5	0.3	0.6	0.4
Nitrate and Nitrite as N	0.13	0.05	0.05	0.11	0.05	0.11
Orthophosphorus as P	0.00	0.00	0.00	0.03	0.00	0.01
Dissolved solids (sum of determined constituents)	166.	141.	132.	---	137.	---
Hardness, total	160.	140.	130.	130.	130.	130.
Non-carbonate hardness	14.	11.	15.	---	20.	---
Specific conductance (micromhos/cm at 25°C)	298.	259.	239.	247.	240.	222.
pH (Units)	7.8	7.8	7.9	8.2	8.2	8.0
Water temperature (°C)	2.5	5.0	3.5	6.5	8.5	7.2
Color (platinum-cobalt units)	1.0	1.0	1.	0.	1.	0.
Turbidity (Jackson Turbidity units)	---	---	---	1.	---	2.
Dissolved oxygen	---	---	---	8.9	---	9.0
Total organic carbon	---	---	---	---	---	9.9

\*Calcium and magnesium (calculated as calcium)

TABLE 11 Cont'd

Dissolved chemical constituents and physical parameters for springs, eastern Arctic Slope  
(all constituents reported in mg/L unless otherwise specified) (Sloan, 1976).

Map Number	<u>5</u>		<u>6</u>	<u>7</u>		<u>8</u>	
Station Name	Ivishak Hillside Spring		Echooka R. West Spring	Shublik Spring		Red Hill Spring	
Latitude	69°01'50"		69°15'35"	69°28'20"		69°37'37"	
Longitude	147°43'00"		147°22'50"	146°11'50"		146°01'38"	
Date	05-11-73	04-20-75	05-10-73	05-10-73	04-28-75	04-28-75	08-12-75
Time	---	15:40	11:00	---	14:00	12:45	13:45
Discharge (ft. <sup>3</sup> /s)	194.	74.	22.	24.	24.	0.85	---
Silica	5.8	4.9	5.8	4.8	---	29.	27.
Iron ( )	20.	---	50.	50.	---	---	0.
Manganese ( )	10.	---	0.	0.	---	---	0.
Calcium	36.	47.*	36.	38.	---	---	55.
Magnesium	9.1	---	9.8	11.	---	---	21.
Sodium	0.4	0.4	1.3	1.5	---	130.	120.
Potassium	0.1	0.4	0.2	0.3	---	5.9	5.8
Bicarbonate	137.	128.	131.	127.	124.	---	322.
Carbonate	0.	---	0.	0.	---	---	0.
Alkalinity, total (CaCO <sub>3</sub> )	112.	---	107.	104.	---	---	---
Sulfate	13.	8.9	24.	37.	---	90.	50.
Chloride	0.6	0.3	1.3	1.3	1.3	150.	130.
Fluoride	0.6	0.04	0.3	0.5	---	1.1	1.0
Nitrate and Nitrite as N	0.04	0.08	0.03	0.03	---	0.01	0.02
Orthophosphorus as P	0.00	0.00	0.00	0.00	---	0.03	0.01
Dissolved solids (sum of determined constituents)	133.	---	143.	157.	---	---	569.
Hardness, total	130.	118.	130.	140.	140.	---	220.
Non-carbonate hardness	15.	---	23.	36.	---	---	0.
Specific conductance (micromhos/cm at 25°C)	238.	252.	257.	275.	270.	1000.	950.
pH (units)	8.0	7.5	7.9	8.0	7.9	7.0	8.2
Water temperature (°C)	7.5	0.	7.0	5.5	5.5	33.0	29.0
Color (platinum-cobalt units)	1.	---	1.	1.	0.	0.	2.
Turbidity (Jackson Turbidity)	---	8.7	---	---	1.	2.0	---
Dissolved oxygen	---	5.3	---	---	9.8	0.4	---
Total organic carbon	---	---	---	---	0.8	---	---

\*Calcium and magnesium (calculated as calcium)

TABLE II Cont'd

Dissolved chemical constituents and physical parameters for springs, eastern Arctic Slope  
(all constituents reported in mg/L unless otherwise specified) (Sloan, 1976).

Map No. From Fig. 20	<u>9</u>		<u>10</u>		<u>11</u>		<u>12</u>
Station name	Katakturuk R. Trib Spring		Sadlerochit Spring		Halahula R. Icing Spring		Okerokovik R. Spring
Latitude	69°41'42"		69°39'23"		69°45'39"		69°43'05"
Longitude	145°06'33"		144°23'37"		144°09'15"		143°14'25"
Date	04-28-75	04-27-75	08-07-75	11-16-75	04-28-75	11-26-75	11-24-75
Time	11:15	16:30	14:00	---	10:00	---	---
Discharge (ft. <sup>3</sup> /s)	4.28	35.	37.4	38.7	7.3	4.6	26.
Silica	4.3	10.	10.	9.5	3.1	1.5	3.3
Iron ( )	3.3	---	30.	---	---	---	---
Manganese ( )	---	---	0.	---	---	---	---
Calcium	52.*	78.*	47.	---	51.	---	---
Magnesium	---	---	18.	---	---	---	---
Sodium	0.5	8.2	7.8	6.9	1.8	0.8	1.1
Potassium	0.5	1.1	1.0	0.5	0.7	0.2	0.3
Bicarbonate	130.	156.	140.	126.	116.	66.	163.
Carbonate	---	---	0.	---	---	---	---
Alkalinity, total (CaCO <sub>3</sub> )	---	---	115.	---	---	---	---
Sulfate	1.8	71.	66.	61.	27.	18.	22.
Chloride	0.8	4.0	3.5	3.6	1.3	0.7	1.3
Fluoride	0.1	0.7	0.6	---	0.4	---	---
Nitrate and Nitrite as N	0.08	0.05	0.07	0.10	0.1	0.10	.31
Orthophosphorus as P	0.00	0.00	0.01	0.01	0.01	0.03	0.00
Dissolved solids (sum of determined constituents)	---	---	223.	---	---	---	---
Hardness, total	130.	190.	190.	---	126.	---	---
Non-carbonate hardness	---	---	77.	---	---	---	---
Specific conductance (micromhos/cm at 25°C)	245.	410.	400.	360.	240.	225.	300.
pH (Units)	8.2	7.9	7.3	7.3	8.0	7.2	7.3
Water temperature (°C)	1.0	13.0	13.0	4.0**	1.0	1.0	1.0
Color (platinum-cobalt units)	0.	0.	4.	---	0.	---	---
Turbidity (Jackson Turbidity Units)	1.	1.	---	---	1.	---	---
Dissolved oxygen	11.4	7.0	6.2	---	13.6	---	---
Total organic carbon	2.1	0.7	0.7	---	1.7	---	---

\*Calcium and magnesium (calculated as calcium)

\*\*Measured about 1 mile downstream from spring

TABLE II Cont'd

Dissolved chemical constituents and physical parameters for springs, eastern Arctic Slope  
(all constituents reported in mg/L unless otherwise specified)(Sloan, 1976).

Map No. From Fig. 20	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>
Station name	Aichilik R. Spring	Ekaluakat R. Spring	Kongakut R. Delta Spring	Kongakut R. Above Delta	Kongakut R. Spring	Clarence R. Spring
Latitude	69°31'06"	69°35'27"	69°43'36"	69°42'50"	69°32'36"	69°30'44"
Longitude	143°02'00"	142°18'00"	141°46'07"	141°47'30"	141°49'38"	141°11'37"
Date	04-27-75	04-22-75	04-27-75	11-18-75	04-27-75	04-27-75
Time	13:30	10:00	12:00	---	10:00	10:50
Discharge (ft. <sup>3</sup> /s)	1.5	5.1	37.	88.4	13.	0.5
Silica	2.4	3.9	2.7	3.0	2.3	2.3
Iron ( /L)	---	---	---	---	---	---
Manganese ( /L)	---	---	---	---	---	---
Calcium	65.*	69.*	46.*	---	50.	53.*
Magnesium	---	4.5	1.1	---	1.0	---
Sodium	2.8	.6	1.1	1.1	0.5	0.5
Potassium	2.1	---	---	0.1	---	---
Bicarbonate	148.	165.	122.	62.	134.	124.
Carbonate	---	---	---	---	---	---
Alkalinity, total (CaCO <sub>3</sub> )	---	---	---	---	---	---
Sulfate	39.	25.	17.	17.	25.	12.
Chloride	2.0	3.6	0.5	1.0	0.9	0.7
Fluoride	0.2	0.4	0.1	---	0.1	0.0
Nitrate and nitrite as N	0.08	0.07	0.14	0.16	0.08	0.05
Orthophosphorus as P	0.19	0.00	0.11	0.00	0.00	0.00
Dissolved solids (sum of determined constituents)	---	---	---	---	---	---
Hardness, total	162.	172.	116.	---	---	132.
Non-carbonate hardness	---	---	---	---	---	---
Specific conductance (micromhos/cm at 25°C)	338.	350.	215.	210.	276.	---
pH (Units)	8.0	7.9	7.9	6.7	7.9	7.9
Water temperature (°C)	3.6	6.4	1.0	0.5	1.0	---
Color (platinum-cobalt units)	0.	0.	0.	---	0.	---
Turbidity (Jackson Turbidity Units)	2.	1.	1.	---	1.	---
Dissolved oxygen	12.4	8.1	12.2	---	13.0	---
Total organic carbon	1.2	4.9	0.9	34.	3.9	6.3

\*Calcium and magnesium (calculated as calcium)

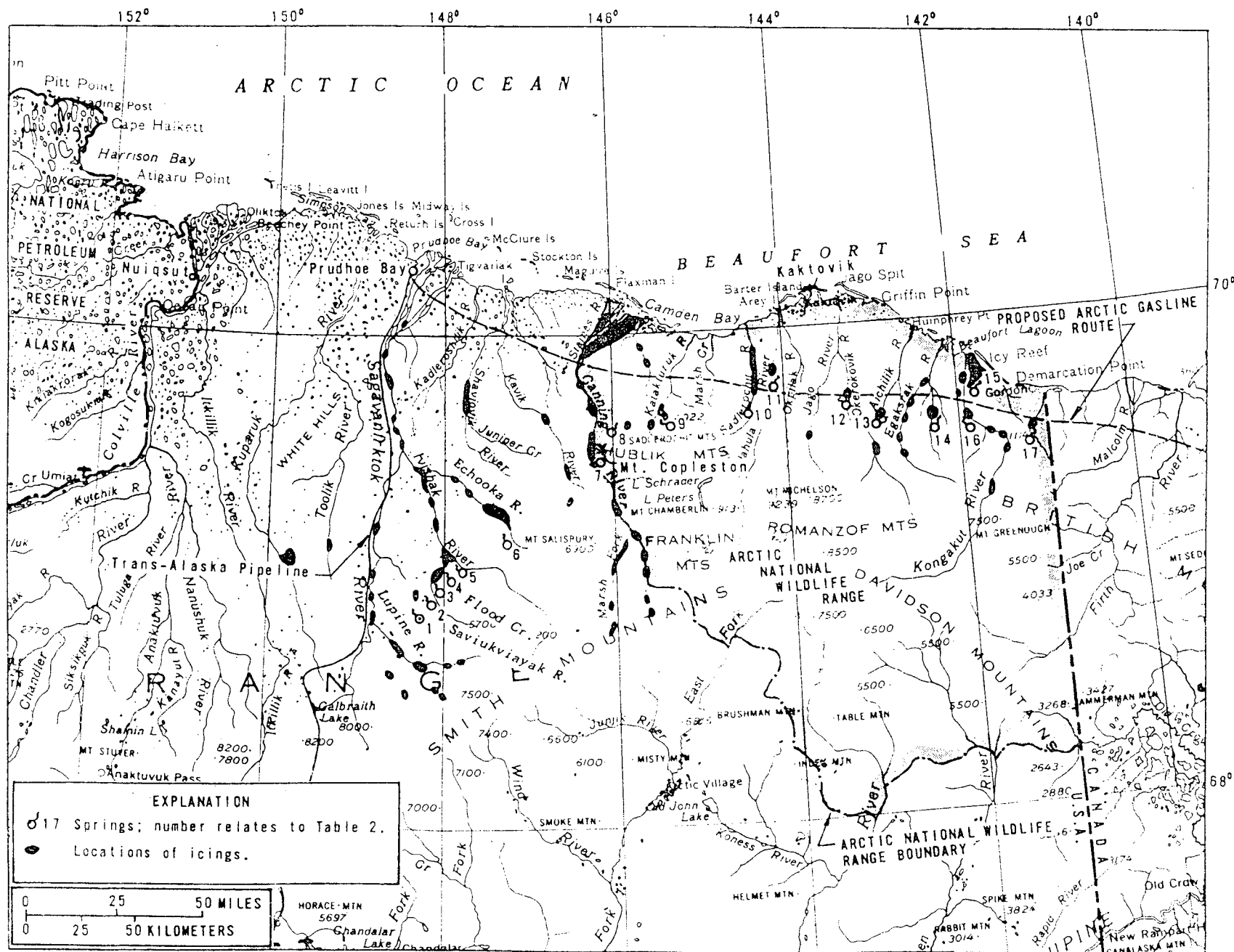


Figure 17 --Location of springs and icings.





ARCTIC REGION  
SITE DATA SUMMARIES



SITE: Sadlerochit

RESOURCE: Reported Hot Springs (Sloan, 1976)

LATITUDE & LONGITUDE: 69° 38' N; 144° 22' W

QUADRANGLE: Mt. Michelson, T4, R31E, UM

BARRIER: Wildlife Withdraw

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Sadlerochit P.G.R.A., 34,004 acres (13,761 hectares). The springs are located at the east end of the east-west trending Sadlerochit Mountains. The mountains have a core of intrusive granite of Devonian to Cretaceous age. The granite intrudes the sedimentary section that forms the North Brooks Range and North Slope. The oldest rocks exposed are Mississippian to Permian limestone, shale, sandstone, and chert. The sequence grades to late Cretaceous sediments until covered by the arctic coastal plain sediments.

Sadlerochit spring is the largest known spring on the Arctic Slope to issue from a hillside bedrock source. Fairly constant discharge of about 37 ft.<sup>3</sup>/s (1.05 m<sup>3</sup>/s) issues at nearly 13°C from a primary orifice and one secondary orifice in talus derived from the Sadlerochit sandstone. The spring maintains an open channel for nearly 50 miles (80 km) downstream even during the coldest part of the year because of its high discharge and temperature. A narrow, thick and elongated icing develops about 5 miles (8 km) downstream from the spring and extends for another 5 miles (8 km) down the valley (Sloan, 1976).

Chemical analysis included in the Table in the Regional write up, Figure 10.

SOCIO-ECONOMIC:

The land in this area is located within the Arctic National Wildlife refuge. This would preclude development under terms of the Geothermal Steam Act.

This P.G.R.A. is the most remote in the United States. The nearest settlement is the small village of Kaktovik many miles to the Northeast. Prudhoe Bay is the nearest large settlement once again many miles away.

The proximity to large oil and gas reserves and all the related waste heat available would make use of this geothermal highly unlikely. A migration waterfowl research station might utilize the springs if a development of this kind ever was to be undertaken.

The area has phosphates potential (Selkregg, 1976).

#### ENVIRONMENT:

The nearest climatological recording station is the village of Kaktovik. Summer temperatures average 30 to 46°F (-1 to 8°C), winter -20 to -6°F (-29 to -14°C). Extremes of -59° and 75°F (-51 to 24°C) have been recorded. Precipitation is just 7" (18 cm) annually with 45" (114 cm) of snow. Average winds are east 11.5 kts. The average annual heating degree days are 16,000.

The dominant flora is moist tundra with high brush in the valleys. Caribou, bear, moose and fur bearing animals are the dominant mammals. The area is a major migratory waterfowl nesting habitat.

There are whiteouts and blowing snow hazards most of the winter in this area. The summer and winter daylight hours differ drastically.

There is continuous permafrost in the area as well as a very delicate tundra subject to erosion.

#### KEY CONTACT:

Manager, Arctic Wildlife Refuge  
U.S. Fish and Wildlife Service

#### REFERENCE:

Shear USGS (Interview)  
Arctic Profile  
Sloan (1976)

SITE: Shublik

RESOURCE: Reported Hot Springs (Sloan, 1976)

LATITUDE & LONGITUDE: 69° 28' 20" N; 146° 11' 50" W

QUADRANGLE: Mt. Michelson, T1N R24E, UM

BARRIER: Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Shublik P.G.R.A., 45,894 acres (18,573 hectares). There are speculated hot springs issuing along the east bank of the Canning River. They issue along the southwest flank of Mount Copleston. Mount Copleston forms the end of the Shublik mountains.

Presently the mountains are not mapped geologically. The normal stratigraphy in the area generally consists of a Cretaceous to Devonian sedimentary to metamorphic sequence. This may be intruded by Cretaceous granite near the core of the mountain range.

Shublik Spring, which discharges about 24 ft.<sup>3</sup>/s (0.68 m<sup>3</sup>/s) emerge from two main orifices and descends in a channel about 300 feet (90 m) in one-half mile to the point where it plunges the last 40 feet (12 m) into the Canning River.

In late winter, icings formed by these springs are almost continuous from the upper reaches of the marsh fork of the Canning River throughout the entire length of the main river channel. One of the largest icings in the area forms in the distributary channels of the Canning and the Staines Rivers upstream from their delta (Sloan, 1976). Fluid analysis is included in the Table in the regional write up, Figure 7.

SOCIO-ECONOMIC:

The land in this P.G.R.A. has been selected by the State of Alaska, under the terms of the statehood act. The area is presently withdrawn as part of the Arctic National Wildlife Refuge. This designation would preclude development at this time.

The springs are close to the Canning River. The river is the main drainage found on the east portion of the North Slope. The river is navigatable during the summer mostly by river boat. All terrain vehicles would have to be used during the long cold winter.

The nearest population center is Prudhoe Bay, over 60 miles (96 km) to the northwest. The nearest land transportation corridor is the Trans Alaska Pipeline, 50 miles (80 km) to the west.

Presently there is no end use for the resource.

ENVIRONMENT: EXTRACTED FROM ARCTIC REGIONAL PROFILE

The nearest climatological recording station is the village of Kaktovik on the Arctic Ocean. The summer temperatures average 30 to 46°F (-1 to 8°C), winter -20 to -6°F (-29 to -14°C). Extremes of -59 and 75°F (-51 to 24°C) have been recorded. Precipitation is just 7" (18 cm) annually with 45" (114 cm) of snow. Average winds are east, 11.5 knots. Average annual heating degree days are 16,000.

The dominant flora of the river flood plain is high brush. The surrounding hillsides have a dominance of moist tundra grading to Alpine Tundra. Moose, caribou, bear and fur bearing animals congregate along the Canning River. The Canning River hosts the Native fish of the region such as greyling and arctic char. There is also salmon during the brief summer season.

The fact that this is on a wildlife refuge suggests the abundance of migrating waterfowl that nest here. The north slope does have more lakes than the rest of the United States.

The tundra is a very fragile environment that takes years to repair. Erosion is also a very serious hazard associated with the perennial permafrost.

KEY CONTACT: Alaska Department of Natural Resources

REFERENCE:

Yukon Regional Profile  
Shear Interview  
Sloan, 1976

SITE: Okpilak

RESOURCE: Hot Springs (Sloan, 1976)

LATITUDE & LONGITUDE: 59° 19' 50" N; 144° 02' 40" W

QUADRANGLE: Mt. Michelson; B-1; T15N, R33E, Sec. 25

BARRIER: Within Arctic Wildlife Refuge

RECOMMENDATION: Determine flow rate.

#### DESCRIPTION:

The hot springs issue on the northeast flank of Mt. Michelson near the bank of the Okpilak River in Arctic Alaska.

Mt. Michelson is part of a Cretaceous granitic pluton that intrudes the Devonian metamorphic sequence of the Brooks Range in this area. Younger, less metamorphosed rocks outcrop to the north.

The springs may be associated with the contact of the pluton and the Devonian quartzite schist.

The temperature of the spring is 48.5°C (Sloan, 1976). The chemical analysis:

#### Water Analysis

Specific Conductance 650

#### Solute Analysis (Water):

LI	
MG	0.1
F	14
NH4	
NA	120
CA	9.8
CL	31
N03	
K	4.5
S04	200

#### SOCIO-ECONOMIC:

This spring lies totally within the Arctic Wildlife Refuge, which would preclude development at this time.

The area is probably one of the most remote in North America. There are no permanent residents for hundreds of miles. Kaktovik, many miles to the north, is the nearest permanent village and Prudhoe Bay, 140 miles (224 km) is the nearest major settlement. There are no roads or facilities.

ENVIRONMENT: EXTRACTED FROM ARCTIC REGIONAL PROFILE

The nearest climatological recording station is the village of Kaktovik. It can be assumed that the Mt. Michelson area will have somewhat higher precipitation levels and lower winds. Summer temperatures at Kaktovik average 30 to 46°F (-1 to 8°C). Winter averages -20 to -6°F (-29 to -14°C). Extremes of -59 and 75°F (-51 to 24°C) have been reported. Precipitation averages just 7" (18 cm) with 48" (114 cm) of snow. Average winds are east at 11.5 knots. Annual heating degree days are 16,500 in the Mt. Michelson area.

The dominant flora is high brush in the river valley and alpine tundra on the mountains. Caribou, bear, moose and fur bearing animals dominate this barren land.

There are whiteouts and serious blowing snow hazards most of the winter. Summer and winter daylight hours differ drastically. There is continuous permafrost in the area, as well as very delicate tundra subject to erosion.

KEY CONTACT:

Manager, Arctic Wildlife Refuge

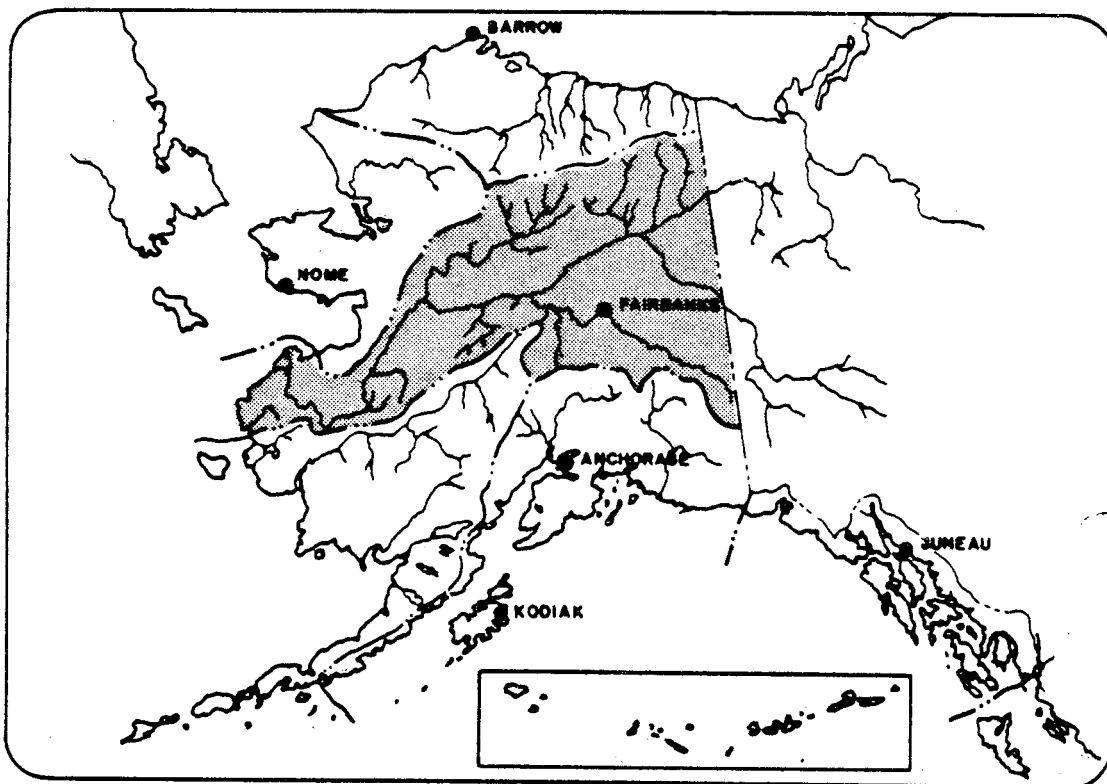
REFERENCE:

Arctic Regional Profile  
Sloan (1976)





## Yukon Region



## YUKON REGION

(Extracted from the Yukon Regional profile)

### Introduction

The Yukon Region covers most of the central portion of the State and extends eastward to Canada. The 204,000 square miles include the south slope of the Brooks Range, all of the Koyukuk drainage, and the delta of the Yukon River; the south boundary follows the north slope of the Kuskokwim Mountains to the Alaska Range in the western part of Mt. McKinley National Park and then along the crest of the Alaska Range into Canada.

### Climate

The climate of the Yukon Region can be generally classified as continental with the exception of a transitional zone in the lower Yukon. The Interior has recorded both all-time State high temperatures of 100 degrees F. (37.8 degrees C.) at Ft. Yukon, and the lowest temperature of -80 degrees F. (-62.8 degrees C) at Prospect Creek. Summer fahrenheit temperatures range from the upper 30's to the upper 60's (5-20 degrees C.) with extremes near 90 degree F. (32.2 degrees C.) not uncommon. Winter temperatures range from the minus 20's to plus 20's (-29 to -7 degrees C.) with extreme low temperatures near minus 60's F (-51 degrees C) not uncommon. Coastal temperatures seldom rise above 60 degrees F. (15.5 degrees C.) in summer or drop below -5 degrees F. (-21.5 degrees C.) in winter due to open waters of the Yukon. Frequently, low wind chill temperatures in the region further reduce the efficiency of man and machine.

Precipitation averages 7-39 inches (18-99 cm) annually, most of which occurs in late summer and early fall. The highest precipitation occurs in the western part of the region.

The Yukon Region has the greatest potential for agriculture in the State. Rainfall is adequate for some crops, but the majority of rain comes during the maturing stage of crop development instead of the growth stage limiting variety. The length of growing season and growing degree days are adequate for some grasses and garden crops, such as marijuana.

Shipping on the navigable rivers and streams is only possible about five months of the year when the streams are free of ice. Flying weather is generally good year-round, since the mountain barriers to the north and south protect the area. There is, however, a high incidence of ice fog in the winter and frequent thunderstorms in the summer.

Winds are moderate to strong near the coast, but are generally light over the remainder of the Region. Wind channeling does occur in isolated areas, giving rise to winds of considerable magnitude.

The intensity of solar radiation depends on the angle of the sun's rays as they strike the earth's surface. The sun's angle is low throughout

Alaska but in the arctic, in winter, it is so low that for a time the sun does not climb above the horizon. Local topography greatly affects the amount of solar radiation received. South-facing terrain receives much more energy per unit area than either flat or north-facing terrain. Mean annual temperature and climate are greatly affected by this solar differential over very short distances.

At many locations in the Yukon region, river valleys expand into broad floodplains. These plains form solar basins in the summer and cold sinks in the winter. Precipitation is often lower as is the wind's energy.

Much of the Yukon region is underlain with permafrost. Ground temperatures hold about a four month lag to surface temperature. It can be said that the high June temperatures are reflected in the ground in November at a shallow depth of six feet. Thermokarst, pingos, frost mounds, frost creep and solifluction are all engineering concerns of this cold region.

### Pollution

The central part of the Yukon region has high winter air pollution potential because of the duration of calm winds. Fairbanks has the most severe problem because, in addition to prevalent calm conditions, abundant pollution sources exist. Persistence temperature inversions concentrate the pollution and prevent dispersal.

Due to the dry early summer months, numerous forest fires are reported each year. The limited transportation system may tax the ingenuity of fire crews and burn extensive areas of the State in dry years.

### Topography

The Yukon region is the area in central and western Alaska drained by the Yukon River system. The northern part of the region, bordered by the Brooks Range crest, includes all or part of the Endicott, Phillip Smith, Franklin, Romanzof, and Davidson Mountains. The Brooks Range is a wilderness of rugged, glaciated, east-trending ridges that rise to summits 7,000-8,000 feet (2,133-2,438 m) in the northeast. The major rivers to the north flow into the Arctic Ocean and to the south into the Yukon and Kobuk systems.

The southern boundary of the region lies along the central and eastern Alaska Range, whose easternmost mountains, the Mentaska-Nutzotin, start a mountain crescent separating the Yukon from the basin of southcentral Alaska. Westward, the region's southern boundary is paralleled by the Kuskokwim Mountains. From these ranges, the drainage is northward to the Yukon system.

The region contains three physiographic divisions: the Rocky Mountain system, the intermountain plateaus, and the Pacific mountain system. Wahrehaftig (1965) has broken the area down into provinces.

The region contains most all land forms found in Alaska. The Porcupine Plateau southeast of the Brooks Range has a topography consisting of low ridges with gentle slopes and rounded flat summits. The Yukon Flats consist of marshy, lake dotted flats rising to only 900 feet (274 m) in the northeast. These lakes are abundant throughout the flats, as are rolling silt and gravel terraces. The area around Eagle consists of rolling hills, contrasting to the inspiring pinnacles of the Alaska Range, much of which is covered by permanent snow and ice. Huge glaciers have carved precipitous cliffs along the slopes of North America's highest peak, Mt. McKinley -- base to top the tallest mountain in the world above sea level.

### Geology

Geologists have reconstructed the principal elements of the geology of the Yukon Region (Lathan, 1973; Holmes, 1975; Churkin, 1973). By late Paleozoic time, the two principal tectonic and structural elements of Alaska were the Arctic and Cordilleran Geosynclines in the north and south of the present Yukon River. The arctic syncline occupied the site of the present Brooks Range, Arctic Foothills, and Arctic Coastal Plain. The Cordilleran geosyncline occupied an area extending through the Yukon-Tanana upland of today and westward along the northern margin of the present Alaska Range. Between them were: the Seward Peninsula stable block; the broad deep Yukon-Koyukuk basin; and the western part of the Yukon Shelf. Most of the Yukon Region lies within the Yukon-Koyukuk basin and Yukon Shelf, with the margins overlapping the margins of the geosyncline.

Throughout Paleozoic and early Mesozoic time, the two geosynclines received a great thickness of sediments. Two episodes of pre-Mississippian folding are recognized in the arctic geosyncline. The Cordilleran geosyncline had a Precambrian to middle Paleozoic history of deposition and deformation.

The Cordilleran geosyncline may have had its primary deformation in late Devonian time. By late Paleozoic and early Mesozoic time, a volcanic arc existed in the general vicinity of the present Alaska Range.

During Triassic time, sedimentation in the northern part of the arctic geosyncline continued, but the site of the present Brooks Range had become a stable area. Mountain building, which resulted in the Brooks Range, began during the mid-Jurassic time. Early to middle Jurassic crystalline igneous masses intruded rocks in the Alaska Range.

In the broad depositional deep of the Yukon-Koyukuk basin, sedimentation from northern and southern sources occurred throughout late Paleozoic and Mesozoic time. Volcanoes occurred, associated with interbedded pyroclastics and marine sediments. The Yukon Shelf seems to have been a stable area of carbonate and shale deposition throughout Precambrian, Paleozoic and Mesozoic times.

By Cretaceous time, the Brooks Range was a dominant landmass and sedimentation from the newly emergent mountains and volcanoes began to fill

adjacent basins. Deformation occurred in late Cretaceous and the present east-west trends were established. South of the Brooks Range, the Yukon-Koyukuk basin was characterized by volcanism during this time. It was also the site of large-scale transcurrent faulting into Tertiary time.

During the end of Cretaceous and early Tertiary time, large movements took place along the Kobuk and Kaltag faults, probably as the result of the eastward movement of the Siberian Plate forming the Seward Peninsula to the east. In early Tertiary time, strong uplift in the Brooks Range produced the present mountain ranges. Uplift and deformation in the Alaska Range produced the mountains that dominate the range today, and volcanism continued in the Yukon-Koyukuk basin.

The Yukon Region lies at the northern edge of the seismically active belt circumscribing the Pacific Ocean. Most of the region is classified as seismic zone 3 by the U.S. Army Corps of Engineers. About once every 10 years a shock of magnitude 7 or greater is felt.

### Mineral Resources

Mining was one of the principal economic activities in the Yukon region during the first half of this century: gold, particularly placer gold, dominated this activity. Iditarod, Circle and Fairbanks mining districts produced the greatest placer gold, while lode gold was produced from Kantishna and Fairbanks districts. Deposits containing mercury, platinum, tin, antimony, silver, lead, tungsten, molybdenum and copper were also mined, although activity was essentially terminated by World War II and subsequent inflation.

Activity related to petroleum has increased greatly in the past few years. The Yukon delta and Yukon flats are rated as having possible petroleum occurrences. Other favorable occurrences are the Kandik, Tanana, Innoko and Yukon-Koyukuk basins.

Coal occurs at numerous sites within the region, generally in Cretaceous and Tertiary rocks. The Nenana coal field is presently producing coal for consumption in the Fairbanks area. Other non-metallic minerals in commercial quantities include limestone, clay, asbestos, oil shale, and phosphate, which are located throughout the region.

### Water

The observed temperatures of surface water in the subregions range from 32-52 degrees F. (0-11 degrees C.). The chemical quality of surface waters in the region are generally good, most all surface expressions have a dissolved solids content less than 200 mg/l. Most all the region has a mean annual runoff between 0.5 and 1 cf/s per square mile.

Ground water is markedly affected by permafrost, restricting recharge, confining and limiting aquifers. Samples of ground water show dissolved solids content from 22 mg/l to 500 mg/l. Some mineral springs have recorded up to 2,000 mg/l. Normally, ground water temperatures range from zero to four degrees C. (32-40 degrees F.).

Water and sewage systems created major engineering problems due to the climate, permafrost and soil stability.

In the interior, cold winter freezing followed by rapid warming in spring causes rapid snowmelt which overflows frozen ice-jammed channels and often results in spectacular spring breakups and floods. Also, the permafrost will not allow penetration of rainfall into the ground, causing the rainwater to become flood water.

#### Hydroelectric Power

The large drainage basin of the Yukon River may have the greatest electric-generating potential in North America. Six potential sites for major dams have been identified along the Yukon course. Other sites have been identified on the Koyukuk, Melozitna, Tanana, Porcupine and Forty Mile Rivers (DOI, Alaska Planning Group, 1974). Presently, electrical energy is obtained by diesel and coal fired steam generators.

#### Terrestrial Vegetation

Forests of the Yukon region experience some of the greatest climatic extremes in North America. The principal trees of the transcontinental bound forests reach their northern limits in the region. Fires, permafrost and erosion have resulted in complex vegetation.

The bottomlands contain spruce-poplar forests, moist and wet tundra. The lowlands habitat is mostly lowland spruce and hardwood forests. The upland spruce and hardwood forests are the most extensive.

In areas where there are no forests, high brush areas may occur. High brush occurs as two distinct subtypes: floodplain thickets and birch-alder willow thickets. Low brush occurs in association with muskeg. Above tree line, alpine tundra predominates.

#### Terrestrial Animals

Animals differ widely in their habitat requirements. Some animals thrive in a broad range of conditions at any season. The gray wolf, wolverine and raven may be found almost anywhere. Others, such as moose, caribou and birds during migration may be found in various habitats during various seasons.

The Yukon-Kuskokwim delta, an important habitat for waterfowl, supports most Alaskan species found in salt marsh or on wet or moist tundra. The lower Yukon-Innoko-Koyukuk area supports higher concentrations of mammals. Grizzly, black bear, dall sheep, buffalo and various other game animals are found in this region, including the Arctic Caribou Herd.

Many wildlife refuges are now being considered and others have been established to protect mammals such as bison and muskox, as well as migratory birds. The Yukon flats is a nesting and resting grounds for various migratory waterfowl. Peregrine falcons have the greatest concentration in this region of anywhere in North America.

### Aquatic Animals

Marine habitats are varied and range from intertidal beaches and mud flats to ocean depths. Marine mammals, commercial fish and birds inhabit these areas.

Pack ice is a special environment which occurs seasonally in the Yukon region. Ice creates areas of high productivity by inducing a "greenhouse" effect. Ice also provides surfaces where marine mammals can rest and bear young. The lack of extensive commercial fisheries hinders what is known about the fish inhabiting offshore areas. Salmon, herring, halibut and sole are all found in offshore waters.

Habitats for marine birds are limited in the Yukon region but are important diet items for the native people. Marine mammals have been important to local subsistence living as well. Whales, walrus and seals are all used for these purposes. Many otter and other fur bearers associated with water are still sought for their fur by a limited local trapping community.

### Utilization of Biotic Resources

Terrestrial animals are particularly important for subsistence in the interior portions of the region. Moose is the mainstay throughout the interior. Caribou is equally important near the more arctic villages. Hare, ptarmigan, waterfowl, and fish are all major additions to the native diet.

Fur animals are taken for subsistence. Commercial use of terrestrial animals is limited to the sale of furs, although considerable associated commerce is derived from sport hunting in the region.

Commercial fishing in the Yukon began in 1918. It has been intermittent ever since. Harvests are limited as compared to other regions in the state, with an annual harvest in the neighborhood of 1.5 million fish, most of which are chum salmon.

Subsistence use of vegetation varies, but forest products for fuel is probably the most important utilization. Some grass and roots are used for basket making.

To date, forests of the Alaska interior have not been intensely managed. Low volume stands, high logging and transportation costs, and very expensive capital costs have kept the interior forests from competing in world markets. However, this will probably change due to improving economics, and utilization of this large resource will begin in earnest.

### History

The eastward migration of natives left the Athabascan in the interior region and the Tupik and Inuit Eskimo along the coastal areas of the region. Most of the settlement took place beside the Kwikpak (Yukon) River and her tributaries. Commerce, customs, legends, gods, wars, plagues and news all travelled along her route. The river was the



thread that held the world together; heaven was at her headwaters and at Kwikpaks end was the end of the world.

The period of western discovery of Alaska began with the Russian expeditions of the early 1700's by Vitus Bering and others. The rise of the Russian-American Company had little affect upon the Interior of Alaska.

It wasn't until 1833 that Michael Tebenkov found the Yukon and established Redoubt St. Michael. There were never more than 1,000 Russians in America during the 120 years of occupation and their dominion was never significant in the interior. In the late 1830's and 1840's, the Russians and Hudson Bay Companies competed for furs in the region. The Chilkoot Indians eliminated the Hudson Bay influence by destroying their post, leaving the upper Yukon free of whites until America eliminated both parties by purchase.

It wasn't until 1883 that our government in Alaska, at the hands of the federal government, sent its first expedition under Army Lieutenant Fredrick Schwatka to interior Alaska. This opened the interior to the hearty and in 1886, Howard Franklin discovered gold on the Forty Mile River. During the exploration there were four major routes to the Yukon: the Edmonton route overland through Canada, the inside passage from Skagway over the Chilkoot Pass, the valley trail and the all water route up the coast and Yukon.

The history of this period really is the history of these routes, the towns that sprang up along them, and where the trails eventually lead -- the Klondike. Although not the first or last, this rush symbolized the development of interior Alaska, the boom-bust gold field economy. Everything in interior Alaska was bound for gold and everything that remained was associated with it.

World War I was generally disastrous for Alaska and the Yukon valley settlements. The government built the Alaska Railroad to revive the area in 1923. World War II and the military finally revived the area by building bases and the Alaska Highway.

Within the last quarter century, three events have changed Alaska and the Yukon region: the Statehood Act, Alaska Native Claims Settlement Act, and discovery of oil. Each affected the people, uniting them and giving them land and money.

### Population

Yukon region in 1970 had a population of 60,984. Population density was one in 3.3 square miles. The white man population was 78.3%; the majority of the remainder was native. Most of the population resided in Fairbanks. There are three men to every two women in this area, and since 1970, there has been a rapid growth in the Fairbanks area. The population is young with the major population group in the 20-24 age group.

## Economy

Economic conditions in interior Alaska are as wide as the region itself. Fairbanks, the primary commercial center, has had an erratic but consistent growth since its founding. It is going through a boom-bust era due to the Alaska pipeline. Recently, the decision to base the Alcan gas line here should put her back in the boom era of a few years ago. The areas outside the pipeline corridor are not experiencing any significant growth and have been historically one of Alaska's problem areas in terms of money income with subsistence the major economic consideration.

The most stable employer on a year-round basis is government, employing 27% of the work force. Construction has been a prime mover of the economy because of the pipeline and pending gas line. Service and trade industries have been able to get a hold as well as some manufacturing. Mining is still an important link in the economic chain today. Tourism and agriculture are becoming more and more important due to government backing in these areas. The search for renewable resources should help accentuate agriculture in the region as exemplified by the new government projects at Delta and the Tanana Loop area. Also, the central campus of the University of Alaska is located in Fairbanks.

## Land

Much of the friction between federal, state, native and private land status is taking place in the Interior. Lack of accurate surveys, overselection, overlapping state and native lands, conflict over the amount of lands set aside under provision (d)(2) of ANCSA, agricultural land sales, speculation and the largest redistribution of land ownership since land grant days have combined to confuse the land situation in this part of Alaska. Major efforts are being initiated to clear up and expedite the title transfers, but the problem will be around for years to come. A new homestead initiative for state lands may yet confuse even more title situations.

## Existing Land Use

There is high density urbanization in Fairbanks. Small villages are scattered along the river systems and recently along the highways, but most of the land is uninhabited.

## Transportation

Air transportation and river barges are the only means of moving people and cargo in the lower Yukon and Delta areas. Snowmachines and dogsleds suffice in winter. The State highway system links the northeast part of the region with Anchorage, the North Slope and Canada. The Alaska Railroad also connects Fairbanks to Anchorage and tidewater. Principally though, the Yukon is still the major link that connects the region. A hover craft system has recently been funded on an experimental basis.

## Communications

Alaska's basic civil communications used to rely on the military system developed for the North American Air Defense Command during the 1950's. A system of VHF radio stations connect the bush to the White Alice System. Communications can be intermittent and generally do not meet the demand. The State and RCA have been establishing earth stations and by the end of this decade, most of the communications in the State should be handled by this more reliable system.

TV, radio and newspaper continue to become more accessible to the people of the interior, although not what one would call reliable as yet. The only major daily paper is the Fairbanks News Miner. The accessibility to services in general relate to the proximity of them to the locality.

## Geothermal

The surface manifestations of geothermal resources of the Yukon Region occur as numerous hot springs in a belt that runs the breadth of West Central Alaska. The hot springs of West Central Alaska occur in several geologic provinces: The Yukon-Koyukuk Basin, the Kokrine-Hodzana Highlands, the Yukon-Tanana Upland and the Kaiyak Hills are included. Granitic Plutons are common to all provinces and the hot springs are especially associated with the contacts of these pluton. Of the hot springs whose bedrock geology is known, all are within 4.8 km of a granitic pluton. The occurrence of hot springs, however, appears to be independent of the age, composition or magmatic history of the pluton (Miller 1973).

Some Quaternary volcanoes are noted in the Porcupine River drainage near the Canadian Border, indicating that there was a recent hot anomaly in the area.

Numerous sedimentary basins exist in the region. At this time it is generally believed that the heat flow in these basins would be relatively high compared with the world wide norm (Forbes Personal communication 1978). Five hot wells have been identified in the Fairbanks area. Each of these wells has a gradient of greater than 30°C/Km (McBeth 1978).

Reed River P.G.R.A. contains a reported Hot Spring.

### REED RIVER, ALASKA

KATEEL RIVER MERIDIAN (Unsurveyed)

T. 22 N., R. 17 E.

T. 23 N., R. 17 E., S/2

Containing 34,333 acres, more or less

Alatna River P.G.R.A. contains a reported Hot Spring.

ALATNA RIVER, ALASKA

KATEEL RIVER MERIDIAN (Unsurveyed)

Tps. 19 and 20 N., R. 25 E.  
T. 20 N., R. 24 E., E/2  
T. 21 N., R. 24 E.  
Tps. 22 and 23 N., Rgs. 22 and 23 E.  
T. 22 N., R. 24 E., W/2, SE/4  
T. 23 N., R. 24 E., W/2

Containing 200,078 acres, more or less

Tunalakin P.G.R.A. contains Tunalakin Lake Hot Springs and Pocohauntas Hot Springs.

TUNALAKIN

KATEEL RIVER MERIDIAN (Unsurveyed)

T. 6 N. E/2, R. 22 E.  
T. 6 N., R 23 E.  
T. 7 N. E/2, R. 22 E.  
T. 7 N., R. 23, 24 E.  
T. 8 N., R. 22, 23, 24 E.  
T. 9 N., E/2, R. 22 E.  
T. 9 N., R. 23, 24 E.  
T. 10 N., R. 23, 24, 25 E.  
T. 11 N., R. S/2, 24 E.  
T. 11 N., R. 25 E.  
T. 11 N., R. W/2, 26 E.

Containing 305,280 acres

Sun P.G.R.A. contains Sun Hot Springs.

SUN

KATEEL RIVER MERIDIAN

T. 5 N., R. 18, 19, 20 E.  
T. 6 N., R. 18, 19, 20 E.

Melozi-Horner P.G.R.A. contains Meolzi and Horner Hot Springs.

MELOZI-HORNER HOT SPRINGS, ALASKA

KATEEL RIVER MERIDIAN, (Unsurveyed)

T. 3 S., R. 20 E., SE/4  
T. 3 S., R. 21, E., SW/4  
T. 4 S., R. 20 E.  
T. 4 S., R. 21 E., W/2  
T. 5 S., R. 20 E.  
T. 6 S., R. 19 E., E/2  
T. 6 S., R. 20 E.  
T. 7 S., R. 19 E., NE/4  
T. 7 S., R. 20 E.,

Secs. 3 to 10

Secs. 15 to 18

Containing 99,211 acres, more or less

Little Melozitna P.G.R.A. contains the Hotsprings of the same name.

LITTLE MELOZITNA HOT SPRINGS, ALASKA

KATEEL RIVER MERIDIAN, (Unreserved)

T. 1 N., R. 26 E., SE/4  
T. 1 N., R. 27 E., SW/4  
T. 1 S., R. 27 E., N/2

Containing 22,908 acres, more or less

Ray River P.G.R.A. contains Kilo and Ray Hot Springs. McDonnell Hot Springs is located to the south along the Ray River course.

RAY RIVER, ALASKA

FAIRBANKS MERIDIAN (Unsurveyed)

T. 11 N., R. 17 W., N/2  
T. 11 N., R. 18 W., NE/4  
T. 12 N., R. 17 W.  
T. 12 N., R. 18 W., SE/4  
T. 13 N., R. 16 W., NE/4, W/2  
T. 13 N., R. 17 W., W/2  
T. 14 N., R. 16 W., S/2

Containing 85,710 acres, more or less

Hutlinana P.G.R.A. contains Hutlinana and Minook Hot Springs

HUTLINANA HOT SPRINGS, ALASKA

FAIRBANKS MERIDIAN (Unsurveyed)

T. 4 N., R. 12 W., N/2  
T. 5 N., R. 12 W.  
T. 5 N., R. 13 W., SE/4  
T. 6 N., R. 11 W., E/2  
T. 6 N., R. 12 W., E/2, SW/4  
T. 7 N., R. 11 W., SW/4  
T. 7 N., R. 12 W., SE/4

Containing 80,061 acres, more or less

Chena Hot Springs P.G.R.A. was designated for its namesake.

CHENA HOT SPRINGS, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 2 N., R. 8 E., N/2  
T. 2 N., R. 9 E., NW/4  
T. 3 N., R. 8 E., S/2  
T. 3 N., R. 9 E., SW/4

Containing 34,256 acres, more or less

Big Windy P.G.R.A. was designated because of the presence of Wolfe Hot Springs.

BIG WINDY CREEK, ALASKA

FAIRBANKS MERIDIAN (Unsurveyed)

T. 4 N., R. 15 E., NE/4  
T. 4 N., R. 16 E., NW/4  
T. 5 N., R. 15 E., SE/4  
T. 5 N., R. 16 E., S/2

Containing 28,644 acres, more or less

Tolovana P.G.R.A. contains the Hot Springs of the same name.

TOLOVANA, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 4 N., R. 7 W., NW/4  
T. 4 N., R. 8 W., NE/4

T. 5 N., R. 6 W., W/2  
T. 5 N., R. 7 W.  
T. 5 N., R. 8 W., SE/4  
T. 6 N., R. 6 W., SW/4  
T. 6 N., R. 7 W., SE/4

Containing 63,100 acres, more or less

Woodchopper P.G.R.A. contains a carbonated spring.

WOODCHOPPER CREEK, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 5 N., R. 21 E., E/2, NW/4  
T. 5 N., R. 22 E.  
T. 6 N., R. 21 E., S/2  
T. 6 N., R. 22 E., S/2

Containing 63,199 acres, more or less

Flat Creek P.G.R.A. is designated on the basis of Hot springs located here known as McCartney.

FLAT CREEK, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 2 N., R. 24, E., N/2  
T. 3 N., R. 24 E., E/2, SW/4  
T. 3 N., R. 25 E., W/2

Containing 39,984 acres, more or less

Manley P.G.R.A. contains springs by the same name.

MANLEY HOT SPRINGS, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 2 N., R. 14 W., W/2  
T. 3 N., R. 14 W., SW/4  
T. 2 N., Rgs. 15 and 16 W.  
T. 3 N., Rgs. 15 and 16 W., S/2

Containing 85,812 acres, more or less

Circle P.G.R.A. designated because of the location of Circle Hot Springs.

CIRCLE HOT SPRINGS, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 6 N., R. 15 E., NE/4  
T. 6 N., R. 16 E., NW/4  
T. 7 N., R. 14 E., NE/4  
T. 7 N., R. 15 E.  
T. 7 N., R. 16 E., W/2  
T. 8 N., R. 14 E., SE/4  
T. 8 N., R. 15 E., S/2

Containing 67,915 acres, more or less

Yukon P.G.R.A. contains a Sulphur Spring.

YUKON RIVER, ALASKA

FAIRBANKS MERIDIAN, (Unsurveyed)

T. 9 N., R. 18 E.

Containing 23,002 acres, more or less



YUKON REGION  
SITE DATA SUMMARIES

SITE: Reed

RESOURCE: Reported Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 67° 17' N 155° 05' W

QUADRANGLE: Survey Pass T22N R17E KRM

BARRIER: National Monument

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Reed River PGRA 34,333 acres (14010 Hectares). In 1886 the Kobuk River Basin was visited by Lieutenant S. M. Stoney of the United States Navy. A warm spring was noted on the Reed River a small tributary of the upper Kobuk.

One hot spring was noted to form a pool 20 feet in circumference and 2 feet deep full of blood-warm temperatured water that wells up quietly from the bottom without bubbles. The water was clear, tasteless and odorless. The overflow runs into and fills smaller pools. The bottoms of all the pools are covered with green moss on which there is a limestone deposit. The ground and rocks around the pools are similarly coated. Natives at the time of Stoney's visit indicated that the temperature of the spring varies, sometimes it was hot enough to cook meat (Waring 1917).

The springs are in the Reed River Valley. The bottom lands are filled with quaternary glacial fill consisting of little modified glacial moraines and assorted drift. The country rock grades older to the south with overlap of Cretaceous and Jurassic sediments. There is Cretaceous granitic rocks outcropping on the valley walls (Selkregg 1976). The probable location of the springs is a contact point between the intrusive and the Paleozoic country rocks. There are numerous faults in the area, major structural trends are east-west.

In 1972 the temperature of the springs ranged from 22° C to 38° C. The springs appeared as a sloping mud patch about 200 feet (61 m) and 50 feet (15 m) wide. The springs are located about 150 feet (40 m) from the Reed River (NAVA 1974).

SOCIO-ECONOMIC:

The land title in this PGRA is held by the United States Government administered by the Bureau of Land Management. The area is withdrawn under section (d)(2) of the Alaska Native Claims Settlement Act for possible inclusion in the Noatak National Wildlife Refuge. This would preclude any development of the geothermal resource under the Geothermal Steam Act.\*

There are state selected lands to the south. There is one township which would allow development but there is no indication that there is any resource there.

This spring system is very remote. The nearest village, Hughes, is approximately 80 miles (128km) to the south. The nearest regional center is Bettles.

There are located mineral occurrences in this area which are the only commercial footholds in the region.

#### ENVIRONMENT:

(Extracted from the Yukon Regional profile).

The approximate climatological information for this area would include summer temperatures in the neighborhood of 40° to 70° F (4° to 21° C) and winter -20° to 20° F (-27° to -6° C). Extremes of -70° and 92° F (-57° to 33° C) could be expected. Precipitation of 14" (36cm) including 70" (178cm) of snow. The heating degree days should be 14,330.

The dominant flora in the region is alpine tundra and barren ground grading into upland spruce and hardwood forest. There are Dall Sheep and moose in the area.

There is continuous permafrost in the area.

Key Contact: Bureau of Land Management  
National Wildlife Service

#### REFERENCE:

Waring 1917  
N.W. Regional Profile  
NAVA (1974)

\*Included in Noatak National monument by the December 1, 1978 invocation of the Antiquities Act. P.L.O. 5654.

SITE: Tunalkten

RESOURCE: Hot Springs (BLM)

LATITUDE & LONGITUDE: 66° 11' N 154° 01' W

QUADRANGLE: Hughes T9N R23E KRM

BARRIER: None

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Tunalkten Lake PGRA 305,280 acres (123,547 hectares). The hot springs are located in alluvial deposits which are probably underlain by Cretaceous grawacke and mudstone. The springs are located about 2.5 miles (4 km) west of the granodiorite of Indian Mountain pluton near its inferred synclinal axis. (Miller 1973)

The area is North 30 miles (48 km) of the Kaltag Fault System which is a major structural feature of Interior Alaska.

No physical examination of the springs has taken place to date.

SOCIO-ECONOMIC:

The land status in the spring area is somewhat in question. It is probable that the Hughes Village Corporation has selected the springs. The State of Alaska has selected the land in the area as well. The village corporation has selected more than their allotment and is presently obtaining title to their lands. This should resolve the question.

The nearest population is the village of Hughes 12 miles (19 km) to the south. Hughes has a population of 98. The principal fuel used for space heating is wood. The electrical needs are met by a 9 kw school and a 70 kw pvt generator. The transportation system is from Fairbanks by Harold Air Services. (Community Energy Survey).

Space heating and agribusiness for this subsistence village are high priority items if the resource is found to be sufficient. River boat access along the Koyukuk River would serve the transportation needs of the small scale agribusiness.

ENVIRONMENT:

The climate recording in Hughes gives the area average summer temperatures between 36° and 68°F (2° and 20°C). Winter temperatures between -18° and 25°F (-28° and -4°C). Extremes of -68° and 90°F (-56° and 32°C) have been recorded. Annual precipitation averages 30" (71 cm) per year, and heating degree days 16,000.

The dominant flora near the Koyukuk River is that of the bottomland spruce-poplar forest. This forest grades into the upland spruce hardwood forests on the hillside to either side of the river.

The dominant fauna is moose and bear. The Koyukuk River is a major anadromous fish stream.

There is a discontinuous perma frost under the flood plain of the Koyukuk River.

KEY CONTACT:

Village Council Hughes

REFERENCE:

Miller 1973  
Yukon Regional Profile

SITE: LeDonne (Dulbi)

RESOURCE: Hot Springs (Miller 1973)

LATITUDE & LONGITUDE: 65° 16' N 155° 16' W

QUADRANGLE: Melozitna B-5 T3S R18E KRM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

This spring is not located within a PGRA. There are several springs which are found within a distance of about 100 meters in a small clearing along the west side of a south flowing tributary to the Dulbi River. Temperatures are estimated at 50° - 60°C (Miller 1973)

The spring is in hornfelsic graywacke and mudstone of Cretaceous age about 3.2 km (2 miles) from a possible pluton inferred from aerial photographs (Miller 1973). There is also possible faulting on the course of the Dulbi River.

No chemical analysis has been taken.

SOCIO-ECONOMIC:

The land status is (d)(1) National Interest Lands under provisions of the Alaska Native Claims Settlement Act.\*

The Dulbi River flows south around the mountain system then north to the Koyukuk River. The nearest village is Ruby on the Yukon River 40 miles (64 km) to the south.

The area is not heavily used, limited use is for subsistence.

ENVIRONMENT:

(Extracted from Yukon Regional profile).

The nearest climatological recording station is Ruby. The average summer temperatures range from 35° to 70°F (2° to 21°C) and winter -12° to 22°F (-24° to -5°C). Extremes of -53° and 98°F (-47° and 37°C). Precipitation averages 17" (43 cm) including 66" (168 cm) of snow. The heating degree days average about 15,000.

The dominant flora is that of the upland spruce hardwood forest. The floodplain of the Dulbi River is dominated by the lowland spruce popular forest.

The dominant fauna is that of caribou, moose, and brown bear.

There is discontinuous permafrost in the area.

Key Contact: BLM Fairbanks  
Tom Miller USGS

REFERENCE:

Miller 1973  
Yukon Regional Profile 1976

- \* Withdrawn by P.L.O. 5653 for further study under terms of the Organic Act of 1976. Withdrawal will last three years under present land laws.

SITE: Sun

RESOURCE: Hot Springs (Miller 1973)

LATITUDE & LONGITUDE: 65° 54' N 155° 00' W

QUADRANGLE: Melozitna D-4 T6N R18E KRM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

This hot springs is located within the Sun PGRA 138,240 (55,943 hectares). There is a spring symbol on the north side of hot springs creek 8 km (5 mi) from the Koyukuk River. Presently there is no information regarding temperature flow etc.

The spring locality is in area of generally hornfelsic andesite cut by numerous quartz latite porphyry dikes. The numerous dikes and widespread thermal metamorphism suggest an unexposed pluton at shallow depth (Miller and Ferrians, 1968).

SOCIO-ECONOMIC:

This land has been selected by the Doyon Regional Corporation under terms of the Alaska Native Claims Settlement Act.

The nearest village is Hughes 38 km (24 mi) to the Northwest. The transportation to and from the springs could be effected by river-boat along the Koyukuk River if some agricultural utilization or cottage industry were started utilizing the hot springs.

The basic economy of Hughes is subsistence. The population is 98 (Rural Energy Survey).

ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Hughes. The average summer temperatures range from 36° to 68°F (2° to 20°C) winter -18° to 25°F (-28° and -4°C). Extremes of -68° and 90°F (-56° and 32°C) have been recorded. Annual precipitation averages 30" (71 cm) per year. Heating degree days average approximately 16,000.

The dominant flora is lowland spruce-poplar forest grading into moist tundra near the Koyukuk river.

The area is adjacent to a nesting area for migratory waterfowl. There are caribou, moose and black bear in the area. The Koyukuk River is an anadromous fish stream.



Permafrost is discontinuous in the area.

Key Contact: Doyon Regional Corporation  
Hughes Village Council  
Tanana Chiefs

REFERENCE:

Miller 1973  
Yukon Regional Profile

SITE: Melozi

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 65° 08' N 154° 40' W

QUADRANGLE: Melozitna A-4 T4S R20E Section 23 KRM

BARRIER: Remote

RECOMMENDATION: Geothermal enhanced animal husbandry for rare meats.  
Local Greenhouse.

#### DESCRIPTION:

Located within the Melozi-Horner Hot Springs PGRA 99,211 acres (40,150 hectares).

The spring is quite unusual in that it issues from the top of a small bluff within a few feet of the edge, in fact, one portion of the springs squirts out of the bluff face into the river below. The unused portion of the hot water from the springs runs over the edge of the bluff into Hot Springs Creek (Ogle 1976).

There is one main spring. The temperature is measured at 55°C. Total flow is 83 L/S (130 gal/min). Reservoir temperature is estimated at 130°C with best estimate of reserve  $.67 \times 10^{18}$  calories (Geotherm File).

The chemical analysis of the hot springs water is NA + k 107, MG 28 CA 11, CL 92,  $\text{SiO}_2$  78,  $\text{SO}_4$  61,  $\text{HCO}_3$  32.00 (Geotherm File).

The hot springs exists in rocky soil approximately 6-10 feet. The spring is in quartz monzonite pluton about 3.2 km (2 mi) from contact with hornfelsic mafic and ultramafic rocks and 2.5 km (1.5 mi) from pelitic schist (Miller 1973).

#### SOCIO-ECONOMIC:

The spring is managed under a hot springs lease from the Bureau of Land Management to Melozi Hot Springs Inc. (F035073). Melozi Hot Springs Inc. controls 160 acres. There are regional selections in the PGRA by Doyon Regional Corporation under A.N.C.S.A. The State of Alaska has selected lands as well under the Statehood Act.

The springs have a long history of use. In December 1911 a two room cabin and a dog house were built on the gravel bank near the springs. Two log bathhouses, apparently of somewhat earlier construction, furnished bathing facilities by means of wooden tubs and sweat chambers (Waring 1917). The area was the site of extensive reindeer herds in the early 1900's.

Warm water from the springs is presently used to heat the main lodge building and some of the out buildings of a small resort. An

indoor swimming pool uses the water after it is circulated through a building still under construction (Ogle 1976).

The lodge owners wish to develop the area for its recreational and agricultural capabilities. Obstacles to development include funding and logistics of supplies.

The nearest population center is the village of Ruby 45 mi (72 km) to the southwest. The population there is 148 people. Supplies reach the village by barge and air.

There is a 1400' gravel air strip at the springs.

The spring owners have expressed an interest in developing their resort to include fishing, kayaking, hunting and skiing. The developing of an exotic red meat business such as bison or reindeer might be considered. Geothermally enhanced animal husbandry could play a key role in this enterprise. A 20' x 100' greenhouse using the geothermal waters is supplying food to the lodge. Development of greenhouses will be the probable avenue of commercialization.

The heat supply described by the resource assessment indicates that the spring could support perhaps a 20 to 30 kw generating plant. A 5 to 10 kw electrical system would be adequate however (Ogle 1976).

Woodburning and a 5 kw gas generator now supplement the geothermal energy supply. The owners are considering a low head hydroelectric generator for the main power supply.

#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Ruby. The summer temperatures average between 35° to 70°F (2° to 21°C) Winter -12° to 22° (-24° to -5°C). Extremes of -53° and 98°F (-47° and 37°C) have been recorded. Precipitation averages 17" (43 cm) including 66" (167 cm). Heating degree days average approximately 15,000.

The dominant flora in the area includes spruce, birch, cottonwood and elders. Hills are wooded. Hills vary from rolling to rugged mountain terrain (Personal correspondence, Doris Loennig).

There is an abundance of wildlife. Caribou, moose and bear abound in the area.

There is discontinuous permafrost in this area. A possible flood problem exists at the spring site.

Key Contact: Doris Loennig, Suite 206, 613 Cushman St.,  
Fairbanks, AK 99701

REFERENCE:

Waring 1917  
Miller 1973  
Ogle 1976  
Yukon Profile

SITE: Horner

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 65° 55' N 154° 47' W

QUADRANGLE: Ruby D-4 T7S R20E KRM

BARRIER: None

RECOMMENDATION: Agricultural

DESCRIPTION:

The springs are located within the Melozi-Horner Hot Springs PGRA 99,211 acres (40,150 hectares).

There is one main spring and seven smaller springs. The temperature is 117°F (47°C). The flow is 45 gpm. Chemical analysis of the spring water is SiO<sub>2</sub> (29); Natk (58); HCO<sub>3</sub> (22); CO<sub>3</sub> (32); SO<sub>4</sub> (45); CL (39); small amount of free H<sub>2</sub>S (Waring 1965).

The springs are in fractured granite of a small pluton. Country rock is probably schist of Precambrian to Paleozoic age. The springs are near the Kaltag Fault system.

The principal spring issues from a granitic cliff 55 m (160 ft) from and 14 m (40 ft) above the creek. Pale salmon colored to green algal growths are found in the runoff channels. The other springs issue at intervals from about 175 to 350 meters upstream from the principal spring. Like the other spring, they come from a fractured and partly disintegrated granitic rock. The water is apparently under some pressure, as it issues with an upward current from each vent (Waring 1917).

The granitic rock from which the springs issue is fractured, so the heated water may pass along a fissure in a zone of faulting that is possibly followed in part by the stream channel (Waring 1917).

SOCIO-ECONOMIC:

A cabin was built by F.G. Horner in 1913. He planted a garden near the springs utilizing the flow from the springs for the vegetation (Waring 1917).

The land in this area has been selected by the Ruby Village Corporation and Doyon Regional Corporation under terms of the Alaska Native Claims Settlement Act. This would leave control of the subsurface geothermal energy in the hands of the Regional Corporation.

The access to this area would be good compared to most spring localities because it is located along the flow of the Yukon River.

River boat access comes within 3/4 of a mile of the springs themselves.

The village of Kokrines is only 8 km (5 mi) along the course of the river. The population is small (less than 30 people). The village of Ruby (population 148) is located 32 km (20 mi) along its course. These areas are potential markets for truck farming vegetables. Other small villages up and down the Yukon River are also potential markets for fresh vegetables.

Wood fuel and oil are basic energy sources for the area now (Rural Energy Survey).

#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Ruby. The summer temperatures average between 35° and 70° F (2° to 21° C) Winter -12° to 22° F (-24° to -5° C). Extremes of -53° and 98° F (-47 and 37° C) have been recorded. Precipitation averages 17" (43 cm) including 66" (167 cm). Heating degree days average approximately 15,000.

The dominant flora in the area grades from bottomland spruce-poplar forest to upland spruce hardwood forest.

The Yukon River is a major anadromous fish stream as well as a migratory waterfowl stopover. Moose, bear and caribou all frequent the spring area.

The area has moderately thick permafrost and flood hazards.

Key Contact: Ruby Village Corporation

#### REFERENCE:

Waring 1917  
Miller 1973  
Yukon Profile 1976  
NAVA 1974

SITE: Little Melozitna

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 65° 28' N 153° 19' W

QUADRANGLE: Melozitna B-1 T1N R27E

BARRIER: Remote

RECOMMENDATION: Exploration - Determine Flow Rate

DESCRIPTION:

Located within the Little Melozitna Hot Springs PGRA on the east bank of Hot Springs Creek, a tributary to the Little Melozitna River. The springs are on a small flat. The hot water issues chiefly from one of the five springs on the left bank of the creek into a log-cribbing bathing pool. The spring temperature is 38° C. The water tastes mildly of hydrogen sulphate and carbon dioxide, and there is a green algae growth in the pool (Waring 1917).

There is about 350 parts per million of solids in solution. The chemical analysis of the spring water contains  $\text{SiO}_2$  (80); Na;  $\text{HCO}_3$ ; CL; Free  $\text{CO}_2$ ;  $\text{H}_2\text{S}$  (Waring 1965).

The estimated reservoir temperature is 130° C. The estimated total stored heat is  $.67 \times 10^{18}$  calories (Geotherm).

The rock exposed in the steep slopes at the edge of the valley is granitic. The granitic area seems to be small and to be confined to the slopes.

The presence of the small area of granitic rock at the springs strongly suggests that the rise of warm water is due to the intrusion of the rock in the country rock schist, and the consequent development of fissures or a zone of fracturing along which the thermal water rises from a considerable depth (Waring 1917).

SOCIO-ECONOMIC:

The land in the PGRA is owned by the State of Alaska under terms of the Statehood Act.

The springs were first utilized by a French trapper in 1913 for a brief period. A roadhouse was built to the south on the Yukon and a trail was built to the springs. The trail is about 43 km (27 mi) long (Waring 1917).

A log-crib bathing pool was built shortly after the turn of the century. The springs have been sporadically used ever since (Waring 1917).

Access to the springs is not available by fixed wing aircraft. River transportation is unfeasible because the flow of the Melozitna River is such that there is 160 + km (100 + mi) to reach the Yukon.

An application would be on the scale of cottage trades and agriculture. The temperature of the outflow would make all applications marginal.

Placer mining is active to the south near the Yukon.

#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Tanana 64 km (40 mi) to the southeast. Summer temperatures average 38° to 70° F (3° to 21° C) Winter -19° to 28° F (-28° to -2° C). Extremes of -76° and 92° F (-60° and 33° C). Precipitation averages 13" (33 cm) including 52" (132 cm) of snow.

The dominant flora in the area is upland spruce hardwood forest. The dominant fauna is moose, caribou and bear.

There is continuous permafrost in the area and potential flood hazards also exist.

Key Contact: Alaska Division of Lands

#### REFERENCE:

Waring 1917  
Miller 1973  
Geotherm Fish USGS  
Yukon Profile



SITE: Ray River

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 65° 57' N 150° 56' W

QUADRANGLE: Tanana T13N R16W FM

BARRIER: Remote

RECOMMENDATION:

DESCRIPTION:

The springs are located within the Ray River PGRA 85,710 acres (34,688 hectares).

The hot springs are at the base of a hill in a flood plain on the north side of the Ray River. There is a slight H<sub>2</sub>S odor. Temperature is 47° C (Miller 1973). Chemical analysis of the hot spring water is Ca (5.6), Mg (0.7), Na (71), K (1.4), HCO<sub>3</sub> (74), CO<sub>3</sub> (22), SO<sub>4</sub> (19), CL (9.1), B (0.6), ph of 9.16 (Miller 1973).

The bedrock is concealed but the springs probably occur on the contact between early Cretaceous quartz monzonite of the sithylemenkant pluton (Patton and Miller 1973) and the pelitic schist of Precambrian and Paleozoic age (Miller 1973).

SOCIO-ECONOMIC:

The land within T13N R16W have been selected by the Doyon Regional Corporation under terms of the Alaska Native Claims Settlement Act.

The spring can be reached by a difficult trail that leads through a narrow gorge to a more open canyon above. To this point it can be reached by riverboat (Waring 1917).

The spring has a history of use by itinerant miners. They used the springs for quick growing vegetables such as lettuce and radishes. Rumor has it that eggs were hatched in the warm gravel around the springs at that time (Waring 1917).

The springs are very remote with the nearest access route is along the Trans Alaska Pipeline 48 km (32 mi) to the East. There are therefore no apparent users in the area at this time.

Cottage trades or subsistence utilization may be considered by the Regional Native Association.

ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological station is Rampart many miles to the east. Summer Temperatures there average 37° to 71° F (30° to 22° C) Winter -22° to 20° F (-30° to -7° C). Extremes of -68° to 97° F (-56° to 36° C). Precipitation averages 14" (36 cm) with 49" (125 cm) of snow. The heating degree days average 15,500.

The dominant flora is that of the upland spruce - hardwood forest. Moose, bear and some caribou are the dominant mammals in the area.

The area is underlain by discontinuous permafrost. There is a potential flood hazard as the springs are in the flood plain of the Ray River.

Vegetation is an indication of the springs location.

Key Contact: Doyon Regional Corporation

REFERENCE:

Waring 1917  
Miller 1973  
Yukon Regional Profile

SITE: McDonnell

RESOURCE: Hot Springs (Miller 1973)

LATITUDE & LONGITUDE: 65° 59' N 150° 35' W

QUADRANGLE: Tanana D-2 T13N R14W

BARRIER: Federal Withdrawal

RECOMMENDATION: Exploration - Determine Flow Rate

DESCRIPTION:

This spring is not included in a PGRA but is located approximately 9 km (6 mi) from the Ray River PGRA.

Several hot springs are found within a distance of 60 meters on a gravel bar on the north side of the Ray River. Temperature is 61° C. The chemical analysis of the hot water is: Ca (11), Mg (0.1), Na (95), K (2.0), HCO<sub>3</sub> (93), CO<sub>3</sub> (21), SO<sub>4</sub> (23), CL (25), B (1.6). The pH is 9.04 (Miller 1973).

Bedrock is concealed but springs are approximately on contact between quartz monzonite of probable cretaceous age and pelitic schist of Precambrian and Paleozoic age (Miller 1973).

SOCIO-ECONOMIC:

This land is part of the Federal Power Withdrawal for the Rampart Power Project (not thought as viable project at this time).

This spring is approximately 24 km (15 mi) from the Trans Alaska Pipeline haul road. At this time the public cannot use the pipeline access road.

The withdrawal of the land makes it unavailable for public or private use. That, added to the remoteness, would make any development in the near future unlikely.

ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Rampart several miles to the east but weather should be similar. The summer temperatures average 37° to 71° F (3° to 22° C) Winter averages range from -22° to 20° F (-30° to -7° C). Extremes of -68 to 97° F (-56° to 36° C) have been recorded. Precipitation averages 14" (36 cm) with 49" (125 cm) snow. Heating degree days average 15,500.

The dominant flora is upland spruce - hardwood forest. The area has caribou, moose and bear as dominant mammals.

There is discontinuous permafrost throughout the area as well as potential flood hazards.

Key Contact: Bureau of Land Management

REFERENCE:

Miller 1973  
Yukon Profile

SITE: Kilo

RESOURCE: Hot Springs (Richard Rome)

LATITUDE & LONGITUDE: 65° 49' N 151° 12' W

QUADRANGLE: Tanana T11N R18W Sction 12 FM

BARRIER: Remote

RECOMMENDATION: Exploration, Local Subsistence Agriculture and  
Space Heating.

DESCRIPTION:

Located within the Ray River PGRA 85,710 acres (34,688 hectares), this spring is located on the Tanana Quadrangle map.

There has been no scientific evaluation of this hot springs. Doyon Native Corporation had an engineering firm evaluate the Ray Mountain Range for their mineral potential. The results of this study were somewhat negative.

The Ray Mountains consist of Cretaceous granitic rocks. The country rocks are Precambrian to Devonian, chiefly limestone, dolomite, marble, shale, sandstone, phyllite, argillite, quartzite and schist (Selkregg 1976).

There is indication that there has been glaciation. There are glacial moraines and drift deposits. The springs issue from a pluton of porphyritic quartz monzonite on or very near the contact with schist and hornfels of Precambrian age (Miller 1973).

The hot springs are on the Kilolithna River and form a distinct area of vegetation in largely treeless surroundings.

Hot springs water analysis collected by Dennis Kendall, Box 81079, College, Alaska. Fe.09, Mn.04, Ca3, HCO<sub>3</sub>, 92, CO<sub>3</sub> 0, SO<sub>4</sub> 47, CL 7, F 13.8, NO<sub>3</sub> .10, PO<sub>4</sub> .05, ph 7.52 specific conduct and 262 T.D.S. 230 lab analysis State Department of Health and Welfare Environmental Health.

SOCIO-ECONOMIC:

The springs themselves and the surrounding 155 acres are under mineral springs lease from the BLM to Richard Rome and Donna Waidtlow, Box 81490, College, Alaska 99701. The surrounding acreage is sparsely homesteaded within the township (105 acres) by Rome and Waidtlow. The remaining land is (d)(1) lands under terms of the Alaska Native Claims Settlement Act.

The hot springs are in mountain peaks with rugged terrain. This area is very remote and inaccessible except by helicopter.

The nearest access corridor is the Trans Alaska Pipeline 80 km (50 mi) to the east. The logical base of operation is Fairbanks 200 km (125 mi).

This spring is very remote and offers little chance for development for the foreseeable future. The local residents might use the spring for agriculture.

The nearest landing point to the spring is a lake about 22 km (12 mi) to the north of the spring.

#### ENVIRONMENT:

There are no climatological recording stations within a reasonable distance of the spring site. Correspondence with spring leasee Rome produced the following quote: "The springs are located at the meeting point of high and low pressure areas producing extreme high velocity winds with double and occasionally triple gust factors. It is not uncommon for us to have storms for weeks where we experience winds in excess of 50 mph, the sky is obliterated by blowing snow. I've seen it pick up a grown 160 pound man and send him head over heels." The average heating degree day is 15,500 estimated and precipitation 25 cm (10 in).

The dominant flora in the area is alpine tundra. The faunae in the area are limited by the mountain elevation of the spring.

There is continuous permafrost in the area.

Key Contact: Richard Rome

#### REFERENCE:

Yukon Regional Profile  
Correspondence Richard Rome

SITE: Minook (Conway)

RESOURCE: Reported hot springs (Waring 1917)

LATITUDE & LONGITUDE: 66° 25' N 150° 00' W approx.

QUADRANGLE: Livengood B6 T7N R12W approx.

BARRIER: None

RECOMMENDATION: Exploration

#### DESCRIPTION

Reported location within the Hutlinana hot springs PGRA 80,061 acres (32,400 hectares).

Frank Conway, a prospector during the early 1900's, reported discovering a spring that was fairly hot and yielded a stream of water several inches wide (Waring 1917).

This general area is underlain by Paleozoic conglomerate shale, and Jurassic Cretaceous mudstone intruded by small granitic stocks of Cretaceous and/or Tertiary age (Waring 1917).

The minook tributary flows north of the Yukon River.

#### SOCIO-ECONOMIC:

The land in this area has been selected by Rampart Village under terms of the Alaska Native Claims Settlement Act. Regional and State selection are also recorded in this area.

Presently there are no roads, facilities, or population in the suspected spring locality. The nearest road is the Manley Hot Springs Road 24 km (15 mi) to the south. This road leads to Fairbanks about 160 km (100 mi) to the south. Rampart Village (population 60) is located 16 km (10 mi) to the northwest.

The Elephant Mountains are part of an old mining district. Numerous mining claims exist in the area related to this activity.

Timber and agriculture are being considered in this area for development. Utilization of the geothermal resource to develop these renewable resources might be an appropriate technology. Geothermal Application, related to subsistence along the Yukon River, could help stabilize economic conditions and add nutritional balance to the region.

The current need is exploration to see the extent of the resource.

## ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The summer temperatures at Rampart average 37° to 71° F (3° to 22° C) Winter -22° to 20° F (-34° to -7° C). Extremes of -68° and 97° F (-55° and 36° C). Precipitation averages 10" (35 cm) including 49" (124 cm) of snow. Heating degree days average 15,000.

The dominant flora is that of the upland spruce-poplar forest. Caribou, moose, bear and fur bearing animals are found throughout the region. Salmon are found in the Yukon River. Indigenous fish are utilized in the area for subsistence.

Discontinuous permafrost dominates this area. Potential flood hazard during break-up season has to be considered in any engineering.

Key Contact: Village Council Rampart

## REFERENCE:

Waring 1917  
Yukon Profile  
Miller 1973



SITE: Hutlinana Creek

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 65° 13' N 149° 59' W

QUADRANGLE: Livengood A-6 T5N R12W FM

BARRIER: None

RECOMMENDATION:

DESCRIPTION:

Located within the Hutlinana Hot Springs PGRA 80,061 acres (32,400 hectares).

Hutlinana Hot Spring issues at the edge of a creek by the same name, 14 km (8½ mi) by trail from the Eureka Post Office. There appears to be only one spring, which issues from a fissure at the base of a cliff that terminates at the steep canyon side to the west edge of the creek. When Waring visited the spring, a bathing place was formed by excavation. A temperature of 114° F (45° C) was recorded with a discharge of approximately 50 gallons per minute (Waring 1917).

Water analysis shows a rather highly concentrated sodium carbonated water containing minor amounts of sulphate and chloride.

The rock at the spring is quartzitic and has nearly vertical bedding or shearing planes that strike N 25° E. It is a phase of the altered sediments, probably of lower Cretaceous age that cover a considerable area in the region. Faulting has not been noted but the presence of the spring would indicate at least steep fracturing and fissuring that permit the escape of water of abnormally high temperatures (Waring 1917).

There is a granitic intrusion of Cretaceous age in the Elephant Mountains about 5 km (3 mi) west (Miller 1973).

Chemical analysis of the thermal spring (Miller 1973); SiO<sub>2</sub> (40), AL (0.014), CA (20.2), Mg (6.6), Na (180), k (7.9), Li<sup>2</sup> (0.16), NH<sub>3</sub> (0.4), HCO<sub>3</sub> (488), SO<sub>4</sub> (55), CL (40), F (0.8), B (0.3) pH<sup>3</sup> (7.66), Temperature 43° C.

SOCIO-ECONOMIC:

The land here has been selected by the State of Alaska under terms of the Statehood Act. Some mineral claims exist in this district.

In 1915 a cabin stood 75 yards below the spring on a small alluvial flat, where potatoes and other vegetables were maturing well. Two older, unoccupied cabins stood on the opposite side of the creek (Waring 1917).

The spring has been used to some extent by the placer miners of the Eureka Creek mining district for bathing.

The springs are only 5 km (3 mi) from the Manley Hot Springs Road. This makes Hutlinana one of the most probable springs for development. Agriculture has already been proven to be viable almost 70 years ago. Markets in Fairbanks are only about 160 km (100 mi) away. Exotic plants and flowers have proven to be high cash crops in Fairbanks, so a greenhouse utilization is a possibility for this area.

NAVA et al (1974) found a trailer on a mining claim about 100 m across the river. A track has been bulldozed to the springs from Eureka. This trail can be followed in a 4 wheel drive vehicle.

#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Manley to the Southwest, 24 km (15 mi). The summer temperatures average 37° to 72° F (3° to 22° C) Winter -21° to 25° F (-29° to 4° C). Extremes of -70° and 90° F (-50° and 32° C) have been recorded. Precipitation averages 15" (38 cm) including 61" (155 cm) of snow. Annual heating degree days average 15,000.

The dominant flora is that of the upland spruce hardwood forest. Caribou, bear, moose, and fur bearing animals frequent the forests here.

This is an area of discontinuous permafrost.

Key Contact: State Division of Lands

#### REFERENCE:

NAVA 1974  
Waring 1917  
Miller 1973  
Yukon Regional Profile

SITE: Pocahontas

RESOURCE: Hot Springs (Meložitna Quadrangle Map)

LATITUDE & LONGITUDE: 65° 58' N 154° 02' W

QUADRANGLE: Meložitna T7N R23E KRM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

A spring is identified on the Meložitna Quadrangle map in T7N R23E. The spring is located within the Tunalaken Lake PGRA 305,280 (123,547 hectares).

The location is on the Pocahontas Creek near the contact between Cretaceous graywacky and mudstone and the grandiorite of the Indian Mountain Pluton (Selkregg, 1976).

The springs are probably the result of deep circulating meteoric water heating at depth and reissuing at the surface as geothermal water.

SOCIO-ECONOMIC:

The land status in the spring area is somewhat in question. It is probable that the Hughes Village corporation has selected the springs under terms of the Native Claims Settlement Act. The State of Alaska has selected land within the same township as well. The village corporation has overselected their allotment.

The nearest population is the village of Hughes 13 km (8 mi) to the northwest. The terrain between the two is somewhat mountainous with no road. Access may be possible by the Pocahontas River.

The population of Hughes is 98 people. Possible use of the springs by these villages could include balneology, aquaculture, agriculture and space heating. The area needs to be explored however to determine the extent of the resource.

ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The recorded climate in Hughes indicates that summer temperatures average between 36° and 68° F (2° and 20° C), winter averages between -18° and 25° F (-56° and -3° C) have been recorded. Annual precipitation averages 30" (71 cm) per year. Heating degree days average 16,000.

The dominant flora on the creek is that of upland spruce hardwood forest grading into alpine tundra above timberline.

The dominant fauna are moose and black bear. The Koyukuk River is an anadromous fish stream.

There is permafrost prevalent in the area.

Key Contact: Village Council Hughes

REFERENCE:

Yukon Regional Report

SITE: Alatna Hot Springs

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 67° 10' N; 153° 30' W approx.

QUADRANGLE: Survey Pass T21N R24E KRM approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Alatna River PGRA 200,078 acres (80,972 hectares).

G.E. Griffin of the Geological Survey reports that the Alatna River was too warm to be pleasant for drinking over a considerable stretch of the upper river. This would indicate that a large quantity of warm water enters the river in that part of its course, but no definite springs have been reported (Waring 1917).

The rocks in the area are mainly of Paleozoic age and are chiefly limestone and metamorphic schists. The warm water possibly issues at a number of places from fractured zones in the rocks. Geologic studies in the vicinity have shown neither extensive faulting nor intrusion of granitic materials into the old sediments near the river, though there is an intrusive granitic mass, several square miles in area on the higher slopes of the river (Waring 1917).

SOCIO-ECONOMIC:

The Alatna River area is very remote. Coldfoot camp, on the trans-Alaska pipeline corridor, is 85 miles (136 km) to the east. The village of Ahtna is 25 air miles (40 km) down river. The land is state selected at this time and therefore available for development if potential exists. However, leasing regulations have to be written to allow for any development. There is no industry in the area.

The Ahtna Village economy is basically subsistence.

The area has a high degree of mineralization with major copper deposits located south and west. Gold, tin, lead and zinc have also been associated with the Alatna River area. Actual mining operations have taken place south of the geothermal resource on the river.

No development of this resource will take place unless there is some activity in the mineral industry. Because there is no site specific surface manifestation, it would be a necessity to drill for any development, and the cost would be prohibitive except for some major application associated with the mineral production.

Many areas of National Monuments have been designated in the area. These do not allow for access under the terms of the Antiquities Act and PLO 5654

#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

There is no recorded climatic information in the area, but at the village of Allakaket, the following statistics were gathered. Summer temperatures were 36 to 71°F (2 to 22°C); winter temperatures were -30 to 16°F (-34 to 9°C). Extremes are -74 to 94°F. Precipitation is 14", (35 cm) including 72" of snow. The heating degree days would be approximately 16,500.

The dominant flora in the area is alpine tundra with some alder and willow located in the valley floors. Animal life is sparse with some moose and caribou. Fur bearing animals are associated with the river.

There is continuous permafrost in the area.

#### REFERENCE:

Yukon Regional Profile  
Waring 1917  
P.L.O. 5654

SITE: Kanuti

RESOURCE: Hot Springs (Miller, 1973)

LATITUDE & LONGITUDE: 66° 20' N; 150° 48' W

QUADRANGLE: Bettles, T18W, R15W, Section 36, FM

BARRIER: None

RECOMMENDATION:

DESCRIPTION:

This spring system is not included in a PGRA. Several hot springs are on the east side of the Kanuti River in a large grassy area, 100 meters in diameter, underlain by alluvium. There is a strong H<sub>2</sub>S odor associated with the springs. The temperature was measured at 66°C (Miller, 1973).

Bedrock is concealed but springs are in an area underlain by mafic volcanic rocks of Triassic and Jurassic age within 400 meters of the contact with Cretaceous granitic rocks of the hot springs pluton (Miller, 1973).

The chemical analysis of the hot springs water is:

NA	111
K	3.7
MG	0.3
Ca	2.70
B	1.3
Cl	28
SO <sub>4</sub>	21
HCO <sub>3</sub>	169
Ph	8.01

The estimated reservoir temperature is 140° C with a stored heat of  $.71 \times 10^{18}$  calories (Geotherm).

A second chemical analysis has been made of another spring: (Miller 1973)

SiO <sub>2</sub>	65
Al	.016
Ac	4
Mg	1
Na	130
K	4.5
Li	.28
NH <sub>3</sub>	4.9
HCO <sub>3</sub>	89.6
SO <sub>4</sub>	54

Cl	134
F	8.5
B	1.3
Ph	7.7
Temp.	59°C

#### SOCIO-ECONOMIC:

Located within the Trans-Alaska pipeline utility corridor. Under institutional control of the Bureau of Land Management.

There are no present population centers near the spring site. Oldman, a temporary pipeline corridor construction camp, is located about 8 miles (13 km) from the spring. This is also the nearest transportation corridor. Presently, the corridor is closed to public use.

An airport and living facilities do exist at Oldman.

This would be a prime development site for some small scale operation which could include lodge, resort, agriculture, aquaculture or other cottage industry. This, of course, would be dependent upon leasing by the federal government which appears unlikely at this time.

The proximity to a land transportation corridor, however, warrants further exploration.

#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile)

The nearest climatological recording station is Allakaket. The average summer temperatures range from 36 to 71° F (2 to 22° C). Winter temperatures range from -30 to 16° F (-34 to -9° C). Extremes of -72 and 94° F (-58 and 34° C) have been recorded. Heating degree days average 16,500.

The dominant flora is that of the upland spruce hardwood forest. Moose and some fur bearing animals dominate the area. Migratory waterfowl nest in great numbers to the west.

There is continuous permafrost throughout the area.

Key Contact: BLM

#### REFERENCE:

Miller, 1973  
Geotherm File.  
Yukon Profile



SITE: Tolovana

RESOURCE: Hot Springs (Miller 1973)

LATITUDE & LONGITUDE: 65° 16' N; 148° 50' W

QUADRANGLE: Livengood B-4; T5N, R6W, Section 7 FM

BARRIER: None

RECOMMENDATION: Agriculture

DESCRIPTION:

Within the Tolovana PGRA 63,100 acres (25,237 hectares). The springs are located near the summit of the hills on the western side of the valley of the Tolovana River. The springs taste slightly alkaline and have a mildly sulphurated odor. There is considerable bubbling from the several small vents a few yards apart on the hillside, but the gas is probably carbon dioxide (Waring 1917).

The springs are in mudstone of Jurassic and/or Cretaceous age, about 1.5 km from granitic rock of Cretaceous or Tertiary age exposed in the Tolovana Hot Springs dome (Miller, 1973).

Spring temperature averages 60° C. There are several springs which have an expected reservoir temperature of 130° C. Estimated total stored heat is  $.67 \times 10^{18}$  calories (Geotherm File) however, the flow is considered small (Waring, 1965).

The chemical analysis of the hot springs water is: (Miller 1973)

Na	321
K	23
MG	1.2
Ca	82
F	.2
Cl	615
SiO <sub>2</sub>	75
SO <sub>4</sub>	40
HCO <sub>3</sub>	49
Ph	7.70

SOCIO-ECONOMIC:

160 acres immediately around the springs are under a Federal Hot Springs Lease to Bud Seltenreich and James Dawson, Box 965, North Pole, Alaska, 99705. The area around the lease has been selected by the State of Alaska under terms of the Statehood Act.

There is a small airstrip near the spring site at the top of the ridge. The river is navigable to within 5 miles of the spring system (Waring, 1917). The Trans-Alaska Pipeline haul road and Manley Hot Springs road are to the north of the springs. Winter trails are designated to the west 5 miles (8 km). The Manley Road is 3 miles (5 km) further west.

The road to Fairbanks (Elliot Highway) is kept open during the winter. Fairbanks is about 65 miles (104 km) to the south by road.

This area is a target development spring because of its relatively easy access to Fairbanks. An agricultural use would be a logical application.

The entire natural setting appears to be completely monopolized by a swimming pool (Nava et al 1974). This pool is considered a private pool as there is no evidence of commerce involved in its use.

#### ENVIRONMENT:

(Yukon Regional Profile)

The nearest climate station is Livengood, 18 miles (29 km) to the northeast. The summer temperatures average 38 to 72° F (3 to 22° C). Winter averages -18 to 22° F (-28 to -5° C). Extremes of -54 and 90° F (-48 and 32° C). Heating degree days average 15,000.

The dominant flora in the bottom of the Tolovana Valley are low brush and muskeg bog. The hot springs are located in upland spruce and hardwood forest.

The fauna are dominated by moose and black bear. Some caribou do range in this area. The Tolovana River is a well known angling stream.

The area is underlain by continuous permafrost.

Key Contact: Bud Seltenreich

#### REFERENCE:

Waring, 1917  
Miller, 1973  
Chapman, USGS, Open File Map 1971, Livengood Quad.  
Yukon Profile  
Nava et al (1974)

## MANLEY

Manley Hot Springs is located about 90 miles (145 km) northwest of Fairbanks, Alaska. This hot spring is presently one of only a handful of springs actually initiating geothermal energy development at this time. For this reason, Manley hot springs is considered one of the prime development prospects for Alaska.

The springs are located in Section 17, Township 2 North, Range 15 West of the Fairbanks Meridian, which is part of the Manley hot springs PGRA, 85,812 acres. The Village of Manley is about  $\frac{1}{4}$  mile away. The village has a population of 69 people year around and swells to 100 people during the pleasant summer months. The population includes about 30% Athabascan Indians, which made the village eligible for participation in the Alaska Native Land Claims Settlement Act.

The land on which the springs are located belongs to Charles Dart, who purchased his homestead in 1955. The land immediately around the springs is owned by other private land owners. The PGRA is involved in some land title problems in that the village corporation has over-selected its allotment under the ANCSA, as well as selecting previously State selected lands. This land title situation will be cleared up as the village corporation's selections are completed and it receives patent to its lands.

Presently, the energy needs of the area are met by oil and gas, supplemented by wood. A 110 kw generator supplies the energy needs of the town itself. The fuel is brought in by barge and truck. A road services the area and provides a link with Fairbanks, the regional center for interior Alaska.

Manley Hot Springs, under the stewardship of original homesteader Karshner and investor Frank Manley, turned the springs into an agricultural center of interior Alaska shortly after the turn of the century. A 60 room hotel was built, as well as bathing pools, stables, hot barns and greenhouses, all utilizing the hot water as energy for space heating. The end of the mining era in Tofty gold zone spelled the end of the golden years at Manley Hot Springs.

Today, a renewed interest is being shown in the area. The present owner is using the spring waters in his 72' x 120' greenhouse. A public bath and the Dart's home both utilize the geothermal resource.

The University of Alaska proposes to conduct research into the techniques for directly utilizing the low grade geothermal energy resource for agricultural production of various economically viable crops. This project will ideally take 3 years and will include 4 phases: 1) an in-depth geological/geophysical survey of the resource; 2) demonstration of effective soil heating and space heating for greenhouses; 3) horticultural experimentation; and, 4) evaluation of an organic-Rankine cycle turbine generator of the 2-5 MW size. This project is contingent on funding by the Federal Department of Energy, and had all gone well, would have started January 1, 1979. DOE, however, has since failed to fund this project thereby necessitating a new starting date for the scenario.

The principal hot springs are in the valley of Karshner Creek, a tributary to Hot Springs slough. The temperature of the springs has been recorded at 59° C, with a flow rate of between 560-757 lpm. Estimates of the subsurface reservoir temperatures are in the 140° C range.

The springs are located near the contact between the quartz monzonite of the Hot Springs Dome pluton and the surrounding Jurassic or Cretaceous shales and siltstones that are the country rock. Black hornfels crops out 800 m up Karshner Creek where the abundance of biotite granite float suggests the contact is very close.

The Hornfels probably represents metamorphosed sedimentary rocks of Jurassic and/or Cretaceous age. This might suggest that the country rock has been too highly recrystallized to retain desired porosity and permeability. However, the dimensions of the subsurface geometry of the pluton and contact aureole is unknown.

The planned development should encounter no significant legal or institutional problems. A drilling permit to obtain water rights will be required for a proposed shallow well in the Ormat test. Environmental regulations are applicable if the fluid chemistry of the creek is changed.

Mr. Dent is presently applying for an appropriate technology grant from the Federal Department of Energy to expand his agricultural base.

#### SITE DATA SUMMARY

SITE: Manley

##### ..Physical Reservoir Data

##### ..Temperature °C

Surface: 59

Subsurface: 140 (White, 1975)

##### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

.22 x 10<sup>18</sup> Cal.

##### ..Type of Overlaying Rock:

##### ..Estimated Depth to Top of Reservoir (meters):

1,500 (Estimated White 1975)

##### ..Site Land Status

..Total Acres

Federal: 88,812

State: 0 Private: Less than 50,000 acres Other: 0

..Geothermal Development Status:

Heating of owner's home and 72' x 120' greenhouse (Leonard, 1975).

..Local and State Attitude Toward Geothermal Development:

Owners have expressed interest in developing their resource. The Geophysical Institute has applied to DOE to get monies for a demonstration project.

..Land Use and Population:

Area population is approximately 70. Presently, the land is being used for some agriculture. This is a recreational resort area for interior Alaska.

SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: Manley

..Latitude: 65° 00' N

..Longitude: 150° 38' W

..Rectilinear: T2N, R15W, FM

..County:

Unorganized Borough. Doyon Regional Native Corporation.

..Adjacent Counties:

..Topography

Springs located in a small depression between two hills. General mountainous topography associated with plutonism of Manley Hot Springs dome on the edge of Tanana River flood plain.

..Present Land Use:

Hot water is taken by gravity from the two largest hottest springs and circulated through 2" aluminum pipe with 4" fins in the greenhouse with a feeder line space heating the owner's house, and a small sump used for a bath house.

..Future Land Use Plans:

University of Alaska is applying to DOE to obtain monies to put in 2-5 kw low temperature binary electrical demonstration at the springs and open an agricultural experiment station there.

..Aesthetics:

Truly a shangrila in this area of vast wilderness.

..Historical/Archaeological Significance:

Discovered in 1901 by J.F. Karsher. With the discovery of gold in the Eureka and Tofty areas, Manley became a trading center. A 60 room hotel was built. This developed into the agricultural center for interior Alaska. By WWI, the rush was over and the town returned to its sleepy present day setting.

GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: Manley

..Geological Description:

The springs are located near the contact between the quartz monzonite of the hot springs dome pluton (age about 60 million years) and the surrounding Jurassic or Cretaceous sedimentary rocks such as shales and siltstone. The resource consists of several springs and seeps in a 20 acre area near the confluence of Karshner Creek and Hot Springs Slough. A hot well is reported about  $\frac{1}{2}$  mile to the north of the springs site.

The presence of hornfelcic argillaceous rocks about  $\frac{1}{2}$  mile above the spring suggests the country rock has been too highly recrystallized to retain desired porosity and permeability for a large reservoir at depth (Leonard 1978).

..Geophysical Summary:

None to date.

..Geologic Hazards:

There is possible mass wasting and flooding potential in the area.

## RESERVOIR CHARACTERISTICS

SITE: Manley

### ..Reservoir Temperature (White 1975)

..Surface: 59° C  
..Subsurface: 140° C  
..Geochemical

SiO<sub>2</sub>: 115° C  
Na-K-Ca: 137° C

..Flow Rates: 560-757 LPM

Miller, 1973

SiO <sub>2</sub>	65
Al	0.046
Fe	---
Mg	2.9
Na	130
K	4.8
Li	0.28
NH <sub>3</sub>	0.5
HCO <sub>3</sub>	90.7
CO <sub>3</sub>	---
SO <sub>4</sub>	51
Cl	132
F	8.2
Br	---
B	1.2
pH	7.72
Temp. °C	56

..Estimated Non-electric Energy Potential (MBtuh 30 years):

.2 x 10<sup>18</sup> Cal. (White, 1975)

## LAND OWNERSHIP AND LEASING

SITE: Manley

### ..Land Ownership

Total Area: 88,812

Federal: Facility withdrawal in area.

State: State has selected acreage within PGRA, but these claims are subject to provision of ANCSA.

Private: Village has selected considerable acreage in the PGRA. They have selected more than allotted so land picture is hazy.

### ..Tentative Lease Sale Dates:

Total Area: 20 acres

Federal: 0

State: 0

Private: 20 acres 1/1/79 for University - since presently unfunded this may be set back as per scenario.

### ..Summary of Leasing Status and Needs:

It seems that any immediate leasing activities and developments will take place on private lands owned by Dart.

## GEOHERMAL DEVELOPMENT STATUS

SITE: Manley

### ..Present Development Status:

Used for agriculture and space heating a 72' x 120' greenhouse. Soil warming is being employed in a small outside garden as well.

The hot water also supplies a bath house and space heats the owner's house.

### ..Projected or Planned Development:

University of Alaska plans on using area for demonstration of 5 kw binary electrical production. A project is now under review for funding by the DOE that was submitted by the Geophysical Institute of the University of Alaska. The project will last three years and will integrate four aspects of research: 1) an in-depth geophysical and geochemical reconnaissance of the Manley geothermal resource; 2) the demonstration of effective soil heating and space heating for greenhouses; 3) horticultural experiments; 4) evaluation of the Ormat organic Rankin cycle turbine generator.\*

\*University did not receive this funding.



## INSTITUTIONAL CONSIDERATIONS

SITE: Manley

### ..Institutional Requirements:

Private lands required nothing at this time.

Compliance with environmental regulations and drilling permits.  
Should obtain water rights.

### ..Agency and Public Attitudes:

Owner has been working in conjunction with U of A in putting together the proposal to DOE. Owner has applied for an appropriate technology grant for expenses of his greenhouse facilities.

## ENVIRONMENTAL FACTORS

SITE: Manley

(Extracted from Yukon Regional Profile)

### ..CLIMATE

..Precipitation (Annual): 15" (38 cm) with 61" (155 cm) snow

#### ..Average Temperature:

Summer: 37 to 72°F (3 to 22°C)  
Winter: -21 to 25°F (29 to -4°C)  
Minimum: -70°F (-57°C)  
Maximum: 91°F (33°C)

..Degree Days (Annual): 15,000

### ..AIR QUALITY:

Generally good. Some temperature inversions during winter.

### ..WATER QUALITY:

Near the shores of Tanana River. Major tributary to the Yukon. Geothermal energy owned by Mr. Dart. Measurements on water quality taken by C. Sloan.

### ..NOISE:

None.

..BIOLOGICAL:

..Dominant Flora:

Birch wood forest, alpine tundra

..Dominant Fauna:

Black bear, salmon, use of area by migrating waterfowl.

TRANSPORTATION AND UTILITIES

SITE: Manley

..Utility or Energy Transmission Corridors and Facilities:

Manley Utility Company, 111 kw generator system consuming 15,000 gallons of oil per year is located in the village (Rural Energy Survey).

..Transportation Corridors or Facilities:

Manley Hot Springs Road - Open during summer to Fairbanks some winter traffic as well. Access by barge.

Trans-Alaska Pipeline - 80 miles

POPULATION

SITE: Manley

..General Description of Population

The village of Manley has about 60 permanent residents. Approximately 30% are Athabascan Indians and the remaining 70% are caucasian. During the summer months, the population increases to about 100. There is no local government, but there is a one room school.

..Economics

..Present Land Use:

The area economy is based on service industries. Much of the population is retired from the job market. Some subsistence fishing.

..Future Land Use:

The area has a potential for agriculture.

SITE: Dall

RESOURCE: Reported Hot Spring (Miller, 1973)

LATITUDE & LONGITUDE: 66° 12'N; 149° 50' W, Approx.

QUADRANGLE: Beaver, T16N; R11W, approx.

BARRIER: No data

RECOMMENDATION: Exploration

DESCRIPTION:

Brosge', et al (1970) show a possible hot spring near Dall River.

The Yukon Flats area consists of thick valley bottom silt and sand, predominantly Eolian, but locally interlayered with water-laden deposits. The general area is underlain by pelitic schist of Precambrian to Devonian age. These rocks are intruded by Cretaceous granitic rocks in the Fort Hamlin mountains (Selkregg, 1976).

Warm water ranging in temperature from 37°C to 54°C bubbles from the ground in several places. The presence of a few logs indicates that there had once been a structure over one of the warm streams.

The springs form a clear basin about 85 meters across on a sloping hillside (Nava 1974).

SOCIO-ECONOMIC:

A winter ice road leads to this remote area from the Trans-Alaska pipeline haul road. Presently, and in the foreseeable future, the road will remain closed to private traffic. This fact makes all areas north of the Yukon River the most remote land area on the continent. However, if the haul road could be utilized, the ice road to Dall City would only be the 250 meters from the spring sites. The ice road would be 30 miles (48 km) from the haul road to the nearest point to the springs.

The land classification in this area is determined by the BLM. The land is presently withdrawn as an energy corridor for the Trans-Alaska pipeline. Lands to the east are classified (d)(2) and (d)(1) under terms of the Alaska Native Claims Settlement Act. (d)(2) lands would be included in the wilderness category.

The land to the east is some of the best agricultural potential in Alaska (Selkregg, 1976).

Stevens Village (pop. 72) is the nearest population center. This can be reached by river boat depending on the navigability of the Dall River.

Nava visited the springs in 1974. He landed on Guishiemana Lake and walked southeastwards about 2 miles (3.2 km) along the winter ice road to a spot where water at a temperature of 26°C was crossing the road through a culvert. About 250 meters northeast of this point the hot springs had formed a clear basin.

#### ENVIRONMENT:

(Extracted from Yukon Regional Profile)

The nearest climatological recording station is Rampart, 50 miles (80 km) to the south. The summer temperatures range from 37 to 71°F (3 to 22°C). The winter temperatures range from -22 to 20°F (-30 to -13°C). Extremes of -68 and 97°F have been recorded. The average annual precipitation is 10" (25 cm), including 49" (124 cm) of snow. Heating degree days average approximately 15,700 in the springs area.

The dominant flora is the upland spruce hardwood forest. The fauna are caribou, fur bearing animals, and some moose. The area to the east is a concentrated waterfowl range. Continuous permafrost occurs in this area.

Key Contact: BLM, Fairbanks

#### REFERENCE:

Miller, 1973  
Yukon Profile

## CHENA HOT SPRINGS

Chena Hot Springs is located 70 miles northeast of Fairbanks along the Chena Hot Springs road. These springs have one of the highest potentials for further development because of the road access to the springs. The present owners of the resort there have expressed interest in further development. Their plans tentatively include a sports pavilion, rental cabins, stables, greenhouses, hyperponic gardening year round, and perhaps even a ski resort. The feeling is that, with the road, the spring utilization has a built in market.

The hot springs area exists because of the resort there. All commerce in the immediate area revolves around the resort and the gold mining in that local.

The springs are located within the Fairbanks North Star Borough within T1N, R2E, FM. The topography of the area is characterized by high rolling hills reflecting the dominant N.E. structural trends of the Yukon-Tanana uplands.

The present resort has an enclosed olympic sized swimming pool, lunch counter/bar, and therapeutic pool. Overnight cabins are for rent and there is a gas station. The resource is used presently for space heating the buildings and in the pool and bath. A greenhouse also supports an experimental agricultural use.

Presently, the resort uses 60¢ per gallon diesel fuel to power a generator to provide for its electric needs. Wood is the general fuel for space heating in the area where geothermal waters are not used. At this time, the technology to utilize the low temperatures for electric generation has not been proven and is not generally thought of in the development plans of the owners. Economics is the reason that wood is used for space heating away from the springs.

The springs were first located by Felix Pedro in 1905. A year later, George Wilson Homesteaded the springs. The area rapidly became a popular resort and health spa for interior residents and miners. Following the decline of mining activity in the area, use of the springs declined. Ownership and upkeep followed an erratic pattern until 1953 when Carl Wilson purchased the homestead. He rebuilt and modernized the resort. Recently a limited partnership of Fairbanks residents purchased the springs. The resort is one of interior Alaska's leading attractions today. And is visited by many of Fairbanks' residents.

The Chena Hot Springs are thought to be representative of the thirty some thermal springs which occur in the broad zone which extends across central Alaska from the Yukon-Tanana upland to the Seward Peninsula. These springs occur at or near the margins of the late Cretaceous or early Tertiary granitic plutons. Metamorphic rocks associated with the granitic pluton in the area are greenschist and lower amphibolite facis.

There are four areas of warm ground in a linear anomaly pattern along Cold Creek. Ten springs with a natural surface discharge of 14 liters/second are located here. The springs have a pH of 9.14 with a rela-

tively low (388) total dissolved solids count. The surface temperature of the springs range from 50° to 65°C. Geochemical analysis indicates that the reservoir temperature is in the neighborhood of 150°C.

At the time of this writing, no reservoir analysis has been conducted on the Chena area. There has been some speculation that drilling might not enhance production of the springs area. This is due to the possible limited flow in deep circulating meteoric systems such as this associated with faulting near plutons. However, until drilling is done nobody will know.

The present surface discharge could support many direct use applications. Animal husbandry, space heating, geothermal enhanced agriculture including greenhouses and soil warming, aquaculture and balneological uses have all utilized temperatures within this range. Whatever potential use of geothermal energy that will be used in the area will probably be commercial in nature because of the lack of domestic need.

The legal and institutional requirements on the homestead appear to be minimal. Drilling permits would be required if activity of that sort was to take place mainly to secure water rights. Under present planning by resort owner, no drilling is planned.

The scenario is based on personal correspondence with the owners of the hot springs resort. The next two years will be used to evaluate the area for the potential utilization that is being considered. Most of the geophysical studies required have already been conducted and summarized in Norma Bigger's 1973 masters thesis on the area. Construction of the least capital intensive industries should begin in 1979. More site studies will be required for the more ambitious development plans. A decision may be reached as soon as 1980 on whether to build the ski resort and sports pavillion. Construction would begin at that time. Design for these facilities is presently being considered by a Fairbanks consulting company. It should be noted that the state is planning to spend over one million dollars to upgrade the road to Fairbanks this next year.

Further references on the area can be obtained from Norma Bigger's masters thesis referred to in the bibliography or through Brian Borjesson consulting engineer, Fairbanks, Alaska.

## SITE DATA SUMMARY

SITE: Chena Hot Springs

### ..Physical Reservoir Data

#### ..Temperature °C

Surface: 57° (White 1975)  
Subsurface: 140° (White 1975)

#### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

.2 x 10<sup>18</sup> cal (White 1975)

#### ..Type of Overlaying Rock: Biotite-Quartz Monizonite Intrusive (Bigger 1973).

### ..Site Land Status

#### ..Total Acres 34,256

State: State selections have been made in area under State-hood Act.

### ..Geothermal Development Status:

Used as resort - swimming and therapeutic pools. Space heating of old lodge is still used.

### ..Local and State Attitude Toward Geothermal Development:

Owners of the area are going ahead with development. Local agricultural development is being advocated by the State as a renewable resource as evidenced by The Big Delta Land Sale 1978.

### ..Land Use and Population:

Just a few year-round residents, mainly miners live here. The State plans land sales in area.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: Chena Hot Springs

..Latitude: 65° 03' N

..Longitude: 146° 03' W

..Rectilinear: T1N, R2E, FM

..County: North Star Borough

..Adjacent Counties: None

..Topography

Characterized by high rolling hills which reflect the dominant N.E. structural trends of the Yukon-Tanana uplands. Drainage is dendritic to the south and west.

..Present Land Use:

Enclosed swimming pool, lunch counter/bar, overnight cabins, gas station and therapeutic pool. Area is used as summer resort by Fairbanks residents.

..Future Land Use Plans:

Sports pavillion, rental cabins and cabins for sale, ski slopes, stables, greenhouse, hyperponic gardening (commercial).

..Aesthetics:

Typical interior Alaska. The spring makes the area a popular retreat for Fairbanks residents.

..Historical/Archaeological Significance:

Discovered 1905 by Felix Pedro gold prospector. George Wilson homesteaded and commercialized the springs as a health spa. Erratic usage until recently (1953). Use since then has steadily increased until today (Bigger 1973).

#### GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: Chena Hot Springs

..Geologic Description (Bigger 1973):

Surficial deposits in the area include alluvial fill in the valley floors and colluvial on the valley walls. Alluvial fans have accelerated due to devastation of valley sides by a recent forest fire.

No evidence has been found for glaciation at the springs site but Pewe et al (1967) describes evidence for Illinoian glaciation of Fan Mountain (1406 m) at the head of Monument Creek. Air photos indicate Cirque basins are located in the vicinity.

Matamorphic rocks occur as resistant outcrops and rubble on high ridges northwest and south of the hot springs and appear to be more



resistant to weathering than the adjacent granitic rocks. Metamorphism grades toward the North in the area. The Chena Hot Springs pluton is a biotitic-quartz monzonite intrusive with minor quartz diorite and granite variations. The elongate mass measures approximately 24 km along a ENE axis and 9.5 km in width.

During an early period of metamorphism, the crystalline schists of the Yukon-Tanana Upland were deformed into 130° clinal fold striking NW-SE toward the northeast (Brittan 1970). In the Chena area, the folds exhibit a N.S. orientation about the margin of the pluton showing disruption during emplacement of the pluton.

#### ..Geophysical Summary:

A near surface temperature survey detected four areas of warm ground, forming a linear anomaly pattern oriented 108° along Cold Spring Creek. It also indicated that Cold Spring Creek extended a cooling influence on the soil temperature. A portable geomagnetic survey of the area was dominated by a magnetic low of -280 gammas near the springs. This was interpreted to be due to hydrothermal alteration of near surface minerals.

A passive seismic survey was conducted but was hindered by man made noises and was not interpreted. Radiogenic Age Determinations were made of the Chena pluton and an age of  $58.9 \pm 2.7$  M.Y. was calculated. Using these determinations, it was concluded that radiogenic minerals of the pluton are not responsible for the total thermal energy manifested in the springs.

Chemical and gradient analysis indicates that meteoric waters could obtain proper temperatures and associated chemical constituents at 4 km assuming rapid adiabatic of waters.

#### ..Geologic Hazards:

Rapid erosional patterns and possible permafrost.

#### RESERVOIR CHARACTERISTICS

SITE: Chena Hot Springs

#### ..Reservoir Temperature

..Surface: 57°C (White 1975)

..Subsurface: 140°C (White 1975)

..Geochemical:

SiO<sub>2</sub>: 129°C (White 1975)

Na-K-Ca: 137°C (White 1975)

..Flow Rates:

..pH: 9.14 (Bigger 1973)

..Total Dissolved Solids: 388 (Bigger 1973) Abnormal high fluoride

..Fluid Chemistry:

SiO <sub>2</sub>	85
Al	0.028
Fe	---
Ca	1.3
Mg	0.13
Na	110
K	3.3
Li	0.3
NH <sub>3</sub>	2.7
HCO <sub>3</sub>	114.7
CO <sub>3</sub>	---
SO <sub>4</sub>	68
Cl	28.9
F	18.6
Br	---
B	1.3
pH	9.14
Temp. °C	57

..Estimated Non-electric Energy Potential Estimate (MBtuh 30 years):

.2 x 10<sup>18</sup> cal (White 1975)

..Subsurface Area of Reservoir Estimated:

1.5 km<sup>2</sup> (White 1975)  
Thickness 1.5 km<sup>2</sup>  
Volume 2.25 km<sup>3</sup>

#### LAND OWNERSHIP AND LEASING

SITE: Chena Hot Springs

..Land Ownership

Total Area: 34,256

Federal: 0

State: Remainder of PGRA appears to be in state land grants, mental health selections, and State patent pending lands. Some of the mineral rights are reserved in patent pending lands. Mineral claims are staked in the area.

Private: 149 acres of homestead

..Tentative Lease Sale Dates:

None planned.

..Summary of Leasing Status and Needs:

No leasing planned - any development will take place on private lands at this time.

GEOHERMAL DEVELOPMENT STATUS

SITE: Chena Hot Springs

..Present Development Status:

The resource is being utilized as a resort area. An olympic sized swimming pool and therapeutic bath are presently employed in the resort system. Space heating of lodge and greenhouse is also taking place.

..Projected or Planned Development:

The owners have expressed quite a bit of enthusiasm for development. Their plans include a ski resort, agricultural development and resort development. They feel with a 70 mile year round road open to Fairbanks they can have a major development and a built-in market. Some of the least capital intensive aspects should be built in 1979 including greenhouses. A sports pavillion is being considered as well as more resort cabins and the like. The plans are not complete for the final development picture. The State of Alaska plans to upgrade the road to Fairbanks. State land sites may allow opportunities for future utilizations.

INSTITUTIONAL CONSIDERATIONS

SITE: Chena Hot Springs

..Institutional Requirements:

There are no requirements for development on private lands.

State development would require issuance of permits as prescribed by leasing regulations.

..Agency and Public Attitudes:

State is committed to development of agriculture. This area is being considered as a potential agricultural site.

..Status of Requirements (i.e., EIA/EIS Requirements:

None started. None required.

## ENVIRONMENTAL FACTORS

SITE: Chena Hot Springs

(Extracted from the Yukon Regional Profile)

### ..CLIMATE:

..Prevailing Winds:

..Precipitation (Annual): 14" (36 cm) with 61" (155 cm) SN.

..Days of Sunshine (Annual):

..Average Temperature:

Minimum: -59°F (-51°C)

Maximum: 92°F (33°C)

..Degree Days (annual): 15,000

### ..AIR QUALITY:

Interior Alaska has problems of temperature inversions.

### ..WATER QUALITY:

Fresh water may be a problem in the immediate area. Cold Spring Creek does flow acceptable water according to the owner.

### ..NOISE:

This is located within one of the major mining areas in Alaska and noise is associated with activities.

### ..BIOLOGICAL:

..Dominant Flora:

Upland spruce and hardwood forest (non commercial) Altered by forest fire. Low birch regrowth.

..Dominant Fauna:

Winter moose concentrations, black bear, summer caribou range and some anadromous fish in area.

## TRANSPORTATION AND UTILITIES

SITE: Chena Hot Springs

### ..Utility or Energy Transmission Corridors and Facilities

None. All State lands reserve section lines for corridors that would be used for transmission lines.

### ..Transportation Corridors or Facilities:

Chena Hot Springs road connecting with Fairbanks to service Chena Hot Springs.

### ..Other:

Trans-Alaska Pipeline crosses the highway in the Fairbanks area approximately 60 miles.

## POPULATION

SITE: Chena Hot Springs

### ..General Description of Population:

Closest population center is Fairbanks 70 miles away with a population of 30,462.

Population density within 10 miles of the site is less than 1 per square mile. (Selkregg 1973)

### ..Economics

#### ..Present Land Use:

The present economics is based on the Hot Springs Resort. The employment figures are such that a single family runs the lodge. Gold mining continues in the area sporadically.

#### ..Future Land Use:

A major development such as a ski resort would produce an economic base for more people to work in service industries.

## CIRCLE

Circle hot springs is located 137 miles northeast of Fairbanks on a spur of the Steese Highway. Since there is a road to it and an airstrip Circle hot springs is one of the best prospects in the State for future geothermal development. An agricultural adaptation utilizing the transportation system such as commercial greenhouses would be a likely candidate for this site.

The springs are located in Section 34, T8N, R15E of the Fairbanks Meridian. The 15 acres immediately around the springs is owned by the Circle Hot Springs Resort. Doyon Native Corporation has selected lands in the area. There is a federal facility withdrawal and (d)(1) and (d)(2) lands in the PGRA. There is some question as to whether the State of Alaska has selected land in the PGRA as well. (d)(2) land status has recently been changed to conform to the Antiquities Act withdrawal December 1, 1978 creating a national monument.

The land use in Circle hot springs revolves around the lodge, gold mining and some subsistence. The energy consumption for the area runs about 50 kw. The energy is supplied by a diesel generator. The consumption is between 12,000 and 15,000 gallons according to consultant Bill Ogle.

These springs have been the site of a resort for many years. The land was homesteaded by Frank Leach in 1918, but the springs were used long before that. The present installation consists of a 22 room hotel and 13 cabins, various out buildings, and a large swimming pool, all heated from the springs. The springs themselves issue from a hill immediately behind the buildings. The water is circulated through the buildings by gravity flow, except for a small pump used for the third floor of the hotel.

The springs issue at 1704 liters/minute with a surface temperature of 59.5°C. The best guess at the reservoir temperature is 145°C, using an average geochemical indication. The estimate of stored potential is  $.75 \times 10^{18}$  calories according to the U.S. Geological Survey although very speculative.

This resource could produce between 30-40 kw of electric power if a binary generator were installed according to consultant Bill Ogle in a report conducted for Sandia Laboratories. He mentioned that there was no cold water supply within 2 miles, but that the resort consumes the springs waters after cooling.

Some agriculture has been initiated in the past with limited success at the springs. A new twist in the agricultural utilization might come with the introduction of the flower industry to the present greenhouses. The industry is just beginning and is flourishing in the Fairbanks area. The strains of roses grown are unique in all the world. This type of agriculture is being tested at the University of Alaska's experimental greenhouse utilizing the waste heat from a generating station and has proved very successful. This would indicate an applicability to hot springs that seems reassuring. If successful in the initial year of

experimentation, further expansion is expected which will eventually lead to full utilization of the springs.

A potential land title problem exists if the State of Alaska and the Doyon Native Corporation have selected the same land outside the resort area. Further information is needed to determine this land status.

## SITE DATA SUMMARY

SITE: Circle

### ..Physical Reservoir Data

#### ..Temperature °C

Surface: 54°C (White 1975) 59.5° (Owners Report)  
Subsurface: 145°C (White 1975)

#### ..Estimated Non-Electrical Potential (MBtuh\* 30 years) speculative:

$.2 \times 10^{18}$  Cal (White 1975)

#### ..Type of Overlaying Rock:

Granite intrusive (White 1975)

#### ..Estimated Depth to Top of Reservoir (meters):

1.5 km (White 1975)

### ..Site Land Status

#### ..Total Acres

Federal: 67,915  
State: Selections Possible  
Private: Homestead and Mining Patents  
Other: Native Allotments not Transferred

### ..Geothermal Development Status:

Site of a resort for many years. The land was homesteaded by Frank Leach in 1918 but apparently the springs were used long before that. The present installation consists of a 22 room hotel and 13 cabins, various outbuildings and a large swimming pool, heated by the springs (Ogle, 1976).

### ..Land Use and Population:

The present land use for the area is for a resort and for placer mining.

### ..Comments and Critical Issues:

Some family members opposed to large scale development. Fresh water is not found within 2 miles.



## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: Circle

..Latitude: 65° 29' N

..Longitude: 144° 39' W

..Rectilinear: Circle, B-2, T8N, R15E, Section 34, FM

..Topography:

The Circle area is part of the central plateau of Alaska. The plateau in this area consists of broad rolling mountains, dissected by dendritic drainage.

..Present Land Use:

The land around the springs is used for the resort. Placer gold concentrations are mined in the area.

..Future Land Use Plans:

Agriculture.

..Historical/Archaeological Significance:

The Doyon Corporation has applied for cemetery/historical sites in the area under the Alaska Native Claims Settlement Act.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: Circle

..Geologic Description:

This area is located at the approximate boundary of the Yukon Flats geologic province and the Yukon-Tanana upland and Eagle trough province. Major faulting does occur in the area. One system arcs in a northwest trend with the base of the arc SW. The other faults generally trend northeast and are more en-echelon.

A fault trending to the northwest is found along the base of the mountains to the north in the Circle area. To the north, the rocks are predominantly eolian. To the south, the basement is Paleozoic and Precambrian schist quartzite and gneiss. To the south and west, Cretaceous intrusive granite outcrops (Selkregg, 1976).

Rocks associated with the springs are these granites and the country rock which is schist (Waring, 1965). Alluvium covers the slopes of the mountains.

..Geophysical Summary:

None to date.

..Geologic Hazards:

Moderate earthquake hazard. There are erosional problems associated with breakup and permafrost.

RESERVOIR CHARACTERISTICS

SITE: Circle

..Reservoir Temperature: (White)

..Surface: 54°C (55.9)

..Subsurface: 145°C

..Geochemical:

SiO<sub>2</sub>: 135°C

Na-K-Ca: 143°C

..Flow Rates: 494 lpm White 1704 cpm (owner)

..Total Dissolved Solids:

SiO <sub>2</sub>	95
Al	0.012
Fe	---
Ca	20.8
Mg	0.3
Na	230
K	9.8
Li	0.34
NH <sub>3</sub>	0.1
HCO <sub>3</sub>	184.6
CO <sub>3</sub>	---
SO <sub>4</sub>	96
Cl <sup>4</sup>	249
F	9.7
Br	---
B	1.1
pH	7.58
Temp. °C	57

..Estimated Non-electric Energy Potential (MBtuh 30 years):

.2 x 10<sup>18</sup> Cal (White 1975) estimated; .75 x 10<sup>18</sup> cal (Geotherm)

## LAND OWNERSHIP AND LEASING

SITE: Circle

### ..Land Ownership:

Total Area: 67,915

Federal: There are Federal facility withdrawals. (d)(1) and (d)(2) classification in area.

State: Yukon Regional Profile says that the State has selected the area under terms of the Statehood Act.

Private: Native population has located cemetary historical sites and region withdrawals. There are private placer gold claims in the area as well as the resort homestead.

### ..Summary of Leasing Status and Needs:

None planned. If State does have land, some potential agricultural sale could then take place.

## GEOHERMAL DEVELOPMENT STATUS

SITE: Circle

### ..Present Development Status:

There are several springs issuing from the side of the hill immediately behind the buildings at the site. The installation consists of a 22 room hotel and 13 cabins, various outbuildings, and a large swimming pool, all heated from the springs. The water is circulated through the buildings by gravity flow, except for a small pump used for the third floor of the hotel. The pipes are gradually rusting away, leading to an appreciable maintenance problem.

### ..Projected or Planned Development:

An experimental greenhouse will be erected in the 1979 summer season to test the economic viability of rose production at the spring site.

## INSTITUTIONAL CONSIDERATIONS

SITE: Circle

### ..Institutional Requirements:

Since the springs are owned privately the only requirements are meeting the State and Federal environmental standards.

..Agency and Public Attitudes:

State is presently considering this and other areas of the interior for agricultural land sales.

..Status of Requirements (i.e., EIA/EIS Requirements:

Non started. None required.

ENVIRONMENTAL FACTORS

SITE: Circle

(Extracted from the Yukon Regional Profile)

..CLIMATE:

..Precipitation (Annual): 14" (36 cm) with 61" (155 cm) of snow

..Average Temperature:

Summer: 38 to 72°F (3° to 22°C)  
Winter: -22 to 20°F (-29° to -6°C)  
Minimum: -60°F (-51°C)  
Maximum: 94°F (34°C)

..Degree Days (Annual): 14,700

..AIR QUALITY:

Possible temperature inversions.

..GEOLOGIC FACTORS:

Minimal earthquake.

..WATER QUALITY:

No fresh water within 2 miles. Mean annual runoff is approximately 0.5 cu. ft/sec/mi. sq. Hazard of flooding during breakup.

..BIOLOGICAL:

..Dominant Flora:

Upland spruce, hardwood forest, lowland brush, bog and muskeg.

..Dominant Fauna:

Caribou, moose, black bear.

## TRANSPORTATION AND UTILITIES

SITE: Circle

### ..Utility or Energy Transmission Corridors and Facilities

None.

### ..Transportation Corridors or Facilities:

The Circle Hot Springs road is an 8 mile (13 km) spur off the Steese Highway. This land closes for the winter about November.

## POPULATION

SITE: Circle

### ..General Description of Population:

The population of Circle Hot Springs fluctuates seasonally. The summer population is in the neighborhood of 90 full time residents, in the winter, about 22.

### ..Economics

#### ..Present Land Use:

The area has an economic base of gold mining, the hot springs resort and subsistence.

The springs has an airstrip, state maintained.

#### ..Future Land Use:

Agricultural development.

SITE: McCartney

RESOURCE: Hot Springs (Waring)

LATITUDE & LONGITUDE: 65° 04' N 142° 45' N Approx.

QUADRANGLE: Charley River T3N, R24E, FM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the flat creek PGRA 39,984 acres on the North Slope of Mt. Sorenson. The springs were reported to Waring in 1917 by C.H. McCartney. He reported that the hot springs were probably issuing from the slopes above Flat Creek, a tributary to Charley River. During the winter, Flat Creek stays open along part of its upper course about which considerable vapor rises. No vents or hydrogen-sulphide was noted.

The rock near the springs is probably an ancient schist, which occupies a considerable area near the headwaters of Flat Creek. Devonian to Mississippian sediments as well as Cretaceous granite rocks outcrop in the immediate area. The heated water possibly rises along the contact zone between one of intrusive granites and the older sediments. (Waring 1917)

Extensive faulting is noted in the area (Selkregg 1976).

Nava reported a 20-25 meter wide snow free mound indicating thermal activity. No water could be seen draining from the area from the air.

SOCIO-ECONOMIC:

The land in this area has been selected by the Doyon Regional Corporation under terms of the Alaska Native Land Claims Settlement Act. Lands in the area to the west are (d)(1) until the Charley River is reached. The lands around the Charley River have been included in the wild and scenic rivers system (P.L.O. 5654). This is subject to litigation

The springs are very remote with Eagle 45 miles (72 km) the nearest population center. Flum Creek 5 miles (8 km) to the South has an airport of questionable maintenance.

Since there is no probable user in the area at this time, it is premature to predict an end use. The Native community probably has title to the springs, a resort, agricultural center or combination of both would be a good guess at this time for future use. Until exploration takes place nothing concrete can be planned.

## ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Eagle. Summer temperatures average 37° to 73°F (3° to 22°C). Winter temperatures average -24 to 25°F (-31 to -4°C). Extremes of -75° and 95° (-60° and 34°C) have been recorded. Precipitation averages 11" (28 cm) 50" (125 cm). Heating degree days average 15,000.

The area is forested with a dominance of upland spruce hardwood forests. There are bear, moose, Dall sheep and caribou population in the area.

The area is underlain by continuous permafrost. There is also some potential for flood hazards and snow slides.

Key Contact: Planner, Doyon Regional Corporation

## REFERENCE:

Waring 1917  
Yukon Profile  
Nava et al 1974

SITE: Wolfe

RESOURCE: Hot Springs (Waring 1965)

LATITUDE & LONGITUDE: 65° 13'N 144° 29' W

QUADRANGLE: Circle T5N, R16E, FM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Big Windy Creek P.G.R.A. 28,644 acres (11,592 hectares). The springs are located on the Circle quadrangle map along the north bank of the Big Windy Creek.

The underlying rock units are Paleozoic and Precambrian schist quartzite, and gneiss; primary early Paleozoic slate, phyllite, schist, graywacke (Selkregg 1976).

Cretaceous intrusive rocks of granite origin outcrop on the Happy Jack mountains south of the spring. The springs lie close to the contact of the granite and Precambrian rocks. Major faults cut the area trending northeast (Selkregg 1976).

The area has been heavily glaciated. Drift deposits are abundant in the area.

Nava reported in 1974 that the Waring site was located in a steep rock walled canyon having a little vegetation on its north slopes. The only real vegetational effect was that produced by a half dozen deciduous trees above a rocky side hill from which the snow had completely melted. These were all aerial observations.

SOCIO-ECONOMIC:

The land area within the P.G.R.A. is federal lands. There is a portion in the Eilson military reserve. The majority of land including the springs are located in (d)(1) National Interest lands under terms of the Alaska Native Claims Settlement Act. This classification could allow development.

The area is quite remote. Big Windy Creek drains into the Yukon River. The nearest road or population area is Circle Hot Springs 16 miles (76 km) to the north. The springs area is unpopulated. Exploration is needed to determine the extent of the resource.

Yukon Flats National Monument has been designated in this area. It is assumed that this spring is not included in the monument from the limited information available.



#### ENVIRONMENT:

(Extracted from the Yukon Regional Profile).

The nearest climatological recording station is Circle Hot Springs. The summer temperatures average 38° to 72°F (3° to 22°C) winter -22° to 30°F (-30° to -1°C). Extremes of -90° and 94°F (-51° and 34°C) have been recorded. Precipitation averages 11" (28 cm) including 53" (135 cm) of snow.

The area is forested with dominance of upland spruce hardwood forests. There are bear, moose, Dall sheep, and caribou population in this area.

The area is underlain by continuous permafrost. There are also potential flood hazards along Big Windy Creek.

Key Contact: BLM Fairbanks

#### REFERENCE:

Waring 1965  
Yukon Profile

SITE: Glacier

RESOURCE: Reported Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 63° 49' N 151° 15' W

QUADRANGLE: Mt. McKinley T14S, R19W, FM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located 40 miles (64 km) north of Mt. McKinley. J.D. Courtney who resided at glacier in the upper Kantishna River Basin reports that warm springs probably rise 6 or 8 miles (10 to 13 km) west of Glacier. This area has many subsidence holes, a few acres in area and as much as 15 meters below normal ground level. They contain dead trees standing in water that remains unfrozen throughout the winter. The sunken areas are probably depressions in the uneven surface of the glacial gravels and clays that cover parts of the regions. Distinctly thermal water may issue from springs in some of these depressions (Waring 1917).

The area is covered with alluvium. Late Precambrian and early Paleozoic highly metamorphosed clastic rocks, including argillite, graywacke, phyllite, quartzite and gneiss (Selkregg 1976).

SOCIO-ECONOMIC:

The reported springs are located within the north addition to Mt. McKinley National Park. The land title is with the Federal Government under management of the National Park Service.

The area is very remote with no land transportation system in the immediate vicinity. A winter trail leads from Wonder Lake within the national park near the area on to the North. There is a road to Wonder Lake 15 miles (24 km) to the North open in the summer. If the park expands, a possible park facility might be developed around a hot springs such as this.

The nearest village is Glacier. There is no industry in the locality.

ENVIRONMENT:

(Extracted from the Yukon Regional Profile)

The nearest climatological recording station is Lake Minchumina 35 miles (56 km) to the Northwest. Summer temperatures average 38° to 68°F (3° to 20°C). Winter -14° to 26°F (-25° to -3°C). Extremes of -62° and 89°F (-52° to 32°C) have been recorded. Precipitation averages 13" (33°C) including 50" (127 cm) of snow. Average wind is ENE 6.1 kts.

The dominant flora is that of moist tundra grading to upland spruce hardwood forest. High brush dominates the stream bottom. Caribou, moose, bear and fur bearing animals abound in this area. This area is a moderate use waterfowl range.

Continuous permafrost is present.

Key Contact: Mt. McKinley Park Superintendent

REFERENCE:

Waring 1917  
Yukon Profile

SITE: Courtney

RESOURCE: Reported Hot Springs

LATITUDE & LONGITUDE: 63° 53' N 15° 43' W

QUADRANGLE: Mt. McKinley T12S, R16W, FM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located 15 miles (24 km) west of the Forks Juncture on the Toklat River. The locality has a series of acre-sized and larger sunken areas up to 15 meters lower than the surrounding lands. Unfrozen water stands in the bottom of these sinks. Thermal waters may cause this phenomenon, or local conditions may be such that it protects the surface waters from freezing (Waring 1917).

For this region, the waters of both Toklat River and Moose River sink for stretches of a mile or two and reappear apparently warmed (Waring 1917).

Most of the rocks in the area are undifferential deposits. The Kantishna hills to the south reveal a sedimentary to metamorphized sequence in age from late Precambrian to Mississippian (Selkregg 1976).

SOCIO-ECONOMIC:

This reported thermal locality is within the north addition to Mt. McKinley National Park. The land is under management of the National Park Service (P.L.O. 5654).

This area is very remote. No access other than helicopter is practical at this time or in the near future.

As the National Park expands in future years, a hot springs locality such as this might be considered for its recreational use.

The logistic center for this reported spring would be the town of Clear about 50 miles (80 km) to the northeast.

ENVIRONMENT:

(Yukon Regional Hot Springs)

The nearest climatological recording station is Lake Minichumina 50 miles (80 km) to the west. Summer temperatures average 38° to 68°F (3° to 20°C). Winter temperatures average -14° to 25°F (-26° to -4°C).

Extremes of -62° and 89°F (-52° and 32°C) have been recorded. Precipitation averages 13" (33 cm) including 50" (127 cm) of snow. Average wind is ENE 6.1 kts.

The dominant flora is that of moist tundra that grades to upland spruce hardwood forest. Caribou, bear, moose and fur bearing animals are here. Lakes in the vicinity provide a habitat for migrating waterfowl.

There is continuous permafrost in the area. Flooding might also be a problem.

Key Contact: Mt. McKinley Park Superintendent

REFERENCE:

Waring 1917  
Yukon Profile

SITE: Hale

RESOURCE: Reported Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 64° 00' N 156° 15' W Approx.

QUADRANGLE: Nulato T17S R13E KRM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

A prospector reported a hot springs on a tributary of the Upper Innoko River to Waring in his 1917 report. The flow was construed to be considerable and decidedly hot. The springs are probably related to granitic intrusions (Waring 1917).

The geologic section of the Kayak Hills includes ancient metamorphic rocks, interbedded lavas and associated sedimentary rocks of Carboniferous age and non-metamorphic sedimentary rocks of Paleozoic and Mesozoic ages. The hard rocks have been intruded by Mesozoic granitic rocks (Mertie 1937).

SOCIO-ECONOMIC:

The land in this area has been selected by the State of Alaska under terms of the Statehood Act.

It is a remote uninhabited land with few natural resources of commercial value. The nearest permanent inhabitants are along the Yukon River 50 miles (80 km) to the north.

There is no form of transportation into the area other than helicopter. The probable logistics center would be Fairbanks.

Since no Exploration has been done, that should be the first priority on developing this resource. However, it must be realized that there is no end user at this time. Perhaps a resort facility could be developed around the springs themselves if the resource is sufficient.

ENVIRONMENT:

The climate can only be estimated. Summer temperatures average somewhere between 40° to 70°F (4° to 21°C). Winter temperatures average -20° to 20°F (-29° to -6°C). Extremes range from -60° to 90°F (-51° to 32°C). Heating degree days average 17,000.

The dominant flora are upland spruce and hardwood forest. Caribou, Moose and bear are found here. Continuous permafrost prevades this landscape.

Key Contact: State Department of Natural Resources, Division of Lands

REFERENCE:

Mertie (1937)  
Waring (1917)  
South West Regional Profile

SITE: Flat

RESOURCE: Reported Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 62° 27' N 157° 56'W

QUADRANGLE: Iditarod T27N, R47W

BARRIER: Lack of Exploration

RECOMMENDATION: Subsistence Agriculture

DESCRIPTION:

Located within the Flat P.G.R.A. 22,842 acres. These reported hot springs are located on Otter Creek 10 miles (16 km) southeast of Iditarod. Temperature and chemical analysis has not been recorded. The springs issue near the contact of granite and slate where fissures of seams extending to considerable depths very probably furnish means of escape for deeper thermal waters. No noticeable deposit is formed by the springs, but the rock is considerably stained by iron (Waring 1917).

The granite is Cretaceous in age. It intrudes Jurassic and Cretaceous sedimentary sequence.

SOCIO-ECONOMIC:

The land in the PGRA has been selected by the State of Alaska under terms of the Statehood Act. Numerous mining claims have been staked in the area and a number are being brought to patent.

The Village of Flat (population of 27) is located 4 miles (6 km) to the west. The spring discovery site is located in the hub of mining activities of the area.

The historical Iditarod trail is still used in a yearly dog sled race from Anchorage to Nome. It passes through this PGRA.

The Village of Flat has an airstrip but no facilities for outside visitors. The economy of the town is based on the mineral industry and subsistence.

No exploration has been conducted on the springs to date. However, if flow and temperature are sufficient, fresh vegetables could be grown in a greenhouse for local use.

ENVIRONMENT:

(Extracted from the Yukon Regional Profile)

The average summer temperatures range from 38° to 71°F (3° to 27°C). Winter temperatures range from -10° to 24°F (-23° to -4°C). Extremes of -60° and 90°F (-51° and 32°C) have been recorded.



Precipitation averages 10" (41 cm) including 55" (140 cm) of snow.  
The wind averages ESE 6 kts.

The dominant flora is that of the upland spruce hardwood forest grading to alpine tundra in the mountains. Caribou and moose dominate the local game supply. The course of the Iditarod River is a nesting area for migratory waterfowls.

Discontinuous to continuous permafrost is found throughout the locality.

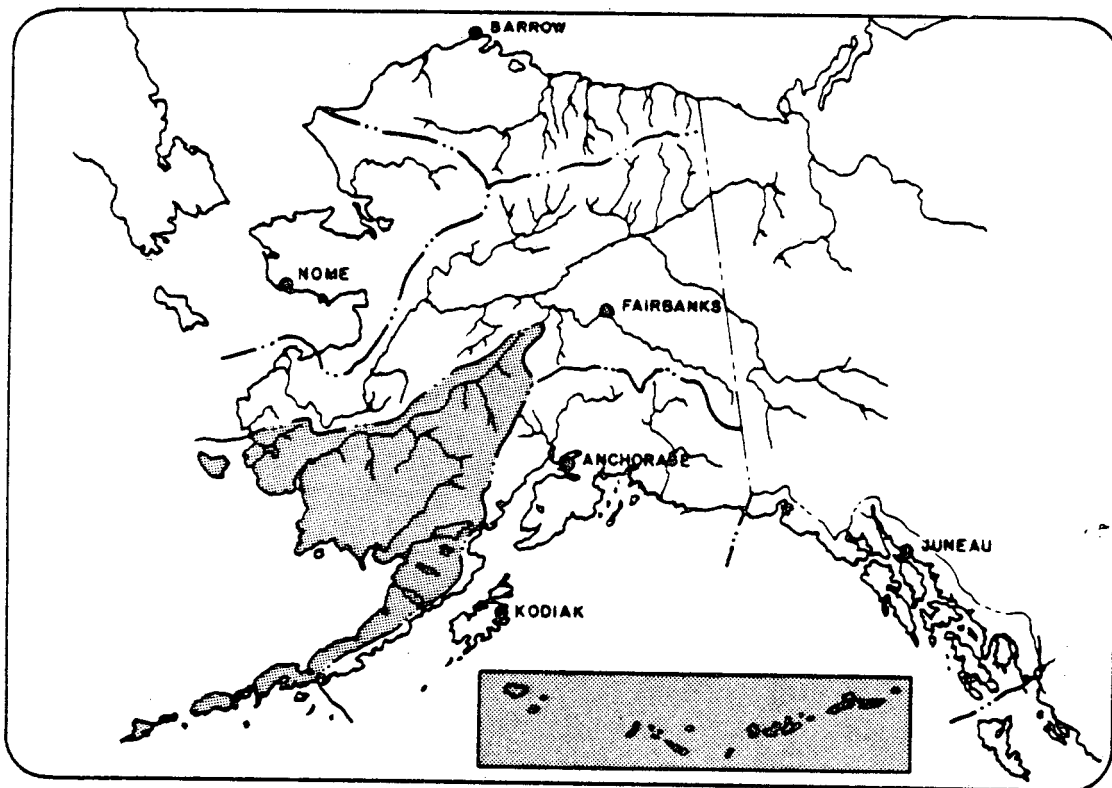
Potential Flood Hazard.

Key Contact: Flat Village Chief

REFERENCE:

Waring 1917  
S.W. Regional Profile

## Southwest Region



## SOUTHWEST REGION

(Portions Extracted from Southwest Regional Profile)

This section describes the environment of the Southwest Region for geothermal energy.

The islands and waters of the Aleutian Chain extend westward more than 1,100 miles (1,760 km). The islands are part of one of the world's most active seismic zones and form an arc comprised of more than 50 islands that separates the Pacific Ocean and the Bearing Sea. The subregion has wet, overcast, stormy weather. The islands are treeless. The adjoining waters contain heavy growths of marine vegetation and are rich in sea life. Human settlement is scattered and oriented to the sea. This is, in fact, one of the most remote places on earth.

### Climate

Water completely surrounds the Aleutians and exerts a strong influence on the climate. In winter, the ocean is a source of heat and moisture and the cloud cover that results slows down the loss of heat from the water surface. Normally, there are less than seventy clear days per year.

Home heating begins when the air temperature is near 65°F (18°C). Mean temperatures below 65° (18°C) accumulate heating degree days (HDD). The Aleutian Islands record between 9,000-10,000 HDD with maximums up to 500 more than the average.

The Aleutians are in one of the transition zones for the three major air circulation cells between the equator and the North Pole. This zone of upward moving air provides the conditions for the storms that form in the northern and western Pacific Ocean and move eastward to the south of the Aleutian Island Chain into the Gulf of Alaska. Extreme winds resulting from these storms have reached 121 kts. or 224 kph at Shemya on the extreme western portion of the Chain. Average winds are in the 8-15 knots range. Winds may be increased by channeling.

One result of the high winds is the extreme chill factors encountered in the Islands. The rate of loss depends on the amount of insulation, but it must be reckoned with for construction purposes. One must also consider the structural requirements needed to withstand the extreme winds.

The temperature remains rather chilly year round; the average summer temperatures range from 35°F to 50°F (1 to 10°C), and winter temperatures range from 25°F to 40°F (-4 to 4°C). Extremes are about 0°F and 75°F (-18 to 24°C).

Precipitation is quite dependent upon local terrain, but averages between 25 and 70 inches (63 and 124cm) annually.

Soil temperatures are particularly important in Alaska. Engineers use them to determine construction designs and depth placement for water and sewer pipes. The dates of ground freeze and thaw influence excavation and agricultural activities. The mean last spring day occurrence of 32°F (0°C) is usually around the first week of May. The mean first fall day occurrence of 32°F (0°C) is in the last half of October.

Aviation is the primary form of transportation for the area. Because of the inclement weather, area transportation systems are severely hampered by the various obstructions to vision.

### Pollution

Pollution concentration requires a source, proper terrain and favorable air conditions. Where terrain forms a bowl and when temperature inversions occur to trap the air, accumulation will likely occur. The potential for pollution is greatest during the winter months when the temperature inversion is strongest and most persistent. In summer, warmer daytime temperatures usually eliminate the inversions. Some of the more mountainous islands of the Aleutians could possibly meet the necessary requirements for such a pollution situation.

### Marine Environment

The Bering Sea is an extension of the North Pacific Ocean, cut off from the main water mass of the Pacific by the Aleutian Islands. Its area is 890,000 square miles (2,305,699 km<sup>2</sup>). This area is one of the most important fishing grounds in the world. It is also used for navigational purposes in the ice-free season, providing essential contact with the villages of the western and arctic coasts.

Much of the Bering Sea and adjacent coast is still inadequately surveyed. Previous oceanographic research, much of it Japanese and Soviet, has been mainly fisheries oriented. Baseline data are very scarce for the inshore areas. The Bering Sea continental shelf extends over 400 miles (645 km) offshore. It is much narrower along the Near Islands and Andreanofs. To the north of the Aleutians is an abrupt submarine escarpment sloping from the edge of the shelf to the basin floor at slopes of 4-5 degrees.

Approximately 45% of the Bering Sea is continental margin. Passes between the Aleutian Islands vary in depth and size. Unimak Pass, 148 feet (45 m) is mostly easterly, and opens into the Bering Shelf. Others, such as Amukta Pass, 1,500 feet (457 m) and Samalga at 565 feet (122 m), are deeper and open into the Bering Sea. To the south of the Aleutians is the Aleutian Trench, with depths of over 7,000 meters. The Aleutians are volcanic islands and are associated with the subduction zone.

The currents operate around the Alaska Stream to the south of the Islands. This stream has a strong westward flow and converges with water moving northward in a sub-arctic gyre, resulting in the formation of a cyclonic eddy over the western Aleutian Basin and an anticyclonic eddy in the vicinity of the North Rat Island Ridge. Currents in the

near shore environment are chiefly tidal. Local currents in the Aleutians may be strong and unpredictable, even in passes, resulting in very dangerous navigational problems. The Aleutians are particularly exposed to wave attack from all sides. The seas are normally very rough.

Sea ice is not considered a major problem, although in extreme years the ice has extended as far south as Unimak Island.

### Topography

There are five groups of islands: The Fox Islands, Islands of the Four Mountains, the Andreanof, Rat and Near Islands. Elevations throughout range from sea level to summit heights which are generally less than 5,000 feet (1,524 m). An arcuate line of 57 volcanoes, 27 reported active, rises 2,000 to 9,000 feet (610-2,743 m) above sea level along the north side of the Aleutian Chain. Many of the islands have wave-cut terraces up to 600 feet (183 m) above present sea level, bordered by low sea cliffs. Islands with elevations above 3,000 feet were heavily glaciated. Streams in the Aleutians are short and swift. Many plunge into the sea over cliffs. Volcanoes of porous rock have widely spaced streams that flow only during exceptionally heavy rains.

### Geology

During Jurassic time, there was an intrusion of a large batholith through the overlaying sediments which now form the backbone of the southern Alaska Range and northern part of the Aleutians. Enlargement of the batholith occurred during late Cretaceous and early Tertiary times, then again during middle Tertiary. Uplift and deformation accompanied.

Tertiary time was marked by widespread uplift and igneous activity throughout the Islands. The Aleutian Range, including the islands, was formed during early Tertiary time by a massive outpouring of volcanic material. Uplift, erosion, intrusion and volcanism continued along this ridge throughout Tertiary, resulting in the deposition of thick sections of pyroclastic and volcanic materials along the flank of the uplift ridge. Burk's (1965) geologic study of the Alaska Peninsula is a standard reference on this area.

Current volcanic and seismic events indicate that these mountain-building processes are still alive, both on the Alaska Peninsula and the Aleutians. The motivating force for the formation of the Aleutians is the subduction of the Pacific Plate into the Aleutian Trench. As the trench melts under the North American plate, upward migration of the magma field vents in the present day Aleutians.

### Seismic

The Aleutians are part of the "Ring of Fire" that circumscribes the entire Pacific. This region is one of the most seismically active in North America, both numerically and in the amounts of energy released. The pressure of extensive unconsolidated glacial and fluvial sediments in lowland areas increases the potential hazard for structural damage.

## Tsunamis

Tsunamis are generated by earthquakes that create movements associated with the Aleutian Trench. There have been six major waves since 1950, including the one that destroyed Valdez and Crescent City, California during the 1964 Alaska earthquake. The Islands may fall prey to tsunamis from other areas such as Kamchatka or South America because of their exposure to the open Pacific.

## Volcanism

Volcanism is very prevalent with over 40 different craters known to be steaming or to have been reported active since 1760. Some type of activity has been reported almost every year. Most of these volcanoes are andesitic and many times very explosive when erupting. Some characteristic eruptive phenomena associated with the andesitic volcanoes are eruptions of pyroclastic materials, turbulent clouds of bursting gas, steam and ash rising up to 50,000 feet, limited lava flows and large violent explosions which have caused destruction of large portions of the summit areas. Other possible hazards are mud flows, flash floods by quick snow melt, lightning discharges, earthquakes and sea waves.

## Mineral Resources

Geology determines the occurrence of minerals, therefore detailed geologic data is needed to determine the location and extent of mineral resources in any given region. Many occurrences of base and precious metals are reported in and around contact zones of granitic intrusives in the Aleutian Islands. Reported lodes are restricted to gold deposits and metallic sulfide occurrences. There are known occurrences of cadmium, copper, gold, lead, pyrite, silver, sulfur and zinc in the Aleutians. Mining activity is slight, mostly concentrated west of Port Moller and on Unalaska Island.

Coal, oil and gas provinces correspond to the major sedimentary basins. The Bering Sea Tertiary province, southeast of Nunivak Island, has a very high potential for oil and gas occurrences. To date, no wells have been drilled; offshore lease sales should occur in the 1980's. Some wells have been drilled on the Alaska Peninsula which did show traces of oil and gas indicating good prospects for the Bristol Bay Area.

## Water Resources

Water is especially important in the eastern Aleutians where canneries operate year-round. The most modern water distribution systems and treatment systems are found on the military bases. General chemical character of water is good and usually contains less than 75 mg/l of dissolved solids. The average suspended sediment concentration is believed to be in the range of 50 mg/l. If glacier fed, the concentration could be 500 mg/l or more. Water temperatures average between 33°F (.5°C) to 49°F (9.5°C). Sparse population, a lack of water yielding deposits, availability of substantial amounts of surface water, and the costs involved in drilling wells in remote areas combine to limit the development of ground water. Most of the islands would yield between 1-10 gpm for wells because of the bedrock nature of the area.

## Soils

Volcanic rocks dominate the Alaska Peninsula and Islands. The soils derived from ash are close to volcanic cones, but have sandy or silty texture on most lower slopes.

## Vegetation

In the Aleutians, the vegetation can be considered alpine. The relatively cool summers combine with terrain and climate to prevent the establishment of forests. A luxuriant tundra is present throughout, with uplands covered with lichens and mosses.

## Aquatic Vegetation

Despite the harsh conditions which limit species diversity, those which have adapted make the Bering Sea one of the most productive areas in the world. There are three vegetable types: phytoplankton, emergent grasses and sedges in the coastal marches, and algae growing on the bottom in shallow water. These are important in the food chain of both fish and water fowl. Man has used both seaweed and kelp commercially.

## Terrestrial Animals

Brown bear, wolf and wolverine are prevalent on the Alaska Peninsula. Barren ground caribou extend out as far as Adak Island. Reindeer are commercialized in small quantities on Unmak Island. Fox is mainly concentrated on the Peninsula. A total of 183 species and subspecies of birds have been recorded for the Aleutian Islands. Seventy-five are common migrants. Included is the entire 100,000 emperor goose population.

## Aquatic Animals

Intertidal faunae are prevalent. Some of the mud-dwelling invertebrates, such as clams, are abundant. During spawning season, the salmon are abundant. Sea lions and fur seals are prevalent. Most of the world's sea otters inhabit the shallower water along the shore. Beluga whales concentrate near the mouths of river drainages. Harbor porpoises and killer whales have also been reported. Important economically are the bottom fish, whale, salmon, crab, halibut and shrimp.

## Commercial

Formerly, marine mammals comprised a significant resource, until harvest activities were closed by the Marine Mammals Protection Act of 1972. Whaling is now done mainly by Soviets and Japanese. The bottomfish industry, a major resource development, has just begun to emerge. There were three billion pounds taken in 1969. Salmon fishing and shellfish are major commercial activities in the area for Americans.

Limited use is made of vegetation. Natives fashion baskets and handicrafts from grasses. There is some production of kelp.

## People

The main Native people of the area are Aleuts. This group is one of the three Eskimo families. The area is rich in artifacts and historical sites. There are well over 100 archeological sites on the Islands. These people led a subsistence lifestyle until June 4, 1741, when two Russian ships arrived under the command of Vitus Bering. When the ships returned to Russia with several hundred pelts of fur animals, it initiated 43 years of fur hunting and the subsequent destruction of the Aleut people. Russia controlled Alaska for 67 years, then sold it to America. During this time, much of the native culture was eroded. This was especially true in the Aleutians.

Under American domain, the fishing industry was introduced. Dutch Harbor flourished in the 1880's as a coaling station for the Klondike. Whaling and fur trapping also have historic pasts. World War II disrupted the Islands and the villages by embroiling them in what is now known as the "1,000 Mile War". It also brought the military bases; those that remain are still the major population and transportation centers for the western islands.

## Economy

The economy is best described as a traditional subsistence system upon which a variety of non-traditional economic forces have been imposed. Hunting, whaling and development of the salmon fisheries have, until recently, involved seasonal exploitation and importation of labor. Native and Village Corporations are just beginning to develop the industry's local potential.

Government is, by far, the largest employer in the area. The present economy resembles the dual economic systems in many underdeveloped countries. The traditional subsistence economy, with a cash economy stimulated by government, work together to develop the region. With the emergence of the native corporations, the federal and state assistance programs, and the massive amounts of money that could come available to the regions, a great potential for development exists. This development will probably be of renewable resources and oil, which will tend to stabilize the economy.

## Land Status

Dramatic changes in land ownership and in land status, perhaps the most dramatic in the nation's history, is taking place now in Alaska. Much of the western Aleutians have escaped this with the existing establishment of the Aleutian Islands National Wildlife Range and other federal withdrawals. The eastern portion of the Islands and the Alaska Peninsula are strongly influenced by the (d)(2) Native claims and statehood issues. Fortunately, the interaction between agencies seems to be moving rather smoothly. This is due, in part, to the sparse population.



## Land Use

Patterns within the region reflect the dependency of the population on subsistence. Settlements are widely scattered throughout the region and population density is less than one person per five square miles. In the last few decades, there has been a slight migration to population centers because of improved transportation and convenience. Most of the land is still virgin. Forty-four percent of the people live on two military bases: Adak and Shemya. Many of the present villages are small and far apart.

## Transportation

Settled areas are accesible only by air or water. These modes are severely limited by weather. The feasibility of waterborne commercial transportation is marginal because of the sparsity of villages and their small populations. This could be rectified if a major industrial user existed.

## Communications

The area relies mostly on the complex military system developed for NORAD during the 1950's. The system is presently being replaced by a satellite communication system, but despite this, the Aleutians suffer from a paucity of communications more seriously than any other section of the state.

## GEOHERMAL

Optimism concerning development of Alaska's geothermal resource has always been enhanced by the existence of over forty active volcanoes and 140 volcanic expressions located mainly along the Aleution Islands and the Alaskan Peninsula. Sixty-three of these volcanoes are located within the southwest region.

The Hot Springs within the region fall into two Tectonic settings. One of these geologic associations is with Quaternary volcanoes in the Aleutian Islands and Alaska Peninsula. The second association is with Cretaceous or Tertiary granitic plutons such as the Hot Springs near Iditarod.

There are deep sedimentary basins in this region which have not been evaluated in this report for local gradient. There are five hot wells reported in the region along the Alaska Peninsula. Each of these has a heat gradient greater than 30°C/km.

This P.G.R.A. contains Flat Hot Springs:

FLAT, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

T. 27 N., R. 46 W., NW/4  
T. 27 N., R. 47 W., NE/4  
T. 28 N., R. 46 W., SW/4  
T. 28 N., R. 47 W., SE/4

Containing 22,842 acres, more or less

This P.G.R.A. contains Ophir Hot Springs and depending upon exact location, possibly Tuluksak Hot Springs:

KILBUCK MOUNTAINS, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

Tps. 11 to 13 N., Rgs. 57 to 60 W.

Containing 274,856 acres, more or less

There is a reported Hot Springs in this P.G.R.A.:

ATTU ISLAND, ALASKA

All those portions of Attu Island between longitude 174°45'00" East and longitude 173°00'00" east above MHT.

Containing 67,700 acres, more or less

Kiska P.G.R.A. was designated for its association with recent volcanoes.

KISKA ISLAND, ALASKA

All of Kiska Island north of latitude 52°00'00" north above MHT.

Containing 23,248 acres, more or less

This P.G.R.A. contains three volcanoes: Cerberus, Ragged Top and Sugarloaf. There is also one Hot Springs.

SEMISOPCHNOI ISLAND, ALASKA

Approx. Lat. 51°47'N, Long. 179°30'E.

All of Semisopochnoi Island above MHT of Bering Sea and Pacific Ocean.

Containing 54,600 acres, more or less

This P.G.R.A. encompasses the volcano and one Hot Spring.

LITTLE SITKIN ISLAND, ALASKA

Approx. Lat. 51°57'N, Long. 178°30'E.

All of Little Sitkin Island above MHT of Bering Sea

Containing 15,200 acres, more or less

This P.G.R.A. contains one volcano of the same name.

SEGULA ISLAND, ALASKA

Approx. Lat. 52°01'N., Long. 178°09'W.

All of Segula Island above MHT of Bering Sea.

Containing 8,100 acres, more or less

This P.G.R.A. contains four volcanoes: Koravinski, Korovin, Kliuchef, and Serichef. There are three Hot Springs as well.

ATKA ISLAND, ALASKA

All those portions of Atka Island east of longitude 174°34'00" west above MHT of Bering Sea and Pacific Ocean.

Containing 191,600 acres, more or less

This P.G.R.A. contains two volcanoes: Moffet and Adagdak, and one hot spring location. It is the site of the only geothermal drilling to date in Alaska.

ADAK ISLAND, ALASKA

All those portions of Adak Island north of Latitude 51°51'30" north above MHT of Bering Sea.

Containing 40,700 acres, more or less

This P.G.R.A. contains a volcano of the same name plus one associated hot spring.

SEGUAM ISLAND, ALASKA

Approx. Lat. 52°17'N., Long. 172°30'W.

All those portions of Segum Island above MHT of Bering Sea and Pacific Ocean.

Containing 50,900 acres, more or less

This P.G.R.A. contains one volcano that forms the islet.

GARELOI ISLAND, ALASKA

Approx. Lat. 51°46'N., Long. 178°48'W.

All of Gareoli Island above MHT of Bering Sea.

Containing 94,100 acres, more or less

This P.G.R.A. contains two volcanoes: Tanaga and Takawangha, and one Hot Spring.

TANAGA ISLAND, ALASKA

Approx. Lat. 51°52'N., Long. 178°06'W.

All those portions of Tanaga Island north of latitude 51°45'00" north that are above MHT of Bering Sea.

Containing 94,100 acres, more or less

This P.G.R.A. contains one volcano of the same name plus an associated Hot Spring.

KANAGA ISLAND, ALASKA

Approx. Lat. 51°53'N., Long. 177°07'W.

All those portions of Kanaga Island north of latitude 51°50'30" north that are above MHT of Bering Sea.

Containing 22,900 acres, more or less

This P.G.R.A. contains one Hot Spring and one volcano of the same name.

GREAT SITKIN ISLAND, ALASKA

Approx. Lat. 52°03'N., Long. 176°08'W.

All those portions of Great Sitkin Island above MHT of Bering Sea.

Containing 36,600 acres, more or less

This P.G.R.A. contains a volcano of the same name.

CARLISLE ISLAND, ALASKA

(NO MERIDIAN) Approx. Lat. 52°54'N., Long. 170°03'W.

All of Carlisle Island above MHT of Bering Sea.

Containing 9,700 acres, more or less

This P.G.R.A. contains Twin and Yunaska Volcanoes.

YUNASKA ISLAND, ALASKA

(NO MERIDIAN) Approx. Lat. 52°39'N., Long. 170°39'W.

All of Yunaska Island east of longitude 170°42'00" West, and above MHT of Bering Sea and Pacific Ocean.

Containing 21,800 acres, more or less

This P.G.R.A. contains a volcano of the same name.

AMUKTA ISLAND, ALASKA

(NO MERIDIAN) Approx. Lat. 52°30'N., Long. 171°15'W.

All of Amukta Island above MHT of Bering Sea and Pacific Ocean.

Containing 12,000 acres, more or less

This P.G.R.A. has two volcanoes: Makushin and Table Top. Two springs as well; Makushin and Summer Bay.

MAKUSHIN VOLCANO, ALASKA

All of that part of Unalaska Island lying north of latitude 53°48'00" north; all of that part of Unalaska Island lying north of MHT line of Makushin Bay and west of longitude 166°50'00" west, and all of Amaknak Island and Hog Island in Unalaska Bay.

Containing 241,000 acres, more or less.

This P.G.R.A. contains two volcanoes: Kagamil and Uliaga with one Hot Springs named Kagamil.

KAGAMIL ISLAND, ALASKA

All of Kagamil Island, approx. latitude 52°58'N., longitude 169°42'W.

Containing 10,300 acres, more or less

This P.G.R.A. contains two volcanoes: Cleveland and Tana and one Hot Springs (Chuginadak).

CHUGINADAK ISLAND, ALASKA

All of that part of Chuginadak Island west of longitude 169°52'30" west.

Containing 13,400 acres, more or less

This P.G.R.A. is dominated by the volcano by the same name. There is a similarly named Hot Springs.

AKUTAN ISLAND, ALASKA

All of Akutan Island, approx. latitude 54°09'N., longitude 165°54'W.

Containing 82,095 acres, more or less

This P.G.R.A. contains a volcano and Hot Spring of the same name: Akun.

AKUN ISLAND, ALASKA

All of Akun Island, approx. latitude 54°11'N., longitude 165°32'W.

Containing 39,353 acres, more or less

This P.G.R.A. contains two volcanoes: Pogromni and Westdahl and one Hot Springs (Unimak).

POGROMNI VOLCANO, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

T. 62 S., R. 102 W.,

All that portion above MHT line of the Bering Sea

T. 63 S., R. 102 W.,

All that portion above MHT line of the Bering Sea

T. 64 S., Rgs. 102 & 103 W.,

All those portions above MHT line of the Bering Sea

T. 65 S., Rgs. 103 & 104 W.,

Containing 136,100 acres, more or less

This P.G.R.A. contains portions of three volcanoes: Shishaldin, Isanotski and Round Top.

UNIMAK ISLAND, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

Tps. 62 & 63 S., Rgs. 94, 95, 96, & 97 W.

Containing 183,536 acres, more or less

This P.G.R.A. contains False Pass Hot Springs.

BECHEVIN BAY, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

T. 60 S., R. 92 W., S/2

All that portion south and east of the MHT line  
of Bechevin Bay

T. 61 S., R. 93 W.,

Secs. 3 to 10, inclusive;

Secs. 15 to 18, inclusive;

All those portions above MHT line of Bechevin Bay

Containing 14,800 acres, more or less

This P.G.R.A. contains three volcanoes: Morziovoi, Dutton and Frosty. There is also one Hot Springs (Cold Bay).

COLD BAY, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

- T. 57 S., R. 86 W.  
T. 57 S., R. 87 W.,  
    Secs. 1 to 17, inclusive;  
    Secs. 20 to 29, inclusive;  
    Secs. 33 to 36, inclusive;  
    Those portions east of and above MHT line of Cold Bay  
T. 57 S., R. 88 W.,  
    Secs. 31 to 33, inclusive;  
    Those portions above MHT line of Cold Bay  
T. 57 S., R. 89 W.,  
    Secs. 13 to 36, inclusive;  
    Those portions west of and above MHT line of Cold Bay  
T. 58 S., R. 86 W., N/2  
T. 58 S., R. 87 W.,  
    Secs. 1 to 4, inclusive;  
    Secs. 9 to 12, inclusive;  
    Secs. 13 to 16, inclusive;  
    Those portions east of and above the MHT line of Cold Bay  
T. 58 S., R. 88 W.,  
    Secs. 4 to 10, inclusive;  
    Secs. 15 to 23, inclusive;  
    Secs. 26 to 34, inclusive;  
    All those portions west of and above MHT line of Cold Bay  
T. 58 S., R. 89 W.  
T. 59 S., R. 88 W.,  
    Secs. 3 to 10, inclusive;  
    Secs. 15 to 22, inclusive;  
    Secs. 26 to 35, inclusive;  
    All those portions above MHT line of Cold Bay  
T. 59 S., R. 89 W.,  
T. 59 S., R. 90 W.,  
    Secs. 13 to 30, inclusive;  
    Secs. 32 to 36, inclusive;  
    All those portions above the MHT line of Morzhovoi Bay  
T. 60 S., R. 88 W.,  
    Secs. 1 to 12, inclusive;  
    Secs. 14 to 16, inclusive;  
    Secs. 23 to 26, inclusive;  
    All those portions above MHT line of Cold Bay, Deer Passage, and Thinpoint Cove  
T. 60 S., R. 89 W.,  
    Secs. 1 to 35, inclusive;  
    All those portions above MHT line of Thinpoint Cove, Sandy Cove and the Pacific Ocean



- T. 60 S., R. 90 W.,  
Secs. 1 to 5, inclusive;  
Secs. 8 to 17, inclusive;  
Secs. 21 to 27, inclusive;  
Secs. 34 to 36, inclusive;  
All those portions above MHT line of Morzhovoi Bay
- T. 61 S., R. 89 W.,  
Secs. 3 and 4;  
Sec. 6;  
All those portions above MHT line of Sandy Cove and the Pacific Ocean
- T. 61 S., R. 90 W.,  
Secs. 1 and 2;  
Secs. 13,14,23,24 (Amagat Island);  
All those portions above MHT line of the Pacific Ocean

Containing 185,408 acres, more or less

This P.G.R.A. contains one Hot Spring of the same name.

STANIUKOVICH, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

- T. 50 S., R. 72 W.  
Secs. 18 to 19, inclusive;  
All those portions above MHT of Port Moller.  
Secs. 30 to 31, inclusive;  
All those portions above MHT of Port Moller.
- T. 50 S., R. 73 W.,  
All those portions above MHT of Port Moller.

Containing 16,937 acres, more or less

This P.G.R.A. contains Chigngak volcano, and one Hot Spring of the same name.

MOTHER GOOSE LAKE, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

- T. 34 S., R. 47 W., SW/4  
T. 34 S., Rgs. 48 & 49 W., S/2  
T. 35 S., R. 47 W., W/2  
T. 35 S., Rgs. 48 & 49 W.

Containing 76,374 acres, more or less

This P.G.R.A. contains Peulik volcano and two Hot Springs.

MT. PEULIK, ALASKA

SEWARD MERIDIAN, (Partially surveyed)

T. 27 S., R. 43 W.,  
Secs. 29 to 35, inclusive;  
Those portions above MHW of Becharof Lake  
T. 27 S., R. 44 W.,  
Secs. 8 & 9;  
Secs. 13 to 36, inclusive;  
All those portions above MHW of Becharof Lake  
T. 28 S., R. 43 W.  
T. 28 S., R. 44 W.,  
All those portions above MHW of Upper Ugashik Lake

Containing 87,000 acres, more or less

This P.G.R.A. contains three volcanoes: Vsevidof, Recheschinoi and Tulik.

UMNAK ISLAND, ALASKA

All of Umnak Island, approx. latitude 53°15'N,  
longitude 168°15'W.

Containing 401,000 acres, more or less

This P.G.R.A. includes the Okmok Caldera and Spring System.

OKMOK CALDERA

Lands within the boundary of latitude 53°22'N and  
53°30'N, longitude 168°02'W and 168°13'W.

Containing 44,800 acres, more or less

This K.G.R.A. was designated on the Geyser and Hot Spring resource  
at Geyser Bight.

GEYSER SPRING BASIN

Lands within latitude 53°13'N to 53°16'N and  
longitude 168°17'W to 168°26'W and within latitude  
53°11'N to 53°15'N and longitude 165°26'W to 168°31'W.

Containing 20,960 acres, more or less

This P.G.R.A. contains one volcano known as Black or Purple and one Hot Spring (Port Heiden).

BLACK PEAK, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

Tps. 41, 42 & 43 S., Rgs. 60 & 61 W.

Containing 137,456 acres, more or less

This P.G.R.A. contains two volcanoes: Veniaminoff and Kuprianof.

VANIAMINOFF, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

T. 42 S., Rgs. 66 & 67 W.,

All those portions above MHT of Bristol Bay

Tps. 43,44,45,46,47 & 48 S., Rgs. 64,65,66 & 67 W.

This P.G.R.A. contains two volcanoes: Kailaguik and Aniakchak.

ANIAKCHAK, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

Tps. 37,38 & 39 S., Rgs. 55,56 & 57 W.

Containing 178,536 acres, more or less

This P.G.R.A. contains six volcanoes: Emmons, Dutton, Aghileen, Pavlof, Pavilof sister and Little Pavlof. Also one Hot Spring (Emmons) is found here.

PAVLOF VOLCANO, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

T. 54 S., R. 81 W.,

Secs. 6 to 7, inclusive;

Secs. 18 to 19, inclusive;

Secs. 30 to 31, inclusive.

T. 55 S., R. 81 W.,

Secs. 6 to 7, inclusive;

Secs. 18 to 19, inclusive;

Secs. 30 to 31, inclusive.

Tps. 54 & 55 S., R. 82 W.

T. 56 S., R. 82 W., N/2, SW/4

Tps. 54,55, & 56 S., R. 83 W.

T. 54 S., R. 84 W., S/2  
Tps. 55 & 56 S., R. 84 W.  
T. 55 S., R. 85 W., E/2  
T. 56 S., R. 85 W., E/2

Containing 236,160 acres, more or less

TABLE III - Southwest Region

## MAGNITUDES AND HEAT CONTENTS OF IDENTIFIED VOLCANIC SYSTEMS

(U.S.G.S. Circulation #726 - White, 1975)

NAME OF AREA	LAT.	LONG.	COMPOSITION LAST ERUPTION	AGE DATA	CHAMBER AREA Km <sup>2</sup>	CHAMBER VOLUME RANGE Km <sup>3</sup>	CHAMBER VOLUME V <sub>B</sub> Km <sup>3</sup>	SOLID- IFICATION STATE °C	$\Delta Q$ TOTAL CALORIES X 10 <sup>18</sup>	$\Delta Q$ NOW CALORIES X 10 <sup>18</sup>	$\Delta Q$ OUT CALORIES X 10 <sup>18</sup>	REMARKS
BULDIR	52°23'N	176°01'E	Basic	<2x10 <sup>3</sup> ?								>10KM Depth
KISKA	52°06'N	177°36'E	Basic	Active								>10KM Depth
SEGULA	52°01'N	178°08'E	Basic Sillicic?	<10 <sup>4</sup> ?								Need Better Data On Composition & Age
DAVIDOF	51°58'N	178°20'E	No Data	<10 <sup>4</sup> ?	5. A <sub>C</sub>	125-50 V <sub>C</sub>	12.5	>650°	7	7		
LITTLE SITKIN	51°57'N	178°32'E	Basic	Active	17.3 V <sub>C</sub>	45-180 V <sub>C</sub>	75	>850°	43	43		
SEMISOPOCHNOI (CERBERUS)	51°56'N	179°35'E	Basic	Active	42.4 A <sub>C</sub>	106-424 V <sub>C</sub>	150	>850°	86	86		
SUGARLOAF	51°54'N	179°38'E	Basic	<10 <sup>4</sup> ?								> 10 KM Depth
GARELOI	51°48'N	178°48'W	Basic	Active								> 10 KM Depth
TANAGA	51°53'N	178°07'W	Basic?	Active	85.9 A <sub>C</sub>	215-860 V <sub>C</sub>	400	>850°	230	230		
TAKAWANGHA	51°52'N	178°00'W	Basic?	<10 <sup>4</sup>	8.9 A <sub>C</sub>	22.5-90 V <sub>C</sub>	>225	>650°	13	13		
BOBROF	51°55'N	177°27'W	Basic?	<10 <sup>4</sup> ?								> 10 KM Depth
KANAGA	51°55'N	177°10'W	Basic?	Active	230 A <sub>C</sub>	575-230 V <sub>C</sub>	75	>850°	43	43		
MOFFET	51°56'N	176°45'W	Basic	<10 <sup>4</sup> ?								> 10 KM Depth
ADAGDAK	51°59'N	176°36'W	Basic	<10 <sup>4</sup> ?								> 10 KM Depth
GREAT SITKIN	52°04'N	176°07'W	Basic	Active	1.8 A <sub>C</sub>	4.5-18 V <sub>C</sub>	>5	>850°	3	3		
KASATOCHI	52°11'N	175°30'W	Basic?	Active?								> 10 KM Depth
KONIUJI	52°13'N	175°08'W	Basic?	Active?								> 10 KM Depth
SERGIEF	52°19'N	174°53'W	No Data	No Data								Need Composition & Age Data

TABLE III - Southwest Region Cont'd.

## MAGNITUDES AND HEAT CONTENTS OF IDENTIFIED VOLCANIC SYSTEMS

(U.S.G.S. Circulation #726 - White, 1975)

NAME OF AREA	LAT.	LONG.	COMPOSITION LAST ERUPTION	AGE DATA	CHAMBER AREA Km <sup>2</sup>	CHAMBER VOLUME RANGE Km <sup>3</sup>	CHAMBER VOLUME V <sub>B</sub> Km <sup>3</sup>	SOLID- IFICATION STATE °C	$\Delta Q$ TOTAL CALORIES X 10 <sup>18</sup>	$\Delta Q$ NOW CALORIES X 10 <sup>18</sup>	$\Delta Q$ OUT CALORIES X 10 <sup>18</sup>	REMARKS
KOROVIN	52°23'N	174°10'W	Basic	Active								> 10 KM Depth
KLIUCHEF	52°19'N	174°09'W	No Data	No Data	28.6 A <sub>C</sub>	70-280 V <sub>C</sub>	>100		58			Need Composition & Age Data
SARICHEF	52°19'N	174°03'W	Basic?	Active?								> 10 KM Depth.
SEGUAM	52°19'N	172°23'W	No Data	Active	20(2) A <sub>C</sub>	100-400 V <sub>C</sub>	200	> 850	115	115		Appears to be a Double caldera. Not reported Needs Investigation
AMUKTA	52°30'N	171°16'W	Basic?	Active								> 10 KM Depth?
CHAGULAK	52°35'N	171°09'W	Basic?	< 10 <sup>4</sup> ?								> 10 KM Depth?
YUNASKA	52°39'N	170°39'W	No Data Basic?	Active	12.1 A <sub>C</sub>	30-120 V <sub>C</sub>	40	> 850	23	23		
HERBERT	52°45'N	170°07'W	Basic?	< 10 <sup>4</sup> ?								> 10 KM Depth?
CARLISLE	52°54'N	170°04'W	Basic?	Active								> 10 KM Depth?
CLEVELAND	52°49'N	169°58'W	Basic?	Active								> 10 KM Depth?
ULIAGA	53°04'N	169°47'W	Basic?	< 10 <sup>4</sup> ?								> 10 KM Depth?
TANA	52°50'N	169°46'W	Basic?	No Data								> 10 KM Depth?
KAGAMIL	52°58'N	169°44'W	Basic?	Active								> 10 KM Depth?
VSEIDOF	53°08'N	168°42'W	Silicic	Active								Need More Data
RECHESCHNOI	53°09'N	168°33'W	Basic?	< 10 <sup>4</sup>								Need More Data
OKMOK	53°25'N	168°03'W	Basic	Active 8x10 <sup>3</sup> T <sub>C</sub>	62.9 A <sub>C</sub>	155-620 V <sub>C</sub>	250	> 850	144	144		
TULK	53°23'N	168°03'W	Basic	No Data								> 10 KM Depth
BOGOSLOF	53°56'N	168°02'W	Basic	Active								> 10 KM Depth

TABLE III - Southwest Region Cont'd.

## MAGNITUDES AND HEAT CONTENTS OF IDENTIFIED VOLCANIC SYSTEMS

(U.S.G.S. Circulation #726 - White, 1975)

NAME OF AREA	LAT.	LONG.	COMPOSITION LAST ERUPTION	AGE DATA	CHAMBER AREA Km <sup>2</sup>	CHAMBER VOLUME RANGE Km <sup>3</sup>	CHAMBER VOLUME V <sub>R</sub> Km <sup>3</sup>	SOLID- IFICATION STATE °C	$\Delta Q$ TOTAL CALORIES X 10 <sup>18</sup>	$\Delta Q$ NOW CALORIES X 10 <sup>18</sup>	$\Delta Q$ OUT CALORIES X 10 <sup>18</sup>	REMARKS
MAKUSHIN	53°52'N	166°56'W	Silicic?	Active	3.6 A <sub>c</sub>	9-36 V <sub>c</sub>	>10	>850	6	6		
TABLE TOP	53°58'N	166°40'W	Basic	No Data								> 10 KM Depth
AKUTAN	54°08'N	166°00'W	Basic?	Active	3.5 A <sub>c</sub>	9-36 V <sub>c</sub>	>10	>850	6	6		
MT. GILBERT (AKUN)	54°16'N	165°39'W	Basic?	No Data								> 10 KM Depth?
POGROMNI	54°34'N	164°42'W	Basic	Active								> 10 KM Depth
WESTDAHL	54°31'N	164°39'W	No Data	Active								Need More Data
FISHER	54°38'N	164°25'W	Basic	Active? < 2x10 <sup>3</sup> Y	122.6 A <sub>c</sub>	300-1200 V <sub>c</sub>	600	> 850	345	345		
SHISHALDIN	54°45'N	163°58'W	Basic	Active								> 10 KM Depth
ISANOTSKI	54°45'N	163°44'W	Basic?	Active								> 10 KM Depth?
ROUNDTOP	54°48'N	163°36'W	No Data	Active? < 2x10 <sup>3</sup> ?								
AMAK	55°25'N	163°09'W	Basic?	No Data								> 10 KM Depth?
FROSTY	55°04'N	162°51'W	Silicic? Basic?	No Data								
WALRUS (MORZHOVOI)	55°00'N	162°50'W	Basic	No Data > 10 <sup>4</sup> ?								> 10 KM Depth
DUTTON	55°11'N	162°16'W	Basic	No Data								> 10 KM Depth
EMMONS	55°20'N	162°04'W	Basic	Active	117.3 A <sub>c</sub>	300-1200 V <sub>c</sub>	600	> 650	345	345		
HAGUE	55°22'N	161°59'W	Basic	Active								
DOUBLE CRATER	55°23'N	161°57'W	Basic	Active?								
PAVLOF	55°25'N	161°54'W	Basic	Active								> 10 KM Depth

TABLE III - Southwest Region Cont'd.

## MAGNITUDES AND HEAT CONTENTS OF IDENTIFIED VOLCANIC SYSTEMS

(U.S.G.S. Circulation #726 - White, 1975)

NAME OF AREA	LAT.	LONG.	COMPOSITION LAST ERUPTION	AGE DATA	CHAMBER AREA Km <sup>2</sup>	CHAMBER VOLUME RANGE Km <sup>3</sup>	CHAMBER VOLUME V <sub>B</sub> Km <sup>3</sup>	SOLID- IFICATION STATE °C	$\Delta Q$ TOTAL CALORIES X 10 <sup>18</sup>	$\Delta Q$ NOW CALORIES X 10 <sup>18</sup>	$\Delta Q$ OUT CALORIES X 10 <sup>18</sup>	REMARKS
PAVLOF SISTER	55°27'N	161°51'W	Basic	Active								> 10 KM Depth
DANA	55°37'N	161°12'W	Silicic	No Data 10 <sup>4</sup> ?	1.6 A <sub>C</sub>	4-16 V <sub>C</sub>	> 5		3			Need More Data
KUPREANOF	56°01'N	159°48'W	No Data Basic?	Active								Need More Data
VENIAMINOF	56°10'N	159°23'W	Basic	Active 3.7x10 <sup>3</sup> T <sub>C</sub>	50.4 A <sub>C</sub>	125-500 V <sub>C</sub>	200	> 850	115	115		
BLACK (PURPLE)	56°32'N	158°37'W	Silicic	<10 <sup>4</sup> ?	6.9 A <sub>C</sub>	17.5-70 V <sub>C</sub>	> 20	> 650	12	12	6	Need More Data
ANIAKCHAK	56°53'N	158°10'W	Silicic	Active 3.6x10 <sup>3</sup> T <sub>C</sub>	55.6 A <sub>C</sub>	140-560 V <sub>C</sub>	225	> 650	129	129		
CHIGNIGAK	57°08'N	157°00'W	Basic? Silicic?	Active								Need More Data
KIALAGVIK	57°12'N	156°42'W	No Data	No Data								No Data
PEULIK	57°45'N	156°21'W	Basic?	Active?	10.5 A <sub>C</sub>	25-100 V <sub>C</sub>	> 30	> 650	17	17		Silicic in focus of both caldera & Mt. Peulik; perhaps young basic eruption on N. flank Peulik. Need Age Data.



SOUTHWEST REGION  
SITE DATA SUMMARIES

SITE: Mitchell

RESOURCE: Reported Hot Springs (Miller 1973)

LATITUDE & LONGITUDE: 61° 18' N., 157° 40' W. Approx.

QUADRANGLE: Sleetmut T14N, R47W, SW Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

The Chuilnuk mountains are centered on a semielliptical stock. The exposed contacts of the stock dip gently outward. The contacts are well exposed. The stock is completely surrounded by a contact metamorphic zone in adjacent sedimentary rocks. This zone averages 2 miles (3 km) wide. A well defined fault is noted on the north front of the mountains.

The stock in the Chuilnuk mountains range from granodiorite on the west, comparable to that of Kiokluk mountains, through quartz monzonite, to granite on the east. The presence of the granodiorite on the west side of the stock, nearest to the Kiokluk mountains, suggests that the rocks of the two stocks derived from a common magmatic source, connected at depth. The igneous rocks of the mountains are unaltered. Hot Springs occur along the North-eastern contacts of the stock near the largest of several lakes. (Cady 1965)

SOCIO-ECONOMIC:

The land near Chuilnik mountain has been selected by the State of Alaska under terms of the statehood act.

The location of this system is very remote. The nearest population is Sleetmute 25 miles (40 km) to the north. The mode of transportation to the springs would probably have to be helicopter.

No exploration has taken place on this spring system. Any future application would require temperature and flow rates measurements.

The Kuskokwim mountains are part of an extensive mineralized zone. Rare metals have been found in the streams.

ENVIRONMENT: (Extracted from Southwest Regional Profile)

The nearest climatological recording station is Sleetmute. Summer temperatures there average 37° to 66° (3° to 19°C) winter -12 to 24 (-24° to -4°C) with extremes of -58° to 90° (-50 to 32°). Precipitation averages 21" which includes 90" of snow.

The dominant flora is upland spruce hardwood forest. The mountains are covered by alpine tundra. Caribou, moose and bear all flourish. The lands to both east and west of the Kuskokwim mountains are major nesting areas for migratory waterfowl.

There is discontinuous perma-frost here.

KEY CONTACT: State Department of Natural Resources

REFERENCE: (Cady 1965); Southwest Regional Profile

SITE: Tuluksak

RESOURCE: Reported Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 61° 00' N., 160° 30' W. Approx.

QUADRANGLE: Russian Mission/Bethel T10N R63W SM Approx.

BARRIER:

RECOMMENDATION: Exploration

DESCRIPTION:

There has been a reported hot spring along the Tuluksak River. Algae growth and a distinct sulphurous odor were reported. (Waring 1917)

The geology of the region is covered in the flats by coastal and alluvium sediments. Jurassic to Cretaceous interbedded layers of graywacke and shale outcrop in the hills. Cretaceous granite rocks intrude these sediments. (Selkregg 1976)

SOCIO-ECONOMIC:

The land classification in the area is (d)(1). Surrounding lands are selected by the Bristol Bay Native Association under terms of the Alaska Native Land Claims Settlement Act.

The nearest village is Tuluksak at the confluence of the Tuluksak and Kuskokwim rivers. Tuluksak River is navigable over much of its course. The springs are approximately 20 miles (32 km) from the village. They are also 15 miles (24 km) from Nyac mining camp. Air service is available from Bethel to either of these areas. One swamp buggy road exists from Nyac along the Tuluksak River.

The springs have had no evaluation. In fact, they have not even been confirmed at this time. If a viable resource can be confirmed, a possible development project could establish a market for fresh vegetables. This would supplement the subsistence lifestyle of the area residents. Geothermal energy could make this a viable project.

ENVIRONMENT: (Extracted from the Southwest Regional Profile)

The climate can only be estimated. The winds are predominantly from the north-northeast at approximately 10 knots. Making wind energy a possible energy source. The precipitation in the area averages 16" (40 cm), including 50" (127 cm) of snow. Average summer temperatures range from 39-62°F (4-17°C) winter from -3 to 20°F (-2 to -7°C) with extremes of -46 and 86°F (-43 and 30°C). The heating degree days average about 13,200.

The dominant flora is wet tundra. Moose and bear are found in relative abundance. The area is a high density waterfowl range. Salmon is a possible commercial fish along the lower Tuluksak River.

Permafrost is found under the tundra.

KEY CONTACT: Tuluksak Village Council

REFERENCE: Waring 1917; SW Regional Profile

SITE: Ophir Creek

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 61° 11' N; 159° 51' W

QUADRANGLE: Russian Mission, T13N, R59W, Section 21

BARRIER: Remote

RECOMMENDATION:

DESCRIPTION:

A spring occurs on Hot Springs Creek at the headwaters of Ophir Creek within the Kilbuck Mountains PGRA 274,856 acres (111,234 hectares). The valley floor slopes at about five degrees and adjacent hill slopes are about 10-15 degrees. The Ophir Creek drainage descends down the northeastern flank of Mt. Hamilton.

Two main bedrock types underlie the Ophir Creek valley. The mountains to the south of Ophir Creek and the divide between hot springs and Ophir Creek are composed of intrusive igneous rocks of granitic composition. The igneous intrusion is a stock composed predominantly of quartz monzonite of Tertiary Age.

The stock has been intruded into Cretaceous volcanic rocks, chiefly massive andesitic flows interbedded with greywacke, siltstone, pebble conglomerate, limestone and shale. These rocks outcrop to the east, north and west of Ophir Creek (Baker, 1977).

The springs are composed of one major and one minor pool near the head of the Hot Springs Creek valley. The major pool is several feet in diameter, about 1' deep and discharges 225 gpm (850 lpm). The water temperatures were measured to be 63°C. A second pool is located about 50' (15 m) south-southeast of the main pool. The spring has a temperature of 30°C and flows at an estimated 1-2 gpm (4-7 lpm).

Presently, the lease holder, Mr. Harry E. Faulkner, diverts water through a 4" (10 cm) pipe 1,500 feet (457 m) to his house. The pipe running from the spring to Faulkner's house is insulated, covered with aluminum, and the inner conductor is plastic. The pipe uses, perhaps, one-third of the output of the spring. The water running into the creek keeps the creek open. Mr. Faulkner intends to implace a Lavel turbine in this open water to produce electricity (Ogle, 1976).

The chemical analysis of the spring is:

H <sub>2</sub> S	0.02*
NH <sub>3</sub>	0.04*
NO <sub>3</sub>	0.4

Phosphate, Ortho	0.25
Alkalinity, Bicarbonate	239
Alkalinity, Carbonate	0
CO <sub>2</sub>	0.4*
Chloride	3.5
TDS	412*
Hardness (Total)	16
F	1.4*
SO <sub>4</sub>	240*
Se <sup>4</sup>	0.002
Cu	0.005
Ca	2
Na	97
K	1
Ag	0.00015
Pb	0.003
Cd	0.0003
Cr	0.0012
SiO <sub>2</sub>	30
Al <sup>2</sup>	0.02*
As	0.02
B	0.1
Fe	0.06
Mg	0.1
Mn	0.003
Ni	0.012
Sb	0.06
Zn	0.001
Hg	0.001
V	0.01
Conductance (umohs/cm)	400
**Temperature (°C)	24
pH	9.4*
Date	6-3-77

\* Exceeds ADF&G water quality criteria for salmon aquaculture.

\*\* Temperature at which chemical analysis was accomplished.

About 13 miles in a direct line east of south from the spring there is a siliceous sinter core 150' high near the east ridge of Myrtle Creek. Any water issuing here probably issues into the creek (Waring, 1917).

#### SOCIO-ECONOMIC:

Approximately 40 acres of land surrounding the geothermal springs is subject to a mineral springs lease issued to Harry E. Faulkner, P.O. Box 153, Bethel, Alaska, 99559 (#FF 019136). All the land below the geothermal spring along Hot Springs Creek to its confluence with Ophir Creek, including the airstrip, is owned by Mr. Faulkner as a homestead and patented land. Surrounding lands are classified as public interest lands (d)(1).

An historical place application AA 10267 has been filed by Calista Corporation upstream in nearby Section 28.

There is access by light aircraft. The airstrip is in reasonable repair, and would be enlarged to accommodate larger planes. There are airstrips at the nearby natives village of Aniak and Tuluksak on the Kuskokwim River and the mining community of Nyac. Bethel, 75 miles (120 km) southwest is a logical staging area. All necessary facilities are available at Bethel.

The State Fish and Game Department has rated the spring as being a moderate potential fish hatchery site. The major drawback was the logistics of building it there. The associated fishermen of Lower Yukon and Kuskokwim regions and Calista Native Corporation have been interested in the salmon enhancement possibilities of Ophir hot springs. There are also mining interests in the area.

Many of the buildings of the mining town of Nyac have been moved to the hot springs. It has yet to be confirmed if Mr. Faulkner is now operating a lodge utilizing the geothermal resource but is is rumored so.

#### ENVIRONMENT: EXTRACTED FROM THE SOUTHWEST REGIONAL PROFILE

The climate can only be estimated. The winds are predominantly from the north-northeast at approximately 10 knots. The precipitation in the area averages 16" (40 cm), including 50" (127 cm) of snow. Average summer temperatures range from 39-62°F (4-17°C); winter ranges from -3 to 20°F (-2 to -7°C), with extremes of -46 to 86°F (-43 to 30°C). The heating degree days are around 13,200.

The fresh water is rejuvenated by a small stream which flows 2 cfs. Ophir Creek flows 41 cfs. There is localized permafrost. The geothermal and fresh water adjacent do not completely meet water quality standards for salmon aquaculture with high bacteria counts. There are possible flooding problems. (Baker 1977)

The dominant flora is wet and alpine tundra. Moose and bear frequent the area with a high density waterfowl range nearby. Whitefish, char, pike, and trout dominate the drainage, although salmon are present in adjacent drainages.

KEY CONTACT: Harry Faulkner

#### REFERENCE:

Baker. Salmon Aquaculture Study  
Ogle. Visit to Ophir Springs  
Waring. 1917 Report on Hot Springs  
Selkregg. Southwest Regional Profiles



SITE: Attu

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 52° 50' N; 173° 10' E.

QUADRANGLE: Attu

BARRIER: Resource Undefined

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Attu Island PGRA 67,700 acres (27,398 hectares). The island of Attu is the westernmost of the Aleutian Chain. The island has several small lakes which are reported comfortable for bathing in the summer. Although there is no direct evidence of warm springs, it seems probable that thermal water does issue, for there is reported to be a small active volcano or area of solfataras on the island (Waring, 1917).

Personal correspondence with people in the area has not, to date, located the hot springs (Ogle, 1978).

The area does have granitic and gabbroic intrusive rocks intruding Tertiary and Cretaceous sedimentary rocks, also including pyroclastics, lava flows and pillow basalts

SOCIO-ECONOMIC:

The island of Attu is actually closer to Japan than it is to the City of Anchorage. This makes the logistics very expensive and difficult getting to and from the island.

The nearest major settlement is Shemya Air Force Base, 35 miles (56 km) to the east. Attu itself has a small contingent of Coast Guard personnel and a population of 40 people. The base was once much larger, and, therefore, has a pretty extensive road system, good airport and decent harbor facilities.

The island has a dramatic World War II history in that it was one of two islands that were occupied by Japanese forces. This was the only area in the United States actually invaded. There are eight Native archeological sites on Attu Island as well.

Part of the island is in the National Wildlife Refuge System, precluding development. Part of the island is under control of the Department of Defense. Native claims have been filed on the island, but are subject to adjudication before they will be approved (Selkregg, 1975).

Further exploration is needed to determine if, in fact, a potential resource exists. Presently, energy needs are met by a base generator. (DEPD Rural Energy Survey, State of Alaska)

ENVIRONMENT: EXTRACTED FROM WOUTHWEST REGIONAL PROFILE

Attu Coast Guard station records an average summer temperature between 40-60°F (4-16°C) with winter temperatures of 28-39°F (-2 to 4°C). Extremes of 15-77°F (-9 to 25°C) have been recorded. Precipitation averages 56" (142 cm) including 91" (231 cm) of snow. The average wind is westerly at 11.3 knots, with an extreme of southwesterly at 106 knots recorded.

The dominant flora is tundra. There is considerable potential for offshore bottomfishing in the area.

KEY CONTACT: Coast Guard Commander, Attu

REFERENCE:

Waring. 1917 Report on Hot Springs  
Southwest Regional Profiles

SITE: Kiska

RESOURCE: Volcano (Coats et. al.)

LATITUDE & LONGITUDE: 52° 06' N; 177° 36' E.

QUADRANGLE: Kiska (Unsurveyed)

BARRIER: No End User

DESCRIPTION:

Located within the Kiska Island P.G.R.A., 23,248 acres (9,408 hectares). Kiska Island is in the Rat Islands group of the Aleutian Islands and is composed of two major geologic elements. The south half of the island is part of a submarine ridge, and the north half is a volcano. Kiska Volcano is a young composite andesitic volcano. It is underlain and flanked on the south by the Kiska Harbor formation, which represents the remnants of an older composite volcano. The Kiska Harbor formation is unconformable with the Vega Bay formation to the south. The Vega Bay formation is a mass of deformed submarine volcanic rocks. (Coats, et. al.)

Both Kiska Volcano and the Kiska Harbor formation are composed of interbedded andesitic to basaltic pyroclastic rocks, lava flows, and sedimentary rocks formed of volcanic debris. The rocks of the Vega Bay formation are older and more deformed than the other rocks of the island; they are composed of moderately well indurated pyroclastic rocks and substantial amounts of dark submarine basalt flows and minor amounts of sandstone and conglomerate formed of volcanic debris. (Coats, et. al.)

The island was sculptured first by marine and fluvial erosion, and the southern part of the island was later modified by glaciation. The northern part of the island shows no signs of glaciation. The island is thinly veneered by volcanic ash derived largely from volcanoes on nearby islands (Coats, et. al.). Kiska itself was seen smoking in 1907 and 1927. Tests taken on the island by the U.S. Navy indicate that there is a local heat gradient of approximately 3°C. per 100 meters. (Personal Communication U.S. Navy)

The island comprises these regions, which are conspicuously different in topography: the south half, a region of strong dissection dominated by a sharp, sinuous drainage divide; the north-central part, a region of isolated plateaus; and the northern tip, which is the symmetrical cone of Kiska Volcano. (Coats, et. al.)

SOCIO-ECONOMIC:

Kiska is presently under the control of the Department of Defense. Any development at this time would have to be done by them and there are presently no plans. It should be noted that Kiska Harbor is one of the few good harbors in the Aleutians. A detailed survey of the harbor was made in 1904, but was never published.

Additional surveys were made in 1934 and 1935 after which Kiska was closed to the public.

Vitus Bering discovered the island in 1741. At that time, it had a substantial Aleut population, which thereafter rapidly declined and disappeared during the 19th Century. Sea otters and fox have been trapped for commercial purposes.

Because of the remote location, good fishing and good harbor, some sort of development will probably take place should the Dept. of Defense let the island go back to the public. There is such a poor geothermal resource, according to Navy reports, that the development will probably not utilize this form of energy. There are seven archeological sites.

ENVIRONMENT: (Extracted from the Southwest Regional Profile)

Temperatures in the summer range from 39-51°F. (4 to 11°C) Winter temperatures range from 29-35°F. (-2 to 2°C). The precipitation is approximately 50 inches annually, with 70 inches of snow. The wind is usually 15 kts. coming from the west.

There are some major fresh water lakes in the Kiska Volcano area.

Plant life is standard to that of the rest of the Aleutians. Waterfowl are prevalent as are some sea otters and foxes.

KEY CONTACT: Base Commander Adak Naval Air Station

REFERENCE:

Coats, et. al.  
Personal Communications U.S. Navy, Adak  
Southwest Regional Profile

SITE: Little Sitkin Island

RESOURCE: Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 51° 57' N; 178° 32' E.

QUADRANGLE: Rat Islands (Unsurveyed)

BARRIER: Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Little Sitkin P.G.R.A., 15,200 acres (6,151 hectares). The island consists entirely of volcanic rocks, and sediments derived from them of probably Pleistocene and Recent age. An exploration report conducted by PETROFF states that there is a hot spring located near a sulfatious volcano (Waring, 1965).

Little Sitkin Island, in the Rat Island group of the Aleutian Islands, is composed of extrusive igneous rocks ranging in age from Tertiary to present. The youngest rocks are about fifty years old. The island is a calcic petrographic province and has an alkali-lime index of 63.5. Composition of lavas and pyroclastic debris ranges from basalt to rhyodacite, but most rocks are andesite, basalt, or dacite. Three periods of volcanism were separated by periods of caldera formation. Lavas and pyroclastics debris of the first volcanic period were dominantly andesite and originally constitute 78% by weight of all extrusive rocks on the island (Snyder, 1959).

There has been no evaluation or exploration of the hot springs.

SOCIO-ECONOMIC:

The nearest transportation center would be Amchitka Island, 30 miles (48 km) to the southeast. At this time, there is no permanent population. Anchorage is 1,340 miles (2,144 km) east from Amchitka; 235 (376 km) west is Shemya AFB, pop. 1,131 (Selkregg, 1976). As for Little Sitkin itself, there are no permanent residents other than the wildlife. There is a trapper cabin located on the northwest portion of the island. Transportation to and from the island would have to be by helicopter or boat. Much of the island has a wave cut beach which precludes landing boats on the majority of the island (Snyder, 1959).

The entire island is located in the Aleutian Island Wildlife Refuge, which will preclude any development under existing laws. In the Aleutian Islands, government activities, seafood processing and subsistence are the basis of the regional economy.

There are three archeological sites located on the island (Selkregg, 1976).

#### ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The weather is controlled by the Bering Sea and North Pacific zones. The air is wet, overcast, stormy and the islands are treeless. Temperature in summer runs from 38-51°F. (3°-11°C). Winter temperatures range from 29-39°F. (-2 to 11°C). Extremes are 7-63°F. (-14 and 17°C). Precipitation is 37" (94 cm) including 70" (178 cm) of snow. Wind is a major factor with average wind at WNW 15.9 kts. The adjoining waters have heavy growth of marine vegetation and are rich in sea life.

Major environmental factors are this island is part of a wildlife refuge, an area of high seismicity, high winds, and poor visibility due to fog.

The dominant flora is alpine tundra. The dominant fauna is migratory waterfowl. Sea mammals and bottomfishing are noted in the area.

#### REFERENCE:

"Alaska Regional Profiles - Southwest". Federal-State Land Use Commission  
G. L. Snyder - Volcano Investigation 1959  
Waring (1965)

SITE: Semisopchnoi

RESOURCE: Volcanoes and Hot Spring

LATITUDE & LONGITUDE: 52° N; 179° 30' E.

QUADRANGLE: Rat Islands (Unsurveyed)

BARRIER: Part of Aleutian Island Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Semisopchnoi PGRA, 54,600 acres (22,096 hectares). Semisopchnoi is the largest of the young volcanic islands of the western Aleutians. The island consists entirely of volcanic rocks and sediments derived from them of probably Pleistocene and Recent age. It is a large shield-shaped basaltic volcano with parasitic cones of andesite and basalt. The higher elevations collapsed to form an elliptical caldera almost 5 miles (8 km) in width. A hot springs has been observed on the island, but at this time, no scientific investigation has taken place concerning it. (Coats, 1959) There are three identified volcanic expressions.

SOCIO-ECONOMIC:

Most of the island is bordered by high rocky cliffs and many offshore reefs. Two broad sandy beaches on the southwest and two on the southeast sides of the island offer easy landing places where the surf is not too high. Several trappers cabins and the remains of a U.S. Army weather station offer shelter. The island is located 35 miles (56 km) northeast of Amchitka and any probable access would be by helicopter. (Coats, 1959)

At this time, there is no foreseeable use of the resource due to its remoteness. There is offshore bottom fishing now, indigenous to the area. A military base at Amchitka is the other economic factor in the area.

This island is entirely within the Aleutian National Wildlife Refuge and this would exclude any possible geothermal development under present laws.

ENVIRONMENT: (Extracted from the Southwest Regional Profile)

The temperatures in summer run from 38-51° F. (3° to 11°C); winter is 29-39°F. (-1 to 3°C). Extremes are 7-63°F. (-14 to 17°C). Precipitation is 37" (94 cm), including 70" (178 cm) of snow. Wind is a major factor averaging from WNW at 15.9 kts. The adjoining waters are heavily laden with marine vegetation. Many marine mammals live on the rocks there. It is also home to many water fowl. Heating degree<sub>2</sub> days average 9,500 annually. Mean annual runoff 2 c.f./sec./mile<sup>2</sup>.

SITE: Tanaga Island

RESOURCE: Hot Springs and Volcanoes

LATITUDE & LONGITUDE: 51° 45' N; 178° 00' W.

QUADRANGLE: Adak (Unsurveyed)

BARRIER: Included in Aleutian Islands Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION: EXTRACTED FROM FRASER-BARNETT (1959)

Located within the Tanaga Island P.G.R.A., 94,100 acres (38,082 hectares). The island is divided into two provinces. The north half of the island is dominated by two volcanoes, Takawangha and Tanaga. They are composed of basaltic and andesitic flows with local pyroclastic deposits. The south half of the island is interbedded lava flows, pyroclastic deposits and sedimentary rocks. The age of this portion of the island is Tertiary.

Tanaga volcano was active in the 1763-70 era. On June 7, 1791, there are reports that the island was smoking. In 1829 and in 1914, some activity was reported. (A lava flow and volcanic plug).

A hot springs has been noted in the Hot Springs Bay area on the east portion of the island. At this time, there is no data on this geothermal expression.

#### SOCIO-ECONOMIC:

The island of Tanaga is located wholly in the Aleutian Island Wildlife Range, precluding any geothermal development at this time under existing laws. There is no permanent population on the island. The nearest population center is Adak Naval Air Station, 50 miles (80 km) to the east. In the hot springs bay area, there are a few abandoned cabins near Trunk Pt.

On the west side of the island on Cape Amagalik there is an abandoned landing strip and a few abandoned buildings with interconnecting dirt roads. If Hot Springs Bay were a reasonable harbor area, perhaps some type of fisheries industry or ranching facility could someday be considered. The hot springs here should be studied to see the extent of the resource. There are seven archeological sites. (Selkregg, 1976)

#### ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The climatic conditions of Tanaga are very formidable. Temperatures average 40-55°F (4-15°C) in the summer and 29-41°F (-2 to 4°C) in the winter. Extremes reach 3-75°F. (-16 to 24°C). Precipitation is 68" (172 cm) per year, including some 98" (249 cm) of snow. Average wind is from the west at 12.6 kts. Extreme winds could reach 85 kts. Heating degree days at 9,500.



There are the volcanic and earthquake considerations that are prevalent throughout the Aleutians. This is a major nesting area for many of the migratory birds that inhabit the Aleutians during the summer.

The dominant flora is alpine tundra.

Migratory water fowl and also offshore bottom fisheries are major concerns in the area.

KEY CONTACT: Base Commander, Adak Naval Air Station  
Manager, Aleutian Islands Wildlife Refuge

REFERENCE:

Waring, G.A. "Mineral Springs of Alaska" USGS Water Supply Paper 492 (1917)

Fraser-Barnett (1959)

Southwest Regional Profile

SITE: Kanaga Island

LATITUDE & LONGITUDE: 51° 50' N; 177° 10' W

QUADRANGLE: Adak

BARRIER: Located within the Aleutian Islands Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Kanaga Island PGRA 22,900 acres (9,268 hectares). The oldest rocks recognized comprise a sequence of basalt flows and tuff beds, and remnants of a cone that was formed near the present north coast. These rocks are believed to be late Tertiary in age. After the cone was partly destroyed by erosion, a basaltic shield volcano called Mt. Kanaton was built nearby, and on its flanks at least two composite basalt cones were formed. Near the end of Pleistocene time, following an eruption, the central shield collapsed. Renewed eruptions from the floor of the caldera built up the present cone of Kanaga Volcano, which has been intermittently active during historic time. Recent explosive eruptions have blanketed the island with pumice. Basaltic lava was erupted from the sides of Kanaga volcano as recently as 1904 and 1906. In 1933, activity was also seen on the island. A hot spring associated with this volcanism was noted by Gerald Waring. (1917)

The outline of Kanaga Island is likened to that of a pistol, the barrel pointing west and the butt extending north. The barrel and breech consist of successive marine terraces, the highest of which is 600' (183 m) in latitude. The terraces are dotted with lakes and partially dissected. To the north is the volcanic sequence already discussed. In 1946 the hot springs reported at the foot of Kanaga Volcano was not found. There are, however, conspicuous fumaroles near the summit on the southeast, south and southwest sides.

SOCIO-ECONOMIC:

The Kanaga Volcano and reported hot springs area (Waring 1917) are only some 25 air miles (40 km) from Adak Naval Air Station. Any access would have to be by air because of the sea cliffs associated with the volcano on the north end of the island. Kanaga Island is totally located within the Aleutian Islands Wildlife Range, which would preclude any geothermal development at this time.

There are no inhabitants on the island. There are a couple of abandoned cabins, but they would provide no relief from the Aleutian climate. There is a lake big enough for a float plane on the southeast flank of the volcano that could assist in any evaluation of the resource. At this time I see no feasible development of the resource in this PGRA. There are six archeological sites. (Selkregg 1956)

#### ENVIRONMENT:

(Extracted from Southwest Regional Profile).

Climate is similar to that of the Adak Naval Air Station, which is the only recording station in the area. Temperatures range in the summer from 41-56°F (5 to 13°C); winter temperatures are 39-41°F (4 to 5°C). Extremes are 3-75°F (-16 to 14°C). Precipitation is 68" (173 cm), including 98" (249 cm) of snow. Average wind is from the west at 12.6 knots. Extremes are 84 knots.

#### FAUNA:

The area is a major nesting ground for migratory waterfowl.

There are numerous environmental hazards that should be considered: volcanic, seismic and climatic conditions are significant enough to warrant special structural design and location.

#### FLORA:

Alpine Tundra

#### KEY CONTACTS:

Base Commander U.S. Naval Air Station Adak  
Manager Aleutian Islands Wildlife Refuge

#### REFERENCE:

Coats, Robert. "Geology of Northern Kanaga Island, Alaska."  
USGS Bulletin 1028-D.  
Waring (1917)  
Southwest Regional Profile

SITE: Great Sitkin

RESOURCE: Hot Springs (Waring 1917) Volcano

LATITUDE & LONGITUDE: 52° 04' N; 176° 05' W

QUADRANGLE: Adak (Unsurveyed)

BARRIER: Aleutian Islands Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION: SIMONS AND MATHEWS (1955)

Located within the Great Sitkin P.G.R.A., 36,600 acres (14,812 hectares). Great Sitkin Island is about 11 miles in maximum diameter, and its highest altitude is 5,740 feet (1750 m) which is the summit of Great Sitkin Volcano. The island is rugged, with the active Great Sitkin volcano taking up most of the northern half, and deeply dissected remnant of an older volcano making up most of the southern half.

The oldest rocks exposed are the Finger Bay volcanics in the south. These rocks, assumed to be Late Paleozoic, are highly altered and deformed lavas, volcanic breccia and tuff of andesitic and basaltic composition cut by numerous dikes. The Sand Bay volcanics, which form the bulk of the southern half of the island, comprise a lower pyroclastic sequence, consisting mainly of agglomerate, and an upper sequence of andesitic and basalt flows of Tertiary age. The suggested source is the remnant cone.

The rocks of the main cone that forms the northern half of the island is designated Great Sitkin volcanics, and are of late Tertiary and Quaternary age. The steep slopes of the cone suggest that its core is made up of pyroclastic material. The crater of Great Sitkin lies at 4,000 feet (1219 m) and is three quarters of a mile long and a mile wide with a recent dome occupying the center. Numerous plugs have extended the northwest flank of the core. The floor of a creek valley is covered by a fairly recent mudflow. Entrenched streams and low marine terrain suggest that the island has been uplifted recently.

Volcanic history: 1872 - minor explosion eruption; 1892 - smoke; 1904 - smoke; 1933 - minor explosive eruption; 1945 - lava flow, some explosive activity.

A large group of hot springs, mud pots and fumeroles occurs at the head of the west fork of Big Fox Creek. On clear days, a conspicuous cloud of condensed steam hangs over the largest of the springs. An area 1,000 feet by 400 feet (305 m x 122 m) is underlain by almost completely decomposed rocks that are bright red, pink and yellow in color. The ground in the area is warm, with profuse growth, with dark green gelatinous algae clogging the overflow channels of the spring.

Several of the low mounds in the fumerole area are hollow shells, from which the sound of boiling water can be heard. Steam vents are abundant on all the mounds.

The largest vent contained a pool of hot, muddy water 6-8 feet (1.8 to 2.4 m) across from which steam bubbled with considerable violence. Little water was being discharged at the outlet, indicating that the boiling water was due largely to passage of steam and not to the influx of boiling water. Most springs discharge very little water. They appear to be fumerole craterlets in which surface water has collected. Pyrite is being deposited in one of the springs. Results of gas analyses of four fumeroles are:

	<u>H</u>	<u>N</u>	<u>O</u>	<u>A</u>	<u>CO<sub>2</sub></u>	<u>SO<sub>2</sub></u>	<u>Total</u>
1.		69.2	17.8	0.8	12.1	0.1	100.0
2.		78.2	20.9	0.9	0.02		100.02
3.	0.2	72.5	17.9	0.9	8.5		100.0
4.		16.7	0.8	0.2	81.5	0.8	100.0

Water from twelve hot springs were tested for temperature, pH and CL with Ag NO<sub>3</sub>) and SO<sub>4</sub> (with BaCL<sub>2</sub>) ions. pH was from 2-7 (1 at 2); seven reacted strongly to SO<sub>4</sub>; four others had weak reaction. All but one reacted to test for CL.

The springs elevation is 609.6 m (2000 ft.). The temperatures are 88°C to 99°C. Estimated reservoir temperature is 125°C. Estimate of stored heat is  $.63 \times 10^{18}$  Cal. (Geotherm File, U.S.G.S.)

#### SOCIO-ECONOMIC:

Great Sitkin lies near the middle of the Aleutians, about 25 miles (40 km) northeast of Adak. This location is 600 miles (960 km) from the Alaska Peninsula and 480 miles (768 km) from Attu. Chikikof was the first white man to sight the island in 1741. Little history took place until 1943 when the Navy established a fueling station at Sand Bay. So far, no evidence has been found of any former permanent inhabitation by Aleuts and there is none at this time. The island was used as a fox farm before World War II.

The coastline is rocky and irregular. Sea cliffs as much as 1,000 feet (305 m) high alternate with narrow, sandy beaches at the mouths of valleys. Along the south are some terraces. Natural harbors are non-existent. Sand Bay and Yoke Bay are fairly well sheltered, which could be used for harbor facilities.

Any economic consideration should determine the quantity of water needed and how to supply it since the outflow is so small. There are numerous streams and five glaciers that could supply water.

The entire Great Sitkin Island lies within the Aleutian Islands Wildlife Range. This precludes any development at this time.

There are four canneries at Adak and probable expansion of the fisheries industry may someday make Great Sitkin an attractive site for agriculture development or processing.

The remains of a Navy facility offers shelter at this time. There is also one archaeological site on the island. (Selkregg, 1976)

ENVIRONMENT: (Extracted from Southwest Regional Profile)

The climate is cool and wet. Prevailing winds are from the north in winter and from the southwest in summer. Average wind is 12 kts. High ridges near Sand Bay cause the wind to blow in strong gusts and to make rapid variations in direction. Precipitation is in the neighborhood of 65" (165 cm) per year. The temperature range for summer is 39-50°F. (2° to 10°C); winter is 29-40°F. (-2 to 4°C). There are much cooler temperatures at high altitudes.

FLORA:

The vegetation along the lower parts of the island is mainly grass and tundra reaching 4-5 inches (10 to 13 cm) in late summer. Small gullies are choked with ferns. The vegetation occurs between 0-1,500 feet (0 to 457 m)

There have been mud flows on the island associated with eruptions.

FAUNA:

Migratory water fowl. The area offshore is a particularly good bottom fishing area.

KEY CONTACTS:

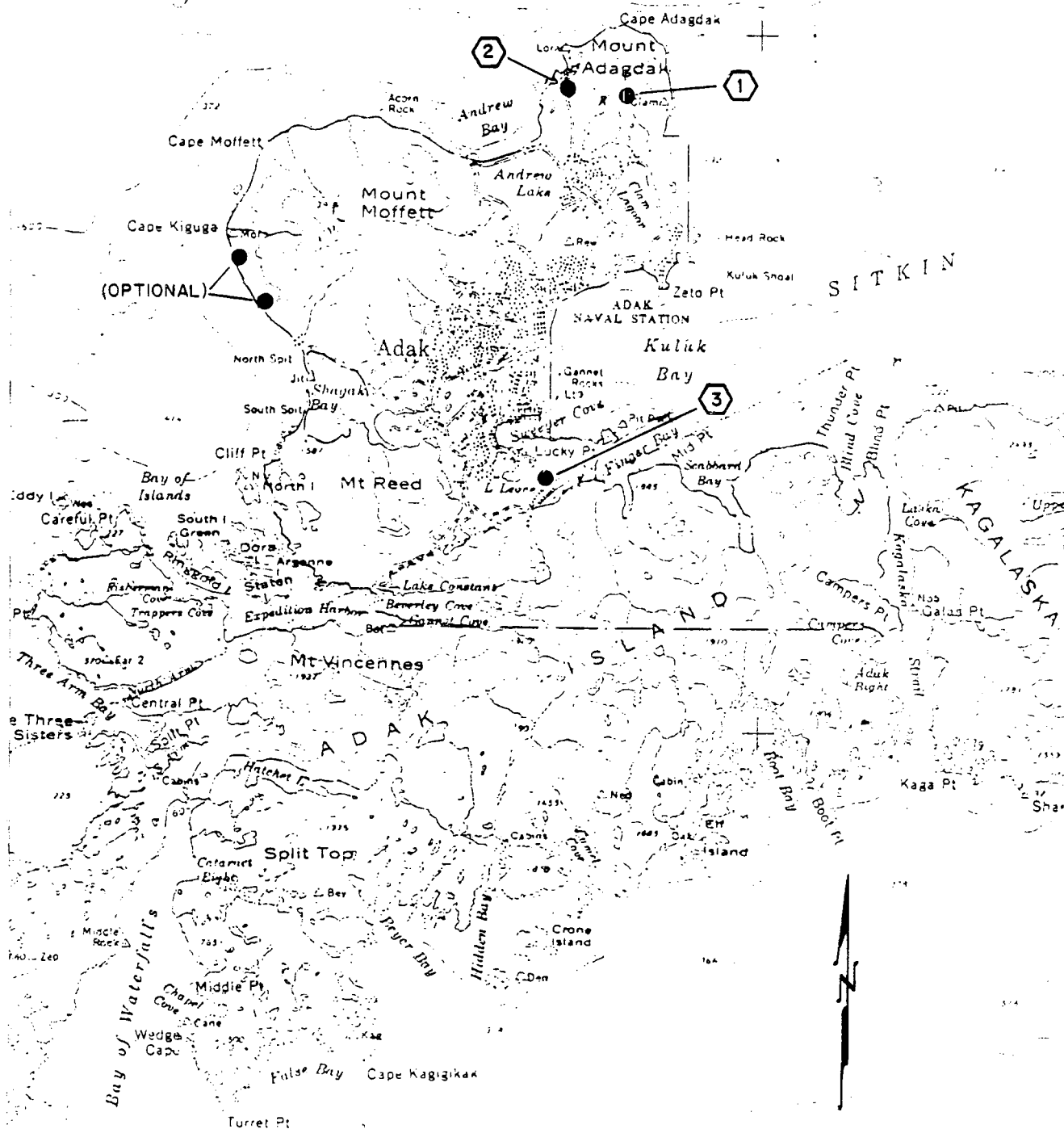
Commander, Adak Naval Air Station  
Manager, Aleutian Islands Wildlife Refuge

REFERENCE:

Simmons, F.; Mathewson, D. "Geology of Great Sitkin Island, Alaska".  
USGS Bulletin 1028-B. (1955)  
Waring (1917)  
Southwest Regional Profile  
Geotherm File (USGS)  
White (1975)

# Adak Island

## Geothermal Exploration Well Locations



## ADAK

Adak Naval Air Station is located approximately 1200 air miles (2240 km) from Anchorage in the Central portion of the Aleutian Islands. The geothermal potential and the interest shown by the U.S. Navy at the site make Adak the number one prospect in the State of Alaska for utilization.

Adak is located at latitude 51° 59' N., longitude 176° 36' W. The topography of the northernmost portion of Adak where the Naval air station is located has been largely controlled by volcanic activity originating at three centers: Mountains Moffet, Andrews and Adagdak. These structures are deeply dissected with steep walled cirques narrowing to V-shaped vallies. Vigorous wave action has created sea cliffs on the north shore.

The population and commerce of the island is concentrated at the Naval air station. Approximately 5,000 military and civilian employees work there. There is a major airport facility and shallow draft dock facility. Elementary and secondary schools, library and military facilities are located at the base. There is water, power and sewage utilities systems in place. Some fishing commerce is reported out of the base area. Recently the canneries have been closed.

Presently, energy needs for the base are supplied by electrical generators using jet (JP-5) fuel as an energy source. The Navy is actively exploring a potential geothermal applications as an alternative to the present system. The fact that the Navy is the only land management unit outside the wildlife refuge would indicate that the island will be utilizing the geothermal resource if capital, economics and the resource are proven out.

The geothermal potential of the island is presently under much scrutiny. Exploration for geothermal power sources at Adak are being conducted by the geothermal power group, based at the Naval Weapon Center, China Lake, California.

Exploration has been active for three years now. During the first year, the U.S. Geological Survey conducted various magnetic, electrical and gravity surveys to pinpoint possible geothermal resources. One such area was located on the south slope of Mt. Adagdak.

During the 1977 program two wells were drilled in the area sited by the Geological Survey. One at the center of the hot spot was terminated at 1,500 feet (457 m) because of drilling problems. The second hole along the Loran station road was terminated at the 2,000 foot (610 m) depth. The hole had a bottom hole temperature of 150°F (66°C). This hole shows promise as a heat source. (Well locations are shown on Fig. 18)

An attempt was made to sink a third hole in the Finger Bay area. This area was selected on geological formations not of USGS work. The Finger Bay hole was terminated at about 300 feet (91 m) because of drilling problems caused by an abundance of ground water.



Plans were made but not consumated to drill a deeper hole in the 1978 summer season. The hole would have been in the 4-5,000 foot (1219-1524 m) depth range.

A study was conducted by Clifton Stine to provide a preliminary evaluation of the geothermal resources at Adak, Alaska. A 25 mw power level was assumed for electricity and heat. This would provide for projected facilities growth. Geothermal was compared with nuclear, wind/pump storage, tidal, fossil fuel and the present system. For all new systems, the payback period was quickest for the geothermal system. Undiscounted costs favored the geothermal system to that of the present system.

The geothermal system was evaluated as to whether it should be total electric or a combination. The years to completion, undiscounted cost and payback period favored the all electric system, however, suspected lower resource temperatures have prompted the Navy to opt for the combination system.

The Navy is proceeding with the necessary zeal to develop the resource. If the resource is proven in the next summer season, 1979, the three year change-over to geothermal energy should begin in 1980. The Navy has indicated that a block appropriation for a power and heating system will be discussed at the Congressional level in 1979. If funded, the Navy will drill a 4,000 to 6,000 foot (1219 m to 1524 m) production hole. Drilling costs are estimated at 7.2 million dollars. The hole should be completed by October, 1979.

## SITE DATA SUMMARY

SITE: ADAK

### ..Physical Reservoir Data

..Temperature °C (White 1975)

Surface: 68

Subsurface: 187

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

Greater than 25MW/yr

..Type of Overlaying Rock: Volcanics and clay (Usually)

..Estimated Depth to Top of Reservoir (meters): 1219 to 1829 m

### ..Site Land Status

..Total Acres: 40,700

..Total Acres Leased: All Department of Defense Land

### ..Geothermal Development Status:

Navy conducted geophysical exploration and drilled three exploratory holes. A fourth hole was abandoned during drilling this year. Numerous studies accompanied this work.

### ..Local and State Attitude Toward Geothermal Development:

Very favorable for both possibilities of electrical and space heating.

### ..Land Use and Population:

5,000 people stationed at Adak Naval Air Base. The military installation is the economic base of the island. (U.S. Navy)

### ..Comments and Critical Issues:

Entry to Naval Base must be obtained in advance from the Base Commander. Adak must compete for money with other Navy projects in California. Funding for Adak project will require a Congressional appropriation in 1979.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: ADAK (COATS, 1956)

..Latitude: 51° 59' N

..Longitude: 176° 36' W

..Rectilinear: Adak Quadrangle (Unsurveyed)

..County: None

..Adjacent Counties:

..Topography:

The topography of northernmost Adak has been largely controlled by volcanic activity originating at three centers: Moffett, Andrew and Adagdak from east to west. These structures have been deeply dissected with steep walled cirques narrowing to Vee shaped valleys. Vigorous wave action has created cliffs on the north of the island.

..Present Land Use: Area is site of Adak Naval Air Station.

..Future Land Use Plans: Naval Air Station. Possible Fisheries.

..Aesthetics: No known redeeming features.

..Historical/Archaeological Significance:

Many significant WWII encounters were staged from this base. Site of many bombing raids by U.S. Navy when Japan had occupied Kiska and Attu. There are nine archeological sites on the island (Selkregg, 1975).

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: ADAK

..Geologic Description: (Coats, 1956)

There are two physiographic and geologic divisions to the northern part of Adak Island. One, a deeply glaciated southern area of folded, faulted and intensely altered volcanic rocks of paleozoic age, intruded by gabbro and rocks of intermediate composition. A second mountainous northern area comprised of remnants of three distinct basaltic volcanoes of Tertiary or Quaternary age exists. In the northern part of the southern area, there are five volcanic domes of light colored andesite porphyry, probably of late Tertiary age, not connected with the northern volcanics. Minor amounts of

sedimentary rocks are associated with the volcanoes. A blanket of volcanic ash from nearby island volcanoes cover most of the lowlands.

A recent geologic study of the Mt. Adagadak area has been completed by Tom Miller of the USGS and should be in print by the completion of this report.

#### ..Geophysical Summary:

An aeromagnetic survey of the north part of Adak indicated a 700 gamma anomaly is associated with a gabbro mass north of Finger Bay. Anomalies associated with the basalt domes on Mt. Adagdak and the composite parasitic olivine basalt on the northeast flank of Mt. Moffett were also observed (Keller and others, 1954, USGS).

Gravity surveys indicate the dominant feature is a northward decrease of bouguer anomaly values of about 2 mgal per km. One large local anomaly is indicated in the vicinity of Mt. Adagdak and to the south.

Both gravity and magnetic data support the other available data in suggesting that the Mt. Adagdak area is an anomalous heat area (Mabey, 1976). Adiomagnetotelluric, telluric traverse, geonics EM-16R and self potential surveys were also used. The self potential surveys, while very speculative, do suggest a large deep source below the center of Adagdak of proper polarity for a geothermal system. Telluric data suggest that a broad conductor exists under the part of Adagdak surveyed. It seems reasonable that this could be a fault zone which has channeled thermal solutions near to the surface (Mabey, 1976).

#### ..Geologic Hazards:

The island is part of the seismically and volcanically active Aleutian Island arc. All associated hazards including tsunamis are possible

### RESERVOIR CHARACTERISTICS

#### SITE: ADAK

#### ..Reservoir Temperature (White, 1975)

..Surface: 68°C

..Subsurface: 187C

U.S. Navy expects to encounter 82°C temperatures at 1219 m to 1829 m.

..Geochemical:

SiO<sub>2</sub>: 187°C

Na-K-Ca: 196°C

..Flow Rates:

It is expected that between five and eight wells will supply the electrical and heating needs of the Naval Base.

..pH;

..Total Dissolved Solids:

..Fluid Chemistry:

Geologic report covering Adak Island Hot Springs and siting considerations will be published in 1978. (USGS-MILLER) U.S. Navy has made chemical analysis of wells but this information is not now available.

..Estimated Non-electric Energy Potential (MBtuh 30 years):

25 MW of power, indefinite.

..Subsurface Area of Reservoir:

LAND OWNERSHIP AND LEASING

SITE: ADAK

..Land Ownership: Land owned by Department of Defense

..Total Acres: 40,700

GEOHERMAL DEVELOPMENT STATUS

SITE: ADAK (U.S. NAVY)

..Present Development Status:

Phase I FY 76/77 by USGS used chiefly electrical methods to determine resistivity of the rocks with gravity, magnetic and seismic studies contributing. During Phase II, April-May, 1977, a contract was let to Dr. Richard Ulrich of Brigham Young University to study the engineering and economics of piping geothermal fluids at Adak. Phase III geophysical studies were completed in 1977. Two deep heat flow holes were drilled in the summer, 1977. Both wells were completed with steel liners to enable heat flow measurements and

swabbing. Well #2 bottom hole temperature measured at 123°F (51°C) seven days after well completion. A study of alternate energy systems for Adak Naval Air Station has been completed. A third well was started, but abandoned.

Slim Hole: Hole #1 drilled to 1,055' (320 m), abandoned. Hole #2 drilled 2,087' (636 m) gradient 8.2°C sec. 100m, bottom hole 123°F (51°C), as deep as Navy would drill. Hole #3 drilled 120' (37 m), washing problems. (U.S. Navy)

#### ..Projected or Planned Development:

Current plans are to monitor the temperature of the two heat flow holes through spring of 1978. Drill two deep exploratory holes as funds are made available. The wells to be 8-3/4" (22.23 cm) diameter. (James A. Hamilton, Inc., of Anchorage)

Economic studies indicate that a 25 MW electric power plant utilizing the geothermal resource would be the most feasible approach to usage of the resource. This type of development should have a five year payback, according to U.S. Navy calculations (USN).

In 1979, the U.S. Navy will seek Congressional funding for combination electrical/space heating geothermal application at Adak Naval Air Station. Cost of system will be \$54,000,000 and will include twelve miles of pipeline and produce the equivalent of 25 MW of power to be on line by 1985. (U.S. Navy personal communications.)

### INSTITUTIONAL CONSIDERATIONS

SITE: ADAK

#### ..Institutional Requirements:

Must comply with Title 43, Sec. 3200 CFR and Title 30 CFR. See legal and institutional portion of this report.

#### ..Agency and Public Attitudes:

Navy is only entity involved and they are doing the development.

#### ..Status of Requirements (i.e., EIA/EIS Requirements):

Have completed the EIS for the Geophysical/exploration portions of the program. Have sporadically submitted and are developing EIS for possible production of geothermal energy.

## ENVIRONMENTAL FACTORS

SITE: ADAK (SOUTHWEST REGIONAL PROFILE)

### ..CLIMATE

..Prevailing Winds: 12.6 kts (23.3 kph) West

..Precipitation (Annual): 68" (173 cm), 98" (249 cm) snow

..Days of Sunshine (Annual):

..Average Temperature:

Summer: 41-56°F (5 to 13°C)

Winter: 29-41°F (-2 to 5°C)

Minimum: 3°F (-16°C)

Maximum: 75°F (24°C)

..Degree Days (Annual): 9,500

..Relative Humidity (Seasonal Peaks)

Summer:

Winter:

..AIR QUALITY: Possible temperature inversions.

..GEOLOGIC FACTORS: High seismic potential.

..WATER QUALITY:

1-10 gpm flow from basement bedrock. Mean annual runoff 2 cf<sup>3</sup>/sec/mi<sup>2</sup>. Water right held by U.S. Navy through BLM.

..NOISE: From wind.

..BIOLOGICAL

..Dominant Flora: Alpine tundra

..Dominant Fauna: Marine mammals, waterfowl range, crab

..Endangered Species:

Flora:

Fauna:

## TRANSPORTATION AND UTILITIES

SITE: ADAK

### ..Utility or Energy Transmission Corridors and Facilities:

Naval Base lines for electric and sewer. Access to right-of-way.

### ..Transportation Corridors or Facilities (Adak Profile):

There is a road to Loran site being used by exploration teams. Access to right-of-way. The road system is quite extensive on the Base.

There are two major runways on Adak. One is 7880 ft. long (2402 m), the other is 7600 ft. long (2316 m).

Two deep water docks are there, but they function without power.

## POPULATION

SITE: ADAK

### ..General Description of Population:

There are between four and five thousand people at Adak at all times. All are military and dependents. Temporary civilian workers on the Base as well.

### ..Economics

#### ..Present Land Use:

Used as military base. Many recreational uses such as ski resorts and swimming pools are on the base.

#### ..Future Land Use:

Same, with about a 10% increase in personnel.



SITE: Kliuchef/Korovin

RESOURCE: Reported Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 52° 20' N; 174° 10' W.

QUADRANGLE: Atka (Unsurveyed)

BARRIER: Access/wildlife refuge

RECOMMENDATION: Reconnaissance exploration

DESCRIPTION:

Located on the north portion of Atka Island, within the Atka Island P.G.R.A. 191,600 acres (77,540 hectares). Atka Island is located midway along the Aleutian Islands in the Andreanof group.

There are three major volcanic expressions associated with the north portion of Atka Island. Some basic data has been gathered on Mt. Kliuchef, which indicates the heat content to be approximately  $58 \times 10^{18}$  calories (White, 1975).

Associated with these volcanics are two hot spring systems. One is located near Conical volcano (Korovin), the other near Kliuchef volcano. The Korovin system has mud pools, some of which are boiling. The water appears to be sulfurous. No data is given on the Kliuchef springs (Waring, 1965).

The rocks on the north third of Atka Island are andesitic and basaltic lava flows with local pyroclastic deposits.

SOCIO-ECONOMIC:

The land area around the springs system was withdrawn for native selection under the Alaska Native Claims Settlement Act, but the land was not selected. The land use prior to this withdrawal was that of Aleutian Islands Wildlife Refuge.

The north portion of the island is rugged, which would make any access to these two spring systems very difficult.

The population on the island is concentrated at the village of Atka, which has 22 families and approximately 90 people (Rural Energy Survey). The major economic considerations are fishing and subsistence. The village has a dock and a small airplane strip. Adak is the nearest population and supply center, 120 miles (192 km) to the west. A supply tug runs once per month between the two.

There is a potential for sheep herding on the island.

## ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

The nearest climatological station to the spring sites is Atka. The springs are located at a much higher elevation. The climate station at Atka records an average wind speed WNW at 13 knots. The annual precipitation is 60" (153 cm), with 60" (153 cm) of snow. The average summer temperatures range from 39-55°F (4-13°C), winter 29-40°F (-2 to 4°C). Extreme temperatures of 12 and 77°F (-11 and 25°C) have been recorded.

## FLORA AND FAUNA:

The dominant flora is alpine tundra. There is no prevalent fauna in the area, but the offshore waters hold commercial quantities of crab and bottomfish. Sea mammals and waterfowl frequent the near shore waters (Selkregg, 1976).

There is potential environmental hazards associated with the extreme volcanic and seismic characteristics of the north Atka volcanic zone.

## KEY CONTACT:

Village Council, Atka Village  
Aleutian Pribilof Native Assoc., Anchorage  
Manager, Aleutian Islands Wildlife refuge.

## REFERENCE:

Waring, 1965 World Springs Report  
Southwest Regional Profiles

SITE: Korovin

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 52° 11' N; 174° 14' W.

QUADRANGLE: Atka

BARRIER: Access/Insufficient Capital

RECOMMENDATION: Exploration

DESCRIPTION:

Located on Atka Island within the Atka Island P.G.R.A. 191,600 acres (77,540 hectares). Atka is part of the Andreanof Islands in the central Aleutian group.

Atka Island is divided into two distinct parts. The northern quarter is dominated by Mt. Kliuchef volcano. The rocks are basaltic to andesitic lava flows with local pyroclastic deposits. South of Korovin Bay, the rocks are Tertiary interbedded lava flows, pyroclastic deposits and related sedimentary rocks. There is at least one eroded volcano on the west end of the island, Mt. Sergief.

The hot springs are located about 5 miles (8 km) from Korovin Bay. This is speculated to be west of the village of Atka (Waring, 1965). The exact location has not been determined, but information obtained by word of mouth indicates the spring is in the drainage directly west of the village. No assessment of the springs has been recorded.

SOCIO-ECONOMIC:

The land in the suspected spring area has been selected by the Atka Village Corporation. Atka Village itself is only a few miles from the springs. There is also an archeological site near the village.

The Aleutian Pribilof Native Corporation is in the process of assessing the possible funding sources for direct heat applications at Atka. An economic impediment may occur because of the extreme high cost of development combined with the small local demand. If some commercial utilization could be found to help carry the initial capitalization the direct heat utilization would be very beneficial to the community. Since the resource is relatively undetermined, perhaps some benefit may come from utilizing the surface discharge once its extent is determined.

Atka has a population of ninety people. The economic base is composed of fishing and subsistence. Presently, a construction project of renovating eleven housing units is taking place. The present energy source in Atka is a 40 kw generator that is used for the school there. Atka has bulk storage capacity for 39,500

gallons of oil. Transportation to Atka is by tug from Adak once a month. A small airstrip is located on the jeep trail between Atka and Korovin Bay (Rural Energy Survey).

The recommendation for this manifestation is a reconnaissance exploration project to obtain the basic data needed to begin a development program. A scenario should be drawn up at that time. The Aleutian Pribilof Native Corporation is applying for an appropriate technology grant to research and actually use this resource for an agricultural application.

#### ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

The climatological station at Atka records an average wind speed WNW at 13 knots. The annual precipitation is 60" (153 cm) with 60" (153 cm) of snow. The average summer temperatures range from 39-55°F (4-13°C), winter 29-40°F (-2 to 4°C). Extreme temperatures of 12 and 77°F (-11 and 25°C) have been recorded. The heating degree days have been estimated at 9,600. There is also a mean annual runoff of 1.7 cu. ft./sec./sq. mi.

#### FLORA AND FAUNA:

The dominant flora is moist to alpine tundra. The fauna concentrated in the area are waterfowl, some marine mammals, and offshore commercial crab.

Potential environmental hazards may occur due to the active seismic zone and volcanos.

#### KEY CONTACT:

Village Council, Atka Village  
Aleutian-Pribilof Native Corporation

#### REFERENCE:

Southwest Regional Profiles  
Rural Energy Survey  
Miller (1970)  
Waring (1917)

SITE: Seguam

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 52° 18' N; 172° 28' W.

QUADRANGLE: Seguam (Unsurveyed)

BARRIER: Part of Aleutian Islands Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

The entire Seguam island consists of Quaternary volcanics. Basaltic and andesitic flows are embedded with local pyroclastic deposits. Seguam volcano makes up the major portion of the island. Pyre Peak forms the top of the cone with a 3/4 mile diameter round crater. In 1827, smoke was reported, in 1891, there was a minor explosive eruption and in the spring of 1892, a major explosive eruption followed. In 1902 there was a reported explosive eruption attributed to Seguam. In 1927, smoke was once again reported. A hot springs and mud pool areas have been reported on the island, although no data has been gathered concerning them.

The island is elliptical with high sea cliffs around the majority of it. There is a saddle between Seguam volcano and an older eroded volcano to the east. The saddle opens to the northeast.

SOCIO-ECONOMIC:

The entirety of this island exists within the Aleutian Islands Wildlife Refuge, which would preclude any development at this time. The lack of a proper anchorage would also be a major hinderance.

The vegetation on the island grows mainly between 0-1,500 foot levels with grass covering the lower flanks of the mountain.

Recommend further analysis of the resource.

ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

Nearest climatological recording station is Atka, 60 miles (96 km) to the west. Average summer temperatures are between 35-50°F (2-10°C); winter temperatures are between 26-39°F (-3 to 4°C). Heating degree days average 9,600. Mean annual runoff is 2 cu.ft./sec/sq.mi.

FLORA AND FAUNA:

The dominant flora is moist to alpine tundra. The dominant fauna is the sea bird. This is a major sea bird colony. Bottom fish and crab are noted offshore and sea mammals are found on shore.

KEY CONTACT:

Commander, Adak Naval Air Station  
Manager, Aleutian Wildlife Refuge

REFERENCE:

Waring, (1965) (1917)  
SW Regional Profiles

SITE: Chuginadak Hot Springs

RESOURCE: Hot Springs (Waring 1965)

LATITUDE & LONGITUDE: 53° 50' N; 169° 45' W. Approx.

QUADRANGLE: Samalga Island (Unsurveyed)

BARRIER: National Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Chuginadak Island P.G.R.A., 13,400 acres (5422 hectares) among the Islands of Four Mountains. A spring has been reported at the base of the volcano on Chuginadak Island (Waring, 1965).

The island of Chuginadak is composed of two volcanoes: Cleveland to the west and Tana to the east. The island is volcanic with Quaternary andesites, basalts and pyroclastics forming the bedrock.

SOCIO-ECONOMIC:

The island is entirely within the Aleutian National Wildlife Refuge. This would preclude any development under terms of the Geothermal Steam Act.

There is no population or facilities located on or near the island. The nearest facilities would be at Adak, close to 200 miles (320 km) to the west.

The wave cut shoreline would make boat landings very difficult. There are four archeological sites indicated.

There is no probable end user in this area at this time. No exploration has taken place to determine the extent of the resource.

ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

The weather in this part of the world moderates between harsh and severe. High winds, driving rain and snow predominate. Summer temperatures average 40° to 60°F (4° to 16°C) and winter 30° to 40°F (-1° to 4°C). Extremes of 0° and 75°F (-18° to 24°C) could be expected. Mean annual runoff averages 3ft.<sup>3</sup>/sec/mi<sup>2</sup>. Annual heating degree days average 8700.

FLORA AND FAUNA:

The dominant flora is alpine tundra. This is a major seabird colony. It is also a low density waterfowl range. Offshore crab and bottom fisheries are viable here.

KEY CONTACT:

Manager, Aleutian Islands National Wildlife Refuge  
Commander, U.S. Naval Air Station

REFERENCE:

Waring, 1965  
Southwest Regional Profile



SITE: Kagamil

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 52° 59' N; 168° 42' W. Approx.

QUADRANGLE: Samalga (Unsurveyed)

BARRIER: Wildlife Preserve/Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Kagamil P.G.R.A., 10,000 acres (4168 hectares). Springs and fumeroles are reported on Kagamil Island (Waring, 1965). The island is an active volcano in the Islands of Four Mounts Region of the Aleutian chain. The rocks are andesitic and basaltic with proclastic deposits of Quaternary age. No scientific study has been made concerning the resource.

SOCIO-ECONOMIC:

The island is part of the Aleutian Islands National Wildlife refuge. This would preclude development under terms of the Geothermal Steam Act.

There is no population or facilities on the island. The nearest population is located at Adak, almost 200 miles (370 km) to the west. Adak would be the logistical base for any reconnaissance.

Exploration is the next logical step before any consideration can be given to future development.

ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

Summer temperatures would average between 40° and 60°F (4° to 16°C). Winter 20° to 40°F (-8° to 40°C). Heating degree days average about 9700.

FLORA AND FAUNA:

The dominant flora is alpine tundra. The animal population is sea birds. This is part of a large waterfowl range. Offshore crab and bottomfish ranges are indicated in Bristol Bay.

Environmental hazards exist from active volcanoes and high seismic activity.

KEY CONTACT: Manager, Aleutian National Wildlife Refuge

REFERENCE:

Waring, 1965  
South West Regional Profile

SITE: Bogoslof

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 54° 50' N; 168° 03' W.

QUADRANGLE: Umnak (Unsurveyed)

BARRIER: Wildlife Refuge

RECOMMENDATION: Exploration

DESCRIPTION:

Located in the Bogoslof P.G.R.A. Hot water and steam issue at several places on Bogoslof Island, a volcanic mass in the Aleutian group 30 miles (48 km) north of Umnak Island. The waters issue from numerous crevices in the rock around the lower part of the island. (Waring, 1917)

The island of Bogoslof has a history of volcanic eruption. Merriam in 1899, characterized it as having been in recent years the seat of more violent volcanic activity and as having undergone greater changes in form than any other part of North America.

The rock of the several peaks is practically all volcanic, consisting of hornblende andesite, basalt, basaltic agglomerate, and pumice. Some of the rocks contain much disseminated pyrite, which is probably the source of at least a part of the sulfur and the sulfurous gasses. (Waring, 1917).

Geysers that rise as much as 100' (35 m) have been reported by observers in the area (Ogle, personal communication).

SOCIO-ECONOMIC:

The location is in the Bogoslof National Wildlife refuge. There is no population center close at hand. Nobody has been on Bogoslof Island for years. Potential bottom fisheries, oil production and crab fishing are economic possibilities in the area. Application for geothermal energy at this site appears highly unlikely.

ENVIRONMENT:

The estimated summer temperatures would average between 33° to 55°F (1 to 13°C) and winter 22° to 39°F (-6 to 4°C). Extremes of 0° and 75°F (-17 to 24°C) might be expected. Annual heating degree days average 9800.

FLORA AND FAUNA:

The dominant flora is alpine tundra. The island is a major seabird colony.

The volcanic and seismic hazard is extreme.

KEY CONTACT: Manager, Bogoslof National Wildlife Refuge.

REFERENCE:

Waring, 1917  
Southwest Regional Profile  
Bill Ogle Personal Interview

SITE: Rootok

RESOURCE: Reported Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 54° 03' N; 125° 30' W.

QUADRANGLE: Unimak, T71S, R110W, SM

BARRIER: Remote/No User

RECOMMENDATION: Exploration. Development potential poor.

DESCRIPTION:

A reported hot spring exists on an islet southeast of Akutan Island (Waring, 1965). The island is assumed to be Rootok.

Rootok Island is comprised of coarse to fine-grained sediments and pyroclastic rocks with lava flows, cut by small intrusive bodies (Selkregg, 1976). No exploration of the resource has taken place to date.

SOCIO-ECONOMIC:

Land has been selected by Akutan Native Association. There are no people or facilities located on the island. There is no potential harbor site or plans to inhabit the island. Because of this remoteness and no data on the springs, the only recommendation that can be made is to locate and do some reconnaissance exploration.

Potential agricultural grazing area could be considered as there are no predators and good pasture.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

There are no climatological recording stations other than Akutan in the area. The average temperatures for summer range from 40-60°F (4-15°C) and 27-37°F (-3 to 3°C) in the winter. The winds average southeast at 9.6 knots; precipitation is 58" (142 cm), with 84" (205 cm) of snow. The heating degree days average about 9800.

FLORA AND FAUNA:

The dominant flora is tundra. There are few, if any, terrestrial mammals. Fish and sea mammals frequent the coastal waters. Dominant fauna is migratory water fowl.

KEY CONTACT:

President, Akutan Village Corporation  
Aleutian Pribilof Native Corporation

REFERENCE:

Waring, 1965 World Springs Report  
Southwest Regional Profile

## HOT SPRINGS BAY

Three hot springs are identified in the eastern valley at the head of Hot Springs Bay on the northeast side of Akutan Island. Akutan Island is at the extreme eastern end of the Aleutian Island chain. All the springs are located along the western margin of the valley bottom. Another hot spring area is located in the western valley at the head of Hot Springs Bay as well.

The hot springs investigated by Baker, et. al., 1977, are all located at the base of a ridge that forms the western margin of the eastern valley. The valley itself is about one half mile wide, flat, and oriented north-northeast. A series of low parallel hills, 20-40' (6-12 m) high cross the valley within 1/4 mile (.4 km) of the mouth. There are old beaches and sandbars.

Like most of the Aleutian Islands, Akutan is composed of Quaternary volcanic rocks, primarily basaltic andesitic flows and pyroclastic materials. The Akutan volcano is located about 7 miles (11 km) west and is still very active. The volcano has had observable volcanic activity 23 times since 1700, with its most recent eruption on May 6 and 7, 1977, when it spewed forth ash and incandescent material.

The three springs studied by Baker appeared to be controlled by fractured rock dipping roughly to the east. It is possible that more springs exist, but their flow is masked by surficial soil deposits in the muskeg environment.

One spring in the intertidal area had a temperature of 55°C and flowed at least 3 gpm, and perhaps up to 10 gpm. The middle spring flowed an estimated 20 gpm at a temperature of 60°C. The third location recorded temperatures as high as 83°C and low as 37°C in the pools, with discharges of about 11 gpm.

The estimated heat content of the reservoir is  $.3 \times 10^{18}$  calories, with a subsurface temperature of 180°C. These estimates are very speculative, as there has been no field reservoir assessment.

If these estimates were to hold true, there is a possible electric generating capacity. If electrical production is considered, a commercial use would need to be found since there is no local use with the demand to warrant this kind of development. Akutan Village, with a demand of 110 kw, 5 miles (8 km) away, is the only local user. Energy intensive aluminum and manganese nodule processing have been suggested as possible industries with high energy needs that could foster development of the geothermal resource.

Space heating, agriculture, aquaculture, and other cascading uses of the resource could very well be spinoffs of such a large scale development. Space heating as a target development would probably be too capital intensive and costly in the long run to warrant development at this time if assumptions made in Pacific-Sierra's economic predictions for nearby Nikolski hold true. This would be attributed to the small demand for such usage and high cost of drilling and distributing.

The harbor at Akutan is very well protected and might serve as an impetus for future development if it is determined to be suitable for deep draft shipping. A transportation problem is encountered ascending and descending the very steep valley walls in the area of the springs, as well as crossing the muskeg to get to the springs from Akutan.

Legal and institutional problems seem to be minimal after the BLM transfers title to the private ownership of the Native corporations under terms of the Native Claims Settlement Act. Drilling permits and environmental regulations will have to be met, but the relative simplicity of leasing from private concerns should prompt consideration of this area as a target development area for energy intensive industries.

There are environmental hazards to consider with the potential for volcanic eruption being so high. Related seismic activity and tsunami potential pose design and location considerations.

## SITE DATA SUMMARY

SITE: HOT SPRINGS BAY

### ..Physical Reservoir Data

..Temperature °C (White, 1975)

Surface: 83°C

Subsurface: 180°C

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

$.3 \times 10^{18}$  (White, 1975)

..Type of Overlaying Rock: Basalt/andesite (Baker, 1977)

..Estimated Depth to Top of Reservoir (Meters):

1.5 km (White, 1975) speculative

### ..Site Land Status Akutan Island P.G.R.A.

..Total Acres: 82,095

..Total Acres Leased:

All lands near the springs have been selected by Akutan Native Association.

..Geothermal Development Status: None to date.

..Local and State Attitude Toward Geothermal Development:

No real pursuit at this time, although this spring was considered in the State of Alaska's Salmon Hatchery Feasibility Study (Baker, 1977).

..Land Use and Population:

Area not used at this time. Akutan village is basically a subsistence and fishing village. The village seems to be dying at this time and unless some source of industry is created, the village will probably cease to exist.

..Comments and Critical Issues: Active volcano in area.



## SITE LOCATION AND PHYSICAL DESCRIPTION

### SITE: HOT SPRINGS BAY

- ..Latitude: 54° 10' N.
- ..Longitude: 165° 50'W.
- ..Rectilinear: Unimak, T69S, R113W, SM
- ..County:
- ..Adjacent Counties:
- ..Topography:

Located at western margin of valley 1/2 mile (.8 km) wide. Flat oriented N-NE S-SW. A series of parallel hills, 20-40' (6 to 12 m) high across valley within 1/4 mile (.4 km) of the mouth, 1/2 mile (.8 km) to the ocean. Large glaciated mountains in area. Volcanic origin. Extremely steep valley walls.

- ..Present Land Use: None.
- ..Future Land Use Plans:

Direct heat use for village. Possible commercial use of hot springs.
- ..Aesthetics: Spectacular mountain scenery rises from the ocean.
- ..Historical/Archaeological Significance: None apparent.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: HOT SPRINGS BAY

- ..Geologic Description: (Baker et. al., 1977)

Akutan is composed of Quaternary volcanic rocks, primarily basaltic and andesitic lava flows and pyroclastic materials (Beikman, 1975). Akutan volcano is located 7 miles (11 km) west and is still active. The volcano has had 23 eruptions or other activity recorded since 1700. Soils along most of the valley floor are organic deposits (muskeg). The northern two thirds of the island may not have been glaciated.

Low ridges paralleling the coast near the mouth of the valley appear to be composed of fine sand and silt and may be old beaches or bars formed at the head of a new abandoned lagoon.

..Geophysical Summary: None to date.

..Geologic Hazards: (Baker, et. al., 1977)

High volcanic risks with moderate related avalanche risks. High seismic activity is reported. Tsunami probability is considered moderate.

#### RESERVOIR CHARACTERISTICS

SITE: HOT SPRINGS BAY

..Reservoir Temperature (White, 1975)

..Surface: 83°C

..Subsurface: 180°C

..Geochemical (White, 1975)

SiO<sub>2</sub>: 152°C  
Na-K-Ca: 179°C

..Flow Rates (Baker, 1977)

Spring #1: About 10 gpm; Spring #2: About 20 gpm; Spring #3:  
About 11 gpm.

..pH:

..Total Dissolved Solids:

H <sub>2</sub> S	0.02*
NH <sub>3</sub>	0.04*
NO <sub>3</sub>	0.3
Phosphate, Ortho	0.25
Alkalinity, Bicarbonate	122
Alkalinity, Carbonate	0
CO <sub>2</sub>	12*
Chloride	140*
TDS	490*
Hardness (Total)	60
F	0.96*
SO <sub>4</sub>	195*
Se <sup>4</sup>	0.008
Cu	0.010
Ca	8*
Na	150*
K	10*
Ag	0.00015
Pb	0.006
Cd	0.003

Cr	0.0012
SiO <sub>2</sub>	40
Al	0.01
As	0.04
B	3.2
Fe	0.05
Mg	1.0
Mn	0.004
Ni	0.005
Sb	0.05
Zn	0.07*
Hg	0.001
V	0.01
Conductance (umohs/cm)	600
**Temperature (°C)	24
pH	7.2
Date	5-20-77

\* Exceeds ADFG water quality criteria for salmon aquaculture.  
 \*\* Temperature at which chemical analysis was accomplished.

..Fluid Chemistry:

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.3 x 10<sup>18</sup> calories estimate (White, 1975).

..Subsurface Area of Reservoir:

LAND OWNERSHIP AND LEASING

SITE: HOT SPRINGS BAY

..Land Ownership: Estimates from Land Records

..Total Acres: 82,095

..Federal Acres: 20,000

..Other: 62,000 ANCSA

..Summary of Leasing Status and Needs:

No leases planned on BLM lands. Native selected lands are available as private lands after transfer of title.

## GEOHERMAL DEVELOPMENT STATUS

SITE: HOT SPRINGS BAY

..Present Development Status: None to date.

..Projected or Planned Development:

The subsurface temperatures are sufficient to generate electricity if estimations are accurate. If this is so, a possible manganese nodule or aluminum processing plant could be idealized with cascading uses for space heating the village of Akutan and agricultural and aquacultural uses.

No definitive plans have been initiated to date, although the Aleutian-Pribiloff Native Association has expressed interest in alleviating the depressed economic state of Akutan Village.

## INSTITUTIONAL CONSIDERATIONS

SITE: HOT SPRINGS BAY

..Institutional Requirements:

Compliance with environmental and drilling laws.

..Agency and Public Attitudes: No Opinion.

..Status of Requirements (i.e., EIA/EIS Requirements): None

## ENVIRONMENTAL FACTORS

SITE: HOT SPRINGS BAY (EXTRACTED FROM THE SOUTHWEST REGIONAL PROFILE)

..CLIMATE

..Prevailing Winds: SE, 9.6 knots

..Precipitation (Annual): 58" (147 cm) with 81" (205 cm) snow.

..Days of Sunshine (Annual):

..Average Temperature:

Summer: 40-60°F (4-16°C)

Winter: 27-37°F (-3 to 3°C)

..Degree Days (Annual): 9,800

..WATER QUALITY:

Two creeks nearby. West: 5 cfs; east 125 cfs. Groundwater at surface. Low permeability of soil. Quality not meeting water quality standards for salmon aquaculture. Mean annual runoff: 3 cu.ft./sec./sq.mi.

..NOISE: Wind

..BIOLOGICAL

..Dominant Flora: Tundra/stunted willow

..Dominant Fauna:

Sticklebacks and dolly varden, some salmon. Bears, crab, sea mammals and some waterfowl.

TRANSPORTATION AND UTILITIES

SITE: HOT SPRINGS BAY

..Utility or Energy Transmission Corridors and Facilities: None

..Transportation Corridors or Facilities: None

POPULATION

SITE: HOT SPRINGS BAY

..General Description of Population:

The native village of Akutan is located some 5.5 miles (8.6 km) to the south of the hot springs area. The population is sixty people, who are mainly native in heritage. This includes some 22 families. (Rural Energy Survey)

..Economics

..Present Land Use:

The town of Akutan derives what cash economy that it has from fishing. The village is quite dependent upon subsistence. The energy needs of Akutan are provided by gas at \$1.75 per gallon, brought in by barge/air via Cold Bay. A small hydro operation exists as well. 110 kw demand in the village has been noted (Rural Energy Survey).

..Future Land Use:

Regional Native corporations and the State have targeted southwest Alaska for development.

## HOT SPRINGS COVE

Hot Springs Cove is located on the beach at Inanudak Bay on Umnak Island. Umnak Island is the first island beyond the Alaskan Peninsula, 600 miles (900 km) from Anchorage. The geysers present, and the estimated reservoir temperatures, make this one of the hottest prospects in Alaska. The interest shown by the Aleutian Pribilof Native Corporation, owners of the property, makes it one of Alaska's prime development prospects.

The fact that there is no population present at the site makes it almost imperative that some industrial application be considered. The industrial application the Aleutian Pribilof Corporation is in the process of planning, is for a salmon aquaculture project at the hot springs bay, part of the Geysers' Okmok Crater KGRA.

The reasoning behind choosing the hot springs cove manifestation rather than Okmok Crater on the Geyser Bight portion of the KGRA rests in the fact that the Aleutian Pribilof Island Native Corporation owns the land around Hot Springs Bay. The land stewardship of the Okmok Crater and Geyser Bight areas are in the Bureau of Land Management. Also, a road in disrepair enters the general area from the abandoned Fort Glen area to the east.

The resource itself is rather impressive. There are 28 hot springs and geysers in the area. The natural heat flux is in the neighborhood of 167440 j/s. The surface temperature is 89°C and the estimated reservoir temperature is estimated at 180°C, according to the U.S. Geological Survey.

In the vicinity of Hot Springs Cove, the thermal springs are exposed for 1/2 mile (.8 km) at low tide. The maximum temperatures recorded there was 70½°C. Additional hot springs occur inland .8 miles (1.2 km) from the cove. These springs are thought to be the source of those on the beach.

The rocks underlying Umnak Island are late Tertiary and Quaternary volcanic rocks that rest on a basement complex of probable Tertiary plutonic and low grade metamorphic rocks. At this time, there has been no geophysical or reservoir exploration to see the extent of the resource or confirm the basement structure. The close association with the Aleutian Trench subduction zone, however, does give credence to both the basement conjecture and probable extensive heat source.

The water quality and capacity of the reservoir is as yet unknown. Speculations into these areas would assume that a probable reservoir could be found because of the volcanic island environment and the plumbing of such systems.

The eventual end product of any development will depend on confirmation of a large reservoir. If the system proves large enough, there is enough predicted temperature to utilize the resource for even electrical production. Major industrial applications such as aluminum processing and manganese nodule processing have been visualized by local consultant

Bill Ogle. The development of a fish hatchery utilizing the geothermal energy for process heat may help determine the future capabilities of such a large scale venture. The cascading uses of such a large development would be quite useful for the economically depressed Aleutian Region.

Fresh vegetables are a rather rare commodity in the Aleutian region. Greenhouses such as those now used in Iceland would be very well received. There has been talk of relocating some of the village of Nikolski to the site if the economic impetus of building and maintaining the commercial developments proves out. This would create a need for space heating as well. This concept of moving to the energy source may prove to be a planning tool for future development in Alaska.

The remoteness of the area is the major drawback to development at this time. There are no major population centers for hundreds of miles. The inclement weather is such that the Aleutian Islands have remained virtually without population for years. The cost of doing business is very expensive as a result of the logistical problems encountered here.

It can, however, be pointed out that the social impact would be minimal to even major development because of the remoteness. If the development were properly done, it could be very beneficial to both the economy and the standard of living of the area residents. It might also help to stabilize the Aleut culture by enhancing the chances of continued habitation of the oldest continuous settlements in the western hemisphere at Nikolski.

The possible restrictions to development other than economic would probably have to concern itself with the environment. The tundra in the Aleutians is very fragile. This area has not, to date, been developed for any purpose other than grazing for reindeer and sheep. The environmental, physical and economic concerns associated with building a dock facility at Inunadak Bay are quite perplexing as with the siting and building of any plants.

Legal ramifications seem to be minimal, as the land is privately held. If any federal leasing were required, the wait for federal action would be very long for an IES or such because of the mammoth job BLM has in Alaska with Statehood, Native Claims, (d)(2) Organic Acts., etc., workloads and the relatively small staff to deal with them.

Personal communications at this writing indicate that the Aleutian Pribilof Native Corporation is now applying for a D.O.E., P.R.D.A. to study the engineering and economic feasibility of the direct heat applications of the proposed scenario. This P.R.D.A. has been rejected.



## SITE DATA SUMMARY

SITE: HOT SPRINGS COVE

### ..Physical Reservoir Data

..Temperature °C (White, 1975)

Surface: 89°C

Subsurface: 155°C

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

$3 \times 10^{18}$  cal. (White, 1975)

..Type of Overlaying Rock: Andesite (Miller, 1973)

..Estimated Depth to Top of Reservoir (meters):

### ..Site Land Status

..Total Acres:

11,000 Native Reservation. Area immediately around the Hot Spring selected by Aleutian Pribilof Native Association.

..Total Acres Leased: -0-

..Geothermal Development Status: None

..Local and State Attitude Toward Geothermal Development:

State/natives considering this or Geyser Bight for development of fish hatchery.

..Land Use and Population: No population - some grazing permits issued.

..Comments and Critical Issues:

Determine if Inanudak Bay can take deep draft boats.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: HOT SPRINGS COVE

..Latitude: 53° 14' N.

..Longitude: 168° 21' W.

..Rectilinear: Umnak T80S R132W SM

..County: Unorganized borough - Aleut Regional Corporation

..Topography

Located on neck between Vsevidorf Recheshol volcanic structures and Okmonk caldera, glaciated hills of volcanic origin.

..Present Land Use: None

..Future Land Use Plans:

Possible animal husbandry/fish hatchery/agriculture center.  
Practical site for aluminum or manganese nodule processing plant.

..Aesthetics: On a sunny day, quite remarkable.

..Historical/Archaeological Significance:

Cemetery Cove is Ancient Aleut archeological site.

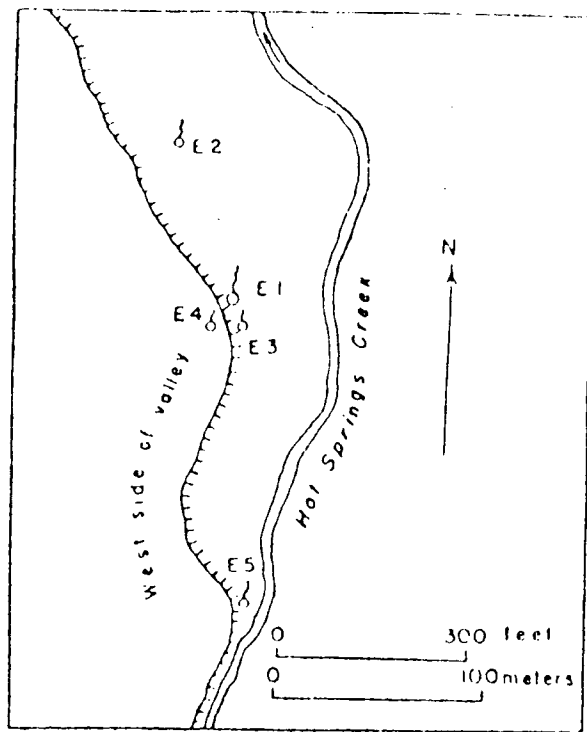


Fig. 4--Sketch map of thermal springs locality  
0.8 mile south of Hot Springs Cove

Thermal spring	pH	Average discharge	Temperature	Temperature above annual mean (4.1°C)	Heat carried away
		lit/sec	°C	°C	kcal/sec
E1	6.4	0.9	87	83	75
E2	5.7	0.9	47	43	39
E3	6.4	0.1	65	61	6
E4	5.0	0.6	35	31	19
E5	6.0	3.4	67	63	204
Totals, <sup>a</sup> Hot Springs Cove area		6			350

(Extracted from Ogle Hot Springs Report, 1976)

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: HOT SPRINGS COVE

### ..Geologic Description: (McFadden, 1971)

The rocks underlying Umnak Island are Late Tertiary and Quaternary volcanic rocks that rest on a basement complex of probable early to middle Tertiary plutonic and low grade metamorphic rocks (Byers, 1949). Thermal springs and small geysers occur south of Inanudak Bay in alluvium floored valleys. The thermal springs are near sea level below the base of late Tertiary and early Quaternary volcanics. In the vicinity of Hot Springs Cove, the thermal springs are exposed for 1/2 mile (.8 km) at low tide. Additional hot springs occur .8 mile (1.2 km) inland from Hot Springs Cove and it is believed that the springs near tidewater are heated by inland thermal springs which are draining seaward. These springs and geysers emerge chiefly from a small boulder filled basins, 2-6 ft. (1-2 m) in width and less than 3 feet (1 m) in depth. Silaceous sinster has been deposited around the pools.

Ogle revisited springs in 1976 to determine resource potential. He indicated the surface expressions have changed somewhat because of recent activity. Overall temperature and flow of system seem to be relatively constant.

### ..Geophysical Summary: None to date.

### ..Geologic Hazards:

This is an area of high seismicity. The area is also exposed to volcanic activity. Okmok Crater erupted in the 1940's.

Tsunami's may also effect the area.

## RESERVOIR CHARACTERISTICS

SITE: HOT SPRINGS COVE

### ..Reservoir Temperature

..Surface: 89°C (White, 1975)

..Subsurface: 155°C (White, 1975)

### ..Geochemical

SiO<sub>2</sub>: 131 (White, 1975)

Na-K-Ca: 154 (White, 1975)

..Total Dissolved Solids:

SiO <sub>2</sub>	99	65
Al	--	--
Fe	--	--
Ca	153	116
Mg	3.3	1.1
Na	153	427
K	27	24
Li	2	2
NH <sub>3</sub>	--	--
HCO <sub>3</sub>	69	65
CO <sub>3</sub>	--	--
SO <sub>3</sub>	86	73
Cl <sup>4</sup>	1104	782
F	0.9	0.5
Br	--	--
B	27	20
pH	6.4	6.0
Temp. C°	--	68

..Fluid Chemistry:

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.3 x 10<sup>18</sup> cal. (White, 1975)

..Subsurface Area of Reservoir: (White, 1975)

Thickness: 2KM, 2KM<sup>2</sup>  
Volume: 4KM<sup>3</sup>

LAND OWNERSHIP AND LEASING

SITE: HOT SPRINGS COVE

..Land Ownership (Geyser Spring Basin)

..Total Acres: 20,960

St. George Village Association has selected this land but geothermal subsurface rights will be under the control of the Aleutian Pribilof Native Association.

..Total Private Acres: 11,000

..Land Leased: -0-

..Highest Priced Leases: N/A

..Tentative Lease Sale Dates: None planned.

..Number of Sales Offered But No Bids: N/A

..Summary of Leasing Status and Needs:

Native corporation will have to initiate the bidding procedure.

#### GEOHERMAL DEVELOPMENT STATUS

SITE: HOT SPRINGS COVE

..Present Development Status: None

..Projected or Planned Development:

State has expressed interest in developing K.G.R.A. for a fish hatchery. Aleutian Pribilof Native Corporation is interested in the development of reindeer husbandry/experimental farm. The native corporation has expressed interest in leasing the hot water to produce fresh vegetables in greenhouses for the Aleutian Islands.

The plans submitted by U.S. Department of Commerce N.O.A.A. Auke Bay for the fish hatchery are 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  
B. Excavate site for hatchery tanks and 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 returning hatchery fish (Pink salmon only)

Year #5: A. Stock hatchery with eggs from returning fish  
B. Formulate an expanded program

Aleutian Pribilof Native Corporation have applies to D.O.E. for PRDA for economic and engineering studies of this and other geo-thermal direct heat applications.

## INSTITUTIONAL CONSIDERATIONS

SITE: HOT SPRINGS COVE

### ..Institutional Requirements:

This is private land. The Native Corporation will have to comply with State permitting for drilling and State environmental laws.

### ..Agency and Public Attitudes:

State pursuing development. Native Corporation pursuing development.

### ..Status of Requirements (i.e., EIA/EIS Requirements): None Required once in private lands.

## ENVIRONMENTAL FACTORS - SOUTHWEST REGIONAL PROFILE

SITE: HOT SPRINGS COVE (NIKOLSKI)

### ..CLIMATE

..Prevailing Winds: NW 13.8 kts (25.5 kph)

..Precipitation (Annual):

82" (208 cm) and 34" (86 cm) snow

..Average Temperature:

Summer: 37° to 50°F (3° to 10°C)

Winter: 6° to 39°F (-14° to 4°C)

Minimum: 0° (-17°C)

Maximum: 76° (24°C)

..Degree Days (Annual): 9800

..AIR QUALITY: Possible volcanic debris.

### ..GEOLOGIC FACTORS:

High seismic activity. Low tsunami hazard. Soil conditions are unfavorable for construction in certain areas.

### ..WATER QUALITY:

Mean annual runoff: 4 cf/sec/mile. Fresh water lens indicate good water supply.

..NOISE: Excessive winds

..BIOLOGICAL

..Dominant Flora: Wet tundra

..Dominant Fauna:

Anadromous fish, migratory water fowl, domestic sheep and reindeer. Offshore crab.

TRANSPORTATION AND UTILITIES

SITE: HOT SPRINGS COVE

..Utility or Energy Transmission Corridors and Facilities: None

..Transportation Corridors or Facilities:

Ft. Glenn to Stepanof Road, 3 km, from springs with mountain ridge between Cove and Road.

POPULATION

SITE: HOT SPRINGS COVE

..General Description of Population:

Nearest population is Nikolski, 30 miles away. Population is approx. 50.

..Economics

..Present Land Use:

Cash economy based on the men leaving the village to work then returning.

..Future Land Use:



## OKMOK CALDERA

Umnak Island lies in the eastern Aleutian Islands. It is 75 miles (120 km) long and is separated into a northeastern part and a more rugged southwestern part by a constriction in the central part of the island. The northern part is dominated by Okmok Caldera.

The nearest population is Nikolski, population fifty, on the extreme western edge of the island. The abandoned Cape Air Force Base is located on the flank of the caldera. The native groups in the area are presently experimenting with reindeer as a possible commercial enterprise on Umnak Island. Sheep have been introduced and a slaughterhouse exists. Geothermal applications in these commercial ventures should be prominent in the minds of developers as the costs of fuel oil and fossil fuels are so high on Umnak Island. Fuel oil is flown in at a cost of .85/gallon to Nikolski according to the Rural Energy Survey taken by the State Division of Energy and Power Development. The developer would have to bear this cost in feeding, husbandry and processing.

Okmok Volcano consists of a low shield volcano with outward dips. The volcano consists mainly of basalt flows of Tertiary and Quaternary age. The most recent eruption was in 1945. A fault is exposed a short distance at the periphery of the crater, and displacement is toward the crater. A steep facing cliff of the caldera is inferred to be the scraps of a ring fault.

General lines of the thermal springs and fumeroles are existent in the vicinity of volcanic cones in the caldera. Exploration of lava fumeroles from one cone ranged from 320°C in December, 1945, to 90°C in September, 1946 (Byers, 1959). The temperatures of the fumeroles when last measured were in the 95°C range.

Sixteen large thermal springs discharging 115 cfs giving off 21,000 kilograms calories per second on September 7, 1946. The USGS estimated the content of the system  $.4 \times 10^{18}$  cal.

No serious reservoir assessment has been performed on the caldera to date. With the experience of caldera taps in Iceland being what they are, there is most probably not going to be any large scale development in the bowels of this active volcano. Animal husbandry or some such small scale use might be an attractive utilizing of the surface manifestation.

The central caldera area appears to be in the control of the Bureau of Land Management at this time. The extent of village selections by the St. George group is in the process of being reviewed and patented and at that time the land ownership situation will be clear. Legal problems will exist until the land transfers are complete.

## SITE DATA SUMMARY

SITE: OKMOK CALDERA

### ..Physical Reservoir Data

..Temperature °C (White, 1975)

Surface: 100

Subsurface: 125

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

$.4 \times 10^{18}$  cal. (White, 1975)

..Type of Overlaying Rock: basalt (McFadden, 1971)

..Estimated Depth to Top of Reservoir (meters):

### ..Site Land Status

..Total Acres: 44,800

Native selections in area by St. George Native Association

..Geothermal Development Status: None

..Local and State Attitude Toward Geothermal Development:

State has shown interest in the area for a fish hatchery. Major development would probably encounter opposition from environmental coalition.

..Land Use and Population: Very low density. No utilization.

..Comments and Critical Issues:

Lands have been claimed by natives, but no title transfer yet. Depending on the final selection Native lands are not necessarily in the KGRA.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: OKMOK CALDERA

..Latitude: 53° 29' N.

..Longitude: 168° 06' W.

..Rectilinear: T78S, R131W, SM, Umnak Quadrangle

- ..County: Unorganized Borough
- ..Topography: Shield volcano with caldera.
- ..Present Land Use: None. Abandoned Army Base.
- ..Future Land Use Plans: Possible reindeer facility.
- ..Aesthetics: Geysers present.
- ..Historical/Archaeological Significance:

There are numerous Indian historical sites on the island. One is on the northeast slope of the caldera (Selkregg, 1976).

#### GEOLOGICAL/GEOPHYSICAL DESCRIPTION

##### SITE: OKMOK CALDERA

- ..Geologic Description: (McFadden, et. al., 1971)

The Okmok volcano consists mainly of basalt flows of latest Tertiary and Quaternary age. The structure of Okmok volcano is that of a low shield volcano with gentle outward dips. The rocks underlying Umnak Island as a basement complex are plutonic and low grade metamorphic rocks of probable middle Tertiary age.

The collapse caldera structure has a boundary expression of a ring fault. A few radial faults are recorded in the literature.

- ..Geophysical Summary: None to date.
- ..Geologic Hazards:

Seismic, volcanic. The last eruption of the volcano occurred in October and December of 1945. A minor explosive eruption with some lava and smoke endangered and eventually convinced the Army to abandon Ft. Glenn. Activity has been recorded at Okmok Crater in 1817, 1824-29, 1830, 1899 (major eruption), 1931 and 1945.

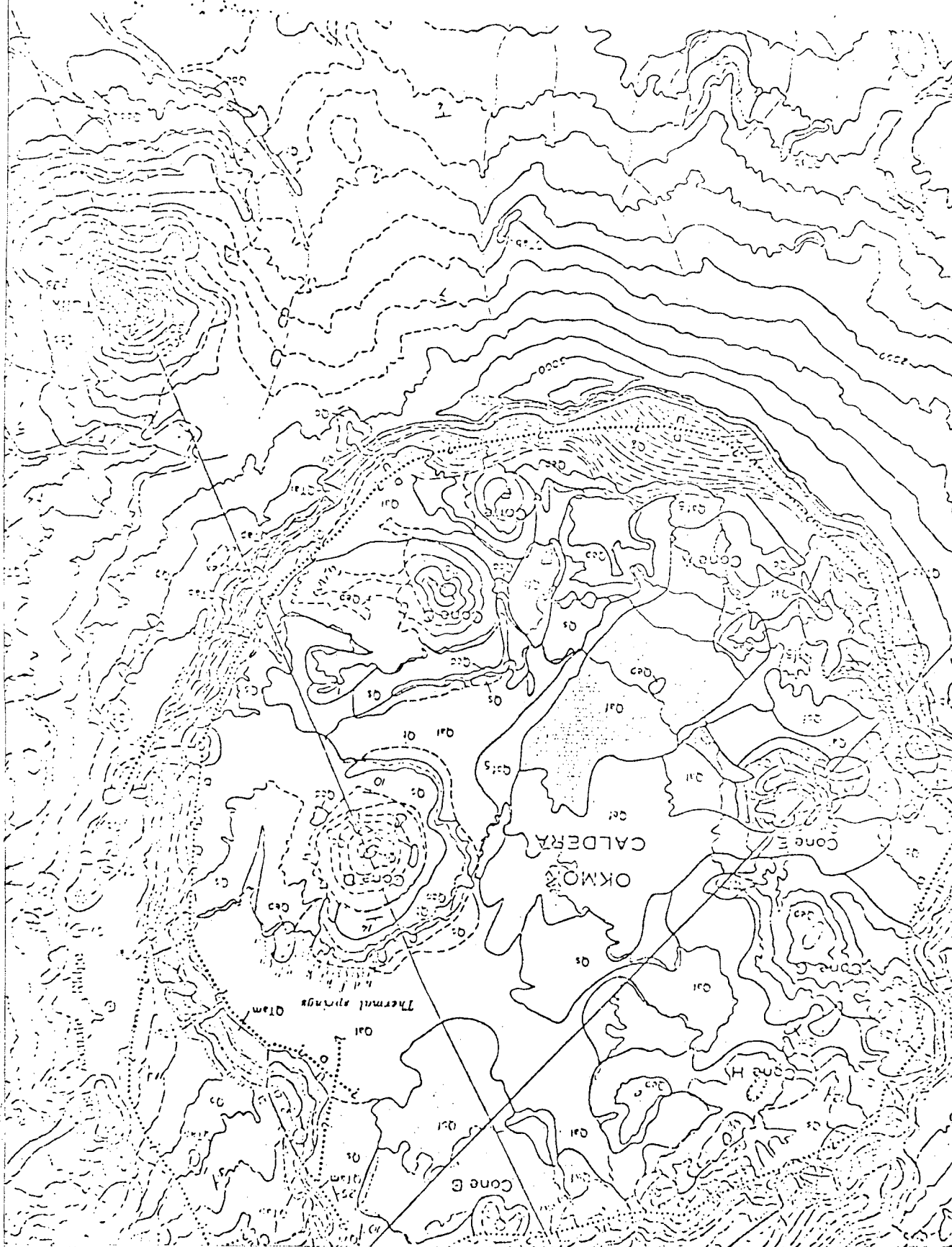
#### RESERVOIR CHARACTERISTICS

##### SITE: OKMOK CALDERA

- ..Reservoir Temperature (White, 1975)
  - ..Surface: 100°C
  - ..Subsurface: 125°C

Topography Map  
Okmok Caldera

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..Geochemical (White, 1975)

SiO<sub>2</sub>: 110  
Na-K-Ca: 75

..Flow Rates:

Aggregate discharge of 115 ft.<sup>3</sup>/sec. from sixteen of the springs.

..Total Dissolved Solids: (McFadden)

SiO <sub>2</sub>	59
Al	--
Fe	--
Ca	18
Mg	7.5
Na	53
K	5.6
Li	--
NH <sub>3</sub>	--
HCO <sub>3</sub>	--
CO <sub>3</sub>	--
SO <sub>3</sub>	69
Cl <sup>4</sup>	39
F	0.1
Br	--
B	3
pH	--
Temp. °C	22

..Fluid Chemistry:

About eighteen springs exist near the 1945 eruption in the Caldera.

..Estimated Non-electric Energy Potential (MBtuh 30 years):

.4 x 10<sup>18</sup> cal. (White, 1975)

..Subsurface Area of Reservoir: Unknown

..Fluid Chemistry:

About eighteen springs exist near the 1945 eruption in the Caldera.

..Estimated Non-electric Energy Potential (MBtuh 30 years):

.4 x 10<sup>18</sup> cal. (White, 1975)

..Subsurface Area of Reservoir: Unknown

#### LAND OWNERSHIP AND LEASING

SITE: OKMOK CALDERA

..Land Ownership (Okmok PGRA)

..Total Acres: 44,800

Native selections in area from St. George Native Association.

..Total Federal Acres: 44,800

..Land Leased: None

#### GEOHERMAL DEVELOPMENT STATUS

SITE: OKMOK CALDERA

..Present Development Status: None

..Projected or Planned Development:

Possible reindeer experimental station. Interest shown on part of natives for such activities. No real planning at this time.

#### INSTITUTIONAL CONSIDERATIONS

SITE: OKMOK CALDERA

..Institutional Requirements:

Need letter of concurrence from native group to lease lands from federal government if land selected by natives. CFR Title 43, Sec. 3200 will be in effect. This will demand competitive bidding until Title has been given to Natives. At that time, the geothermal rights will be under their control. The natives gain control when Title is tentatively approved.

..Agency and Public Attitudes:

No known opposition but possible environmental intervention on large project.

..Status of Requirements (i.e., EIA/EIS Requirements):

None to date.

## ENVIRONMENTAL FACTORS

SITE: OKMOK CALDERA (SOUTHWEST REGIONAL PROFILE)

### ..CLIMATE

..Prevailing Winds: NW 13.8 knots (25.5 kph)

..Precipitation (Annual):

82" (170 cm), 34" (86 cm) snow

..Average Temperature:

Summer: 37 to 50°F (3 to 10°C)

Winter: 26 to 39°F (-4 to 4°C)

Minimum: 0 (-18°C)

Maximum: 77 (25°C)

..Degree Days (Annual): 9,800

..AIR QUALITY: Possible volcanic debris.

..NOISE; High winds

### ..BIOLOGICAL

..Dominant Flora: Alpine tundra

..Dominant Fauna:

Salmon, sea mammals, low density waterfowl, pollock.

## TRANSPORTATION AND UTILITIES

SITE: OKMOK CALDERA

..Utility or Energy Transmission Corridors and Facilities:

Ft. Glen lines abandoned. Distance from the site is 10 miles (13 km).

..Transportation Corridors or Facilities:

Stepanof Bay road. Numerous jeep trails below 1,000' (305 m) level. Distance from the site is 4 miles (5 km).

## GEYSER BIGHT

Geyser Bight is located on Unmak Island, some 600 miles (960 km) from Anchorage in the eastern Aleutian Islands. Geyser Bight is also one of the most exciting geothermal resources found in Alaska. It is exciting not only in its physical characteristics, but in the fact that both the State government and the appropriate private concerns (Native corporations owning the surrounding land) seem genuinely interested in developing the resource.

The chief settlements are Cape Air Force Base, also known as Fort Glenn (now abandoned) and the Aleut village of Nikolski (pop. 50). The entire energy needs of Nikolski are supplied by oil fired generators. The demand in the village is 120 kw supplied by Nikolski Light and Power. There are 8 miles (13 km) of federal and Native selected lands between the village and Geyser Bight. It would appear the energy costs are not sufficient to justify development of the hot springs with such a small utilization. However, some commercial interest such as aluminum or manganese nodule processing or bottomfishing might be very interested in a cheap, constant energy source, such as that potentially offered by Geyser Bight.

Twenty-eight thermal springs occur in Geyser Creek Valley of which eight were slightly superheated in Beyer's 1946 visit. Steam fumaroles on the west side of the valley emitted steam at a temperature of 99°C. Four of the springs were geysers. Local consultant Bill Ogle visited the springs in 1976, and reported the estimated flow rates were clearly less than reported by Beyers in his 1949 report. The proper springs were still boiling or superheated. Geysering was obvious, but did not seem to be as vigorous as noted. Another noticable change, however, was the presence of five new springs. Tom Miller of the USGS recently spent some time at the springs and his paper should be forthcoming. Flow rates could be estimated in the 300 gallons per minute range. The estimated reservoir temperature is in the 210°C range, according to spring chemistry. The estimated heat content of the reservoir is  $.9 \times 10^{18}$  calories.

This type of speculative resource could handle any geothermal application that is used in the world, from space heating to electrical production. The reservoir characteristics are unknown though. The thermal activity is probably related to emissions along fractures cutting conduits to the island's volcanic expressions at depth. Pyroclastic rocks underlying recent Okmok lava flows may be potential reservoir rocks. Recent basalts may form a cap rock that could insulate the reservoir. Further exploration is needed to determine the extent of the resource, however, before any large scale development is going to take place.

The legal question of who owns the resource is in question at this time. Native selections have been made, however, all the transfers of title have not been completed at this time. The land around the geysers area is probably going to remain in the hands of the BLM. If this, in fact, happens, the potential developer will have to deal with the exhausting federal leasing procedure as well as the fact the BLM is extremely shorthanded to complete any EIS in this area on short notice.



## SITE DATA SUMMARY

SITE: GEYSER BIGHT

### ..Physical Reservoir Data

..Temperature °C (White, 1975)

Surface: 100

Subsurface: 210

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

.9 x 10<sup>18</sup> Cal. (White, 1975)

..Type of Overlaying Rock: Andesite (McFadden, 1971)

..Estimated Depth to Top of Reservoir (meters):

### ..Site Land Status

..Total Acres: 20,960 (Federal)

Native selections made in area but not specifically in Geyser Valley.

..Geothermal Development Status: None.

..Local and State Attitude Toward Geothermal Development:

State Energy Office is pushing for salmon hatchery development orchestrated with the (Regional) and Aleutian Pribilof Native Corporation. Pacific-Sierra Corporation conducted a study on direct heat applications at Nikolski (1977). Economics were not favorable because of low demand. This did not consider possible industrial applications.

..Land Use and Population:

Some reindeer cattle and sheep grazing. Village of Nikolski 30 miles (48 km) away.

..Comments and Critical Issues:

Land is under management jurisdiction of the Bureau of Land Management. The Bureau is presently understaffed to complete any EIS in the Unmak area with present planning.

## SITE LOCATION AND PHYSICAL DESCRIPTION

### SITE: GEYSER BIGHT

..Latitude: 53° 13' N.

..Longitude: 168° 28' W.

..Rectilinear: T81S, R133W, Umnak Quad. SM

..Topography:

Located in the Inanudak Bay region, between the Okmok Caldera to the NE and the Vsevidof-Recheshal volcanic system. Glaciated.

..Present Land Use:

Some grazing, but it is range grazing and rather haphazardous.

..Future Land Use Plans:

Salmon hatchery, cascading agri-business, aluminum processing plant has been suggested for the area. Manganese nodule processing and bottom fishing are going to be developed in the Gulf of Alaska and, perhaps, the energy source could be tapped from these developments.

..Aesthetics: Okmok Volcano presents rugged beauty.

..Historical/Archaeological Significance:

Nine archaeological sites on Umnak Island. None at Geyser Bight. One near at cemetery cove (Selkregg, 1976).

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: GEYSER BIGHT (McFADDEN, 1971)

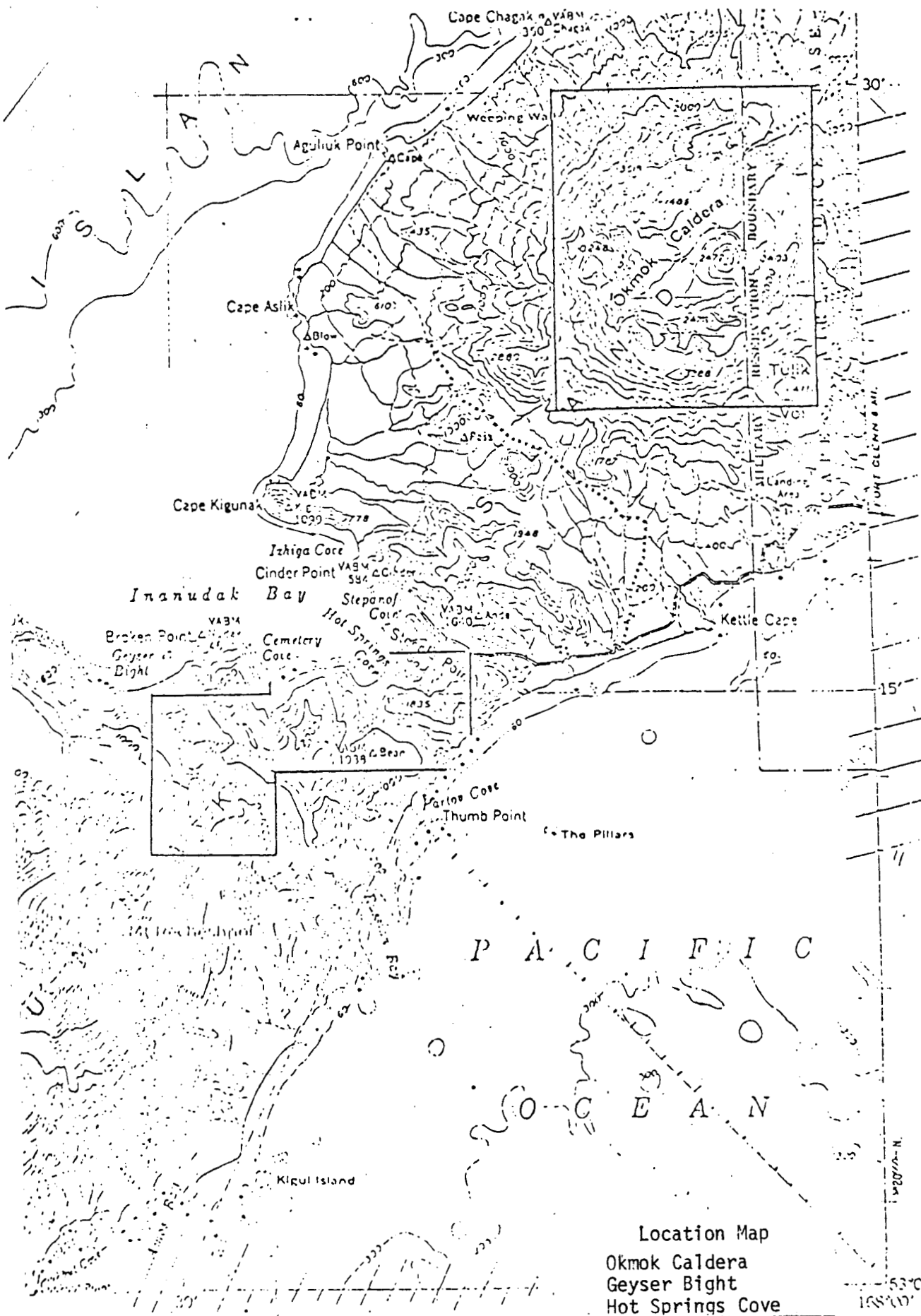
..Geologic Description:

The rocks underlying Umnak Island are late Tertiary and Quaternary volcanic rocks that rest on a basement complex of probable early to middle Tertiary plutonic and low grade metamorphic rocks (Byers, 1949). Recent volcanic activity in Okmok Volcano suggest a deep-seated magma chamber in the volcanic submarine ridge underlying the Aleutian Islands.

The surface area shows exposed basalts and andesites of Quaternary age. These flows might act as cap rocks for hot reservoir in pyroclastic layers.

..Geologic Hazards:

This area is one of high seismicity. Volcanic activity is high as well. There are Tsunami considerations for onshore/offshore instal-



lations although there is a northern exposure to the bay that would help protect the site.

# RESERVOIR CHARACTERISTICS

SITE: GEYSER BIGHT

## ..Reservoir Temperature (White, 1975)

..Surface: 100°C

..Subsurface: 210°C

## ..Geochemical

SiO<sub>2</sub>: 210

Na-K-Ca: 236

## ..Flow Rates:

SiO <sub>2</sub>	150	88
Al	---	---
Fe	---	---
Ca	0.2	163
Mg	40	1.2
Na	350	603
K	18	33
Li	2	3
NH <sub>3</sub>	---	---
HCO <sub>3</sub>	29	67
CO <sub>3</sub>	10	---
SO <sub>3</sub>	130	88
Cl <sup>4</sup>	482	1126
F	1.2	0.6
Br	---	---
B	49	29
pH	6.9	---
Temp. °C	101	89

## ..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.9 x 10<sup>18</sup> cal. (White, 1975)

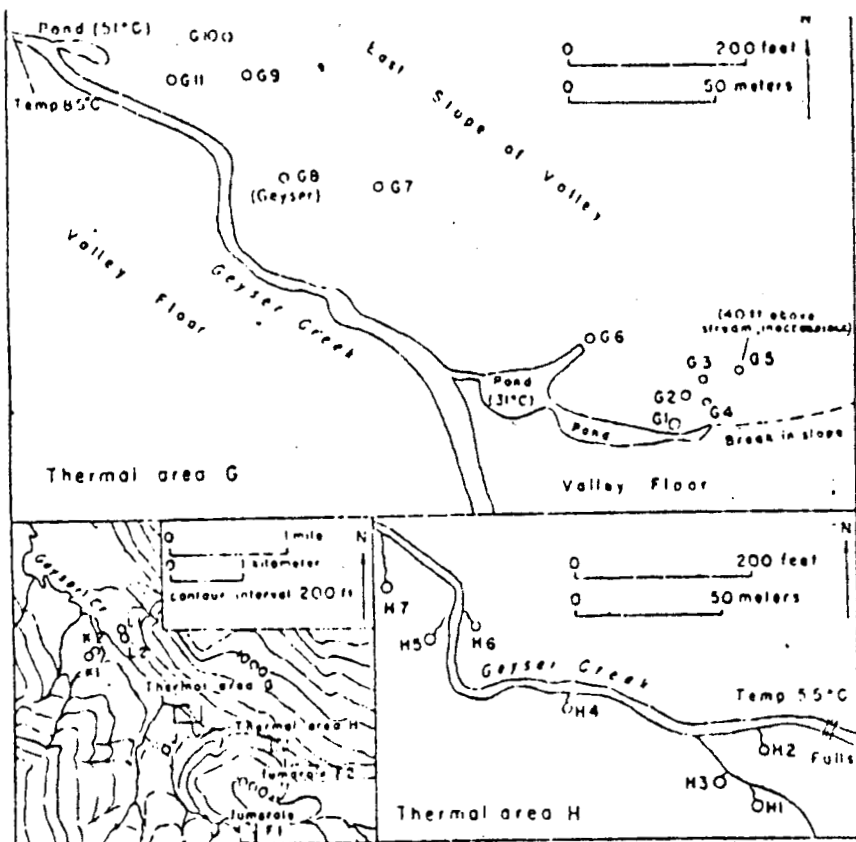


Fig. 5--Sketch maps of thermal spring localities,  
2.5 to 4.5 mi southeast of Geyser Blight

Thermal spring	pH	Average discharge	Temperature	Temperature above annual mean (4.1°C)	Heat carried away
G1	7.5	4.3	101	97	417
G2	7.2	0.1	88	84	8
G3	6.8	0.3	100.5	96.5	29
G4	...	0.6	98	94	56
G5 <sup>b</sup>	...	...	...	...	...
G8	6.8	1.4	95	91	127
G7	7.0	1.4	82	78	109
G8 <sup>c</sup>	7.5	2.8	100.5	96.5	270
G9	7.4	0.1	100.5	96.5	10
G10 <sup>d</sup>	7.8	2.8	99	95	266
G11	...	2.8	77	73	204
H1 <sup>c</sup>	6.9	11	101.5	97.5	1070
H2 <sup>c</sup>	7.1	10	101	97	970
H3	6.8	none	53	...	...
H4	7.0	5.7	101	97	553
H5 <sup>c</sup>	7.1	1.4	101	97	136
H6	7.4	1.1	100	96	106
H7	6.8	4.3	90	86	370
Totals, <sup>a</sup> C and D area		50			4600
J	6.8	12	88	84	1000
K1	...	2.8	58	54	152
K2	...	1.4	70	66	92
L1	...	1.4	69	65	91
L2	...	1.4	67	63	88
Totals, <sup>a</sup> Geyser Blight area		70			6000

(Extracted from Ogle Hot Springs Report, 1976)

<sup>a</sup>Totals are approximate. Those indicated for the Hot Springs Cove area are the results of measurements made on June 21, 1947; those indicated for the Geyser Blight area are those obtained on September 4, 1947.

<sup>b</sup>Vigorous, continuous bubbling of hot gases in natural well. No measurements made.

<sup>c</sup>Typical geyser; cycle, three to ten minutes of which 2 1/2 to 3 1/2 minutes consisted of vigorous ebullition to a height of two feet.

<sup>d</sup>Hot gases bubbling vigorously through water. In cycles of one to three minutes, bubbling increases, then decreases. This spring is believed midway in type between a thermal spring and a fumarole.

## LAND OWNERSHIP AND LEASING

SITE: GEYSER BIGHT

### ..Land Ownership

..Total Area (Acres): 20,960

..Total Acres (Federal): 10,960

..Total Acres (State): 0

..Total Acres (Private):

Approx. 10,000 acres selected by Aleutian Pribiloff Native Corporation. St. George Native Association has selected about half of the acreage in the KGRA.

### ..Summary of Leasing Status and Needs:

No leases planned. BLM stated reluctance to lease due to the fact title has not been transferred. State is hopeful that if Native corporation takes the initiative, fish hatchery lands might be leased.

## GEOHERMAL DEVELOPMENT STATUS

SITE: GEYSER BIGHT

### ..Present Development Status: None

### ..Projected or Planned Development:

There is enough surface discharges to space heat fifty homes (Ogle, 1976). This would be enough for the entire village of Nikolski if it were to move here. The State of Alaska Departments of Energy and Fish and Game have expressed interest in using the geothermal resource to build a fish hatchery. Bottom fisheries are a new industry that will be developing in the Aleutian Islands. Perhaps cheap energy resources might help persuade the industry to locate on Umnak. Consultants in the area have suggested the site for a possible bauxite/aluminum processing center. Hand in hand is the future manganese nodule processing business. The area is being used for sheep grazing. Experimental reindeer husbandry has just begun.

This scenario is constructed on the basis of an eventual electrical generating facility for various processing industries. The other applications would be initiated by the available supplemental energy derived from a cascading use of the high energy electrical application.

## INSTITUTIONAL CONSIDERATIONS

### SITE: GEYSER BIGHT

#### ..Institutional Requirements:

A statement of concurrence from the Aleut Native Corporation will be needed to initiate leasing within the KGRA for lands not transferred but selected. Developers will have to follow CFR Title 43 regulations pertaining to geothermal leasing. Lands whose title is still in the hands of the BLM would have to be leased following normal procedures in CFR Title 43.

#### ..Agency and Public Attitudes:

State is suggesting usages to Native Corporation at this time. Native Corporation planning on submitting proposal to DOE for research money.

#### ..Status of Requirements (i.e., EIA/EIS Requirements):

None to date.

## ENVIRONMENTAL FACTORS

### SITE: GEYSER BIGHT (SOUTHWEST REGIONAL PROFILE)

#### ..CLIMATE

..Prevailing Winds: NW, 13.8 kts (25.5 kph)

..Precipitation (Annual):

82" (208 cm), 34" (86 cm) snow

..Days of Sunshine (Annual):

..Average Temperature:

Summer: 37-57°F (3 to 14°C)

Winter: 6-39°F (-14 to 4°C)

Minimum: 5°F (-14 to 4°C)

Maximum: 77°F (25°C)

..Degree Days (Annual): 10,000

..Relative Humidity (Seasonal Peaks)

#### ..AIR QUALITY:

Possible volcanic pyroclasts as this is an area of active volcanism.

..GEOLOGIC FACTORS:

High seismic area. Possible Tsunamic considerations. Steep walled canyons. Mud flats.

..WATER QUALITY:

Bedrock area yield 0-10 gpm. 4cf/sec/mi. mean annual runoff.

..NOISE: Extreme winds.

..BIOLOGICAL

..Dominant Flora: Moist tundra

..Dominant Fauna:

Salmon, marine mammals, low density waterfowl range, crab, pollock offshore.

TRANSPORTATION AND UTILITIES

SITE: GEYSER BIGHT

..Utility or Energy Transmission Corridors and Facilities:

Nearest facility is Nikolski 30 miles (48 km). Nikolski Light and Power has 120 kw generating plant. It has a 20,000 gallon storage capacity for oil. Retail cost of this oil is 85 cents/gallon. Anica also has a storage capacity of 34,700 gallons. Standard Oil is the distributor. Oil delivered by air charter (Alaska Rural Energy Survey).

..Transportation Corridors or Facilities:

Stepanof Bay road and numerous jeep trails are found near the site. Distance from the site is approx 3-5 miles (8 km). No access to right-of-way at this time, and the easements would have to cross native lands.

POPULATION

SITE: GEYSER BIGHT

..General Description of Population:

None at site. Village of Nikolski has population of 57, predominately native.

..Economics



..Present Land Use:

Grazing and fishing provide cash to what is predominately a subsistence economy. Economic analysis of utilization of local gradient geothermal resource was conducted in 1977 by Pacific/Sierra Corporation. Conclusion: Without industrial end users, development would be uneconomical.

..Future Land Use:

The village of Nikolski is a dying community. Local interest is high to keep the community active and economically viable. Utilization of geothermal energy in an intensive energy end use application could optimistically follow this philosophy in designing scenario.

SITE: Makushin

RESOURCE: Hot Springs/Volcano (Waring, 1917)

LATITUDE & LONGITUDE: 53° 52' N; 168° 56' W.

QUADRANGLE: Unalaska, T73N; R120W, SM

BARRIER: Lack of access

RECOMMENDATION: Exploration

DESCRIPTION: (Drewes, 1961)

Located within the Makushin P.G.R.A. 241,000 acres (97,532 hectares). Basalt and andesitic flows and pyroclastic rocks of the Makushin volcanics unconformably cap the Unalaska formation and plutonic rocks. The Unalaska formation consists of altered andesitic intrusive and extrusive rocks, and sedimentary rocks derived from similar igneous rocks. The batholiths are grandiorite.

Scattered around the main vent are several fumeroles and much sulfur im-pregnated clay. Gases from the vent are largely water vapors. A large fumerole area is active at the head of Glacier Valley, about 3 miles (5 km) southeast of the summit vent and a smaller fumerole area lies 2 miles (4 km) south of the summit. Hot springs are found in these areas (Drewes, 1961).

Reservoirs analysis has not been conducted, but heat content has been estimated at  $6 \times 10^{18}$  calories for Makushin volcano (White, 1975).

#### SOCIO-ECONOMIC:

The area around the springs is under control of the Department of Defense in its Sand Point withdrawal (Mapmakers, 1976). The area is very high in the slopes of the 6,680 foot (2,036 m) Makushin volcano. The mountain is very rugged and is located over 25 miles (40 km) from the village of Unalaska. Any development of this area would have to contend with a very expensive, tough engineering feat to gain access to the springs. No development is seen at this time.

It is also probable that if the Department of Defense lets the land go back to the BLM, the land would go into the Aleutian Island Wildlife Refuge.

#### ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The climate at the 6,000' (1,828 m) level of Makushin is going to have completely different weather conditions than the nearest climatological recording station in Unalaska. The following data for Unalaska is, therefore, intended as a datum for projecting the weather conditions at Makushin.

Winds average southeasterly at 9.0 knots; precipitation is 58" (147 cm) with 81" (205 cm) of snow. Summer temperatures average 40 to 60°F (4 to 16°C), and winter 27 to 39°F (-3 to 3°C). Extremes have been recorded at -5 to 74°F (-21 to 23°C). The heating degree days are 9,500 annually.

The hot springs are located above timberline, where the dominant flora is alpine tundra and few animals venture forth.

There are serious implications to an environment in the venting area of an active volcano. The seismic and related volcanic events will help determine the feasibility of any structures being considered.

KEY CONTACT: Mayor, Unalaska

REFERENCE:

Waring (1917)  
Drewes (1961)  
White (1975)

## UNALASKA

Unalaska Island is in the Fox Island group of the Aleutian Islands. It is located 850 miles (1,360 km) from Anchorage. The island is the second largest west of the Alaska Peninsula.

The geothermal potential is considered high because the reported hot spring resource is located near an active volcano and the existing village of Unalaska. The extent of the resource, however, is not known at all. The potential utilizations of the resource, should it be sufficient, could range from electrical to space heating for Unalaska's 300 families, and processing heat for the local fish canneries. Adequate exploration needs to take place to determine the extent of the resources.

The potential of this form of energy utilization has never before been explored for this particular site. The interest in the resource is unexplored on the local level, but there seems to be no major restrictions for possible utilization. Legal considerations might arise from land selected by the village corporation not yet having been transferred in title to the Native corporation from the BLM.

Economic analysis at Adak Island, to the west, indicates that geothermal energy is a viable alternative energy source in this remote part of our country. Perhaps the resource will prove to be an alternative to the fossil fuel 300 kw electric facility and space heating units already on Unalaska as well.

## SITE DATA SUMMARY

SITE: UNALASKA

### ..Physical Reservoir Data

- ..Temperature °C
- ..Total Dissolved Solids (PPM):
- ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):
- ..Type of Overlaying Rock:
- ..Estimated Depth to Top of Reservoir (meters):

### ..Site Land Status

- ..Total Acres: 241,000 (Federal)

### ..Geothermal Development Status: None to date.

### ..Local and State Attitude Toward Geothermal Development:

Considered a prime area for exploration. If a resource is found, the potential for space heating is great.

### ..Land Use and Population:

The main industry in Unalaska is fishing. Thirteen canneries are located here, making this one of the leading fishing centers in America.

### ..Comments and Critical Issues:

There is no proven resource at this time.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: UNALASKA

### ..Latitude: 53° 5' N.

### ..Longitude: 166° 25' W.

### ..Rectilinear: Unalaska, T72S, R116W.

### ..County: Unalaska is a first class city with a council mayor government. (Unalaska Profile)

### ..Topography:

Unalaska is the second largest island in the Aleutian Islands, and includes 1,200 square miles (3,072 sq.km). Most of the island is ruggedly mountainous and the coastline is deeply indented by fjords, but the southwestern end is hilly and is less deeply indented by bays (Drewes, 1961).

..Present Land Use:

Summer Bay is presently used for recreation.

..Future Land Use Plans:

Possible space heating. Fish processing, Aquaculture. Agriculture.

..Historical/Archaeological Significance:

Several archaeological sites are located on the island. None are in Summer Bay, however.

GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: UNALASKA

..Geologic Description: (Drewes, 1961)

The oldest rocks on the island are the Unalaska formation, consisting of altered andesitic intrusive and extrusive rocks, and sedimentary rocks derived from similar igneous rocks. The batholiths are granodiorite, the heterogeneous border phases are as mafic as gabbro against hornfelsoid argillites as mafic as, and equivalent in composition to metagabbro. Belts of hydrothermal wallrock alteration surround the batholiths.

Basalt and andesite flows and pyroclastic rocks of the Makushin volcanics unconformably cup the Unalaska formation and plutonic rocks form most of Makushin Volcano (Drewes, 1961).

The hot springs are found on the east side of the valley bottom 1.5 miles (2 km) from the shore of Summer Bay, 20 km from Makushin Volcano. (Waring, 1917).

..Geophysical Summary: None to date.

..Geologic Hazards:

The area is one of high seismicity. Akutan Volcano and Makushin Volcano are in the vicinity. Akutan is very active and Makushin as well, giving rise to possible related environmental problems.

RESERVOIR CHARACTERISTICS

SITE: UNALASKA

..Reservoir Temperature: Unknown

..Geochemical: Unknown

..Total Dissolved Solids: Unknown

..Estimated Non-Electric Energy Potential (MBtuh 30 years): Unknown

## LAND OWNERSHIP AND LEASING

SITE: UNALASKA

### ..Land Ownership:

Land in the immediate area of the village has been selected by the Unalaska Native Association under terms of the A.N.C.S.A.

### ..Land Leased: None

## GEO THERMAL DEVELOPMENT STATUS

SITE: UNALASKA

### ..Present Development Status: None

### ..Projected or Planned Development:

The position of Unalaska as a principle fish processing center makes any geothermal adaptation to this processing an attractive alternative. District space heating is an economical and practical application if the resource is available according to Military predictions at Adak.

Pacific Sierra Corporation completed an economic assesment for geothermal energy use at Nikolski in the southwest region. It was considered uneconomical primarily because of lack of demand. If the same assumptions used at Nikolski are used at Unalaska, with its significantly greater demand as the only significant difference the economics would be very favorable for development of the geothermal resource. This fact alone should initiate the first time lines on the scenario.

## INSTITUTIONAL CONSIDERATIONS

SITE: UNALASKA

### ..Institutional Requirements:

Need to determine exact land status of springs. If it is on Native land, it is private and the developer would have to comply with State drilling and environmental regulations. If the lands are under BLM or military control, CFR Title 43 regulations are in effect. If lands have been selected but not transferred through a letter of concurrence plus CFR Title 43 would be needed.

### ..Agency and Public Attitudes:

State Energy Office considers this an area in need of exploration.

### ..Status of Requirements (i.e., EIA/EIS Requirements): None to date.

## ENVIRONMENTAL FACTORS

### SITE: UNALASKA (SOUTHWEST REGIONAL PROFILE)

#### ..CLIMATE from Dutch Harbor

..Prevailing Winds: SE 9.6 kts (17.8 kph)

..Precipitation (Annual): 58" (147 cm), 81" (206 cm) snow

..Average Temperature:

Summer: 40-60°F (4° to 16°C)

Winter: 27-37°F (-3° to 3°C)

Minimum: -5°F (-21°C)

Maximum: 74°F (23°C)

..Degree Days (Annual): 9,500

#### ..AIR QUALITY:

Possible pollutants from invension and volcanism. Extreme winds.

#### ..GEOLOGIC FACTORS:

Area of high seismicity. Definite volcanic hazards.

..WATER QUALITY: Mean annual runoff 2.5 Cu. Ft./Sec./Miles

..NOISE: Winds

#### ..BIOLOGICAL

..Dominant Flora: Moist tundra

..Dominant Fauna:

Shrimp, salmon, sea birds, crab, offshore bottom fisheries.

..Endangered Species:

..Fauna: Bald eagle.

## TRANSPORTATION AND UTILITIES

### SITE: UNALASKA

#### ..Utility or Energy Transmission Corridors and Facilities:

Village of Unalaska located approx. 3 miles (5 km) from the site. Has water, sewer and electrical supplied by Unalaska Municipal Utilities. Major fuel depot for Standard Oil (300 kw demand). Rural Electric Survey)



..Transportation Corridors or Facilities:

No roads outside of the village itself. Reeve Aleutian Airways has three scheduled flights per week to Anchorage.

SeaLand and Pioneer Alaska sea lines deliver products. (Unalaska Profile)

POPULATION

SITE: UNALASKA

..General Description of Population:

During the seasonal peak, as many as 2,000 people are in the area for the fishing season. Five hundred people live there year round. There are schools, motels, apartments, etc. Aquaculture, fishing and processing lead the employment figures. Fifty skilled, semi-skilled and trade service workers are available for work year round (Regional Profiles).

The city has a good tax base on real property and fish.

There are some 1,500 migrant workers who descend on Unalaska for employment with the fish processors at peak seasons (Community Profiles).

..Economics

..Present Land Use:

The village of Unalaska's main economic interest is its fishing industry. Regional Government offices are found here. An abandoned military base at Dutch Harbor across the Bay also exists.

..Future Land Use:

Twenty housing units are to be built under a HUD proposal according to the Rural Energy Survey. With the impending development of the bottom fish industries, this excellent port with the room to expand its facilities is a likely staging area.

SITE: Akun

RESOURCE: Reported Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 54° 14' N; 165° 39' W.

QUADRANGLE: Unimak, T69S, R110W, SM

BARRIER: Remote

RECOMMENDATION: Exploration (No Development)

DESCRIPTION:

A hot spring is reported northwest of Akutan Island on Akun Island (Waring, 1965). This is located within the Akun Island P.G.R.A. 39,353 acres (15,926 hectares). The island is generally composed of three parts, the northern one-third is dominated by Mt. Gilbert, an extinct volcano. The middle third is dominated by glaciated ridges that are drained into Akun Bay. The southern third is generally flat muskeg plain.

The Mt. Gilbert area is composed of Quaternary basalt and andesitic flows with pyroclastic deposits. The southern two thirds of the island is composed of Tertiary coarse to fine grained sediments and pyroclastic rocks with lava flows, cut by small intrusive bodies and pyroclastic deposits (Selkregg, 1976).

SOCIO-ECONOMIC:

There has been native village selections made on Akun Island, but because the exact location of the springs is unknown, it is not known if the springs are on Federal or selected lands. It is assumed that the springs have been selected, however.

Lost Harbor and Akun Bay form two somewhat protected harbors on the island. Sea cliffs do not appear to be a problem.

There is no population or facilities located on the island at this time. With no demand and no data on the resource, projection as to utilization seem optimistic. However, an exploration program should probably determine the extent of the resource.

An historical site exists on the island (Selkregg, 1976).

ENVIRONMENT: EXTRACTED FROM THE SOUTHWEST REGIONAL PROFILE

There is no climatic recording station other than Akutan in the island area. The average temperatures for summer range from 40-60°F (4-15°C) and 27-37°F (-3 to 3°C) in the winter. The winds average SE at 9.6 knots, with 58" (142 cm) of precipitation with 84" (205 cm) of snow. The heating degree days average 9,800.

The dominant flora is tundra. There are no significant mammal populations on the island. Commercial fish are found off the coast. Waterfowl and sea mammals are also present in significant numbers.

There are serious environmental hazards associated with the volcanic potential of nearby islands. Related high seismicity is a serious engineering consideration. High winds are also a hazard.

KEY CONTACT: President, Akutan Native Corporation

REFERENCE:

Waring (1965) Report on Hot Springs  
Southwest Regional Profiles

SITE: Unimak

RESOURCE: Hot Springs Reported (Waring, 1965)

LATITUDE & LONGITUDE: 54° 40' N; 164° 42' W. Approx.

QUADRANGLE: Unimak T63S, R103W, SM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Pogromni Volcano P.G.R.A. 136,100 acres (55,080 hectares). Many springs and hot marshes are located near Pogromni Volcano on Unimak Island. (Waring, 1965). The geology of the west portion of Unimak Island is dominated by three volcanos: Pogromni, Westdahl, and Fisher. These volcanos are basaltic and andesitic with a high percentage of volcanic rock particles, ash and pumice flanking the volcanic cones.

The mountains have been glaciated, moraine and associated drift are found in abundance on the Northwest portion of the island (Selkregg, 1976).

SOCIO-ECONOMIC:

The hot springs are located within the Izembek National Wildlife Refuge. This would preclude development under terms of the Geothermal Steam Act.

There are no pockets of population on this end of Unimak Island. Cape Sarichef Lighthouse has an airstrip 8 miles (13 km) to the southwest of the speculated spring site.

There are nine archeological sites on Western Unimak Island. One is depicted very close to the spring site (Selkregg, 1976).

Being located within a national wildlife refuge would suggest some utilization concerning itself with the wildlife in the area. A research facility utilizing the geothermal resource for space heating, animal husbandry, and experimentation might be considered. Scientific study of the springs should be conducted to determine the extent of the resource at this time.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The average summer temperatures at Cape Sarichef range from 40° to 54°F (4° to 12°C). Extremes of -5° and 74°F (-20° and 23°C) have been recorded. Winter 26° to 40°F (-3° to 4°C).

Winds average 16.9 kts and precipitation averages 28" (71 cm) including 32" (81 cm) snow annually. Heating degree days average 9,900. Mean annual runoff equals 3 ft<sup>3</sup>/sec/mi<sup>2</sup>.

#### FLORA AND FAUNA:

The dominant flora is moist tundra grading to alpine tundra on the volcanos. The animal life is associated with the water. Seabird colonies and migratory waterfowl are abundant. Marine mammals, crab and offshore bottomfishing exists along the N.W. Unimak Coast.

Seismic and volcanic hazards exist.

KEY CONTACT: Wildlife Refuge Superintendant

#### REFERENCE:

Waring, 1965  
Southwest Regional Profile

SITE: Amagat

RESOURCE: Reported Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 54° 53' N; 162° 52' W.

QUADRANGLE: False Pass T61S, R90W, SM

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

A spring is reported on Amagat Inlet at the mouth of Morzhovoi Bay in the Fox Island group along the Aleutian Peninsula.

The rocks of Amagat Island are Quaternary volcanics with a high percentage of volcanic rock particle, ash and pumice near the volcanic core (Selkregg, 1976).

SOCIO-ECONOMIC:

The land classification has not been determined for certain. It would appear to be included in the False Pass Native Corporation selections under the terms of the Alaska Native Claims Settlement Act.

False Pass is the nearest settlement 15 miles (24 km) to the west. Fishing is the base of the cash economy there. There is a significant subsistence economy that might utilize a hot spring for anything from space heating to agriculture depending on the settlement of some population there. If the resource proved sufficient, perhaps some ranching enterprise could be attracted to the islet because of the geothermal resource.

There would appear to be a problem with docking facilities with the volcanic lava flows creating the shore line.

Exploration should be completed to determine the extent of the geothermal resources.

ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

The nearest climatological recording station is False Pass. The average summer temperatures range from 40° to 55°F (4° to 13°C), winter 28° to 35°F (-2° to 1°C). Extremes of -13° to 78°F (-25° to 26°C) have been recorded. Annual heating degree days average 10,000. The winds generally are SSE 17.1 kts. Precipitation averages 33" (81 cm) with 52" (132 cm) snow. Mean annual runoff averages 4 ft. / sec/mi.<sup>2</sup>.

#### FLORA AND FAUNA:

The dominant flora is alpine tundra. The fauna is oriented to the sea. Salmon, marine mammals, crab, waterfowl and halibut ply these waters. There is a major seabird colony here. The endangered Peregrin falcon is found here. Offshore bottom fisheries will probably develop in the future near Amagat.

KEY CONTACT: False Pass Village Corporation

#### REFERENCE:

Waring, 1965  
Southwest Regional Profile

SITE: False Pass

RESOURCE: Hot Springs (Baker, 1977)

LATITUDE & LONGITUDE: 54° 56' 40" N; 163° 15' 02" W.

QUADRANGLE: False Pass, T61S, R93W, SM

BARRIER: Remote

RECOMMENDATION:

DESCRIPTION: (Baker, et. al., 1977)

Located within the Bechevin Bay P.G.R.A. 14,080 acres (6,160 hectares). A single hot spring area has been identified on the western side of a valley extending southeasterly from the head of Hot Springs Bay near False Pass. The hot springs is located about one-half mile (.8 km) inland from the bay at the base of a mountain rising to the west. There is a small unnamed stream 500' (152 m) to the east that flows through the valley. The ground from the spring rises on a 2-3° slope to the west to the base of the mountains.

The glacial trough extends from Hot Springs Bay in the north to an unnamed lagoon on the Pacific Ocean to the south. Distinct glacial deposition is lacking with the valley appearing to have fine grained alluvial deposits. Thin colluvial deposits mantle the steep mountain slopes. Limited quantities of gravel are present in the spits and bars located in Hot Springs Bay. Bedrock is Quaternary volcanic rocks including basaltic, andesitic flows and pyroclastic rocks (Beikman, 1975).

Two main hot springs are identified within the False Pass area. The first is a pool 8' (2.5 m) in diameter and has a maximum temperature of 63°C. The estimated flow is approximately 40 gpm (151 lpm). Another smaller pool 3' (1 m) in diameter was located about 10' (3 m) south of the main pool. The temperature was 63°C with a flow of 20 gpm (75 lpm).

Several other pools were located 40 to 50' (12 to 15 m) downslope (Baker, 1977), but these do not flow and have been excavated by local residents for bathing.

Geochemical data has been gathered for the site. Geologic hazards exist for volcanism and seismicity. A moderate danger exists from avalanches.

H <sub>2</sub> S	0.16*
NH <sub>3</sub>	0.04*
NO <sub>3</sub>	0.2
Phosphate, Ortho	0.25
Alkalinity, Bicarbonate	27



Alkalinity, Carbonate	0
CO <sub>2</sub>	0.2*
Chloride	45*
TDS	300
Hardness (Total)	60
F	0.25
SO <sub>4</sub>	580*
Se	0.002
Cu	0.004
Ca	15*
Na	48
K	1
Ag	0.0002
Pb	0.007
Cd	0.001
Cr	0.002
SiO <sub>2</sub>	22
Al	0.05*
As	0.04
B	1.0
Fe	0.7
Mg	0.1
Mn	0.004
Ni	0.004
Sb	0.02
Zn	0.001
Hg	0.001
V	0.01
Conductance (umohs/cm)	250
**Temperature (°C)	24
pH	8.3*
Date	5-21-77

#### SOCIO-ECONOMIC: (Baker, et. al., 1977)

The lands surrounding the springs have been selected by the False Pass Native Corporation under terms of the Alaska Native Claims Settlement Act. An easement has been established for an existing access trail 25' (7.7 m) wide, from Hot Springs Bay southeast to the hot springs. This easement is intended to facilitate public utilization of the hot springs for recreation and scientific study. This is recorded easement #5D9.

Construction materials and equipment would probably have to be hauled by barge to the head of Hot Springs Bay. The closest approach to the site would be about .5 mile (.8 km) from the head of the bay, since the head is a very shallow lagoon.

Some facilities, primarily housing and lodging, are available at False Pass, 8 miles (10 km) away. Access to False Pass is via a twenty minute small aircraft flight from Cold Bay. Telephone communications exist at False Pass via satellite. The nearest medical facility is Dillingham.

The False Pass area supports a fishery which is primarily dependent upon salmon. The greatest concentration is in Ikatan Bay. Average catches are 500 King; 38,700 Reds; 500 Coho; 77,400 (even year), 33,300 (odd year) Pinks; 206,500 Chum (Baker, 1977). False Pass has a cannery which is very old and has been renovated by Peter Pan Seafoods.

Energy sources in the area are provided by oil and gas. There is no bulk storage, however, and the fuel is flown in by air charter at 75¢/gallon for oil and \$1.25/gallon for gas; with annual requirements of 15,000 gallons of oil and 5,000 gallons of gas, according to 1977 figures in the community energy survey conducted by the State Energy Office in 1978.

The population of False Pass is sixty people. The village of False Pass is separated by Insanoski Strait from the hot springs.

Possible agricultural and aquacultural utilizations of the hot springs would be logical. The State Department of Fish and Game conducted water analysis of the area for a possible fish hatchery. The large scale operation was not viable compared to other locations in the state, but perhaps other smaller scale operations could be initiated in conjunction with Peter Pan Seafoods.

#### ENVIRONMENT: SOUTHWEST REGIONAL PROFILE

The climate of False Pass indicates that there are approximately 10,000 heating degree days. The prevailing winds are SSE 17.1 knots with annual precipitation of 33" (83 cm) with 52" (130 cm) of snow. Average temperatures range from 40-50°F (4-13°C) and winter 28-35°F (-2 to 2°C). Extremes of -13 and 78°F (-25 and 25°C) have been recorded.

The mean annual runoff is about 3 ft.<sup>3</sup>/sec./mi.<sup>2</sup>. One stream that flows 12 cfs is in the springs area. The water does host a small coliform bacteria count that is above recommended levels for salmon (Baker, 1977).

The dominant flora is muskeg with no trees in the area. Brown bear and some caribou are the land animals present. Crab, salmon and offshore bottomfish are big economic species in the area. A high density waterfowl area is located in the Bechevin Bay area.

KEY CONTACT: President, False Pass Village Corporation

#### REFERENCE:

Baker, et. al, Salmon Hatchery Study  
Rural Energy Survey. DEPD  
Southwest Regional Profiles

SITE: Cold Bay

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 55° 13' N; 162° 29' W.

QUADRANGLE: Cold Bay, T57N, R87W, SM

BARRIER: Remote

RECOMMENDATION: Need Flow Rate Data

DESCRIPTION:

Located within the Cold Bay P.G.R.A. 185,408 acres (75,035 hectares). The surficial deposits of Quaternary sediments overlay Tertiary volcanics of the Mt. Dutton Complex. There are outcrops of Jurassic igneous rocks to the east.

There are several springs in the area. The temperature is 54°C with estimated reservoir temperatures of 145°C.

Estimated stored heat is  $.74 \times 10^{18}$  calories. Chemical analysis of the springs have been conducted.

SiO <sub>2</sub>	68
Al	---
Fe	9.9
Ca	229
Mg	7.0
Na	780
K	34
Li	1.5
NH <sub>3</sub>	---
HCO <sub>3</sub>	694
CO <sub>3</sub>	---
SO <sub>3</sub>	---
Cl <sup>4</sup>	1390
F	0.1
Br	---
B	32
pH	7.5
Temp. °C	54

(Miller, 1973)

The springs has a high sulfur content. Jim Frederickson, 1978 personal communication.

## SOCIO-ECONOMIC:

The land within this portion of the P.G.R.A. has been selected by the King Cove Village corporation under terms of the Alaska Native Claims Settlement Act.

The nearest population is located at Cold Bay, 10 miles (16 km) across Cold Bay. The population of Cold Bay is ninety-three. The chief cash economy industry is fishing. There is a military installation here as well. Transportation in Cold Bay is handled by barge and small craft. A large airport exists here as well.

There is high potential for oil and gas production offshore in Bristol Bay to the North. Cold Bay would be a logistical center for the probable lease activities to take place in the 1980's. Bottom fisheries is another new industry that will be developing in the area in the next decade that might affect Cold Bay.

These industries seem too exotic for geothermal energy application for the present. Experimental aquaculture or agricultural applications would be a logical use of the geothermal resources.

## ENVIRONMENT: EXTRACTED FROM THE SOUTHWEST REGIONAL PROFILE

The summer temperatures average 40° to 55°F (4° to 13°C), winter 28° to 35°F (-2 to 1°C). Extremes of -13° to 78°F (-20 to 26°C) have been recorded. The winds average SSE 17.1 kts. Annual heating degree days average 10,000. Precipitation averages 33" (84 cm) with 52" (132 cm) of snow. Mean annual runoff equals 3 ft.<sup>3</sup>/sec/mi..

The dominant flora is moist tundra. Caribou, moose and grizzly bear are abundant in this area. This is one of the major flyaway stopovers for migratory waterfowl. Salmon, crab and shrimp are abundant in the vicinity.

Volcanic seismic activity imposes certain environmental hazards that have to be taken into account.

KEY CONTACT: City Manager, King Cove

## REFERENCE:

Geotherm File  
Waring, 1917  
Southwest Regional Profile  
Miller, 1973

SITE: Emmons

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: Approx. 55° 18' N; 162° 02' W.

QUADRANGLE: Cold Bay, T54S, R86W, SM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Pavlof Volcano P.G.R.A. 236,160 acres (95,574 hectares). The springs are associated with the lava rocks of Mount Emmons near Pavlof Volcano. There are several main springs; also fumaroles on the southwest slope of Mt. Hague. The flow is said to be large. (Waring, 1965)

The springs issue near the contact between the older Tertiary volcanics of the Mount Dutton series and the Pavlof Volcanics that the springs are associated with.

The Aleutian range is an active volcanic and seismic zone. Mt. Pavlof has a very active volcanic history. The most recent activity took place in 1977, with Pavlof sending smoke into the stratosphere.

SOCIO-ECONOMIC:

Land within the P.G.R.A. has been selected by Tanadguisix Village Corporation from St. Paul Island under terms of the Alaska Native Claims Settlement Act. Consolidated Oil and Gas has non-competition oil and gas leases within the P.G.R.A.

It is unknown whether the native corporation selected the springs since the precise location is in question. It appears they did not, which would put the land title in the hands of the Bureau of Land Management.

The nearest population is Belkofski, 15 miles (24 km) to the south. Thirty-four people live in the area. Transportation to Belkofski is limited to seaplanes and boats mainly from King Cove. The heating and electrical needs are supplied by oil. (Rural Energy Survey)

It would appear that no end user is in the vicinity. The cash economy in the Alaska Peninsula is presently based on fishing. There is a developing red meat industry in the Aleutians and perhaps someday the springs could be tied in with one of the industries.

Exploration should be the first priority in future activities here.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The nearest climatological recording station is Cold Bay, 30 miles (48 km) west and 2,500' (762 m) less in elevation. Summer temperatures there average 40° - 55°F (4° to 13°C); winter 28° - 35°F (-2° to 1°C). Extremes of -13° and 78°F (-25° and 25°C) have been recorded. The yearly heating degree days average 10,000.

The dominant flora is alpine muskeg. Mt. Hague is a denning area for grizzly bear. Caribou and moose are found within the P.G.R.A.

There is an environmental risk for seismic and volcanic activity.

KEY CONTACT:

Tanadguisix Village Corporation  
St. Paul Island  
Consolidated Oil & Gas

REFERENCE:

Waring, 1965  
Southwest Regional Profile

SITE: Balboa

RESOURCE: Hot Springs Reported (Waring, 1917)

LATITUDE & LONGITUDE: 55° 38' N; 160° 34' W.

QUADRANGLE: Port Moller, T53S, R74W, SM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Balboa P.G.R.A., 23,040 acres (9,325 hectares). Waring symbolizes a hot springs occurrence at the head of Balboa Bay in his 1917 Water Resources Report.

The rock types in the area of the reported springs are Tertiary volcanic rocks, commonly basaltic and andesitic flows, including some rhyolite. Within the area there are outcrops of igneous intrusive rocks of probably Cretaceous age (Selkregg, 1976).

SOCIO-ECONOMIC:

The land within this P.G.R.A. has been selected by the St. Paul Village Corporation under terms of the Alaskan Native Claims Settlement Act.

There is a portage shown on the Port Moller Quadrangle map that crosses the Alaskan Peninsula from Balboa Bay to the south and Henerdeen Bay. Fosters Camp is shown on the Balboa side of the portage which would be in the general vicinity of the reported spring.

The nearest population center is Sand Point, 15 miles (24 km) to the south across Unga Strait. The major base for the cash economy there is fishing.

If sufficient resource exists in Balboa Bay, perhaps some aquaculture or salmon processing utilization could be developed. The primary objective now should be to develop a data base by doing some exploration.

ENVIRONMENT: EXTRACTED FROM THE SOUTHWEST REGIONAL PROFILE

The nearest climatological recording station is Sandpoint. There wind averages South 10.3 kts. Precipitation averages 43" (109 cm), including 98" (259 cm) snow. Summer temperatures average 34° to 54°F (5° to 13°C), winter 13° to 31°F (-10° to -1°C). Extremes of 11° and 74°F (-12° to 23°C) have been recorded. Annual heating degree days average about 10,000. Mean annual runoff averages 4 ft.<sup>3</sup>/sec/mi.<sup>2</sup>.

The dominant flora is high brush grading to alpine tundra at higher altitudes. Moose, bear and caribou frequent this bay. Marine mammals, salmon, shrimp and crab are found on the coast.

The endangered Peregrine Falcon is found here as well.

KEY CONTACT: Tanadgusix Village Corporation

REFERENCE:

Waring, 1917  
Southwest Regional Profile



SITE: Port Heiden

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 56° 41' N; 158° 50' W. Approx.

QUADRANGLE: Chignik, T40S, R60W, SM Approx.

BARRIER: Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located near the Black Peak P.G.R.A., 137,456 acres (55,628 hectares). Hot springs have been reported near the shore on the Near Bay of Port Heiden. There has been no confirmation in the literature since this early report by Waring. The lower lands in the vicinity of Port Heiden are covered largely with Quaternary gravels and sands that overlies rocks reported to be coal bearing which may be of Cretaceous age. The hot water possibly issues in the lower Quaternary lands from the underlying older deposits. (Waring, 1917).

The springs are in the proximity of the dormant Black Peak Volcano to the south.

SOCIO-ECONOMIC:

The State of Alaska has selected the land here under terms of the Statehood Act. Meshik Native Village Corporation has selected lands to the east up to the town of Port Heiden.

Port Heiden is the nearest village, 15 miles (24 km) to the east across Port Heiden Bay. The population is seventy-five. Fossil fuels are presently used to space heat and produce electricity. Fifteen new H.U.D. housing units are to be built. There is an airport and barge service to Port Heiden. (Rural Electric Survey).

The cash economy of Port Heiden/Meshik area is based on the fishing industry. Some oil exploration has occurred in the area. Port Heiden airstrip was built as a military field during the war. Some remnants of the military remain.

Much of the energy of the village is involved in subsistence living. Agricultural use of the springs would fit very well into the village's subsistence economy.

Presently the springs should be included in an exploration effort to determine the extent of the resource.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The summer temperatures at Port Heiden average 40° to 59°F (4° to 15°C); winter 14° to 33° (-10° to 1°C), with extremes of -25° and 82°F (-31° and 28°C) recorded. Annual precipitation averages 13" (33 cm) including 29" (74 cm) of snow. Annual heating degree days average 10,800. Mean annual runoff equals 2 ft.<sup>3</sup>/sec/mi.<sup>2</sup>.

The dominant flora is wet tundra. Moose, caribou and bear are found in abundance. Marine mammals, neurtic birds and migratory waterfowl all utilize the waters of this area.

The Alaska Peninsula is part of one of the world's most active volcanic and seismic zones. Related environmental hazards are part of any enterprise here.

KEY CONTACT: Village Council, Meshik

REFERENCE:

Waring, 1917  
Southwest Regional Profile

SITE: Staniukovich

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 55° 51' 45" N; 160° 29'35" W.

QUADRANGLE: Port Moller, T50S, R73W, SM

BARRIER: None

RECOMMENDATION: Agribusiness and Exploration

DESCRIPTION:

The hot springs is located on the southwest side of Port Moller Bay, north of Mud Bay within the Staniukovich P.G.R.A., 16,937 acres (6,854 hectares). The hot spring is situated at the head of a shallow gully that drains south and follows the base of a bedrock ridge. The ridge lies at the apex of a cusped bar or raised beach with an elevation of approximately 15' (3.5 m). The surrounding area is undulating and has several middens (early Native refuse heaps) up to 6' (2 m) high. Inland, the terrain is dominated by the eroded Staniukovich Mountain, rising 2,500' (762 m). (Waring, 1917)

Regionally, the area is underlain by Tertiary volcanic and sedimentary rocks that form the mountains south and west of the site. Locally, the bedrock ridge from which the springs issue is sandstone that dips 15° to the west. The soils in the area are sandy (Baker, 1977).

The Alaska Peninsula Mesozoic coal province is partially within the P.G.R.A. as well. Certain gas and oil exploration holes are located across Herendeen Bay to the west (Selkregg, 1976).

The hot spring issues from a pool 11' x 4' (3 m x 3.6 m) feeding a stream that drains to the south into a cove. The temperature of the pool is 69°C and the discharge is 80 gpm (300 lpm) (Baker, 1977).

Geologic hazards include high risks for volcanism and seismicity with Pavlof Volcano within 70 miles (112 km) and Veniaminof, 50 miles (80 km).

The low topography of the site exposes it to potential hazards from tsunamis. The chemical analysis of the hot springs waters are:

H <sub>2</sub> S	0.16*
NH <sub>3</sub>	1.6*
NO <sub>3</sub>	0.2
Phosphate, Ortho	0.25
Alkalinity, Bicarbonate	17*
Alkalinity, Carbonate	0
CO <sub>2</sub>	0.25*

Chloride	1500*
TDS	3022*
Hardness (Total)	480
F	1.9*
SO <sub>4</sub>	50
Se <sup>4</sup>	0.005
Cu	0.008*
Ca	61*
Na	200*
K	14*
Ag	0.00015
Pb	0.3*
Cd	0.003
Cr	0.0012
SiO <sub>2</sub>	8
Al	0.19*
As	0.032
B	2.8
Fe	0.94
Mg	1.0
Mn	0.008
Ni	0.1
Sb	0.025
Zn	0.002
Hg	0.001
V	0.01
Conductance (umohs/cm)	3750
**Temperature (°C)	25
pH	8.1*
Date	5-22-77

- \* Exceeds ADFG water quality criteria for salmon aquaculture.
- \*\* Temperature at which chemical analysis was accomplished.

#### SOCIO-ECONOMIC:

Approximately twenty acres of lands, which include the hot springs, are recorded as being subject to a mineral springs lease (#AA-6465) by the BLM to Arthur H. Johnson, Box 272, South Naknek, Alaska. Surrounding lands have been selected by the State of Alaska.

Transportation to the site is possible from Port Moller, 9 miles (14 km) across the bay by boat or aircraft. Access to Port Moller is via boat or air from Cold Bay, 103 miles (168 km). Telephone communications exist at Port Moller.

Sufficient sand and gravel for construction are available from the beach and shoreline bluffs.

There seems to have been a large native village near the springs at one time, for ruins of huts still remained in 1917. They were half buried by heaps of clam shells 6-8' thick. Temporary camps of native hunters were also found at that time (Waring, 1917).

The economy of the Port Moller and Nelson Lagoon villages are subsistence and fishing. There is no cannery, as they process the fish at King Cove. Agricultural utilization might be useful, as the cost of fresh vegetables is extremely high.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

The climate at Port Moller is characterized by high winds. The average wind speed is south at 10.3 knots. Summer temperatures range from 34-54°F (1-12°C) and winter is 13-31°F (-10 to 0°C). Extremes of 11 and 74°F (-11 and 23°C) have been recorded. Precipitation averages 43" (109 cm) with 98" (249 cm) of snow. Annual heating degree days equal 9,900.

There are no streams flowing past the hot springs. A small lake about 300,000 square feet is in the area. Groundwater may experience saltwater intrusion.

The dominant flora in the area is muskeg. Fauna includes caribou, grizzly bear and there is a major stopover for emperor geese. Crab, sea mammals, salmon and other waterfowl are also found here in significant numbers.

KEY CONTACT: Arthur H. Johnson

REFERENCE:

Baker, et. al, Fish Hatchery Study  
Southwest Regional Profiles  
Waring, 1917 Springs Report

SITE: Mother Goose (Baker, 1977)

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 57° 10' 40" N, 157° 00' 53" W.

QUADRANGLE: Ugashik, T35S, R48W, SM

BARRIER: Remote

RECOMMENDATION:

DESCRIPTION:

The hot springs area is located on the northern slopes of Mt. Chiginagak, within the Mother Goose Lake P.G.R.A., 76,374 acres (31,084 hectares). The springs are located within a narrow valley about one-half mile (.8 km) wide and oriented roughly north-south with increasing elevations toward the south. Volcano Creek flows through the center of the valley. The valley is relatively flat bottomed. This valley turns westward into a larger valley that drains into Mother Goose Lake.

Mt. Chiginagak is a volcano composed of basaltic and andesitic flows. The lower flanks of the mountain on the northwest slope are underlain by Cretaceous and Jurassic sandstones, siltstones, conglomerates and limestones. The volcano has erupted twice since 1700 (Baker, 1977).

A white mineral coating is present on most of the boulders in the upper Volcano Creek channel, originating from the highly mineralized water issuing from the base of the volcano.

Most hot water flows directly into the small stream on the west margin of Volcano Creek valley. Seepage is apparent on a small bench 40-50' (12 to 15 m) above the main hot spring area, and also uphill from the hot springs area. Flow here is minimal and is probably less than 10 gpm (8 lpm).

Most water issues from a hole in bedrock 8-12" (20 to 30 cm) in diameter. The flow is about 100 gpm (378 lpm) with a temperature of 65°C (Baker, 1977). Chemical analysis is:

H <sub>2</sub> S	0.24*
NH <sub>3</sub>	0.12*
NO <sub>3</sub>	0.7
Phosphate, Ortho	0.25
Alkalinity, Bicarbonate	35
Alkalinity, Carbonate	0
CO <sub>2</sub>	5*
Chloride	455*
TDS	2298*
Hardness (Total)	1144
F	0.2

SO <sub>4</sub>	2000*
Se	0.002
Cu	0.024*
Ca	160*
Na	195*
K	40*
Ag	0.0008
Pb	0.002
Cd	0.0003
Cr	0.0012
SiO <sub>2</sub>	80
Al	0.47*
As	0.038
B	1.0
Fe	0.05
Mg	130*
Mn	0.009
Ni	0.035
Sb	0.054
Zn	0.001
Hg	0.001
V	0.01
Conductance (umohs/cm)	2000
**Temperature (°C)	25
pH	7.1
Date	6-2-77

\* Exceeds ADFG water quality criteria for salmon aquaculture.

\*\* Temperature at which chemical analysis was accomplished.

Geologic hazards are present in the forms of volcanic activity. There is also quite a high seismic problem.

#### SOCIO-ECONOMIC:

Approximately 520 acres (210 hectares) surrounding the hot springs are subject to a mineral springs lease #A 058587), issued by the BLM to Alaska Safari, Inc., Box 6221, Anchorage, Alaska. Adjacent lands have been selected according to the Native Claims Settlement Act by Koniag, Inc.

Access is extremely difficult anywhere in the vicinity of Mother Goose Lake. Everything must be airlifted. The nearest facilities and resources are at King Salmon, 110 miles (176 km) away.

Considerable quantities of sand and gravel should be available within the floodplain of Volcano Creek suitable for construction material.

No recommendation is made for utilization.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILES

There are no climatological stations in the vicinity. Estimated summer temperatures are in the 50°F's (about 10°C); winter is 10°F (-12°C).

Water conditions are very mineralized with probable freezing up in the winter.

Dominant flora is muskeg with shrubs up to 8' (2 m). Salmon are reported in the creek (Baker, 1977).

KEY CONTACT: Alaska Safari, Inc.

REFERENCE:

Baker, Fish Hatchery Study  
Selkregg, Southwest Regional Profiles



SITE: Peulik

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 57° 51' 55" N; 156° 29' 55" W. Approx.

QUADRANGLE: Ugashik D-2, T27S, R44W, Section 9, SM

BARRIER: Remote, Included in National Monument

RECOMMENDATION:

DESCRIPTION:

Located within the Mt. Peulik P.G.R.A., 87,000 acres (35,209 hectares). On the southwest shore of Becharof Lake, near the base of Mount Peulik, hot springs were reported to Waring in his 1917 report. He speculated that the issuance of the hot water was related to the volcanic activity of Mt. Peulik. The rock formation near the springs consists of sandstone of Jurassic age.

Mt. Peulik volcano rises a mere 5 miles (8 km) to the south of the spring issuance.

There are two spring systems: West is Ukinik and Gas Rock Springs. West Ukinik is located T27S, R44W, Section 9. Gas Rock Springs is located in T27S, R44W, Section 20.

Gas Rock Springs has a flow rate of 15 gpm at 53°C. The waters specific conductance 65,850 umh/cm (Geotherm File).

A Ukinik Springs is a pool in the bottom of a Maar. It has a temperature of 81°C and a specific conductance of 17,740 (Geotherm File).

SOCIO-ECONOMIC:

The land in this locality was withdrawn as a village deficiency withdrawal under terms of the Alaskan Native Claims Settlement Act. The State of Alaska has selected lands to the South under terms of the Statehood Act.

The nearest village is Kanatak, 25 miles (40 km) to the Southwest. A portage exists over the mountains to Becharof Lake. Egegik Village is located at the mouth of the Egegik River which drains Becharof Lake into Bristol Bay. Both of these villages are many miles away. Each have less than 100 people in their village. Oil exploration wells have been drilled to the south of Mt. Peulik.

There is no apparent user in this area. There has been no exploration effort to date that has confirmed the resource. Any future planning will be contingent upon such an effort.

The shores and area around Becharof Lake have been designated as a national monument under the authority of the Antiquities Act as of December 1, 1978. This was accomplished through P.L.O. 5654.

ENVIRONMENT: EXTRACTED FROM SOUTHWEST REGIONAL PROFILE

Summer temperature average estimates of 45° to 75°F (7° to 24°C) can be extrapolated from data at Port Heiden. Extremes of -50° (-46°C) and 80°F (27°C) can be expected. Heating degree days average 11,200.

The dominant flora is moist tundra. Moose, bear and some caribou are found in the area. The lake shore is a low density waterfowl range. Becharof Lake has numerous fresh water as well as runs of anadromous fish.

The volcanic and seismic related environmental hazards have to be taken into account.

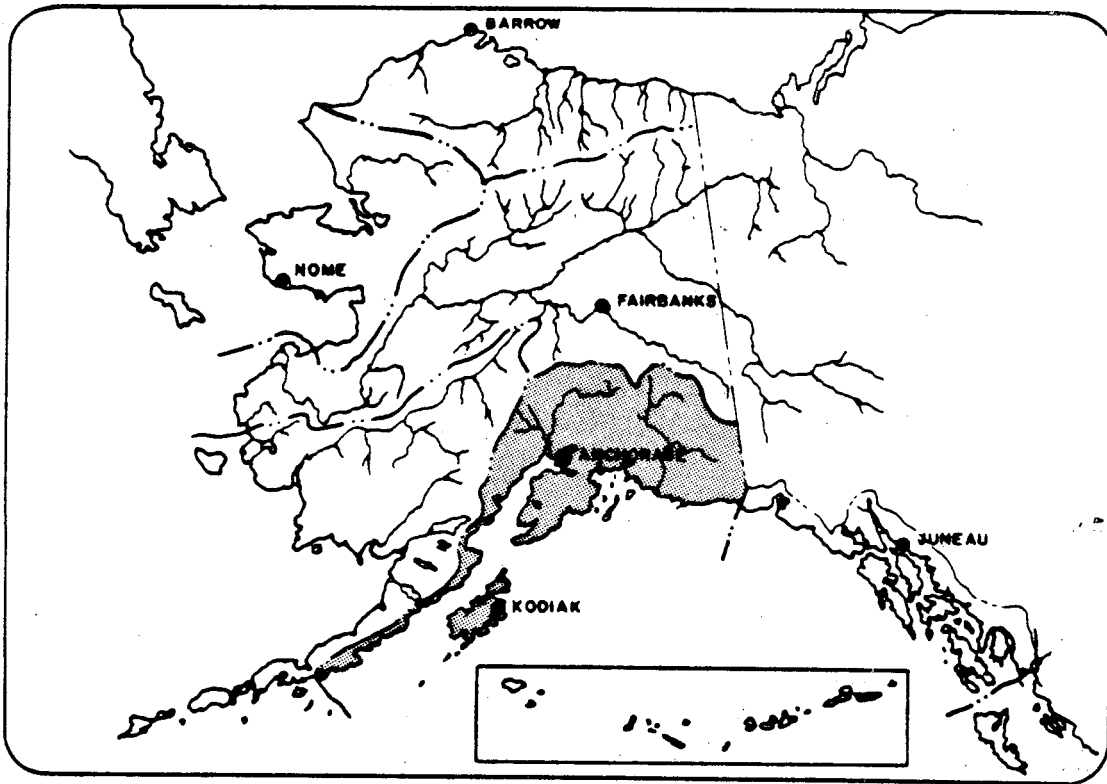
KEY CONTACT: Manager, Becharof National Monument

REFERENCE:

Waring, 1917  
Southwest Regional Profiles  
Geotherm, 1978



## Southcentral Region



## SOUTHCENTRAL REGION

(Extracted from Southcentral Regional Profile.)

### Introduction

The Southcentral region includes areas draining into the Gulf of Alaska between 141 degrees West longitude and Stepovak Bay on the Alaska Peninsula. The area, approximately 53.1 million acres in size, is characterized by rugged mountainous terrain surrounding major drainage basins.

### Climate

The climate of Southcentral Alaska falls into three distinctive zones: The coastal area and islands fall into the maritime zone. This area is characterized by heavy precipitation and relatively mild temperatures. The interior region experiences continental zone weather. Temperature ranges are greater and there is less precipitation. There is also a transitional zone where the weather conditions average between the maritime and continental zones. Temperatures here usually resemble that of continental zone but there is more precipitation and surface winds are terrain-oriented, but not so much as the interior.

In the maritime zone, annual precipitation amounts to about 60" (152 cm) per year with areas receiving as much as 200" (508 cm). Temperatures usually reach the upper 50'sF (10's C) in the summer, and the mean seldom falls below the low 20'sF (7½C) in the winter. The strongest winds also occur in this zone. Offshore speeds average between 12-18 knots. These winds can reach 100 knots when channelled.

The interior climate reaches maximum temperatures in the summer and are mostly in the upper 60's (16°C) and mean lows in winter range from 10 (-12°C) to nearly 30 degrees below zero fahrenheit (-35°C). Precipitation is generally between 10" (25cm) and 15 inches (38cm), the heaviest precipitation occurs in the mountains. Surface winds are light compared to those of the coast. Channeling can, however, produce narrow bands of extreme wind.

In the transitional zone, temperature extremes most resemble those of the continental zone, while precipitation amounts tend to range from light 10 inches (25cm) to heavy enough to maintain glaciers. Surface winds vary.

Heating degree days vary from 9,000 on the coastal regions to 14,500 in some interior passes. Generally, growing degree days range from 900 to 2,000. As a norm, Alaska, including Southcentral, does not have adequate precipitation for crop growth. It is normally too light during growth and too heavy during harvest.

Some interior areas host permafrost. Soil temperature ranges from 20-60 degrees F. (7° to 16°C) in Anchorage, as compared to 21-50 degrees F. (7° to 10°C) in Gulkana. The number of continuous summer frost free days can range from 55 days at Sterling to 162 at Kenai.

## Marine Environment

The coastline of Southcentral Alaska harbors cargo transportation routes linking the bulk of Alaska with the rest of the world. During the winter, intense storms move east across the North Pacific Ocean and Gulf of Alaska. Waves of greater amplitude than 12 feet (3.7 M) occur seasonally with some measuring over 30 feet (9M). The sea state, combined with pack ice, have made the sea transportation links quite hazardous.

The sea ice is located primarily in Cook Inlet. In general, the ice moves slowly south and seldom affects shipping. Tidal action and currents keep the inlet ice shattered. The tidal range measured at Anchorage is one of the highest in the world, with a maximum of 38.9 feet (12M). Mid-channel tidal currents average 3.8 knots at the Forelands area. Both of these extreme conditions require consideration in design.

## Topography

The Kenai Peninsula forms the east shore of Cook Inlet, which is a glaciated lowland of outwash plains extending along the Kenai and Chugach Mountains. The portion to the east and south of Kachemak Bay is quite rugged, with a fjord-indentured coastline. The higher ridges of both mountain ranges are covered with glaciers and ice fields.

The Talkeetna Mountains lie between the Susitna and Matanuska Valleys to the north of Anchorage. These ice-carved mountains sustain glaciers and rise to elevations of 6,000 to 7,000 feet (1,800 to 2,100 m), decreasing northward and westward. The summits are remarkably even.

The western margin of the region is formed by the snow capped Aleutian Range which merges with the Alaska Range. The crest of the range averages 7,000 to 9,000 feet (2,100 to 2,700 m.) (William 1958). Noticeable among this crest are the volcanic peaks that are spaced along a line from Katmai Park to McKinley Park. These giants rise head and shoulders above their surrounding foothills and the greatest giant, Denali (McKinley), although not volcanic, stands as an anchor at the north end of this string of peaks.

The Cook Inlet-Susitna lowland, with an elevation from sea level to 500 feet (150 m), is set between these aforementioned mountains. The lowland is characterized by glacial features, such as moraines and has two branching arms. The Matanuska River drains the northeast and the much larger Susitna drains the northwest, both flowing into Cook Inlet near Anchorage.

The Gulkana upland and Copper River form an intermountain basin that drains the northeast 24,000 square miles (61,920 sq. km) of the region. This is a relatively smooth plain, trenched by the Copper River and its tributaries. The elevation is 1,000 to 2,000 feet (300 to 650 m). The basin is bounded by the Alaska Range on the north, and to the east by the Wrangell Mountains, the latter being a compact cluster of volcanic peaks rising more than 10,000 feet (3,000 m) above the Copper River plateaus.

The Copper River, which flows south to the Gulf of Alaska, separates the Chugach-Kenai range from the Wrangell to the northeast and St. Elias to the southeast. The St. Elias Mountains are desolate, icebound and inaccessible. Massive, isolated peaks 14,000 to nearly 20,000 feet (4,300 to 6,600 m) rise at intervals of 5-30 miles (8-50 km) from a myriad of narrow ridges. Ice rivers of the Bering-Bagley ice field drain the area.

The offshore topography is a continuation of onshore structures onto the gently sloping, shallow continental shelf. The shelf is relatively narrow and reaches its widest at Kodiak (200-220 miles/320-355 km wide) and narrows northward and eastward. This breaks into the steeply descending continental slope and onto the ocean basin cut by the Aleutian Trench.

### Geology

During late Paleozoic and early Mesozoic time, a sea occupied the south-central region. A volcanic island arc existed in the general area of the Alaska Range. Older rocks of the Wrangells, Kenai, Chugach mountains and Copper River plateaus reflect this volcanism. The island arc was uplifted and deformed during Triassic time.

Late Triassic seas expanded and volcanic activity continued through lower Jurassic. The long period of sedimentation in the area south of the Alaska Range was phased out with the initiation of early to middle Jurassic intrusions of large masses of crystalline igneous material. These batholiths now form the core of the Aleutian-Alaska Range and Talkeetna Mountains. From late Triassic time to present, igneous activity has been continuous throughout the region. Mineral activity has been associated with these igneous bodies.

Uplift and erosion of these granite bodies during Jurassic and Cretaceous times provided the sediments of the continental shelf and basins. Sedimentation continued into Tertiary and was accompanied by intrusive activity, uplift and deformation. Volcanics blanketed the Wrangell Mountains.

Uplift during Tertiary time rejuvenated streams in the Talkeetna Mountains. Flows of basalt poured over the area now occupied by the central Talkeetna Mountains. In the Kenai-Chugach area, uplift at the end of the Cretaceous and early Tertiary time produced a mountain range. These ancestral mountains were subsequently worn down and seas once again took the main part of the mountains as sediment. Renewed uplift, and deformation began in late Tertiary and has continued to the present. Areas of high volcanism still exist today.

The development of most of the present landscape took place in Quaternary time. In Southcentral Alaska, glacial deposits record at least four major Pleistocene glaciations. These events shaped the area and the process continues today.

The geologic features of the Southcentral region are characterized by acute, sublinear structures, trending parallel to the Gulf of Alaska, which are highly glaciated.

This region is one of the most seismically active in North America, experiencing thousands of earth shocks each year. Because of the exposed, yet narrow fjord environment, tsunami damage can be extensive during earthquake events, as observed at Valdez during the 1964 Alaska earthquake.

Most of Alaska's active volcanoes occur along an arcuate belt extending over 1,500 miles (2,500 km) from Mt. Spurr opposite Anchorage, to Buldir Island at the extreme east of the Aleutians. One major exception occurs within the region -- that being the Wrangell Mountain's strato volcanic pile. These areas form one of the most active volcanic regions on the continent. Some 28 volcanic centers have been active in recorded history. Many environmental hazards are associated with volcanic eruptions. Large violent explosions, mudflows, flash floods, lightning discharge, earthquakes, sea waves and falling pyroclastic debris can all affect human activity.

### Mineral Resources

There are two areas in the Kodiak-Shelikof area where mineral occurrences appear to be concentrated -- around Chignik and Kodiak Island. Gold, silver, copper, lead, zinc, chromite and platinum have been found. Non-metallics such as coal deposits are found near Chignik, and sulfur near Stepovak Bay and pumice adjacent to the numerous volcanoes. The Chignik and Kodiak areas are rated as areas characterized by high metal concentration (Clark et. al., 1972).

This area also contains portions of three separate sedimentary petroleum provinces: the lower Cook Inlet Tertiary, the Kodiak Tertiary and the Mesozoic provinces (Gates et. al., 1968). The lack of commercial production is attributed to the poor reservoir quality of rocks. Reserves for the Alaska Peninsula have been estimated at 1.5 billion barrels of oil, but this probably includes some of the Bristol Bay province and none of the Kodiak (U.S. Geological Survey, 1972).

The Cook Inlet area is traversed by numerous metal provinces. The area contains deposits of gold, silver, antimony, iron, chromite, molybdenum, copper, lead and zinc. Like most of Alaska, past metallic production has been primarily gold. The principle areas are Redoubt, Yentna, Valdez Creek, Willow, Hope, Homer and Anchorage.

This area also contains occurrences of non-metals: coal, gypsum, limestone, zeolites and sand and gravel (Cobb, 1964). Coal resources have been estimated to exceed 3 billion short tone (Barnes, 1967).

The subregion contains portions of two major sedimentary petroleum provinces. The Mesozoic and Cook Inlet Tertiary provinces (Crick, 1971). The Cook Inlet Tertiary province, to date, has been the second largest producer of oil and gas in the State. Since oil was discovered at Swanson River in 1957, two refineries, tanker terminals, a petrochemical plant and an LNG plant have accompanied the development of the field.



The Copper River-Gulf of Alaska subregion includes several mining districts. The major minerals found include copper, gold, silver, molybdenum, antimony, nickel, iron, lead, and zinc. Gold, copper and silver have been mined commercially. The subregion also contains known non-metals such as limestone, coal and sand and gravel.

The subregion contains two geologic sedimentary provinces with petroleum potential: the Copper River Basin and Gulf of Alaska Tertiary province. The latter is where the first producing oil field in Alaska was discovered in 1902 -- Katalla. The offshore area is now under lease, although no major finds have been reported.

### Water

The mean annual runoff averages from 0.5 ft<sup>3</sup>/sec per square mile in the Central Lowlands, to over 300 ft<sup>3</sup>/sec per square mile on the coastal plain on the Gulf of Alaska. Generally, the mountainous areas receive the highest peak runoff -- greater than 50 cfs per square mile. The chemical quality of nearly all surface water is acceptable for most uses, although most large streams are fed by glaciers, and contain high percentages of suspended sediment. The range of dissolved solids is normally below 50 mg/l, but have shown as high as 117 mg/l on Squirrel Creek near Tonsina (Nichols, Yehle, 1961). Temperatures of surface water ranges from 32-56 degrees F. (0-13 degrees C.).

Water from groundwater sources throughout the region generally appear rather good chemically. Most of the springs in the Copper River basin contain large amounts of sodium chloride in deep wells, however. New water resource data collection is presently being undertaken by the State.

Several river systems in the region have significant flood hazards and this should be taken into account for any development. Two hydro-electric sites are now operating in the Anchorage area, and a proposed billion dollar plus Upper Susitna project indicates the major hydro-electric resource available in this region.

### Terrestrial Vegetation

Terrestrial vegetation in this region varies greatly and includes coastal western hemlock, Sitka spruce forests, bottomland spruce-poplar forests, lowland spruce hardwood forests, high bush, low bush, muskeg bog, moist tundra, wet tundra, alpine tundra and barren ground. These are related by drainage, rainfall, terrain, altitude, permafrost and exposure.

### Aquatic Vegetation

This area is very important to different types of wildlife, especially waterfowl, fish and sea mammals. There are numerous species and the waters are heavily populated, but little of it is presently utilized by man.

### Terrestrial Animals

Habitats of the Southcentral region are particularly important in their function as routes for migrating birds. This area is the gateway to the Pacific Flyway. Bald eagle, endangered peregrine falcons, many passerine species, gulls, terns and other birds inhabit the region. Sport hunting birds, such as ptarmigan, spruce hens, and migratory waterfowl are annually harvested throughout the region.

Black bear, brown bear, wolf, wolverine, caribou, Sitka deer, moose, sheep, and goats are all important recreational and subsistence animals to the region. Bison have recently been introduced as well.

### Aquatic Animals

More than 100 sea bird colonies live along the coast of Southcentral Alaska. The Aghiyuk Island colony has a population of over 1,000,000 birds.

Various marine mammals, seals, sea lions, baleen and toothed whales, and porpoises ply the near shore waters in substantial numbers.

Fish are varied and abundant, as evidenced by active commercial fishing in the area. Halibut, polluck, perch, cod, turbot, salmon and other fish add to the economic base of the region. A diversity of benthic invertebrates such as king crab are also harvested. Demersal animals, such as shrimp, are also in abundance.

Fresh water trout are taken in great numbers by the ardent sport fishermen in the area.

### Subsistence

The Marine Mammals Protection Act of 1972 restricted the heretofore commercial taking of marine birds and animals. Limited trapping still takes place for terrestrial animals commercially and for subsistence. Subsistence and recreation harvesting still depend heavily on the terrestrial animal community. Moose and caribou are the mainstay for red meat diets. Salmon, crab and intertidal marine animals are also used as mainstays to the diet.

Forests within the region are scattered and vary greatly as to timber type and economic potential. Wood is generally used with coal as a subsistence energy source. Climate affects the forest in type as well as growth. Wildfires are a danger as well not only to the vast commercial forests, but the subsistence of many people in the interior regions.

### History

Since the beginning of known history, Kodiak Island, Cook Inlet and Prince William Sound have been focal points for population in Alaska. Kodiak Island has an inferred 6,000 year history of habitation from over 300 known archeological sites there and on Afognak Island.

In recorded history, the Chugachiniut Eskimos have inhabited the Kodiak Islands and Alaska Peninsula, the Tanaina Indians the Cook Inlet region, and the Athabascan-speaking Ahtna people the Copper River basin. The cultures of these groups were based primarily around subsistence for the thousands of years prior to the arrival of the Europeans.

Vitus Bering's initial discovery was followed by other Russian, Spanish and British explorations. It was the Russians who came to colonize, however. In the spring of 1784, the first Russian colony was founded on Kodiak Island. During the 83 years when the Russian American Company and the government ruled together in Southcentral Alaska, the coastlines were thoroughly explored and stable settlements established on Kodiak Island and the Kenai Peninsula. Only one exploration trip was made to the Copper River basin and one up the Susitna drainage.

The first fish cannery was established in the region in 1882 -- the first significant American achievement since purchase. During the next 20 years, canneries were established throughout the region.

In 1885, Lieutenant Henry Allan explored the Copper River region. This was the first of a series of Army explorations conducted in the Alaska Range. These explorations initiated the interest in minerals and railroad development. Though largely forgotten during the Klondike fever, renewed interests for railroad and road links to the interior intensified with the major gold discoveries around Fairbanks. The Richardson trail was cleared and saw commercial trapping between Valdez and Fairbanks. A railroad was built between Cordova and Chitna in 1908, establishing Cordova as a major port city.

Finally, in 1920, the Alaska Railroad was completed between Seward and Fairbanks. The present town of Anchorage was a construction station along the way. The area population remained fairly stable till 1935 when a New Deal resettlement scheme brought colonists to the Matanuska Valley. Although plagued with problems, the colony survived and now is one of the major farming areas of the State.

The Second World War brought the next major wave of migration. The establishment of military bases and the connection to the Alaska Highway boosted the population of Anchorage to 40,000 people. Other military projects, such as construction of the DEW line, continued to be the prime mover of commerce until 1957.

In 1957, oil was discovered at Swanson River. Development has followed the discoveries of oil and gas and spurred this region each time. Even the rebuilding after the 1964 earthquake acted as a spur to the economy. Recently, the discovery of oil at Prudhoe Bay and the resulting pipeline activities have been the motivators of both Southcentral and all Alaska.

#### Population

At the time of the 1970 census, there was approximately 162,000 people in the region. Since then, the figure has approached 250,000. Whites make up the largest share (90%) of the population. Natives are the next major group, but there are significant oriental and black populations in the Cook Inlet region.

## Economy

Prior to World War II, the economic base of the region was primarily related to fisheries, mining and to a lesser degree, trapping and hunting. From the beginning of WW II to the mid-1960's, the economic base shifted to military expansion and federal employment. Oil developers selected Anchorage as their base and the service industries followed suit about that time. Government, trade, construction, transportation, service, manufacturing, mining and farming are all important economic blocks within the region. Fisheries, petroleum, timber, aquaculture, and tourism all utilize the natural resources of the region.

## Land Status

Land status in Southcentral is in a state of flux until Native selections and State selections are completed. State selections pose long term problems because they depend upon Native selections and national interest land designation.

The State and Natives have land claims to much acreage within this region. The Natives have overselected State and Federal lands. The State has overselected as well, so the pictures shape up fuzzy at best.

## Present Land Utilization

Everything from the State's largest urban population center to uninhabited acreage exists within the region. Agriculture, military, small community, strip development, parks, industrial parks, and recreational uses are found throughout the region.

## Transportation

Southcentral's transportation serves not only this area, but the bulk of the state. Air service networks for Alaska are centralized in Anchorage. Anchorage is a key stop for polar and great circle routes as well.

Marine service is based primarily on trans-shipment points at Whittier, Anchorage, Seward and Kodiak. The region forms the axis of the state's primary road system as well as being the base of the Alaska Railroad. Most all of the freight and passenger services from the other states and countries enter and leave Alaska through this region.

## Communications

The State of Alaska and RCA have been developing a new satellite system to replace the backbone of the state communication system that Norad developed under the White Alice project. A major bush system is being tied to the new system.

Utility companies push further and further along the Railbelt extending their services into the rural Alaskan lifestyle. There are numerous newspapers and radio stations serving the area. Virtually everybody in the region has an option to utilize these forms of communications.

## GEOTHERMAL

There is a considerable quantity of geothermal energy in Alaska's South-central District. Two of the largest resources in the state, Mt. Katmai P.G.R.A. and Mt. Wrangell P.G.R.A., are located here. The U.S.G.S. has recorded 25 active or dormant volcanoes in the region.

The volcanoes are associated with two district Genesis.. The Aleutian Island, Alaska Peninsula volcanos occur along an accurate belt extending over 1500 miles (2,400 km). From Mount Spurr, near Anchorage, to Buldir near Attu at the end of the Aleutians. This activity is theoretically related to the Pacific crustal plate diving under the North American Plate along the Aleutian Trench subduct in zone. The melting of the subducted Pacific Plate provides the material for the volcanoes and the subduction zone provides the heat.

The Wrangell Mountains has an area of 7,800 square kilometers. The arial extent of this mass of rock make it one of the largest strato volcanic piles in the world.

There are four hot spring locations and at least three mud volcanoes in the region. Mt. Spurr has a warm lake in its caldera as well. Most of these expressions are of little economic importance at this time.

There are hot water wells associated with oil drilling along the Iniskin penninsula with high heat flow (Blasko 1971). There are 30 reported hot wells in the region, most of which are in the Cook Inlet Subregion near the volcanic east edge. These wells all carry a local gradient of 30°C/km or more (MacBeath 1978).

There appears to be a high heat flow associated with the volcanic centers along the east rim of Cook Inlet. The Cook Inlet oil province has a low thermal gradient as a whole however. (AAPG 1976).

One notable exception in the Red Shirt Well at the north end of the inlet on the Susitna River Valley, the thermal gradient here appears to be 120°C/km. This well is north of the Castle Mountain Fault System which divides the north Cook Inlet geologically.

The heat flow also appears exceptionally high in the Wrangell Mountain area. Snowmelt studies by Dr. Benson of the University of Alaska, indicate that thousands of cubic kilometers of snow has melted out of the Caldera of Mt. Wrangell in recent years (Benson private communication).

The Mt. Katmai P.G.R.A. contains 14 volcanoes and two spring systems. A third spring system is located just to the North and east of the P.G.R.A. and Mount Bondango.

MT. KATMAI, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

Tps. 14,15, & 16 S., R. 25 W.,  
All those portions above MHT, Cook Inlet  
T. 17 S., R. 25 W.,  
All those portions above MHT, Shelikof Strait  
T. 14 S., R. 26 W.,  
All those portions above MHT, Cook Inlet, and  
within Katmai National Monument  
Tps. 15 & 16 S., R. 26 W.  
Tps. 17 & 18 S., R. 26 W.,  
All those portions above MHT, Shelikof Strait  
Tps. 14 & 15 S., R. 27 W.,  
All those portions within Katmai National  
Monument  
Tps. 16 & 17 S., R. 27 W.  
T. 18 S., R. 27 W.,  
All those portions above MHT, Shelikof Strait  
T. 16 S., R. 28 W.,  
All those portions within Katmai National  
Monument  
T. 17 S., R. 28 W.  
Tps. 18 & 19 S., R. 28 W.,  
All those portions above MHT, Shelikof Strait  
T. 17 S., R. 29 W., S/2  
T. 18 S., R. 29 W.  
Tps. 19,20 & 21 S., R. 29 W.,  
All those portions above MHT, Shelikof Strait  
T. 17 S., R. 30 W., S/2  
Tps. 18,19 & 20 S., R. 30 W.  
Tps. 21 & 22 S., R. 30 W.,  
All those portions above MHT, Shelikof Strait  
Tps. 19 & 29 S., R. 31 W. .  
Tps. 21 & 22 S., R. 31 W.,  
All those portions above MHT, Shelikof Strait  
Tps. 19,20,21, & 22 S., R. 32 W.  
Tps. 20,21 & 22 S., R. 33 W.  
Tps. 21,22 & 23 S., R. 34 W.  
Tps. 22 & 23 S., R. 35 W.  
Tps. 22 & 23 S., R. 36 W.  
Tps. 22 & 23 S., R. 37 W.

Containing 842,000 acres, more or less

The Iniskin P.G.R.A. contains Iliamna volcano. The Iniskin penninsula has one well that has produced a high temperature salt brine at depth.

INISKIN, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

- T. 1 S., R. 21 W.,  
Sec. 19  
Sects. 30 to 31, inclusive.
- T. 2 S., R. 21 W.,  
Secs. 6 to 7, inclusive;  
Secs. 18 to 19, inclusive;  
Sects. 30 to 31, inclusive
- T. 3 S., R. 21 W.,  
Secs. 6 to 7, inclusive;  
Sec. 18.
- T. 1 S., R. 22 W.,  
Secs. 1 to 4, inclusive;  
Secs. 9 to 16, inclusive;  
Secs. 19 to 36, inclusive.
- T. 2 S., R. 22 W.
- T. 3 S., R. 22 W.  
All those portions above MHT, Chinitna Bay
- T. 4 S., R. 22 W., NW/4,  
All those portions above MHT, Chinitna Bay
- T. 1 S., R. 23 W., SE/4
- T. 2 S., R. 23 W., E/2
- T. 3 S., R. 23 W., NE/4, S/2
- T. 4 S., R. 23 W.,  
All those portions above MHT, Chinita Bay
- T. 5 S., R. 23 W., W/2
- T. 4 S., R. 24 W.,  
Secs. 10 to 15, inclusive;  
Secs. 22 to 27, inclusive;  
Secs. 34 to 36, inclusive.
- T. 5 S., R. 24 W.,  
All those portions above MHT, Iniskin Bay

Containing 149,000 acres, more or less

Augustine Island P.G.R.A. contains the volcano by the same name. The Island volcano intrudes the sediments of the Cook Inlet Oil province. Two state drilling permits have been applied for by Union Oil for geothermal energy.

AUGUSTINE ISLAND, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

- Tps. 9 & 10 S., Rgs. 24 & 25 W.,  
All those portions above MHT, Cook Inlet

Containing 27,200 acres, more or less

Mt. Redoubt P.G.R.A. contains the volcano by the same name.

MT. REDOUBT, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

T. 5 N., R. 19 W., W/2  
Tps. 4 & 5 N., R. 20 W.  
T. 4 N., R. 21 W., W/2  
T. 5 N., R. 21 W., W/2

Containing 80,366 acres, more or less

Mt. Spurr P.G.R.A. contains the volcano of the same name. Warm water is contained in the Caldera Lake.

MT. SPURR, ALASKA

SEWARD MERIDIAN, (Unsurveyed)

Tps. 13,14 & 15 N., Rgs. 16 & 17 W.

Containing 137,672 acres, more or less

Tolsona P.G.R.A. was designated because of the location of a mineral springs within its boundary.

TOLSONA, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 2 N., R. 3 W., N/2  
T. 3 N., R. 3 W., S/2  
T. 2 N., R. 4 W., N/2  
Tps. 3 & 4 N., R. 3 W.

Containing 80,068 acres, more or less

Platinum creek is designated perhaps because of its association with the Wrangell volcanoes.

PLATINUM CREEK, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 9 N., R. 12 E., E/2



T. 8 N., R. 13 E., E/2, NW/4  
T. 9 N., R. 13 E., W/2, SE/4  
T. 8 N., R. 14 E., W/2

Containing 57,227 acres, more or less.

The Wrangell Mountains contain three main volcanoes: Mt. Drum, Stanford, and Wrangell and three mud volcanoes (upper and lower Klawasi and Shrub, associated with Mt. Drum. Thermal springs are associated with the caldera of Mt. Wrangell.

WRANGELL MOUNTAINS, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 3 N., R. 1 E.  
T. 4 N., R. 1 E.,  
    Secs. 1 to 3, inclusive;  
    Secs. 10 to 15, inclusive;  
    Secs. 19 to 36, inclusive.  
T. 2 N., R. 2 E.,  
    Secs. 1 to 18, inclusive.  
T. 3 N., R. 2 E.  
T. 4 N., R. 2 E.  
T. 5 N., R. 2 E.,  
    Secs. 19 to 36, inclusive.  
T. 2 N., R. 3 E.,  
    Secs. 1 to 18, inclusive;  
    Secs. 22 to 27, inclusive;  
    Secs. 34 to 36, inclusive.  
Tps. 3, 4, & 5 N., R. 3 E.  
T. 6 N., R. 3 E., SE/4  
T. 1 N., R. 4 E., E/2, NW/4  
Tps. 2, 3, 4, 5, & 6 N., R. 4 E.  
T. 7 N., R. 4 E., SE/4  
Tps. 1, 2, 3, 4, 5, 6, & 7 N., R. 5 E.  
T. 8 N., R. 5 E., S/2, NE/4  
Tps. 1, 2, 3, 4, 5, 6, 7, & 8 N., R. 6 E.  
T. 9 N., R. 6 E., S/2  
Tps. 1, 2, 3, 4, 5, 6, 7, & 8 N., R. 7 E.  
T. 9 N., R. 7 E., S/2  
Tps. 1, 2, 3, 4, 5, 6, & 7 N., R. 8 E.  
T. 8 N., R. 8 E., S/2, NW/4  
Tps. 1, 2, 3, 4, 5, & 6 N., R. 10 E.  
T. 7 N., R. 10 E., S/2  
Tps. 1, 2, 3, 4, 5, & 6 N., R. 11 E.  
T. 7 N., R. 11 E., S/2  
Tps. 1, 2, 3, 4, 5, & 6 N., R. 12 E.  
T. 7 N., R. 12 E., SW/4  
Tps. 1, 2, 3, & 4 N., R. 13 E.

T. 5 N., R. 13 E., W/2  
T. 1 N., R. 14 E.  
T. 1 S., R. 5 E., NE/4  
T. 1 S., R. 6 E., N/2  
T. 1 S., R. 7 E., NW/4  
Tps. 1 & 2 S., R. 10 E.  
Tps. 1 & 2 S., R. 11 E.,  
T. 3 S., R. 11 E., N/2  
Tps. 1 & 2 S., Rgs. 12 & 13 E.  
Tps. 1 & 2 S., R. 14 E.  
T. 3 S., R. 14 E., N/2  
Tps. 1 & 2 S., R. 15 E.  
T. 3 S., R. 15 E., NW/4  
T. 1 S., R. 16 E.  
T. 2 S., R. 16 E., N/2

Containing 2,165,159 acres, more or less.

Twelvemile Creek P.G.R.A. is designated by the fact that there is a reported Hot Springs there.

TWELVEMILE CREEK, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 12 S., R. 16 E., E/2  
T. 11 S., R. 16 E., SE/4  
T. 11 S., R. 17 E., S/2  
T. 12 S., R. 17 E.

Containing 51, 769 acres, more or less.

TABLE IV -Southcentral Region  
MAGNITUDES AND HEAT CONTENTS OF IDENTIFIED VOLCANIC SYSTEMS

(U.S.G.S. Circulation #726 - White, 1975)

NAME OF AREA	LAT.	LONG.	COMPOSITION LAST ERUPTION	AGE DATA	CHAMBER AREA Km <sup>2</sup>	CHAMBER VOLUME RANGE Km <sup>3</sup>	CHAMBER VOLUME V <sub>B</sub> Km <sup>3</sup>	SOLID- IFICATION STATE °C	$\Delta Q$ TOTAL CALORIES X 10 <sup>18</sup>	$\Delta Q$ NOW CALORIES X 10 <sup>18</sup>	$\Delta Q$ OUT CALORIES X 10 <sup>18</sup>	REMARKS
KUKAK	58°27'N	154°21'W	No Data	Active?								No Data
DEVILS DESK	58°29'N	154°17'W	No Data	No Data								No Data
KAGUAK	58°37'N	154°05'W	Silicic	<10 <sup>4</sup> ?	4.1 A <sub>C</sub>	10-40 V <sub>C</sub>	>15	>650	9	9	9	Need Age Data
FOURPEAKED	58°47'N	153°42'W	No Data	<10 <sup>4</sup> ?								No Data
DOUGLAS	58°52'N	153°33'W	No Data	Active?								No Data
AUGUSTINE	59°22'N	153°25'W	Silicic	Active								Need Geo- physical Data?
ILIAMNA	60°02'N	153°06'W	Basic	Active								>10KM Depth
REDOUBT	60°28'N	152°45'W	Basic	Active								>10KM Depth
DOUBLE	60°44'N	152°35'W	No Data	No Data								No Data
BLACK	60°51'N	152°25'W	No Data	No Data								No Data
SPURR	61°18'N	152°15'W	Basic	Active								Caldera? Need More Data
DRUM	62°07'N	144°38'W	Silicic	<1.8x10 <sup>5</sup> T <sub>ys</sub> 1.8x10 <sup>5</sup> T <sub>s</sub> 140 A <sub>v</sub> 5x10 <sup>5</sup> T <sub>B</sub>		350-1400 V <sub>v</sub>	400	>650?	230	~200	>100	
SANFORD	62°13'N	144°07'W	No Data	<3.5x10 <sup>5</sup> T <sub>B</sub>								Need data on parasitic vents high on flanks of Sanford(inacces- sible?)
WRANGELL	62°00'N	144°01'W	Basic?	Active >1.7x10 <sup>3</sup> T <sub>C</sub>	15 A <sub>C</sub>	37.5-150V <sub>C</sub>	50	>850	29	29		
WHITE RIVER	61°27'N	141°28'W	Silicic	15x10 <sup>3</sup>		80 V <sub>FE</sub>	80	>650	46	46		
MARTIN	58°09'N	155°24'W	Basic?	Active								>10KM Depth?
MAGEIK	58°12'N	155°15'W	?	Active								Silicic Domes? Need More Data
NOVARUPTA	58°17'N	155°10'W	Silicic	Active	8.1 A <sub>C</sub>	20-80V <sub>C</sub>	50	>650	29	29		
MT. GRIGGS (KNIFE PEAK)	58°20'N	155°08'W	Basic?	Active								>10KM Depth?
TRIDENT	58°14'N	155°07'W	Basic	Active								>10KM Depth?
KATMAI	58°16'N	154°59'W	Basic	Active	8.1 A <sub>C</sub>	20-80V <sub>C</sub>	>20	>850	12	12		
SNOWY	58°20'N	154°41'W	No Data	No Data								No Data
DENISON	58°25'N	154°27'W	No Data	No Data								No Data
STELLER	58°26'N	154°24'W	No Data	No Data								No Data

SITE: Katmai

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: Apx. 58° 30' N 155° 00' W

QUADRANGLE: Mt. Katmai

BARRIER: National Monument/Remote

RECOMMENDATION: Use by National Park Service for balneologic applications

DESCRIPTION:

There are two springs within the boundaries of Mt. Katmai PGRA (842,000 acres)(340,757 Hectares) and one spring along the north border just outside the PGRA.

One spring is located near Katmai Pass. The pass lies between two volcanoes, one scarcely eroded (Mt. Trident) and the other (Mt. Mageik) is furrowed but carries no glaciers. Below the pass on the Katmai side, streams of very hot water burst out of the ground in many places and, joining together form a considerable stream. This water contains much sulferated hydrogen and makes copious precipitates of iron and sulfur. The earth is altered in the area to a brilliant yellowish red. A report since this original one indicates that a crater was opened near these springs and they were buried by volcanic material during the 1912 eruption of Katmai. (Waring 1917)

The second area of springs are located near Mount Katmai including those in the Valley of Ten Thousand Smokes. (Waring 1917) These springs and fumeroles are associated with and were affected by the eruption of Mt. Katmai in 1912. Many of the fumeroles and some of the springs have ceased with the subsidence of volcanic activities associated with the 1912 volcanic eruption.

The third spring is located on the west fork of the Douglas River, 25 miles west of Cap Douglas. The flow is large but unlike the other springs these are related to the Jurassic Strata in the area. (Waring 1917)

This PGRA contains 14 active or dormant volcanoes. The rock type is Tertiary to Quaternary Andesites, Basalts and Pyroclastics. In the area around Cape Douglas the volcanic rocks have been extruded through and over Cretaceous sediments.

## SOCIO-ECONOMIC:

The bulk of the PGRA is located within Katmai National Monument. The spring in the Cape Douglas area is located in the new addition to the Katmai National Monument authorized by the December 1, 1978, P.L.O. 5654. State land selections have been made in the area. It is possible that exact location of the springs, when determined, might be on these lands.

There are no population, transportation, or facilities near the Katmai Pass and Cape Douglas locations. The Katmai spring area has an airstrip and park facilities fairly close. The use of the geothermal energy could become a reality with additions to the spartan facilities at the National Monument.

## ENVIRONMENT: EXTRACTED FROM SOUTHCENTRAL REGIONAL PROFILE

The summer temperatures in the monument average 37° to 65°F (3° to 18°C) Winter 5° to 28°F (-15 to -6°C) Extremes of -28° and 90°F (-33° and 32°C) have been recorded. Precipitation averages 15" per year. Mean annual runoff averages about 4 ft<sup>3</sup>/sec/mi<sup>2</sup>. Average Annual Heating Degree Days equal 11500.

The flora is transitional from the coastal western hemlock sitka spruce forest at the coast through high brush to alpine tundra at the high elevations. Moose and bear abound in this area. Mountain sheep, goats, bald eagles, peregrine falcons, marine mammals, and migratory waterfowl are found in significant numbers.

Volcanic and seismic activity is very high and presents associated environmental hazards.

CONTACTS: Chief Ranger, Katmai National Park (U.S.P.S.)

REFERENCE: Waring (1917); USGS Publication MF-372; South Central Regional Profile.

## CAPITAL SITE

In recent years, the citizens of the State of Alaska voted to move the state capital to a site near Willow from the present one at Juneau. Willow is located at Mile 70 along the Parks Highway, north of Anchorage (30 miles by air).

Numerous studies have been conducted by the State to determine the safest and cheapest energy source for possible development at the site. The studies conducted by the State indicated that three elements must be incorporated into the design of the new city to achieve the highest degree of energy efficiency:

1. A policy concomitant with energy conservation measures;
2. Sufficient control over development to require observance of energy conservation policy; and,
3. Inclusion of district heating and cogeneration elements in the community design.

The eventual design incorporated these concepts for a city of 30,000 people, based on "business as usual" in Southcentral Alaska. By 1994, the new capital will require 1.6 trillion Btu's per year for building space heat. The designed cogeneration plant would provide about 67.5% of the annual energy requirements. The remaining increment falls into two categories.

First, heat produced by the cogeneration plant can only be economically delivered to areas of fairly dense development (about 8,000 sq. ft. of buildings per acre minimum). The low density residential development is excluded from using this energy source. This fraction amounts to about 25% of the total heat consumption.

Second, it is uneconomical to build a coal fired plant so large as to serve the peak thermal demands of the community. Cheaper, oil fired "district heating plants" are most effectively used for serving peak demand requirements. Thus, a fraction of peak heating energy equal to about 10% (7.5% of the total annual community use) of the total served by this system will be generated by the district heating plants.

These designs have not considered geothermal energy. Since the present plan is based on energy economics, the Oregon Institute of Technology did a cost analysis of utilizing the local gradient heat source in the capital site to replace the space heating requirements of the cogeneration facilities.

The study was based on the logs of the Red Shirt #1 well drilled by Hill Productions. The bottom hole temperature of the well was 170 degrees f. (76 degrees C), 2,050 feet from the surface. This is roughly three times the world normal gradient mean (115 degrees C/km).

The interpretation of the logs indicate the top of an igneous rock sequence is picked at 1,840 feet in hole depth. The lithology suggests that the rock is intrusive subject to a considerable period of weathering. Overlaying this igneous complex is a Tertiary section

containing some sandstones. A Quaternary glacial crust rim complex of relative shallow depth lies across the Tertiary sequence. This well is the only abnormally high heat flow well in the immediate area. Perhaps this is because it is the only well in the area north of the Castle Mountain fault and therefore the only well to encounter the crystalline intrusive previously mentioned.

The calculations were made using certain assumptions:

1. The geothermal system could compatibly fit into the existing heating system.
2. Wells drilled would produce 500 g/m.
3. The thermal gradient increases at a constant rate to depth.
4. Geothermal wells would be drilled at the Red Shirt #1 site which would need a 10-13 km pipeline. (It is possible that the wells could be drilled on the capital site, but this was not considered.)
5. A heat exchanger system would be utilized. (It is possible that the water could be pure enough to exclude this requirement.)

Five options were considered:

- Option #1: Geothermal wells would be drilled to a depth of 2,750' which would produce geothermal fluids at 200 degrees F at a rate of 20,000 g/m to supply 500 x 10<sup>6</sup> Btu/m with heating district output water temperature at 140 degrees F.
- Option #2: Geothermal wells would be drilled to 2,050' which would produce 170 degrees F water at a rate of 25,000 g/m. This water would be peaked with the fossil fuel plant to 200 degrees F producing 500 x 10<sup>6</sup> Btu/m. Output temperature would be 140 degrees F.
- Option #3: Geothermal wells would be drilled to 2,750' producing 12,500 g/m at 200 degrees F. The heating system would be changed to maximize the Delta-T across the heat exchanger, lowering output water to 110 degrees F instead of 140 degrees F.
- Option #4: Geothermal wells would be drilled to 2,050' producing 16,700 g/m at 170 degrees F. The district heating system would be modified to maximize the Delta-T across the heat exchanger lowering the output temperature to 110 degrees F instead of 140 degrees F.
- Option #5: Geothermal wells would be drilled to 2,050' producing 9,300 g/m at 170 degrees F. The fluids would be peaked to 200 degrees F. The district heating system would be changed to maximize the Delta-T across the heat exchangers with a system heating output temperature of 110 degrees F.

Each of these options has a payback period of less than 7 years. Option #3 and #5 seem most economical with about a 3 year payback in fuel savings alone.

The scenario construction is based on a shortest time frame possible. This time frame is provided by the capital study. At this time, there is no guarantee that any of the exploration money will be approved to determine if the postulated flow and temperature values can be found. It is, however, speculated that the economics are sufficiently attractive to have officials want to explore the matter further. The University of Alaska does plan to do some resistivity studies and perhaps seismic in the area.

The cogeneration plant is the single most environmentally hazardous element of the entire Capital Site Committee's planned development. Serious environmental impacts will result from the mining, transporting and burning of the coal. Geothermal utilization becomes much more attractive when these environmental considerations are placed in the equation.

This cursory study indicates that elimination of the large cogeneration plant and one of the two district oil peaking plants would maximize the economics of geothermal direct heat applications at the capital site.

Ten percent of the peak heating load would be supplied by the remaining oil fired district peaking plant. This corresponds favorably with the models designed and implemented in Iceland.

If the granitic rocks do not provide the necessary flow rates, hot dry rocks technology might be utilized. Los Alamos officials indicate that demonstration projects are in the offing and this would fit nicely into the scenarios developed for this site.



## SITE DATA SUMMARY

SITE: CAPITAL SITE

### ..Physical Reservoir Data

#### ..Temperature

Bottom hole temperature Red Shirt #1, 170°F (77°C) at 2050' (625 m)

#### ..Total Dissolved Solids (PPM):

#### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

#### ..Type of Overlaying Rock:

#### ..Estimated Depth to Top of Reservoir (meters):

### ..Site Land Status

#### ..Total Acres

100 square miles of state lands surround the capital site. Numerous acres of borough and private lands surround the capital footprint to the west, south and north.

#### ..Total Acres Leased

### ..Geothermal Development Status: None

### ..Local and State Attitude Toward Geothermal Development:

Imperative to explore the potential

### ..Land Use and Population:

Present population apx. 400 - used for recreation and agriculture.

### ..Comments and Critical Issues:

Local gradient south of the Castle Mountain Fault is lower than the world norm.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: CAPITAL SITE

### ..Latitude: 61° 42' N

### ..Longitude: 149° 45' N

..Rectilinear: T18N R3W SM Anchorage Quadrangle (Wellsite)

..County: Mat-Su Borough

..Adjacent Counties: Anchorage Borough

..Topography

Located on the Foothills of the Talkeetna Mountain Range at the Junction of the Susitna and Matanuska Valleys. The area has been glaciated and is gently rolling with dendritic drainage to the west away from the Talkeetna Mountains.

..Present Land Use:

Agricultural and Recreational. Presently the town of Willow is located at mile 70 Parks Highway. The population of the town and the surrounding area is about 400 people.

..Future Land Use Plans:

The State Capital is mandated to move to a 100 square mile area here by the year 1981 under a referendum passed in 1974. The projections now being followed are that a 30,000 + person city will be developed by 1991. (Background Reports Capitol Committee)

..Aesthetics:

Nancy Lake State Park is located to the west indicating the unique natural environment.

..Historical/Archaeological Significance:

The Willow Creek Mining District is located in Hatcher Pass within the Talkeetna Mountains. This was the site of the largest Alaskan hard rock mining operation south of the Alaska range. The Hatcher Pass and Willow areas were staked out in the late 40's and early 50's by homesteaders. Access at that time was by way of the Alaskan Railroad. Little archaeological investigation has taken place.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: CAPITAL SITE

..Geologic Description:

The surface geology of the major portion of the Susitna Valley is Glacio/acustrine of Quaternary time period.

Drilling indicates that the subsurface consists of a Tertiary sedimentary sequence which has some coal bearing strata. In Cook Inlet itself, this sequence produces both oil and gas. Underlying this is a Jurassic to Cretaceous meta-sediment sequence.

The Capital site is north of the Castle Mountain fault which is an east-west trending technologically important fault system. The south side of the fault has a deep sedimentary section while north of the fault has a relatively thin Tertiary section overlaying granitic intrusives.

The Talkeetna Mountains to the east are Jurassic to Tertiary igneous intrusives. (Capitol Comittee Background Report)

..Geophysical Summary:

Exploration has been conducted by oil companies in the vicinity.

..Geologic Hazards:

Seismic activity and volcanic activities are high in the Cook Inlet Basin.

RESERVOIR CHARACTERISTICS

SITE: CAPITAL SITE

..Reservoir Temperature

..Surface:

Bottom hole temperatures of the Red Shirt well 6 miles (9.6 km) from the site indicated a BHT of 170°F (76°C) at 2050' (625 M) (Red Shirt Well Log)

..Subsurface:

..Geochemical

SiO<sub>2</sub>: None

Na-K-Ca:

..Flow Rates:

..pH:

..Total Dissolved Solids: N/A

..Fluid Chemistry:

..Estimated Non-electric Energy Potential (MBtuh 30 years):

$1.44 \times 10^{12}$  BTU/year

..Subsurface Area of Reservoir:

#### LAND OWNERSHIP AND LEASING

SITE: CAPITAL SITE

..Land Ownership:

The land in the capital site is owned by the State of Alaska private and Borough lands are found in the immediate vicinity. Red Shirt #1 is located on State lands. Private lands lie between Red Shirt lands and Capital Site.

..Land Leased

..Highest Priced Leases (Dollars/Acre)

..\$/Acre - Lessee

..Tentative Lease Sale Dates:

..Number of Sales Offered But No Bids:

..Number of Bids Rejected (Resulting in No Lease):

..Summary of Leasing Status and Needs:

#### GEO THERMAL DEVELOPMENT STATUS

SITE: CAPITAL SITE

..Present Development Status:

Initial environment data has now collected for the proposed capital site. Shallow water well drilling is proceeding through November and December of 1978. No geothermal exploration has been initiated.

..Projected or Planned Development:

Central State employees are assumed to move to the new capital from 1982 through 1994. Federal and private sector basic employment should build slowly during the first years of the move. By 1994 the projected population would be over 30,000 people in the 100 square miles of land known as the Capital footprint. There are presently no facilities built or under construction that are

associated with the new capital city design as provided by the new capital city planning process. The siting construction and occupancy of this city will truly be a monumental task to complete in 16 years.

The downtown heating district as outlined by the commission could be easily adapted to geothermal use. Exploration should begin immediately to determine if the potential exists for geothermal space heating. Over the next two years a well should be drilled to determine the extent of any resources.

#### INSTITUTIONAL CONSIDERATIONS

##### SITE: CAPITAL SITE

(Extracted From Capital Committee Background Reports)

##### ..Institutional Requirements:

This construction would be done on State lands. A cadre of state permits and legislative approval would be necessary to develop geothermal resources. Drilling permits, right-of-way easements, capital site commission approval, Legislative approval State environmental Conservation and EPA approval would all be needed to develop.

The State Division of Geology and Geophysical surveys would have to approve and oversee exploration activities as well as Dept. of Natural Resources permitting for such activities.

Borough regulations will have to be followed for construction and easements.

All in all over forty (40) permits by some twenty (20) agencies will be required to erect the capital.

Voter approval is also required for bondable costs.

##### ..Agency and Public Attitudes:

Presently the greatest environmental impact to the new capital site construction is considered to be the proposed co-generation facilities using coal as a fuel. The elimination of this pollutant would meet with enthusiastic support if economically sound.

Recent studies have shown it would be economical if a resource is available. All concerned agencies would be supportive if a realistic chance of finding a resource is shown.

..Status of Requirements (i.e., EIA/EIS Requirements):

Initial environmental studies have been completed. Permitting schedules have been developed for all but the actual geothermal development.

Upon funding, the necessary permitting would be a rather minor portion of the scenario. All the environmental assessments should be completed by FY 1980 if funding were made available.

ENVIRONMENTAL FACTORS

SITE: CAPITAL SITE

(Extracted From Southcentral Regional Profile)

..CLIMATE

..Prevailing Winds: Low to moderate

..Precipitation (Annual): 24" (61cm)

..Days of Sunshine (Annual):

..Average Temperature:

Summer: 40° - 70°F (4° to 21°C)

Winter: -10° to 30°F (-23° to -1°C)

Minimum: -56°F (-48°C)

Maximum: 90°F (32°C)

..Degree Days (Annual): 11,000

..Relative Humidity (Seasonal Peaks): Low

Summer:

Winter:

..AIR QUALITY:

There are no man made sources of degradation at this time. Possible fuel oil and coal plants will be major emission sources. (Capitol Site Background Report 11)

..GEOLOGIC FACTORS: Castle Mountain Fault

..WATER QUALITY:

Two permanent streams in the area. Water quality is acceptable to State standards. Changes in water quality and flow will be major consideration during construction. Testing subsurface water at this writing (Report 11)

..NOISE:

Construction operations and equipment will be a major source of noise during construction of the Capital. The airport and roads will be the chief pollutants after construction. (Report 11)

..BIOLOGICAL:

..Dominant Flora:

Spruce, birch and willow dominate the hillsides. Muskeg bogs are found. (Capitol Committee Background Report 11)

..Dominant Fauna:

Moose, bear and some water fowl and fur bearing animals. Native and anadromous fish are found. (Report 11)

..Endangered Species

Flora:

Fauna:

TRANSPORTATION AND UTILITIES

CAPITAL SITE

..Utility or Energy Transmission Corridors and Facilities:

An existing transmission line passes through the site. A major new easement has been recently granted to connect the capital site with existing electrical grids near Wasilla. There will be further easements if the Susitna hydroelectric facility is built.

A major port facility is in the planning stages for the McKinze Point Arm.

..Transportation Corridors or Facilities:

The Parks Highway traverses the west boundary of the site. Hatcher Pass Road to the north side. No roads presently exist within the Capital goot print.

Numerous subdivision and homestead roads border the site.

..Other

The Alaska Railroad parallels the Parks Highway to the west.

Nancy Lake State Park is found to the west as well.

## POPULATION

### SITE: CAPITAL SITE

#### ..General Description of Population:

The Matanuska Susitna Valley is undergoing rapid growth. This is due to its relationship to Anchorage as a bedroom and recreational community.

The impact of the capital move will accelerate the expansion into this area. The Mat-Su Valley is already one of the fastest growing areas in the country experiencing as much as 40% growth per year as in the case of Wasilla.

It is projected that the population of the Matanuska-Susitna Valleys will increase from 20,000 to 140,000 people by 1990. To date, all population projections for this area have been underestimated.

#### ..Economics

##### ..Present Land Use:

Presently the Valley is a bedroom and recreational community for Anchorage, receiving most of its tax dollars from Anchorage residents. Government is the largest employer. New service and construction industries are joining agriculture as secondary economic bases.

##### ..Future Land Use:

The new capital will increase construction, and service segments of the economy. More than ever, however, the government will be the major employer. The cursory economic look completed by the Oregon Institute of Technology shows a very short pay back period for geothermal development. The Capitol Site Development schedules would not be significantly altered using geothermal energy.



## KLAWASI

The Wrangell Mountains of Interior Eastcentral Alaska comprises an area of approximately 35,000 square kilometers. Very recent volcanics make up the bulk of the Mt. Wrangell Massif. Mt. Drum stands at the west edge of the range 10 miles (16 km) to the east of Glenallen.

The geothermal potential of this area has been studied by the U.S.G.S. The estimated energy potential of Mt. Drum is  $230 \times 10^{18}$  cal. A resource this large with an estimated subsurface temperature of  $650^{\circ}\text{C}$  would allow for electrical production. The scenario is built around this assumption.

AHTNA Native Regional Corporation, in conjunction with Alaska Geological Consultants and Geonomics, Inc., developed a proposal for electrical production using the resource at Mt. Drum in 1975. This proposal has not been funded to date. The end user has not been truly determined, but with continued development of the pipeline corridor, the geothermal potential would appear to be useful within a decade if hydroelectric power is not developed.

The existing energy demands are presently fulfilled by diesel-generated electric power and liquid petroleum at a high cost to the consumer. Growth rates are moderate in this area with a developing agriculture area in the Chitna region.

The proposed site for geothermal energy development is located on Federal lands and lands selected by village and native regional corporations of the Ahtna region under terms of the Alaska Native Claims Settlement Act. The State has selected lands to the south of the site which could be used if the Federal lands are included in the proposed Wrangell-St. Elias National Monument.

The surface expression in the development area consists of three mud volcanoes. The Drum group consists of the Shrub Cone and the Upper and Lower Klawasi Cones. The crest of Mt. Drum is approximately 19 kilometers from the cones. The cones are elliptical in ground plan and drumlinoid in profile 45 to 90 meters high. Maximum diameter is 2.5 km, for the Lower Klawasi cone which is an area barren of vegetation and surrounded by white spruce forest.

The discharge of mineralized waters from the vents has not been measured since 1954. At that time the flow at the upper Klawasi Cone was estimated from 7.6 to 19 liters per minute issuing from two vents. Lower Klawasi Cone ranged from 19 to 38 liters per minute. Thermal waters and gas do not emanate at the crest of the shrub cone, but rather from the flanks. The flow ranges from 7.6 to 18.9 liters per minute. The temperature averages about  $30^{\circ}\text{C}$ .

Initially any development would begin with identification of the geothermal system. The U.S.G.S. has conducted surface investigations that should be published at this time by Tom Miller.

Subsurface investigations and deep well drilling operations to 1500 meters will need to be initiated prior to development.

Studies should be undertaken to determine the technical feasibility and economic realities of any such development. This will be dependent upon federal or state funding for the foreseeable future.

#### SITE DATA SUMMARY

##### SITE: KLAWASI

#### ..Physical Reservoir Data

##### ..Temperature °C

Surface: 30°C (AGC et al. 1975)

Subsurface: 650° (White 1975)

..Total Dissolved Solids (PPM): 30,450 (AGC et al. 1975)

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):  
230 x 10<sup>18</sup> cal (White 1975)

..Type of Overlaying Rock: Basalt (AGC et al 1975)

..Estimated Depth to Top of Reservoir (meters):

1500' (Miller personal communication)

#### ..Site Land Status

Located near Wrangell Mountains PGRA 2.2 million acres (89 million hectares)

##### Total PGRA Acres:

Federal: Approx. 90%

State: Approx. 3%

Private: Approx 7% Native

##### Total Acres Leased:

..Geothermal Development Status: None to date.

#### ..Local and State Attitude Toward Geothermal Development:

AHTNA Native Regional Corporation, Alaska Geological Consultants, Inc., and Geonomics of California have submitted a proposal to develop the geothermal resource for electrical generation.

#### ..Land Use and Population:

This is an isolated intermontane basin typical of interior Alaska presently.

..Comments and Critical Issues:

1. A bridge or power line would have to be built across the Copper River.
2. The site is very near or in a National Monument.
3. Competitive hydroelectric power might be feasible for the vicinity.
4. The demand is not there at this time.

SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: KLAWSI

..Latitude: 62° 03' 29N

..Longitude; 145° 13' 21W

..Rectilinear: Gulkana A-3 T3N R1E NE SE Sect 9 CRM  
T4N, R2E, Sect. 34

..County:

..Adjacent Counties:

..Topography

On the western flank of Mt. Drum in the Copper River Basin is a structural and topographic low in which the Copper River drains south into the Gulf of Alaska. Mt. Drum is the western edge of a massive strato volcanic pile that covers well over 2,000,000 acres. (AGC et.al. 1975)

..Present Land Use:

The mud volcanos/springs are presently unused.

..Future Land Use Plans:

The geothermal resource should be developed into a small capacity electrical generating plant (25 MW) with cascading uses of waste heat.

..Aesthetics:

Lofty ice covered peaks rim a meadowed blue sky basin drained by cascading rivers alive with salmon.

..Historical/Archaeological Significance: Unknown

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: KLAWASI

#### ..Geologic Description: (AGC et. al. 1975)

The tectonic framework of the Copper River Basin is dominated by east-west trending orogens that are concave to the south. The Wrangell massif of lavas rise on the underside of the east leg of the arch.

The regional aeromagnetic map of the Copper River Basin suggests that the Wrangell andesitic lavas underlie the mud volcanoes at relatively shallow depths. The magnetic data can therefore be interpreted to indicate the mud volcanoes are surface manifestations of a much more extensive subsurface heat source.

The area has been heavily glaciated. Volcanic debris from recent eruptions have repeatedly left ash, mud flows, and andesitic lava flows over the Mt. Drum area.

Site-specific studies have been conducted by Tom Miller of the U.S.G.S. which should be in print 1979.

#### ..Geophysical Summary: None to date.

#### ..Geologic Hazards: Volcanic/seismic and snowslides.

## RESERVOIR CHARACTERISTICS

### SITE: KLAWASI

#### ..Reservoir Temperature (AGC et. al. 1975)

..Surface: 30.8°C

..Subsurface: 650°C (White 1975)

..Geochemical

SiO<sup>2</sup>:

Na-K-Ca:

#### ..Flow Rates:

Upper Klawasi Cone 7.6 to 19.0 liters per minute. 19-38 liters per minute Lower Klawasi Cone. Shrub Cone 7.6 to 18.9 L.P.M. (A.G.C. 1975)

..pH: 7.7

..Total Dissolved Solids:

30,450 for NA, CL, C, SiO<sub>2</sub>, Boron (A.G.C. 1975)

..Fluid Chemistry:

Gases CO<sub>2</sub> 96.4% to 99.3% Nitrogen 3.6% to .4% (A.G.C. 1975)  
Upper Klawasi Mud Volcano

Water Analysis: Ph 7.1, Specific Conductance 32200. UMHO/CM

Solute Analysis (Water):

LI	7.9
MG	300
F	0.4
NA	10,000
CA	6.5
CL	11,000
K	240
B	140
SI02	53
S04	740
C03	360
HC03	6,970

Klawasi Group of Springs with Mud Cones - West Spring

Water Analysis: Ph 7.7, Total Dissolved Solids 27500.

Solute Analysis (Water):

LI	6.9
MG	136
NA	10,000
CA	31
CL	12,100
N03	17
K	271
B	169
P04	18
SI02	123
S04	664
HC03	7,230

Multiple Vents in Lower Klawasi Cone (Mud Volcano)

Solute Analysis (Water):

NA	9,390M
CL	12,200M
S04	666
HC03	290M

..Estimated Non-electric Energy Potential (MBtuh 30 years):

$230 \times 10^{18}$  cal (White 1975) For Mt. Drum

..Subsurface Area of Reservoir:

Chamber area Mt. Drum (White 1975)

140 km

km<sup>3</sup> 350-400

..References:

USGS Water Resources Spring Schedule, Anchorage: Nichols and Yehle, 1961, Mud Volcanoes in the Copper River Basin, Alaska., Geol. of the Arctic.

S-S Number:	A-84
Name of Area:	Drum
Latitude:	62° 07' N
Longitude:	144° 38' W
Composition Last Eruption:	Silicic
Age Data:	$1.8 \times 10^5$ Tys; $1.8 \times 10^5$ Ts; $5 \times 10^5$ Tb
Chamber Area Km <sup>2</sup> :	140 A <sub>v</sub>
Chamber Volume Range Km <sup>3</sup> :	350-400 V <sub>v</sub>
Chamber Volume V <sub>B</sub> , Km <sup>3</sup> :	400
Solidification State, C <sub>0</sub> :	650?
Total Calories x $10^{18}$ :	230
Now Calories x $10^{18}$ :	200
Out Calories	100

Remarks:

#### LAND OWNERSHIP AND LEASING

SITE: KLA WASI

..PGRA Land Ownership

Total area: 2,165,159 acres - Mt. Wrangell PGRA Portions of this land has been included in the national park system. AHTNA Native Corporation and the State has selected lands in the springs area. On December 1, 1978, President Carter designated 10.95 million acres as the Mt. Wrangell-St. Elias National Monument under authority of the Antiquities Act. (P.L.O. 5654) The exact legal description of the monument is not known but it can be assumed that a great deal of the PGRA was included.

..Land Leased: None

..Highest Priced Leases (Dollars/Acre)

..\$/Acre - Lessee

..Tentative Lease Sale Dates:

..Number of Sales Offered But No Bids:

..Number of Bids Rejected (Resulting in No Lease):

..Summary of Leasing Status and Needs:

No leasing at present - none planned.

#### GEOTHERMAL DEVELOPMENT STATUS

SITE: KLA WASI

..Present Development Status:

U.S.G.S. has conducted geologic investigations on the Mt. Drum area. AHTNA Native Regional Corporation has put together a proposal to develop the area for energy utilization.

..Projected or Planned Development: (A.G.C. et. al. 1975)

Infrared imagery to be flown

Subsurface exploration - drilling to 200 meters 3 holes

Deep well drilling - 1500 meters

Technical feasibility study

Development of energy resource that could produce some 25 mw by 1985.

No development is expected until the turn of the century.

#### INSTITUTIONAL CONSIDERATIONS

SITE: KLA WASI

..Institutional Requirements:

A whole cache of permits will be necessary before development will be complete. An EIS will have to be completed. Exploration and drilling permits will be required on State and Federal Lands. Drilling permits will be required on Indian lands until they obtain patent.

..Agency and Public Attitudes:

This project was jointly sponsored by AHTNA Regional Corporation and two private companies. They planned on heavy participation by

federal and state agencies. There are currently studies being completed by the U.S.G.S. and the University of Alaska. Some consideration must be given to the proximity to the Mt. Wrangell-St. Elias National Monument and the effect it will have on agency and public attitudes.

..Status of Requirements (i.e., EIA/EIS Requirements)

Land is still under BLM control but has been selected by AHTNA Regional Corporation. Title transfer not completed.

ENVIRONMENTAL FACTORS

SITE: KLawasi

..CLIMATE (Extracted From A.G.C. et. al. Proposal, 1975)

..Prevailing Winds:

..Precipitation (Annual):

24.8 centimeters including 107.7 centimeters of snow.

..Days of Sunshine (Annual):

..Average Temperature:

Summer: 39° to 69°F (4° to 21°C)  
Winter: -22 to 38°F (-30° to 4°C)  
Minimum: -58.9°C  
Maximum: 30°C

..Degree Days (Annual): 13500 Approx.

..Relative Humidity (Seasonal Peaks)

Summer:  
Winter:

..AIR QUALITY: Good. Possible inversions.

..GEOLOGIC FACTORS: Seismic/volcanic related slide activities.

..WATER QUALITY:

Two miles to Copper River. Major drainage in dendritic 1/2 mile further to any of cones from Klawasi Creek. No water rights filed for.

..NOISE: No noise pollution.



..BIOLOGICAL:

..Dominant Flora:

High brush, white spruce forests, some hardwood forests.

..Dominant Fauna:

Moose, caribou, brown and grizzly bear denning area. Mountain sheep and goats.

TRANSPORTATION AND UTILITIES

SITE: KLAWASI

..Utility or Energy Transmission Corridors and Facilities:

Copper Valley Utility: 8 Miles (13 km) Have to cross Copper River.

..Transportation Corridors or Facilities:

Valdez Highway: 6 Miles (10 km) Have to cross Copper River  
Alaska Highway: 12 Miles (19 km) " " " "  
Glenn Highway: 12 Miles (19 km) " " " "

..Other:

Trans Alaska Pipeline: 14 Miles (22 km) Federal State Utility Corridor

POPULATION

SITE: KLAWASI

..General Description of Population:

Minimal employment opportunities, partial subsistence economy. Governmental agencies and projects provide most of the cash economy. Less than 12,000 population. Pipeline construction had major impact on this area which now suffers from post construction adjustment. Transportation hub. Agricultural communities and religious communes have developed here.

..Economics:

..Present Land Use:

Agricultural, trapping and fishing, tourism and transportation.

..Future Land Use:

Same with increasing use of agriculture. Light manufacturing envisioned if cheap energy were available.

SITE: 12 Mile (Barkley)

RESOURCE: Hot Springs (Waring 1917)

LATITUDE & LONGITUDE: 60° 50' N 142° 25' W Approximately

QUADRANGLE: Bering Glacier T12S R17E CRM Approx.

BARRIER: Possible inclusion in National Park/Remote

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Twelvemile Creek PGRA 51,769 acres (20,951 Hectares).

Prospector James Barkley, in 1906, found a small stream of heated water beside Twelvemile Creek. On revisiting the same place in 1913, he could find only a small area of warm mud at the site. (Waring 1917)

This part of the Wrangell Mountains has considerable Andesitic Volcanics. Altered sediments of Paleozoic age are intruded by Granitic rocks in the springs area.

SOCIO-ECONOMIC:

The land in this area is being considered for inclusion in the National Park system under terms of the Native Claims Settlement Act Provision (d)(2). The spring appears to have been included in Wrangell-St. Elias National Monument, December 1, 1978, by Public Land Order 5654, by authority of the 1906 Antiquities Act.

There are no population, transportation or facilities in this area. Economic mineral deposits have been found and mined to the northwest.

This region is one of the most inaccessible regions of Alaska and there is little chance in the near term for any geothermal application being utilized. The extent of the resource is not known and any future activities associated with this resource should concern itself with exploration.

ENVIRONMENT: EXTRACTED FROM SOUTHCENTRAL REGIONAL PROFILE

The nearest climatological recording station is McCarthy 50 miles (80 km) to the Northwest. Summer temperatures average 38° to 71°F (3° to 22°C) Winter -30° to 38°F (-34° to 3°C). Extremes of -57° and 87°F (-49° and 30°C). Precipitation averages 16" (40 cm) with 68" (172 cm) snow. The springs are higher in elevation and closer to the coast than McCarthy.

The dominant flora of this area is high brush grading to alpine tundra at higher altitudes. There are Dall sheep and mountain goats in this area as well as some caribou and moose.

The area is subject to permafrost and heavy run-off during break-up. Extensive glaciers and ice fields dominate this area.

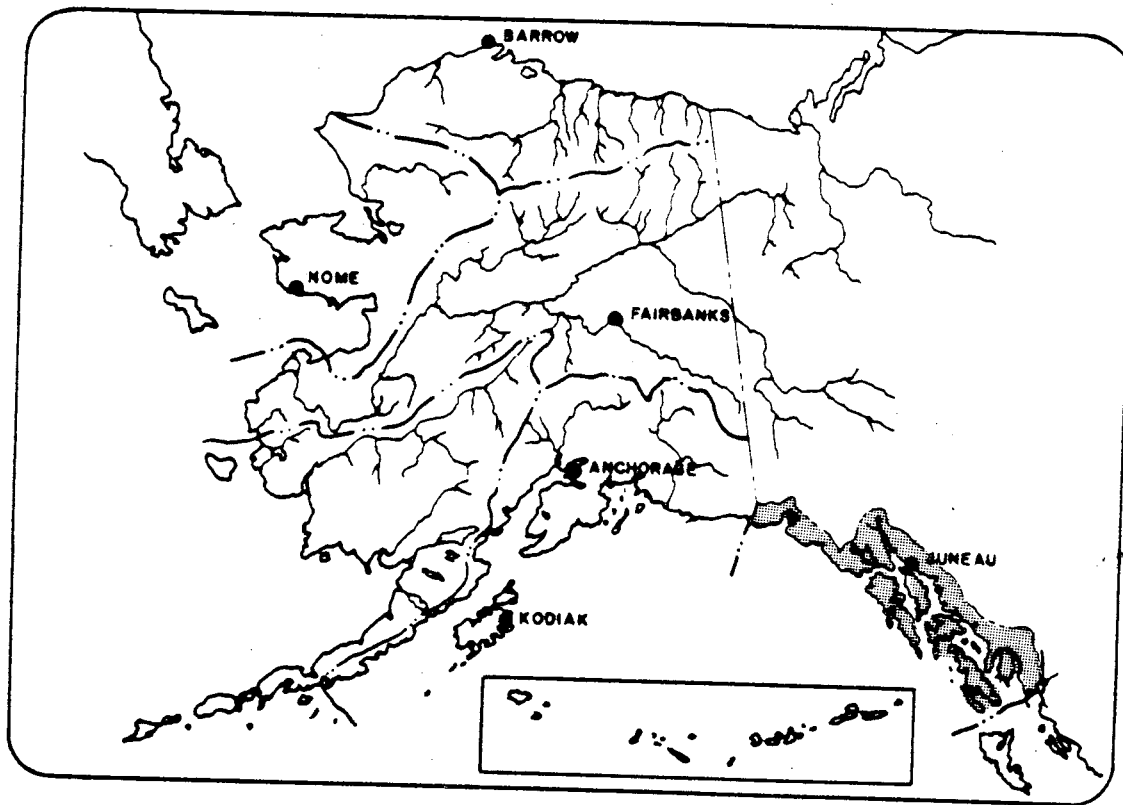
Key Contact: B.L.M.

REFERENCE:

Waring, 1917; South Central Profile; and Public Land Order 5654, Federal Land Policy Management Act, 1976.



## Southeast Region



## SOUTHEAST REGION

### EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The Southeast region is nearly 600 miles (966 km) along a narrow mainland and islands comprising the Panhandle of Alaska. It lies east of the 141 degree longitude and contains some 42,000 square miles (67,200 sq. km).

#### Climate

Strong marine influence is accentuated by the presence of the coastal mountain ranges. The combination results in an extremely high precipitation center, not only in coastal areas, but also inland. Storms and moderate to heavy precipitation occur year round; with heaviest concentration in the November to January winter season. Accumulations of 60" (152 cm) or more of snow is not uncommon in the northern latitudes. In the mountains, more than 200" (508 cm) fall, perpetuating the glaciers. Precipitation varies from 50-200" (127-508 cm) per year, depending on terrain and exposure.

Surface winds are moderate to strong throughout the area. Prevailing winds are generally south or southeasterly, except where local terrain alters the pattern, which can also produce isolated areas with strong winds.

The change in amount of daylight from summer to winter is not as great in Southeast Alaska as the rest of the state. Nautical twilight does, however, last all night to a varied degree for the whole region. Only one area in Southeast has recorded data on Langleys reaching the ground and that is Annette Island. The average daily measurement varied from 34 in December to 451 in June, averaging 224 for the year. Interestingly enough, the skies are overcast 62% of the time at Annette Island.

Southeastern local climate is affected by peaks, valleys, ridges and water. Areas covered by homogeneous climatic conditions can be as small as a city block. The coldest month is January; July is the warmest. In January, temperatures range from 30-40°F (-1 to 4°C) at Yakutat and 40-50°F (4 to 10°C) at Annette. The variations for summer are 50-60°F (10 to 16°C) at Yakutat and 60-70°F (16 to 21°C) at Annette. Heating degree days range from 7,000 in the south to more than 10,000 in the north.

In Southeast Alaska, a major means of transportation for people and supplies is by air, particularly in areas not served by the Alaska Ferry System. The frequent coastal storms, fog, and unpredictable winds make flying in this part of Alaska problematic at best.

Continuous pollution sources in Southeast Alaska include community utility plants, automobiles, home and office heating and lumber and pulp mills. If an inversion puts a lid on a pollutant's vertical dissipation, mountains surround it on three sides and limit the horizontal dispersal, and if the wind is blowing into the valley, a pollutant will

concentrate. Inversions probably occur in all parts of the region fairly frequently. Wind channeling should be considered an environmental hazard.

### Marine Environment

Approximately 30,000 miles (48,270 km) of tidal shoreline, roughly 63% of Alaska's total, forms an intricate pattern stretching from Dixon Entrance to Icy Cape. Nautically, the marine environment of Southeast is the most familiar in Alaska, although much of the coastline is still inadequately surveyed.

Seabottom features in the fjords, canals, and nearshore areas are similar to those on the adjacent land. Steep terrestrial inclines, narrow gorges, rugged ridges and a few plains continue beyond shoreline. The environment is characterized by numerous rocks and reefs surrounded by deep water and the absence of extensive shoals, except at the mouths of glacier fed streams.

Circulation in offshore waters begins with the north Pacific current. This branches in to the north counterclockwise flowing Alaska current, which flows through this region at a velocity of 1.5 knots. Tides average between 8-12 feet (2.4 to 3.7 m). In some funnel shaped inlets, however, the tides may reach 30 feet (9 m).

The marine waters of Southeast Alaska are usually considered ice free, floating patches of slush may form. Glacial ice is discharged directly into the waters by tidewater glaciers.

Water temperature in the Gulf of Alaska region follows a seasonal climatic trend of cool summers and mild winters. Average temperatures vary from 42°F to 57°F (23.6° to 31.6°C), winter to summer. The Gulf is also famous for its raging winter storms and their associated high sea states.

### Topography

Geologic processes operating within the last one million years have produced the majestic peaks, narrow valleys, inlet fjords, and offshore islands. During the Pleistocene, a great sloping sheet of ice completely buried the region. Presently, the glacial system of Southeast Alaska is in a period of overall retreat. Most major coastline indentions are fjords.

Along the north, the Gulf of Alaska coast is a narrow coastal plain less than 200 feet high. It is characterized by numerous outwash plains and belts of unsorted glacial material and marked by longitudinal beaches and dune ridges. One coastal feature of note is the Malaspina Glacier, the world's largest piedmont type. To the north of this plain lie the towering St. Elias Mountains, with a number of massives that rise over 14,000 feet (4,267 m), including Mt. Logan, second highest mountain in North America at 19,850 feet (6,050 m).



Barren ranges on a north-south axis dominate the mainland. They are a glacier covered upland. Fjords dissect it and the area is drained by glacial streams that are normally less than 20 miles (32 km) long.

Most of the island areas consist of north-northwest trending ridges with heavily glaciated features. There are interspersed lowlands, which are largely drowned, that interconnect the mountainous regions.

There has been some volcanic activity, as shown on Kruzof Island and its major expression, Mt. Edgecumbe.

### Geology

The Pacific Oceanic plate, presently being subducted beneath the Aleutian Islands and the Kodiak area, is being driven by an oceanic spreading ridge system in the Pacific to the southeast. Along the coast of Southeast Alaska, the Pacific plate is sliding by the North American plate at the rate of four centimeters a year along the Queen Charlotte Island-Fairweather Fault System. There are serious seismic considerations in the area, but not nearly as severe as the Aleutians.

In recent years, an attempt has been made to interpret what is known about Southeast's geology in light of plate tectonics. Generally, these features exist at converging plate margins where one plate is descending beneath another; a trench, an arc, characterized by volcanic activities, and a zone between the two known as the arc-trench gap. Each system produces distinctive rocks. The trench is filled with finely ground marine sediments, deposited in deep water. In Southeast, the trench feature is represented by a belt of slates and graywackes of late Paleozoic and early Mesozoic age found in the western portion of the region.

The arc of volcanic and intrusive materials is represented by a narrow, linear nearly continuous belt of rock that parallels the continental coast of Southeast Alaska. It is composed of thick deposits of middle Jurassic to middle Cretaceous sedimentary rock, with subordinate volcanics and intrusives.

The arc-trench gap is generally characterized by shallow water fossiliferous sediments deposited on continental shelf and upper continental slope, but its counterpart has not been identified in Southeast. The absence of this belt may be attributed to the emplacement of a fragment of continental crest, called the Alexander Terrace, which was transported northeastward in the late Mesozoic prior to the development of the arc-trench system. This crest fragment was above water and a source of sediment for adjacent troughs, which explains the absence of the arc-trench gap deposition (Berg, et. al., 1972). The development of the present landscape took place during the Quaternary; the two most active processes were glaciation and volcanism.

The dominant process of natural erosion and slope reduction in geologically youthful Southeast Alaska is mass wasting. Creep, earthflow, slump, rockfall and earthslides are all common and rather prevalent and must be considered in evaluation of any development.

Tsunamis are considered an environmental hazard due to the high seismicity, open exposure to the Pacific and channel-like fjords.

### Mineral Resources

Southeast has a long history of metallic mineral activities and production. The Mineral Industry Research Laboratory at the University of Alaska has compiled a table of all recorded mineral deposits in Southeast (Wolff and Heiner, 1971).

Few placer claims have been found and mined due to the heavy glaciation, however, lode claims have been widespread. Seventeen million ounces of gold have been taken from Southeastern mines so far, making it the leading mineral. Silver, copper, palladium, zinc, lead, tungsten and uranium have all been mined in commercial quantities.

Other minerals of commercial interest, found in Southeast Alaska, have been nickel, molybdenum, chrome, iron, titanium, platinum and bauxite. Non-metallic limestone, marble, barite, gypsum, asbestos, fluorite and mica are all found in abundance and have been studied for their commercial value.

### Petroleum

Southeast Alaska can be divided into three petroleum provinces. Moving from northwest to southeast, they are: The Gulf of Alaska Tertiary province, the Keku Island province and the Heceta Islands area. Many large seeps of oil are found in the Samovar Hills, near the north margin of Malaspina Glacier. However, no onshore well has produced commercial quantities of oil or gas. Recent drilling offshore at Icy Bay has been temporarily cut back for reevaluation of prospects as no commercial quantities of oil have been found.

Oil companies have been quite active in the area for twenty years. To the northwest, just outside of the province, the first commercial oil-field in Alaska was discovered at Katalla in 1902.

### Water

Southeast receives a great quantity of precipitation with mean annual runoff as high as 30 cubic feet per second per square mile. Because of this and the conductive terrain, there is a large hydroelectric resource available to the state. More than one-third of the power in the region is supplied by hydroelectric.

The Southeast Region has limited unconsolidated deposits, and groundwater supplies are often obtained from bedrock fractures. Many springs also issue from bedrock fractures.

Floods in Southeast, although rare, are usually the result of long, intense rainstorms and are associated with landslides. Some winter floods might be caused by ice jams.

## Terrestrial And Aquatic Vegetation

Southeast Alaska contains fewer major vegetation types than other Alaskan regions. Within these types, there are diverse plant and animal communities associated with physiographic environments. Because of the milder climate, the recovery time associated with regrowth is much quicker here than elsewhere in Alaska.

There are three major groupings of vegetation: coastal western hemlock and Sitka spruce forests, high brush, and alpine tundra. These are related to altitude and terrain. The area of most concern is the forests. This group can be broken into three subgroups: tree forests, grass-sedge meadows and muskeg. The tree forest is normally old growth, capable of producing trees 200 feet (61 m) high. The forest usually extends from sea level to about 3,000 feet (900 m) in elevation.

The aquatic communities can be divided into three categories: drifting microscopic (photoplankton), algae, and seed plants that are benthic, salt marsh seed plants. The natives have utilized some of these plants directly as food and for making baskets.

## Terrestrial Animals

The unbroken, dense, natural forests are a relatively poor habitat for most wildlife. Most wildlife are associated with breaks in the forest, be it muskeg meadow, streams or treeline. Moose, Sitka deer, black bear, wolves and associated carnivores range throughout the region.

Most birds, such as grouse, are associated with the forest. More bald eagles are associated with Southeast than anywhere in the world. Waterfowl are the predominant bird species. They occupy the extensive meadows of the Yakutat area. This is normally a nesting and feeding area for migration.

## Marine Animals

This group is not only more abundant, it has also been more utilized by man. Bottomfish, salmon, crustaceans, and fur seals have all been taken commercially. A wider variety, including ten species of whales, exists in this area. Sea lions, fur seals, otters and porpoises abound.

## Biotic Utilization

Subsistence use of animals is less important in the Southeast Region than elsewhere in Alaska, mainly because of the more complete conversion of rural residences to a cash economy that depends on commercial fishing and logging.

Sport hunting and fishing is a major regional activity, employing many guides. Commercial use of terrestrial animals is restricted to limited trapping.

Commercial fisheries harvests are conducted by both U.S. and foreign fishermen. The magnitude of each is about equal. Primarily, the

foreign boats are attracted to the bottomfish, such as mollusk. American fisheries concentrate on salmon. Pink salmon, by far, is most sought after. Halibut, shrimp, crab, abalone, lingcod, red snapper, etc. have all been commercially taken.

Marine algae were utilized by natives for consumption. Reeds were used to fashion fishing nets. Kelp has been commercially gathered in Southeastern.

The forest area of Southeast is estimated at 11,201,000 acres or 46% of the land area. Four million, seven hundred ten thousand are considered to be commercially valuable timber (8 mbf per acre). Approximately 87% is old growth timber. The first pulp mill was established in Ketchikan in 1954. Timber is now one of the largest industries in Southeast.

### History

There were two main native groups in the area, the Tlingit and Haida, before the initial European contact. It is estimated that 10,000 lived there at that time. Later migration of the third major group of natives, the Tsinshian, took place under the auspices of a white missionary.

Vitus Bering's crew visited the area in 1741, and this expedition triggered the great fur exploitation that continued over the next half century. Tlingit and Haidas were drawn into the world of commerce as competition became keen for furs in Southeast.

Lord Baranov moved the headquarters of Russian America to Sitka to exploit the resources. Ineffectual wars ensued with the natives, probably incited by outside elements. The Russian dominance in the area was tenuous throughout their occupancy. Despite this, Baranof Castle was erected at Sitka, and provided a frontier facsimile of St. Petersburg court life.

In 1867, America purchased the Alaska Territory. The first years of American control were extremely disorganized. Despite official neglect, various scientific expeditions were sent to investigate the area. In 1878, the first cannery and gold mine were established. These two commodities dominated the settlement patterns for southeasterners until long after the turn of the century.

Tourism began in 1884 by the Pacific Coast Steamship Company because of the beauty of Southeast. By 1889, five thousand visitors had been there.

American influence began in Southeast, and it was here that the seat of government was established by the persistence of Judge Wickersham, Alaska's Home Rule minded delegate to Congress in 1912. The idea of Statehood was debated in the Territorial steps at Juneau, and at present, the future of Alaska is still being determined in Juneau on a State level.

Southeastern, more than any other region in Alaska, has settled much of its land problems, probably because it is where the people came to grips with it earliest. It is one of the most stable areas in Alaska due to its maturity.

#### Population

The 1970 Census Report listed 39,472 people. Whites make up 71% of the population. The remaining 29% consists primarily of Natives.

#### Economy

Natural resources have traditionally been the mainstay of Southeast. The principal resources are marine, minerals, and forest products. Recent growth in state and local government has provided major sources of employment and stimulated the development of retail trade, transportation and construction. Government employees make up 33% of the work force in Southeast. The leading industries, in terms of total dollars worth to the region, are wood products, fisheries, tourism and mineral. If foreign fisheries are included, fisheries is the largest industry.

#### Lands

Ninety-five percent of the land is owned by the federal government, most of which is in the Tongass National Park. Under the Native Claims Settlement Act, Sealaska, the regional native group, will be entitled to 200,000 acres of land, which they have more than selected now. Each village gets 23,040 acres. The state has selected more than 1.4 million acres in Southeast.

#### Land Use

Community development has occurred only along the coast where topography has allowed for access and expansion of native village sites.

#### Transportation

Southeast is tied to the Alaska highway network through the Haines highway. None of the major communities are connected by roads and all transport is either by the Alaska Marine Highway Ferry System or aircraft. There is one railroad connecting Whitehorse and Skagway, a remnant of the mining era.

Air is the most diversified and used form of transportation in and out of Southeastern.

#### Communications

Southeast supports some seven newspapers and has many radio stations. RCA Alascom has installed microwave stations which, combined with earth stations, make up the permanent communications system in Southeast. Telephone service is provided for most communities at this time. The major centers enjoy TV transmission as well.

## GEOTHERMAL

Southeast Alaska has abundant geothermal resources. There are 23 reported Hot Springs localities in this part of the State. Numerous other springs are found to the east in Canada along the course of the Stikine River.

There are two recent volcanic areas found in Southeastern Alaska. One is located on Kruzof Island which is where Mt. Edgecombe volcano is found. Another is located on the Southeast side of Revillagigedo Island near Ketchikan.

Mt. Edgecombe appears to be the most recent in a line of Sea Mount volcanoes that extend in a NW-SE line across the Gulf of Alaska, chronologically younger to the Southeast. This suggests a hotspot origin in the mantle that burns through the moving Pacific Plate on its migration to the Aleutian Trench.

The occurrences of thermal springs on the south side of the Chatham Strait fault appear to be located along a trend. This trend can be projected underneath the continental block to the Pacific Plates North Pacific rise, where it appears to plunge under the southeastern Alaskan Archipilego. Quaternary volcanic eruptions centers are also located along this same trend in the Canadian Coast ranges (Forbes, 1974).

There are fifteen P.G.R.A.'s located in Southeastern Alaska. A great deal of potential for local gradient exist because of the suspected high heat flow of the area. With the tremendous stands of trees and the energy intensiveness of the forestry industry a natural mating might occur here.

Lituya Bay P.G.R.A. has one reported hot springs located within its confines: Lituya Bay hot springs.

### LITUYA BAY, ALASKA

#### COPPER RIVER MERIDIAN, (Unsurveyed)

T. 36.5 S., R. 46 E.

All those portions lying above MHT, Gulf of Alaska

T. 37 S., R. 46 E.,

All those portions lying above MHT, Gulf of Alaska

T. 36.5 S., R. 47 E.

T. 37 S., R. 47 E.,

All those portions lying above MHT, Gulf of Alaska,  
and Lituya Bay

T. 38 S., R. 47 E.

All those portions lying above MHT, Gulf of Alaska,  
and Lituya Bay

T. 37 S., R. 48 E.,

All those portions lying above MHT of Lituya Bay

T. 38 S., R. 48 E.,

All those portions lying above MHT, Gulf of Alaska  
T. 39 S., R. 48 E.,

All those portions lying above MHT, Gulf of Alaska

Containing 72,400 acres, more or less

The Chichagof-Yakobi P.G.R.A. has seven hot springs located within its confines and one along the south boundary. Mud Bay, Nika, Tenakee Inlet, White Sulfur, Lisinaski, Peril, Tenakee and Nylen on the south boundary.

CHICHAGOF-YAKOBI ISLANDS, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 44 S., R. 55 E.,  
All those portions above MHT, Lisianski Inlet  
T. 45 S., R. 55 E., E/2  
T. 46 S., R. 55 E.,  
All those portions above MHT, Gulf of Alaska,  
and Lisianski Strait  
T. 44 S., R. 56 E.,  
All those portions above MHT, Lisianski and Idaho  
Inlets  
T. 45 S., R. 56 E.,  
All those portions above MHT, Lisianski Strait,  
Lisianski Inlet and Stag Bay  
T. 46 S., R. 56 E.,  
All those portions above MHT, Lisianski Strait, Stag  
and Islas Bays  
T. 47 S., R. 56 E.,  
All those portions above MHT of the Pacific Ocean  
T. 42 S., R. 57 E.,  
All those portions above MHT, South Passage and Mud  
Bay  
T. 43 S., R. 57 E.  
T. 44 S., R. 57 E.,  
All those portions above MHT, Idaho Inlet  
Tps. 45 & 46 S., R. 57 E.,  
All those portions above MHT, Lisianski Inlet  
T. 47 S., R. 57 E.,  
All those portions above MHT, Portlock Harbor  
T. 42 S., R. 58 E.,  
All those portions above MHT, Icy Strait  
T. 43 S., R. 58 E.,  
All those portions above MHT, Mud Bay  
Tps. 44 & 45 S., R. 58 E.  
T. 46 S., R. 58 E.,  
All those portions above MHT, Lisianski Inlet  
T. 47 S., R. 58 E.  
T. 43 S., R. 59 E., SW/4

T. 44 S., R. 59 E.,  
     All those portions above MHT, Port Frederick  
 T. 45 S., R. 59 E.,  
     All those portions above MHT, Tenakee Inlet, and  
     Port Frederick  
 T. 46 S., R. 59 E.  
 T. 47 S., R. 59 E.,  
     All those portions above MHT, North Arm of Peril  
     Strait  
 T. 48 S., R. 59 E.,  
     All those portions above MHT, Patterson Bay  
 T. 44 S., R. 60 E.,  
     All those portions above MHT of Port Frederick  
 T. 45 S., R. 60 E.,  
     All those portions above MHT, Tenakee Inlet, and  
     Port Frederick  
 T. 46 S., R. 60 E.,  
     All those portions above MHT, Tenakee Inlet  
 T. 47 S., R. 60 E.,  
     All those portions above MHT, North Arm of Peril  
     Strait  
 T. 48 S., R. 60 E.,  
     All those portions above MHT, North & South Arms of  
     Peril Strait  
 T. 44 S., R. 61 E., N/2  
 T. 45 S., R. 61 E.,  
     All those portions above MHT, The Narrows, Port  
     Frederick  
 T. 46 S., R. 61 E.,  
     All those portions above MHT, Tenakee Inlet  
 T. 47 S., R. 61 E.,  
     All those portions above MHT, Seal and Saltery  
     Bays  
 T. 45 S., R. 62 E.  
 Tps. 46 & 47 S., R. 62 E.,  
     All those portions above MHT, Tenakee Inlet  
 T. 48 S., R. 62 E., N/2,  
     All those portions above MHT, Tenakee Inlet,  
     and Crab Bay  
 T. 46 S., R. 63 E.,  
     All those portions above MHT, Freshwater Bay  
 Tps. 47 & 48 S., R. 63 E.,  
     All those portions above MHT, Tenakee Inlet  
 Tps. 47 & 48 S., R. 64 E., W/2,  
     All those portions above MHT, Tenakee Inlet

Contains 705,000 acres, more or less

The Fish Bay P.G.R.A. was designated because of the Fish Bay Hot Springs.



FISH BAY, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 51 S., R. 62 E., SE/4,

All those portions above MHT of Rodman Bay

T. 52 S., R. 62 E., E/2

T. 52 S., R. 63 E., W/2

Containing 27,600 acres, more or less

The Baranof P.G.R.A. was designated because of Baranof Hot Springs which is located there.

BARANOF HOT SPRINGS, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 55 S., Rgs. 66 & 67, E.,

All those portions above MHT of various bays  
off of Chatham Strait

Containing 28,500 acres, more or less

The Kruzof Island P.G.R.A. was designated because of the presence of the dormant Edgcombe volcano and its surrounding recent volcanoes.

KRUZOF ISLAND, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

All of Magoun Island above MHT of Hayward Strait

All of those portions of Kruzof Island south of  
latitude 57°10'30" north, above MHT of Sitka  
Sound and the Pacific Ocean.

El Capitan P.G.R.A. was designated on the merits of a sulfur spring located along the shore on the east side of El Capitan Passage where it turns west.

EL CAPITAN PASSAGE, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 66 S., R. 78 E.,

All those portions above MHT of El Capitan Passage

T. 67 S., R. 78 E.,

All those portions above MHT of Tokeen Bay, Tenass  
Passage, and El Capitan Passage

T. 66 S., R. 79 E., W/2

Containing 67,000 acres, more or less

Goddard P.G.R.A. was designated on the basis of Goddard Hot Springs. The springs are also known as Sitka Springs.

GODDARD HOT SPRINGS, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

- T. 57 S., R. 64 E., SE/4,  
All those portions above MHT of Redoubt Bay
- T. 58 S., R. 64 E.,  
All those portions above MHT of various passages,  
bays, and inlets of Pacific Ocean
- T. 57 S., R. 65 E., NE/4, S/2
- T. 58 S., R. 65 E., NW/4,  
All those portions above MHW of West Crawfish  
Inlet

Containing 43,400 acres, more or less

Gut Bay P.G.R.A. contains a hot springs bearing the same name.

GUT BAY, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

- T. 59 S., R. 68 E., NE/4, S/2,  
All those portions above MHT of Chatham Strait
- T. 60 S., R. 68 E., NE/4, W/2,  
All those portions above MHT of Chatham Strait

Containing 26,450 acres, more or less

Zarembro P.G.R.A. was designated on the merits of two springs. Zarembro springs is located on the northwest corner of the island and is a carbonated springs with a temperature of 47°F (8°C) compared to 63°F (17°C) for the tidal water.

A second carbonated springs is located at the south end of the island near the shore.

ZAREMBRO ISLAND, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

- Tps. 63 & 64 S., R. 79 E.,  
All those portions above MHT of Sumner and  
Clarence Straits
- Tps. 63 & 64 S., R. 80 E.,  
All those portions above MHT of Sumner Strait
- T. 64 S., R. 81 E., W/2

T. 65 S., R. 81 E.,

All those portions above MHT of Clarence Strait

Containing 67,750 acres, more or less

Vank P.G.R.A. was designated because of the report of a hot springs on the island.

VANK ISLAND, ALASKA

COPPER RIVER MERIDIAN (Unsurveyed)

T. 62 S., R. 82 E.,

All those portions of Vank Island above MHT

Containing 2,920 acres, more or less

The Stikine River P.G.R.A. contains three hot springs to the west of Wrangell, West Shakes Springs and South Stikine. Twenty-eight more hot springs are located across the Canadian border along the course of the Stikine River.

STIKINE RIVER, ALASKA

COPPER RIVER MERIDIAN (Unsurveyed)

T. 60 S., R. 83 E.,

All those portions above MHW of Stikine River  
estuary

T. 59 & 60 S., Tgs. 84, 85 & 86 E.

Containing 137,580 acres, more or less

There are three hot spring locations within the Bell Island-Unuk River P.G.R.A.: Bailey Bay, Bell Island, and Unuk River. Boundary springs is located near the Canadian border and is carbonated. Just south of the P.G.R.A. along the Behm Canal is Barton-Saks Hot Springs.

BELL ISLAND-UNUK RIVER, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

T. 68 S., R. 89 E.,

All those portions above MHT of Bailey Bay, and  
Bell Arm

T. 68 S., R. 90 E.,

All those portions above MHT of Bell Arm, Anchor  
Pass, and Behm Canal

T. 69 S., R. 90 E., N/2,  
 All those portions above MHT of Behm Canal, Hassler  
 Pass, and other tidal waters  
 T. 67 S., R. 91 E., SE/4  
 T. 68 S., R. 91 E.,  
 All those portions above MHT of Anchor Pass,  
 Behm Canal, and Burroughs Bay  
 T. 66 S., R. 92 E., SW/4  
 T. 67 S., R. 92 E.,  
 All those portions above MHT of Burroughs Bay  
 T. 68 S., R. 92 E.,  
 All those portions above MHT of Behm Canal, and  
 associated bays.  
 Tps. 63 & 64 S., R. 93 E.  
 T. 65 S., R. 93 E., E/2  
 T. 66 S., R. 93 E., SW/4, E/2  
 Tps. 67 & 68 S., R. 93 E.  
 T. 69 S., R. 93 E., NW/4, E/2,  
 All those portions above MHT of Behm Canal  
 Tps. 63, 64 & 65 S., R. 94 E.  
 T. 66 S., R. 94 E., W/2  
 T. 69 S., R. 94 E.,  
 All those portions above MHT of Behm Canal  
 T. 65 S., R. 95 E., W/2

Containing 297,210 acres, more or less

New Eddystone P.G.R.A. was designated on the merits of the New Eddystone carbonated spring and the recent volcanics in the area.

#### NEW EDDYSTONE ROCK, ALASKA

##### COPPER RIVER MERIDIAN (Unsurveyed)

T. 73 S., R. 95 E.,  
 All those portions above MHT of Behm Canal  
 T. 74 S., R. 95 E., W/2,  
 All those portions above MHT of Behm Canal  
 T. 73 S., R. 96 E.,  
 All those portions above MHT of Behm Canal, Punchbowl  
 Cove, and Rudyerd Bay

Containing 36,610 acres, more or less

The Soda Bay Trocadero P.G.R.A. was designated because of a carbonated spring near Soda Bay and one at Trocadero Bay.

SODA BAY-TROCADERO BAY, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

- T. 75 S., R. 82 E., S/2,  
All those portions above MHT of Trocadero Bay
- T. 76 S., R. 82 E., N/2,  
All those portions above MHT of Soda Bay

Containing 19,660 acres, more or less

George Inlet contains one sulphur spring on Revillagigedo Island.

GEORGE INLET, ALASKA

COPPER RIVER MERIDIAN, (Unsurveyed)

- T. 74 S., R. 91 E., SE/4,  
All those portions above MHT of George Inlet
- T. 75 S., R. 91 E., NE/4
- T. 74 S., R. 92 E., Secs. 30 and 31,  
All those portions above MHT of George Inlet
- T. 75 S., R. 92 E.,  
Secs. 5 to 8, inclusive;  
Secs. 17 to 18, inclusive,  
All those portions above MHT of George Inlet

Containing 13,720 acres, more or less

SITE: Lituya Bay Resource

RESOURCE: Reported Hot Spring (Waring, 1917)

LATITUDE & LONGITUDE: 58° 43' N; 137° 31' W. Approx.

QUADRANGLE: T27S, R48E, CRM, Mt. Fairweather Quad.

BARRIER: Included in Glacier Bay National Monument

RECOMMENDATION: Locate spring and utilize as park facility.

DESCRIPTION:

Lituya Bay P.G.R.A., contains 72,200 acres (29,219 hectares). Lituya Bay is a fjord feature that trends northeast southwest and empties into the Gulf of Alaska. The embayment is partially blocked by a sandspit extending from the north shore. The structural trends in the area are northwest including the Fairweather Mountain range. Desolation Valley and Fairweather Fault which trend to the northwest from the head of Lituya Bay. The rocks to the east of the fault are those of the Fairweather Range and are Paleozoic in age. The main rock types are slate, phyllite, schist, gneiss and associated rocks of Pennsylvanian and Permian age. Granitic intrusions of Cretaceous and Tertiary age are a probable source of heat in the range. Some granitic intrusions are also found to the west of the fault on the northeast portion of the Bay. These hot springs are probably associated with these intrusions. On the west side of the fault a Jurassic Cretaceous sequence of greywacke, slate and minor conglomerate grades into a late Tertiary siltstone, sandstone, mudstone sequence to the southeast. Quaternary moraines and associated drift are found near the mouth of the bay. The coastal plane is associated with deposits of interlayered alluvial and marine sediments and glacial drift overlying the Tertiary sequence.

Desolation Valley is presently filled with North Crillon Glacier to the south and Lituya Glacier to the north which empty into the Bay.

SOCIO-ECONOMIC:

The entire P.G.R.A. is located within Glacier Bay National Monument which will preclude leasing under terms of the Geothermal Steam Act.

There are no permanent residents in the area and no facilities. Mineral potential exists in the Fairweather Mountain systems for nickel, copper, iron and titanium. Lode deposits have been identified at the southeast head of Lituya Bay.

The nearest logistical support center would be Yakutat approximately 100 miles (160 km) north. The probable center would be Juneau, approximately 130 miles (208 km) to the southeast. Transportation is by boat or air.

The monument is under the jurisdiction of the National Park Service. It is within the SeaAlaska Native Corporation Region.

Some park facility might be developed around the spring in the future.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Summer Temperatures range 44° to 59°F (7° to 16°C), winter 22° to 35°F (-6° to 2°C). Extremes approximately -10° to 80°F (-23° to 27°C). Precipitation approximately 65" (165 cm) including 100" of snow (254 cm). Heating degree days approximately 9,700\*.

Marine mammals are present along the coast in this area. Bald eagles use the area for nesting. Offshore there are known scallop, halibut and bottom fishery grounds.

The dominant flora in the area is that of the coastal western hemlock and Sitka spruce forest.

Special engineering considerations are required due to the seismicity in the area. During the 1964 earthquake, ice fell from the glacier and surged the bay drifting a fishing boat up and over the sand spit barrier into the open sea.

\*Authors Comment.

KEY CONTACT: Park Superintendent, Glacier Bay

REFERENCE:

Southeast Regional Profile  
Waring, 1917  
U.S.G.S. Map I-494

SITE: Nika

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 58° 03' N; 135° 45' W

QUADRANGLE: Juneau, T44S, R60E

BARRIER: Remoteness - undetermined land status

RECOMMENDATION: Exploration

DESCRIPTION:

Located near Nika Bay in the Chichagof Yakobi Island P.G.R.A., 705,200 acres (285,394 hectares). Geology of the area is shown on the U.S. Geological Survey Map I-388.

The Nika Bay area is part of the Chichagof Highlands, which consist of northwest trending ridges 3,000-3,500 feet (914-1,067 m) in height and long fjords and valleys. There are numerous northwest trending fault systems that cross Frederick Sound. One of these is the structural control for the Nika River and Mud Bay valley. Another fault prescribes the northeast shore of Nika Bay (Selkregg, 1976).

Joseph A. Nava visited the area around Nika and Mud Bays on Chicagof Island. Only one spring was found between the two bays. He walked five miles (8 km) up the creek to the springs. There was considerable soil warming in the area. There were four main springs and three smaller ones. The highest recorded temperatures were 46°C, but the water cooled to 10°C before entering the creek (Nava, 1975).

The exact location of these hot springs has not been established. A logical area to search would be the intersection of the two faults previously mentioned.

The hot springs are associated with Paleozoic rocks (Waring, 1965). The rocks to the east of the Nika River and fault are greywacke, shale, siltstone, slates, limestone, conglomerate mudstone, sandstone and dolomite of Silurian to Mississippian in age. Several miles to the west of the fault is a granitic intrusive mass that forms the mountainous region there.

SOCIO-ECONOMIC:

There is some question on the land ownership in the area because of the uncertainty in locating the springs. The property to the east of range 60E CRM has been selected by the Native corporations. The lands west of range 61E are part of the Tongass National Forest.

The National Forest lands are presently being reviewed to determine a new forest management plan. The Forest Service has produced



numerous management plans that range in philosophy from wilderness preservation to resource development. These plans are now being reviewed. In all plans, this particular area is designated as an area of intensive resource development. Portions of the area around the springs are prescribed as timber sales areas, within the next ten years. Under existing management, the area is to be developed and covered by completed EIS.

The nearest town is Hoonah, 8 miles (13 km) across Frederick Sound. Juneau is 50 miles (80 km) to the east.

Hoonah does have a port and an airstrip. The population of the town is 870 people. The major industry is timber (Selkregg, 1976).

The general attitudes in the area are mixed concerning the future development of the area (USFS). Sealaska Regional Corporation and Hoonah Village Corporation are the two native management agencies in the area.

Exploration should be pursued to determine the location and extent of the resource. With the expected development of the area, a utilization might be in the offing. Balenological application or some utilization that would tie into the forest development might be forthcoming on the Native lands.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The nearest climatological station is Gustavus, to the north across Icy Strait. The temperature there ranges from 44-63°F (7-17°C) in summer and 21-35°F (-6 to 2°C) in winter. Extremes of -25 to 87°F (-32 to 31°C) have been recorded. Precipitation averages 54" (137 cm) including 71" (180 cm) of snow. The winds average 5.9 knots from the southeast. These figures are only estimates, as short distances can make serious climatological differences in southeast Alaska. The mean annual runoff approximates 10 cu.ft./sec./sq.mi. Heating degree days average near 9,000.

The area has a dominant flora that consists of coastal western hemlock and Sitka spruce forests. The flats around Nika Bay are a high density waterfowl range. Nika River is a major fish stream for salmon. The Bay itself has numerous sea mammals and the brown bear are rather prolific.

The area is located in a high seismicity zone.

#### KEY CONTACTS:

Forest Manager, Tongass National Forest, Chatham area.  
Sealaska Regional Corporation, Juneau

REFERENCE:

Southeast Regional Profiles  
Draft Management Plan U.S.F.S.  
Alaska Land Map by Mapmakers, Inc., 1977  
U.S.G.S. Map I-388  
NAVA 1974

SITE: Mud Bay

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 58° 10' N; 135° 57' W

QUADRANGLE: Juneau, T43S, R58E, CRM

BARRIER: Forest Service management plan not completed

RECOMMENDATION: Exploration activity to determine extent of resource. Probable use as primitive recreational facility.

#### DESCRIPTION:

Located in the northeast portion of the Chichagof-Yakobi Island P.G.R.A. 705,200 acres (285,394 hectares) on Mud Bay.

Mud Bay and its drainage basin trends northwest-southwest because of a significant fault that runs up the valley and into Nika Bay to the south. The northwest-southeast trend is common to the whole of Chichagof Island. The rocks to the east of the fault are Paleozoic slate, limestone, greywacke, shale, siltstone and associated rocks of Silurian to Mississippian age. To the west of the fault, there are granitic igneous rocks of Cretaceous age. The hot springs would probably be related to either the granitic intrusive or the fault system (author).

#### SOCIO-ECONOMIC:

This area is located within the Tongass National Forest. New development is generally discouraged at this time because the Forest Service is presently developing a management plan for the entire Tongass National Forest. This process has produced several forest-wide proposals from a development oriented prospective to wilderness oriented proposals. Mud Bay would be classified as a resource development area under one plan to a wilderness area under another plan. This issue should be resolved when the forest plan is complete in 1979.

Under present USFS proposals, this area has been designated to be developed. The EIS has been completed. The area is presently a moderate usage area around Mud Bay itself (USFS). Probable development would be forest products.

There are no permanent residences in the area and no facilities. The bay itself is very shallow with mudflats making entrance by sea difficult.

The nearest logistical center would be Gustavus, 18 miles (29 km) across Icy Strait to the north. Mud Bay is about 60 miles to the west of Juneau. Management agency would be the Forest Service.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Gustavus is the nearest climatological recording station. Temperatures in the summer range from 44 to 63°F (7 to 17°C) and in winter they range from 21 to 36°F (-6 to 2°C). Extremes reach -25 to 87°F (-32 to 31°C). Precipitation averages 54" (137 cm), including 71" (180 cm) snow. Average wind is SE, 5.9 knots. Heating degree days are 9,000.

This area is a key waterfowl range. Marine mammals reside in the area. Brown bear also are found. Offshore scallop, halibut and bottom-fish are of predominant economic significance.

The flora of the area is basically a coastal western hemlock, sitka spruce forest.

The springs are located in an area of high seismicity.

KEY CONTACT: Forest Manager, Chatham Area, Tongass National Forest

REFERENCE:

Draft Tongass Land Management Plan  
Southeast Regional Profiles  
U.S.G.S. Publication I-388

SITE: North End, Tenakee Inlet

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 58° 00' N; 135° 55' W

QUADRANGLE: Juneau A-6; T44S, R59E, CRM

BARRIER: Forest Service Management Plan Not Complete

RECOMMENDATION: Possible recreation site. Possible wood drying facility if timber were to be harvested.

DESCRIPTION:

About four miles above the mouth of a large creek that enters the head of Tenakee Inlet, scalding water issues at several points at the right edge of the stream canyon. This area is located within the Chichagof Yakobi Island P.G.R.A., 705,200 acres (285,394 hectares).

Tenakee Inlet is a fault induced, northwest-southeast trending water body. According to the Southeast Regional Profile, the fault system splits north into Frederick Sound. The liniation, however, continues through Tenakee Inlet into Idaho Inlet, suggesting a continuation of the fault system near the springs area. Granite igneous rocks of the area are of Cretaceous Age. A sequence of Silurian to Mississippian age greywacke, shale, siltstone, slate, limestone, conglomerate, mudstone, sandstone and dolomite outcrop to the east along a wide band.

At the springs themselves, the hottest water rises with a temperature of 179°F (82°C) in a shallow algae-lined pool. This pool is about 50 feet long and 3 to 8 feet (1 to 2 m) wide, on the border of a gravel flat at the base of a steep forested slope. During Waring's 1915 visit, the discharge of the pool was about four gallons per minute (15 l/m) and it sank into the gravel after flowing only a few meters northeastward. Near the edge of the creek, however, 70 meters distance along a well defined channel from the main pool, hot water of a considerably lower temperature issued at several small vents. Total flow is estimated at 10 gallons per minute (38 liters per minute).

Although the positions of the minor hot springs suggest that their water may come from the principal spring, the three northernmost springs issue directly from the seams in a low cliff at the cliff's edge. The conditions indicated that all six northern springs issue from a small fissure that extends about S70°W. There are twelve springs in all. The hottest pool, which is apparently supplied from a separate fissure from the northern spring, is distinctly sulfated and also tastes noticeably mineralized. A deposit of lime carbonate is deposited on pebbles in its overflow channel (Waring, 1917).

The rocks exposed in low cliffs on each side of the creek are dioritic, much altered on the surface traversed by white zeolites such as heulandite. The dioritic rock appears to form a ledge trending N60°E through the more prevalent granitic material. The hot water system appears to be associated with the granitic intrusive. The relation of the springs to the two varieties of rock is not clearly evident, however, and the geologic structure to which the issuance of hot water is due may be the contact zone between the intrusive crystalline rocks and Paleozoic sediments. White crystalline limestone float is found in the creek indicating the Paleozoic sedimentary series outcrops not far up stream (Waring, 1917).

#### HOT SPRINGS NEAR NORTH END OF TENAKEE INLET

Miller 1973

SiO <sub>2</sub>	119
Al <sup>2</sup>	4.6
Fe	2.1
Ca	21
Mg	2.3
Na	137
K	4.1
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	48
CO <sub>3</sub>	7.2
SO <sub>3</sub>	226
Cl <sup>4</sup>	33
F	---
Br	---
B	---
pH	---
Temp. °C	81.5

#### SOCIO-ECONOMIC:

No road exists to the springs at this time. It would be comparatively easy to clear a road to them along the creek from the head of the inlet and to pipe the water a few hundred yards downstream to a suitable place for a bathhouse and other buildings (Waring, 1917).

New development is generally discouraged at this time because the Forest Service is presently developing a management plan for the entire Tongass National Forest. This process has produced several forest-wide plans grading from one that is resource development oriented to one which is wilderness preservation oriented. Under most plans, the designation would be for multiple use. This area is presently a timber sale contingency area.

The nearest staging area is Hoonah, 20 miles (34 km) to the east. There is one portage between Port Frederick and Tenakee Inlet. Tenakee springs is located 30 miles (48 km) down the inlet, and Juneau some 60 miles (96 km) east.

It would appear that some commercial forest use or recreational utilization is the logical direction of commercialization due to the lack of local population. A small scale wood products cottage industry could utilize the spring for space heating and drying, even at its present status.

The Forest Service has presently identified the drainage to the east as an area to be developed and covered by an EIS.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Pelican, 10 miles (16 km) to the west, over the mountains, is the nearest climatological recording station. Summer temperatures range from 44-62°F (7-17°C). Winter is 19-36°F (-7 to 2°C) with extremes of -3° to 84°F (-19° to 29°C). Precipitation averages 123" (312 cm) with 106" (269 cm) snow annually. Heating degree days average 8,800.

The dominant flora in the area is related to the coastal western hemlock spruce forest. This area has been identified as a low density waterfowl range and sea mammals are present.

The springs are located in an area of high seismicity.

#### REFERENCE:

Waring, Water Resource Report, 1917  
Draft, Tongass National Forest Management Plan  
Southeast Regional Profile  
U.S.G.S. I-388

## TENAKEE HOT SPRINGS

Tenakee springs, formerly known as Hooniah, is the site of one of the oldest usages of geothermal energy in Alaska. The springs are located about 100 miles (160 km) by sea from both Sitka and Juneau on the east coast of Chichigof Island. In 1891, there was a small Native village near the springs. They were probably locally used to some extent much earlier than this.

In the next twenty years, the springs were used as a bathing resort by whites. Considerable building occurred in the 1905-1915 era. In 1915, the Forest Service and then again in the 1930's the CCC improved both the springs area and the town. Today, the CCC constructed 20' x 30' building with the 8' x 8' pool are still used by the local inhabitants.

The area around Tenakee springs is part of the Chichagof highlands, which consists of northwest trending ridges 3,000-4,000 feet (914-1219 m) high. The Tenakee Inlet itself is structurally controlled by two major fault systems trending northwest, one of which goes through the village area. The whole island has been heavily glaciated and Tenakee Inlet is a fjord feature.

The rock formation in the vicinity of the springs appears to consist of dark gneiss intruded by light gray granite, both of which are phases of an intrusive crystalline area in Paleozoic sediments.

The springs themselves issue along fissures in the gneiss. The flow rate of the twelve springs is about 84 LPM. The waters are about 41°C in temperature. The waters are of the sodium sulphate type and the proportions of the several substances are nearly the same in each. The presence of borax in the water is worthy of note, since no source of borate is evident in the vicinity.

Waring noted in his 1917 visit that the abnormal temperatures of the springs may be due to local crushing, caused by the intrusion of the granitic material into the gneissic rock or perhaps by the rise of the water from considerable depth along the zone of fracturing at the contact of the crystalline and sedimentary rocks.

Estimates using geochemical calculations indicate the reservoir temperature to be in the 120°C range. Best guestimates of the resource size are just that - guesses - as they are based on no reconnaissance of the area. Mr. Waring's notes on the area are in his own estimations. Further exploration is needed to determine the extent of the resource.

The potential utilizations of the surface resource are limited because of the low temperature and flow rate. Animal husbandry, limited agricultural and aquaculture usages could be possible.

The make-up of the town should be a prime consideration of any use of the resource. The fact that the resource is in a town is a distinct advantage. The present use of the springs is a very beneficial asset to the town as it is.



The town is made up of some 87 dwellings. There are approximately 68 permanent residents of which the majority are probably pensioners or otherwise retired people. The people are progressive. They are installing a low head hydroelectric facility to replace an existing diesel generating facility.

The main industries in Tenakee are the crab cannery and the mercantile. The town is in need of sewage and water systems.

Fresh foods and vegetables are expensive to fly in and utilizing the resource for greenhouses would be an ideal usage of the springs in the near term.

Some possible legal questions arise from the fact that the springs have been reserved by the federal government. The scenario construction is based on the resolution of this issue for the greenhouses. The long term development is very speculative, at best, and considers the use of private land as the drilling site.

If development of federal lands takes place, the surface management agency will be the U.S. Forest Service. The Forest Service is presently developing a new management plan for the entire Tongass National Forest. The new plan should be out for review in 1979.

## SITE DATA SUMMARY

SITE: TENAKEE

### ..Physical Reservoir Data

..Temperature °C (White, 1975)

..Surface: 43°

..Subsurface: 115°

..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

.1 x 10<sup>18</sup> cal. (White)

..Type of Overlaying Rock:

Granite intrusive and gneiss (Waring, 1965)

..Estimated Depth to Top of Reservoir (meters): 1.5 km (White)

### ..Site Land Status:

..Total Acres:

P.G.R.A.: 705,200 acres. Most land in this P.G.R.A. is federally administered by the U.S. Forest Service. The State has made limited selections in and around the springs. Small private holdings are noted.

### ..Geothermal Development Status:

A small private bath house utilizes the surface flow.

### ..Local and State Attitude Toward Geothermal Development:

The local inhabitants have researched the legal background on the status of the spring. In the early 1970's, Mr. O'Toole, of the village, actively pursued getting money for a resort facility. General attitude in area is against major development (USFS).

### ..Land Use and Population:

The majority of the residents are retired pensioners and old time Alaskans. Totem Sea Foods employs fifteen people seasonally.

### ..Comments and Critical Issues:

Adjudication over eligibility of Tenakee springs to select lands under Native Claims Settlement Act and National Forest Management plan in review process.

## SITE LOCATION AND PHYSICAL DESCRIPTION

### SITE: TENAKEE

..Latitude: 57° 47' N

..Longitude: 135° 13' W

..Rectilinear: Sitka, D-4, T47S, R63E

..Topography:

The area is part of the Chichagof Highlands, which consists of northwest trending ridges 3,000-4,000 feet (914-1214 m) high. The Tenakee Inlet is a long fjord expression.

..Present Land Use:

Used basically as a retirement community. Some of the people are employed by the Totem Sea Foods in the summer at the cannery.

..Future Land Use Plans:

Possible Forest Service timber sales in the area. Possible balenology application of the geothermal energy.

..Aesthetics: Picturesque.

..Historical/Archaeological Significance:

Formerly known as Hooniah hot springs, Tenakee is one of the best known of the Alaskan spring resorts of the early part of the century. In 1891, there was a small Native village that probably used the springs locally. A Post Office was established in 1903 and various other business ventures started. In 1915, the Forest Service improved the property constructing boardwalks and organizing the city. The present bath house is a concrete and frame building about 20' x 30' and was constructed in the early 1930's by the CCC. (Proposal for incorporation, City of Tenakee.)

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

### SITE: TENAKEE

..Geologic Description:

The geology of the area is portrayed on the U.S. Geologic Survey Map I-388. The rock formation in the vicinity of the springs appears to consist of dark gneiss, intruded by light gray granite, both of which are phases of an intrusive crystalline area in Paleo-

zoic sediments. Small amounts of schist are also present near the springs, apparently in the contact zone between the old sediments and the crystalline rocks. The principle spring rises from a fissure in the gneiss. The other eleven springs possibly rise along fissures, either in the gneiss or in the granite, but the bedrock surface near them is covered by a layer of gravel, cemented by the deposition of lime from the spring (Waring, 1917).

Significant faulting is noted in the Tenakee area. Two major northwest trending faults structurally control Tenakee Inlet. The town of Tenakee in fact, lies along one of these. These systems are associated with the Tectonic setting of southeast Alaska.

..Geophysical Summary:

No exploration to date. Possible exception being if geophysics were used in siting hydroelectric plant.

..Geologic Hazards:

This is a seismically active area. The combination of seismicity and high rainfall make mass wasting a possibility.

RESERVOIR CHARACTERISTICS

SITE: TENAKEE

..Reservoir Temperature (White, 1975)

..Surface: 43°C

..Subsurface: 115°C

..Geochemical (White, 1975)

SiO<sub>2</sub>: 111  
Na-K-Ca: 63

..Flow Rates: 84 lpm

..pH: 9

..Total Dissolved Solids:

TENAKEE HOT SPRINGS

SiO <sub>2</sub>	60
Al <sub>2</sub>	0.05
Fe	---
Ca	28
Mg	0.76

Na	190
K	3.3
Li	0.08
NH <sub>3</sub>	---
HCO <sub>3</sub>	54.8
CO <sub>3</sub>	---
SO <sub>4</sub>	322
Cl	95.4
F	5
Br	---
B	4.4
pH	9.0

(Miller, 1973)

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.2 x 10<sup>18</sup> cal. (est.) (White, 1975)

..Subsurface Area of Reservoir (White, 1975): 1.5 sq. km.

#### LAND OWNERSHIP AND LEASING

SITE: TENAKEE

..Land Ownership:

..Total Area (Acres): 705,200

..Total Acres (Federal): Approx. 95%

..Total Acres (Private):

4% Hooniah Native withdrawal in adjudication.

..Land Leased: Ø

..Tentative Lease Sale Dates: None planned

..Summary of Leasing Status and Needs:

No leases have been applied for. No dates will be set on the lands until this is completed.

## GEOTHERMAL DEVELOPMENT STATUS

SITE: TENAKEE

### ..Present Development Status:

There are four mineral spring reserves located within the Tenakee township. In area, these reserves are approximately 5,000 sq. ft. each. The present bath house was constructed by the CCC in the 1930's, and consists of a concrete and frame building about 20' x 30'. Bathing facilities are merely an 8' x 8' concrete sump directly over the rock fissure which emits the hot spring water. The water spills over the sides of the sump and drains to the tidal flats.

### ..Projected or Planned Development:

Near term development would concern itself with utilizing the surface manifestation for a probable agricultural application such as a greenhouse being a cascading use from the bath house. Rehabilitation of the bath house will also probably take place.

Scenario development is built under the assumption that exploration will take place and a favorable conclusion will be drawn on the resource. Space heating and balneology have been considered as geothermal utilizations. The climate for development in the next five years is probably not generally favorable.

Projections beyond five years have a very low degree of confidence.

## INSTITUTIONAL CONSIDERATIONS

SITE: TENAKEE

### ..Institutional Requirements:

There are Federal, State and private lands. Any development will probably be on the private lands. The developer will have to determine the extent to which he has mineral rights. Tenakee springs is a fourth class city which has no lands of its own. The state could donate lands for a heating district. At present, no state lease forms are written for geothermal leases. Permits etc. required for drilling (if considered) may be found in Lists of Permits Book published by Dept. of Environmental Conservation, State of Alaska.

### ..Agency and Public Attitudes:

State agencies favorable to development of alternate energy sources. Tenakee sentiment is generally not for wholesale development (USFS).

### ..Status of Requirements (i.e., EIA/EIS Requirements): None started.

## ENVIRONMENTAL FACTORS

SITE: TENAKEE (FROM ANGOON)

(EXTRACTED FROM THE SOUTHEAST REGIONAL PROFILE)

### ..CLIMATE

..Precipitation (Annual): Approx. 80" (203 cm)

..Average Temperature:

Summer: 45 to 61°F (4 to 16°C)

Winter: 24 to 36°F (-4 to 2°C)

Minimum: -10

Maximum: 77

..Degree Days (Annual): 8,800

### ..GEOLOGIC FACTORS:

Possible mass wasting, seismically active.

..WATER QUALITY: Mean annual runoff 10 cu.ft./sec./sq.mi.

..NOISE: None

### ..BIOLOGICAL

..Dominant Flora: Coastal western hemlock and Sitka spruce forest

..Dominant Fauna:

Marine mammals. No major concentrations of land mammals, but sparse populations of Sitka deer, bear and other mammals indigenous to Southeastern Alaska.

## TRANSPORTATION AND UTILITIES

SITE: TENAKEE

### ..Utility or Energy Transmission Corridors and Facilities:

City has ordered and is implacing small head hydroelectric facility to replace diesel generating facility.

### ..Transportation Corridors or Facilities:

No roads exist. Transportation links are by sea and seaplane.

## POPULATION

SITE: TENAKEE

### ..General Description of Population (From Application for Incorporation):

There are about 87 dwellings of which 50 are occupied. Some 40% of these homes need major repairs. About ten need to be replaced.

There are currently about 65 permanent residents. The population has steadily decreased from a 1930's high of some 400 people.

The population shows a statewide average of 80% white, 20% natives. The white population has a majority of retired pensioners and old time Alaskans. These people are very individualistic.

### ..Economics:

#### ..Present Land Use (From Application for Incorporation):

The businesses located within the village are Snyder Mercantile, Union Oil, Totem Sea Foods crab cannery, Blue Moone Cafe, Tenakee Tavern, Tanakee theater and Shamrock Fountain.

There are about eight full time employed persons in Tenakee Springs.

#### ..Future Land Use:

Forest Service timber sales are likely in the area (USFS).

The State of Alaska has selected lands around the City to provide for future growth.

The village was in need of a water system at the time of the application for becoming a fourth class city, with only four houses having running water.



SITE: White Sulfur (Hooniah)

RESOURCE: Hot Springs (USFS) (Miller, 1973)

LATITUDE & LONGITUDE: 57° 48' N; 136° 20' W

QUADRANGLE: Sitka D-8, T47S, R56E, Sec. 9, CRM

BARRIER: Presently remote recreation site

RECOMMENDATION: Remain as is

DESCRIPTION:

White Sulfur springs are located on the oceanward coast of Chichagof Island, about 70 miles, (112 km) northwest of Sitka. These springs are located within the Chichagof Yakobi Island P.G.R.A., 705,200 acres (285,394 hectares).

Three distinct rock types are found in the area. There is a Tertiary gabbro outcrop to the south in the Dry Pass area. The springs themselves lie around the contact of the gabbro with an early Cretaceous-Late Jurassic sedimentary sequence of graywacke, slate, conglomerate and limestone. The actual rock associated with the springs is a schist (Waring, 1965). This rock unit is part of a Jurassic and Triassic greenstone schist, graywacke, gneiss, phyllite and limestone association. It dominates the west side of a fault trending northwest-southeast near Golding Harbor, inland from White Sulfur.

The elevation of the springs is 12.19 meters (40 ft.) about 70 meters from the shore. The springs are in a small rock cove in which much driftwood is cast up on a beach of large rounded stone. The principal spring issues at the edge of the forest a few meters above the limit of the driftwood. Water issues at a temperature of 44°C (111°F) from a vertical opening the size of one's hand in a dark schistose rock. The actual flow for the three springs in the area are estimated at 114 liters per minute (30 gal./min.). The spring tastes only faintly sulphurated, and there appears to be no escape of gas. Pale salmon-colored to white, stringy algae growth forms along the runoff channel. (Waring, 1917).

A second spring which issues approximately 3.7 liters/minute (1 gal./min.) issues among the channel some 20 meters east and 2.13 meters (7 ft.) lower than the main spring. Vapor issues from openings in the forest soil, 14 meters shoreward. A third spring somewhat cooler 84°F (29°C), and a flow of .5 gal./min. (1.9 liters/min.) rises with slight bubbling in much of the small stream channel, 47 meters west of the principle spring (Waring, 1917).

Conditions at the main spring, where the water appears to issue directly from a fissure in the schist; indicate that the thermal water rises along such seams in the rock which dips 80°S, 20°W. The abnormal temperature of the water may be due solely to the

depth from which it rises, but it seems probable that it is due, in part, to the presence of intrusive rocks, which form a wide zone to the east of the springs. The schist from which the warm water issues is a common alteration phase of the Paleozoic or Mesozoic sediments near their contact with intrusive rocks throughout South-eastern Alaska (Waring, 1917).

Main spring geochemical data: (Miller, 1973) (Geochemical data is not considered reliable, White, 1975):

SiO <sub>2</sub>	96
Fe <sup>2</sup>	3.1
Ca	8.5
Na K	59
HCO <sub>3</sub>	18
CO <sub>3</sub>	25
SO <sub>4</sub>	35
CL	42

Geochemical indicated reservoir temperatures SiO<sub>2</sub> - 136°C. Average reservoir temperature - 140°C. Subsurface reservoir area - 1.5 km<sup>2</sup>. Thickest reservoir thickness - 1.5 km. Volume - 2.25 km<sup>3</sup>. Heat content - .2 x 10<sup>18</sup> cal. or 5.04 x 10<sup>19</sup> Btu's. (White, 1975).

#### SOCIO-ECONOMIC:

This area is located within the Tongass National Forest. The existing use of the springs consists of a remote bathing house, constructed by the Forest Service. It is designated as a remote camping area for itinerates who enter the area. The present use of the area is moderate. The Forest Service is developing a management plan for the entire Tongass National Forest. This process has produced several forest-wide management proposals. These proposals grade from a resource development oriented proposal to a wilderness preservation oriented plan. The Forest Service is presently accepting public input as to which, if any, of these plans should be adopted. The White Sulfur area is proposed as wilderness under the preservation plan and as multiple use area in the development oriented plan. Under current programs, the area is designated as primary forest sale areas. A previous wilderness study has been conducted in the area (USFS).

The nearest village is Kimshan, 12 miles (19 km) south. The logistical staging place is Sitka. The exact location of the springs make it difficult to reach by sea, because of the rocky coast.

The springs have been used since the 1916 Waring visit as a bath resort.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The nearest climatological recording station is Pelican, 8 air miles (13 km) northeast over the north Baranof Mountains. The assumption can be made that precipitation measurements would be higher at White Sulfur springs because of its exposure and position against the mountains. Summer temperatures at Pelican range from 44-62°F (7-17°C); winter temperatures range from 19-36°F (-7 to 2°C), with extremes of -3 to 84°F (-19 to 29°C). Pelican records 123" (312 cm) of precipitation, but White Sulfur could record half again as much. Mean annual runoff in the area is 16 cu.ft./sec./sq.mi. Annual heating degree days average 8,800.

The dominant flora is that of the coastal western hemlock and Sitka spruce forests. Fauna associated with this area include peale peregrine falcons, razor clams along the beaches, and marine mammals. The area has a major anadromous fish stream, as well as being a key waterfowl habitat. Sitka deer are prevalent and the endangered bald eagle nests here. Offshore bottom fish areas have been designated.

The springs are located in an area of high seismicity.

#### KEY CONTACT:

Forest Manager, Chatham Area, Tongass National Forest

#### REFERENCE:

Waring, "Report on Hot Springs", 1917  
White, USGS Circular #726  
Draft, Tongass Land Management Plan  
Southeast Regional Profile  
USGS, Publication I-388

SITE: Lisianski

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 57° 55' N; 136° 11' W. Approx.

QUADRANGLE: Sitka: T45S, R57E, CRM Approx.

BARRIER: Forest Service Management Plan Not Complete

RECOMMENDATION: Exploration. Possible recreational facility.

DESCRIPTION:

Located along the east shore of the Lisianski Inlet, south of Pelican, within the Chichagof Yakobi Island P.G.R.A., 705,200 acres (285,394 hectares). Lisianski Inlet is northwest-southeast trending and a result of the Peril Strait fault system. The northeast side of the inlet is composed of a greywacke, slate, siltstone, limestone conglomerate, mudstone, sandstone, and dolomite sequence of Silurian to Mississippian age. Granitic intrusions are present east from the inlet (Selkregg, 1975). Hot springs would probably be associated with these (author). West of fault granitic intrusions of Tertiary age are exposed.

Nava visited the Pelican area in search of the hot springs in 1975. He found only a trickle of water (6°C) issuing from under a log on a mud flat exactly at the Village of Pelican. It followed a course not more than 2" (5 cm) wide and 1/2" deep, with the outlet underwater at all times except low tide. Residents reported a small adjacent area which remains clear of snow during most of the winter, thus indicating the presence of some ground heat, though he could detect none with a temperature probe (Nava, 1975).

SOCIO-ECONOMIC:

This area is located within the Tongass National Forest. New development is generally discouraged at this time because the Forest Service is presently developing a management plan for the entire National Forest. This process has produced numerous forest-wide proposals at this time - from a development oriented plan to a wilderness preservation oriented plan. The Lisianski springs area would be a wilderness area if the wilderness plan were adopted, but most other plans would have it developed for forest products. Presently, it is designated as a primary timber sale area.

A logging camp is located near the suspected spring site. Pelican is a few miles from the area where the springs are supposed to be located. Pelican has a population of 200, including 30 natives. It is a feeder line port for the Marine Highway. There are fishing and fish-producing options. The residents generally oppose major changes, including opening of the Yakobi mining district to the west (USFS). Pelican uses both hydro and oil for power and heating. Total generation equals 1,200 kw (DEPD). They pay 7.27¢/kw to the Pelican Utility Company.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The climate data from Pelican indicates that summer temperatures range from 44-62°F (7-17°C); winter from 19-36°F (-7 to 2°C), with extremes of -3 to 84°F (-19 to 29°C). Precipitation includes 106" (269 cm) snow, and averages 123" (312 cm). Mean annual runoff is 12 ft.<sup>3</sup>/sec./mi.<sup>2</sup>. Annual heating degree days average 8,800.

There are brown bear, Sitka deer, and sea mammals in the area. This is both a waterfowl range and an anadromous fish range. The dominant flora in the area is coastal western hemlock-Sitka spruce forest.

Other energy sources include: Hydroelectric, wood and oil.

The springs are in an area of high seismicity.

KEY CONTACT:

Forest Manager, Cathorn Area, Tongass National Forest

REFERENCE:

Draft, Tongass Land Management Plan.  
Southeast Regional Profile  
USGS Publication I-388

SITE: Peril Strait

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 57° 46' N; 135° 49' W

QUADRANGLE: Sitka, T47S, R59E, CRM (Approx.)

BARRIER: Forest Service Management Plan Incomplete

RECOMMENDATION: None

DESCRIPTION:

Hot springs located on the north shore, about three-quarters of a mile eastward from the head of the north arm of Peril Strait within the Chichagof Yakobi Island P.G.R.A., 705,200 acres (285,394 hectares).

The Peril Strait fault system forms the lineation that makes up Peril Strait and Lisianski Inlet. Located on the northeast side of the fault system, north of the inlet is an outcrop of Cretaceous gabbro. Granitic igneous rocks of Cretaceous age form the north shore of Peril Strait and overlap the gabbro series near the head of the strait.

Heated water issued at about half-tide level from mussel and kelp covered rocks. The warm water rises beneath and flows into the sea. Examination at low tide indicates no noticeable taste or odor. Some bubbling and a small amount of vegetation are associated with the springs (Waring, 1917).

Four principal springs issue from fissures in the fractured diorite, about 100 yards northwest of a small cold water stream. The temperature of the spring is 101°F (39°C) with a flow of 3 gpm (11/lpm). Discharge appears to diminish as the tide falls because of draining contaminated sea water and lowering of hydrostatic pressure (Waring, 1917).

Chemical analysis of spring:

SiO <sub>2</sub>	40
Al	5.3
Fe	1.4
Ca	37
Mg	11
Na	206
K	3.8
HCO <sub>3</sub>	35
CO <sub>3</sub>	.0
SO <sub>3</sub>	329
CL <sup>4</sup>	133

(Miller, 1973)

## SOCIO-ECONOMIC:

This area is located within the Tongass National Forest. New development is generally discouraged at this time because the Forest Service is presently developing a management plan for the National Forest. This process has produced numerous management plans, from a development oriented plan to a wilderness preservation oriented plan. Under the development oriented plans, the area would provide for intensive resource development. Under the preservation oriented plans, the area would be designated wilderness. Under present management, the area is designated a primary timber sale area. This is a moderate use area (USFS).

The nearest settlement is Pelican, approximately 15 miles (24 km) to the northwest. The logical support area would be Sitka, 50 miles (80 km) to the south. At present, because of a sparse population, the springs are not utilized. Because the spring is below tide level, no recommendation is made at this time. It is possible that the state has rights to the springs as they are below mean high tide.

The springs are located within the Sitka Borough.

## ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The nearest recording station is Pelican. Summer temperatures range from 44-62°F (7-17°C); winter temperatures range from 19-36°F (-7 to 2°C), with extremes of -3 and 84°F (-19 and 29°C). Precipitation averages 123" (312 cm) which includes 106" (269 cm) of snow. The area averages 8,800 heating degree days, with a mean annual runoff of 12 ft.<sup>3</sup>/sec./mi.<sup>2</sup>.

This is a brown bear range. The area is a high density water fowl range as well as a major anadromous fishing area. Marine mammals are also present.

The dominant flora are those associated with the coastal western hemlock and Sitka spruce forests of Southeast Alaska.

The springs are located in an area of high seismicity.

KEY CONTACT: Forest Manager, Tongass National Forest

## REFERENCE:

Draft, Tongass National Forest Management Plan  
Southeast Regional Profiles  
USGS Publication I-388

## GODDARD HOT SPRINGS

Goddard Hot Springs lie 16 miles (22 km) south along the coast from Sitka. The springs are presently in the process of being rehabilitated for resort potential.

Goddard Hot Springs has a long venerated history among hot springs in Alaska. Formally known as Sitka Hot Springs, the springs received their first attention by Europeans in Sir George Simpson's (Governor of the Hudson Bay Company) report in 1841. At that time, the Russians were using the springs as a hospital for invalids from Sitka. He mentioned that the natives used the springs rather extensively at that time. The Russians expanded this facility and used it as a skin disease control hospital until American purchase. The springs eventually were turned into a combination sanatorium/resort by the Americans. At the turn of the century, a three-story structure with thirty-five rooms, all heated by the hot water, was used to house guests. The hotel eventually burned down. A new bath house that has since come into disrepair, replaced the larger development. A new interest is now being shown in Goddard Hot Springs by the municipal government which should bring it back into common use. This is only fitting for one of the longest used hot springs in North America.

The geothermal resource potential at this time is quite unknown. There has been little serious exploration done in the area to determine the extent of the resource.

The four springs flow at a rate of 49 liters per minute, with a surface temperature of 65°C. This type of heat resource could be utilized in most all of the direct applications found world-wide. Geochemical analysis indicates that the subsurface reservoir should be in the neighborhood of 150°C.

Since the resource is owned by the citizens of the City of Sitka, the utilization should benefit all the people. District heating or the present resort application would be the type that would fit the bill. There is a new hydroelectric project underway in the Sitka area, and the economics appear to be very favorable for using the electricity as a heat source in Sitka at this time.

The City and Borough are presently putting together the final touches to a plan to renovate the hot springs with a small bath house and dock facility. The project should be completed in 1979.

As for future development, the logical first step would be to further assess the reservoir with more exploration. The geology of the area shows evidence that the springs are related to the contact between an intrusive granite pluton and the Paleozoic sedimentary sequence that the pluton intrudes. It would appear that only drilling a hole would answer the question of the extent of this type of resource.



Since the Borough government would do any development in the area, and they have jurisdiction over the land, there appears to be no institutional problems. They would have to hold public meetings however, and appropriate funds for any project.

If the Borough wants to pipe the water to Sitka after a reservoir was confined, they would have to cross Forest Service lands. An EIS and other Federal paperwork would then have to be completed.

## SITE DATA SUMMARY

SITE: GODDARD

### ..Physical Reservoir Data

#### ..Temperature °C

Surface: 67°

Subsurface: 150° (White, 1975)

#### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

.25 best est.  $.75 \times 10^{18}$  cal.

..Type of Overlying Rock: Granite cut by diabase (Waring, 1965)

..Estimated Depth to Top of Reservoir (meters): 1,500 (Geotherm)

### ..Site Land Status:

28.58 acres owned by City of Sitka (Sitka Borough). Sealaska Native Corporation has filed a cemetery and historical site for 8 acres of the springs (BLM).

#### ..Total Acres P.G.R.A.: 43,400

Federal: 43,354

State : 0

Private: Approx. 10

Other : 28.58

#### ..Total Acres Leased: 0

### ..Geothermal Development Status:

Presently used as a resort for the City of Sitka. The general appearance is run down. There is one bath with a 75' (22 m) wooden trough connecting it with a hot spring. There is a boardwalk that connects the springs with a Boy Scout camp some 2,000' (610 m) to the north. (Sitka Borough)

### ..Local and State Attitude Toward Geothermal Development:

The City and Borough of Sitka plans on developing a more modern resort at this time (City of Sitka). General attitudes in the area are mixed on commercial development (USFS).

..Land Use and Population:

The City and Borough of Sitka owns the area directly around the springs and operates it as a resort. The Boy Scouts have a small facility in the area, which include a bunk house and cabins. There is also a parcel of private land.

..Comments and Critical Issues:

Forest Service is in the process of developing their Forest Management Plan for the Tongass National Forest. Numerous plans are being reviewed at this time. These plans range in philosophy from wilderness preservation to resource development. Land in this area has been withdrawn for three years under Public Land Order #5653.T.

SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: GODDARD

..Latitude: 56° 50' N

..Longitude: 135° 22' W

..Rectilinear: T58S, R64E, CRM, USS 1401

..County: Borough of Sitka

..Adjacent Counties: None

..Topography:

The Baranof Mountains, to the east, peak from 3,000-5,300 feet (914 to 1615 m) and have a steep eastern slope. There is a more gentle slope on the western and southwestern slopes with numerous islands and fjords.

..Present Land Use:

Used as a resort for the City of Sitka. It is 15 miles south of the city. There is one bath house there at this time, connected with one of the springs by a 75' (22 m) wooden trough (City of Sitka). There are other buildings in the area, some of which may be heated by hot water, but these are unconfirmed.

..Future Land Use Plans:

The City and Borough of Sitka plan construction of a new bath facility in the area. This construction should be completed by the end of the 1979 summer (City of Sitka).

..Aesthetics:

The southeast Alaska coastline is extremely aesthetic, as evidenced by the great amount of acreage being considered in this area for inclusion in the National Wilderness System and Scenic River categories.

..Historical/Archaeological Significance:

There is a rich history associated with this spring. Sir George Simpson, Governor of Hudson Bay Company, noted in an 1841 visit that there were three cottages employed as a hospital for invalids from Sitka. There were two baths, one for whites and one for Indians. The Indians were reported to come hundreds of miles to the springs to utilize them.

Dall reported that in 1861 a Russian hospital for skin diseases was open at the springs (Waring, 1917).

A hotel was built prior to Waring's arrival. This structure could house thirty guests. The hotel and all the other buildings in the community utilized the hot springs for space heating supplemented by wood burning (Waring, 1917).

This resort eventually burned down. The impact of curtailed mining and timber industries caused the springs to slip into disuse until the last few years when renewed interest produced the development plans now being implemented.

#### GEOLOGICAL/GEOPHYSICAL DESCRIPTION

##### SITE: GODDARD

..Geologic Description:

The springs are in the area of the contact between Tertiary granitic intrusives to the south, and the sequence of Cretaceous to late Jurassic slate, greywacke, conglomerate, and limestone on the north.

In the vicinity of the springs, the granite from which the hot waters issue is cut by narrow dikes of diabase. This diabase is classed as garnet lamprophyne. On numerous rocks and islets dotting the water northward between the springs and Sitka, hard metamorphosed sandstones and other Mesozoic sediments are penetrated by dikes and massive bodies of intrusive granite. Although the hot waters issue at the surface from granite, they may owe their escape from considerable depths to crevices or fissures along contacts between the intrusive granite and the altered sediments (Waring, 1917).

..Geophysical Summary: No geophysical surveys to date.

..Geologic Hazards:

Located in a zone of high seismicity. Exposure to the coast would allow for low tsunami potential.

#### RESERVOIR CHARACTERISTICS

SITE: GODDARD

..Reservoir Temperature (White, 1975)

..Surface: 65°C

..Subsurface: 150°C

..Geochemical

SiO<sub>2</sub>: 148  
Na-K-Ca: 147

..Flow Rates: 49 lpm (White, 1975)

..pH: 7.37 (Geotherm)

..Total Dissolved Solids:

SiO <sub>2</sub>	120
Al	0.018
Fe	---
Ca	380
Mg	1.9
Na	1500
K	61
Li	1.6
NH <sub>3</sub>	---
HCO <sub>3</sub>	78.7
CO <sub>3</sub>	---
SO <sub>3</sub>	110
Cl <sup>4</sup>	2780
F	1.4
B	1.1
pH	7.37
Temp. °C	67

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.2 x 10<sup>18</sup> cal. (White, 1975) (Estimated)  
.75 x 10<sup>18</sup> cal. (Geotherm)

..Subsurface Area of Reservoir: 1.5 sq.km. (White, 1975)(Estimated)

## LAND OWNERSHP AND LEASING

SITE: GODDARD

### ..Land Ownership

..Total Acres: 43,400  
..Federal Acres: 43,354  
..State: 0  
..Private: 10  
..Other: 28.54  
..Native: 8

..Land Leased: 0

..Tentative Lease Sale Dates: None set

### ..Summary of Leasing Status and Needs:

U.S. Forest Service will be federal leasing agent in area. The Forest Service is presently developing land use plans for the Tongass National Forest. There are currently numerous plans under review from a development philosophy to a preservationist philosophy. This plan should be finalized by the fall of 1979. It appears that much of the land around the spring site has been withdrawn under Public Land Order #5653 for a three year moratorium. This action was taken under authority of Federal Land Policy and Management Act of 1976, 43 U.S.C.S. 1714(e).

## GEOHERMAL DEVELOPMENT STATUS

SITE: GODDARD

### ..Present Development Status:

Presently there is one bath in use at the springs. A wooden trough 75' long connects the bath to the largest spring. The overflow from the bath follows along a ditch to the shore. (City of Sitka)

### ..Projected or Planned Development:

The City and Borough of Sitka plan on financing a small development to rehabilitate the area. A new bath house will be constructed under these plans. Part of the plans include a proposed float for docking. (City of Sitka)

## INSTITUTIONAL CONSIDERATIONS

SITE: GODDARD

### ..Institutional Requirements:

Development plans have received Borough approval. Borough must appropriate funds for the project.

..Agency and Public Attitudes: Popular support.

..Status of Requirements (i.e., EIA/EIS Requirements):

Planning staff satisfied.

## ENVIRONMENTAL FACTORS

SITE: GODDARD

..CLIMATE (FROM SITKA AIRPORT-EXTRACTED FROM SOUTHEAST REGIONAL PROFILE)

..Prevailing Winds:

SE 6.2 knots, perhaps higher in this headland area.

..Precipitation (Annual):

86" (218 cm), including 35" (89 cm) snow

..Average Temperature:

Summer: 44 to 62°F (6 to 17°C)

Winter: 28 to 40°F (-2 to 4°C)

Minimum: 0°F (-18°C)

Maximum: 85°F (29°C)

..Degree Days (Annual): Approx. 7,900

..AIR QUALITY: Excellent

..GEOLOGIC FACTORS:

Seismic Zone. Soil conditions favorable for construction and drainage.

..WATER QUALITY:

Large lake to the northeast (Redoubt) that could supply fresh water needs. Mean annual runoff - 20 cu.ft./sec./sq.mi.

..NOISE: None

..BIOLOGICAL

..Dominant Flora: Coastal western hemlock, Sitka spruce forest.

..Dominant Fauna:

The area is not considered a major concentration area for any species. The general fauna for southeastern would be present there in limited numbers.

..Endangered Species: Eagles and Peregrine Falcons

TRANSPORTATION AND UTILITIES

SITE: GODDARD

..Utility or Energy Transmission Corridors and Facilities: None

..Transportation Corridors or Facilities: None.

POPULATION

SITE: GODDARD

..General Description of Population:

No permanent residents. City of Sitka located 18 miles to the north.

..Economics:

..Present Land Use:

Recreational facility. City of Sitka economy based on logging, fishing, tourism and government. Large hydroelectric facility now under construction.

..Future Land Use: Same, including bottom fisheries.



SITE: Mt. Edgecumbe

RESOURCE: Dormant volcano

LATITUDE & LONGITUDE: 57° 01' N; 136° 46' W

QUADRANGLE: Sitka, T55S, R61E, CRM

BARRIER: Technology/exploration

RECOMMENDATION:

DESCRIPTION:

The Kruzof P.G.R.A. contains 60,900 acres (24,646 hectares). The Edgecumbe volcanic system is composed of andesites and basalts of Quaternary age. There are 12 identified volcanic expressions on Kruzof Island (Selkregg, 1975). The volcanic system appears to be the eastward extension of a line of volcanic sea mounts trending northwest-southeast and chronologically youngest to the southeast. This would suggest a possible "hot spot" associated with the movement of the Pacific Tectonic Plate\*. These volcanics have a contact with Cretaceous granitic rocks and an early Cretaceous and late Jurassic sedimentary sequence near Sheilof Bay on Kruzof Island. This neck forms the contract between the volcanics and the older rocks to the north.

The only "smoke" to emanate from Mt. Edgecumbe in recorded history was on April 1, 1972, when, after an excited assault by geologists, it was discovered that a number of smoldering fires produced the "eruption".

\*Personal communications with University of Alaska, Geophysical Institute, Fairbanks, Alaska.

Volcanic Data (White, 1975):

Composition Last Eruption:	Basic, Silicic
Age Data:	Active? $9 \times 10^3$ ; $9 \times 10^3$ T <sub>S</sub>
Chamber Area Km <sup>2</sup> :	74 A <sub>V</sub>
Chamber Volume Range Km <sup>3</sup> :	185-740 V <sub>V</sub>
Chamber Volume V <sub>B</sub> , Km <sup>3</sup> :	250
Solidification State C:	650
Total Calories x 10 <sup>18</sup> :	144
Now Calories x 10 <sup>18</sup> :	144
Out Calories	60

Remarks: Silicic in Focus; Basic on Flanks

## SOCIO-ECONOMIC:

The entire P.G.R.A. is located within the Sitka Borough. The land area covered by the P.G.R.A. is located wholly within the Tongass National Forest. Under present management, the area is a primary timber sales area. Under new management systems, it could become anything from a wilderness, roadless area to multiple use designation.

The nearest population center is Sitka, 15 miles (24 km) across Sitka Sound. There is an abandoned military base at the foot of Mt. Edgecumbe.

No development will likely take place at this time due to lack of knowledge about the resource and lack of technology in tapping volcanic systems.

## ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The nearest climatological recording station is Sitka Japonski Airport, at an elevation 50' across the sound. Average summer temperatures range from 46 to 62°F (8 to 18°C) and winter is 28 to 40°F (-2 to 4°C). Extremes reach 0°F (-18°C) and 85°F (29°C). Average wind speed is SE 6.2 knots. Annual heating degree day average 8,000.

This is an area of high seismicity. A potential tsunami hazard exists because of the exposure to the open sea.

The dominant flora of the area is that of the coastal western hemlock and Sitka spruce forests. At higher altitudes on the volcano, the vegetation is alpine tundra.

There is a high density of Sitka deer that winter range on the east side of the Kruzof Peninsula. A concentration of brown bear are noted in the neck of the Kruzof Peninsula. Key migration routes for waterfowl produce heavy population densities on the peninsula and the wildlife refuge to the south. Sea mammals and offshore fisheries have been, and are, key economic elements in the area.

The springs are located in an area of high seismicity.

## KEY CONTACT:

Forest Manager, Chatham Area, Tongass National Forest.

## REFERENCE:

Southeast Regional Profiles  
Draft Tongass National Forest Management Plan, USFS  
U.S.G.S. Publication I-388  
U.S.G.S. Publication I-411

## BARANOF

Baranof is located 20 air miles (32 km) east across Baranof Island from the City of Sitka. The early history of the old town of Baranof is given in two books written by Wayne Short "The Raw Land" (Authur Barker Ltd., 1972) and "The Cheechakos" (Random House, 1962).

Traditional stories indicate that the Tlingit Indians used the springs for bathing. The earliest recorded use is after the turn of the century when Baranof was established as a fishing and timbering community. In 1920, a pipeline was run from the springs to a bath house not far below by the territory for the use of itinerant fishermen. At about the same time, a bordello was established at another of the springs, which apparently used the hot water for both bathing and heating.

With the decline of the timber industry, the town also degraded. In the 1970's, the new owners put together the present system, which upgraded an existing system.

There are several small hot springs just below Lake Baranof. The water is collected into a concrete collection box a few feet from the springs. Temperatures range from 120 to 150°F (49° to 66°C). There appears to be considerable groundwater mixing, so predictions on the amount of flow and reservoir temperature are speculative.

The collection box is 97' (30 m) above sea level and gravity is used as the driving mechanism for the system. From the box, water flows 60' (18 m) through a 4" (10 cm) plastic pipe then it enters a 3" (8 cm) plastic pipe for the remainder of the 1/2 mile journey to the bath house. The pipe is uninsulated and there is a 6 to 8°F temperature drop.

From a connection near the bath house, the owner has established two circuits through radiators in his house using approximately 1-1/4" plastic pipe connectors. He uses old cast iron radiators in his house and tops it on cold days with an oil furnace.

Unfortunately, no measurements of the flow from the springs are available that are accurate. Estimates from observances range between 50-100 gallons per minute (189 to 379 lpm).

In order to understand the energy use at Baranof, it is also appropriate to note that electricity is furnished by a pelton wheel, 3 kw generator. The area is considered one of high quality hydroelectric potential, as well as geothermal potential. Since Baranof is so isolated, it is fortunate that abundant energy resources are available.

Many direct heat applications of Baranof's resource are possible. Animal husbandry, space heating, and greenhouses, are all possible, depending on the resource and economics. At this time there are few year round residents, so subsistence uses are the only economical uses.

Without further exploration, the extent of the resource is only speculative. The chemical analysis indicates that a 125°C reservoir probably

exists at depths of 1.5 km. With groundwater mixing and a possible fault related system, these values may be speculative at best. Perhaps some commercial utilization could be profitable if the reservoir proved exciting.

The State Department of Fish and Game has begun pursuing the Baranof area as a possible salmon hatchery site. This hatchery would be one of the world's largest, with a capacity of 50 million smolt. Originally, the geothermal resource was considered to heat the water here. The output of the spring system could only produce enough heat for 1/10 of the requirements of the hatchery, according to Fish and Game engineers. Since the geothermal reservoir is so speculative, the Fish and Game Department has focused their attention on the hydroelectrical potential of Baranof Lake for the energy needs of this area. Further studies will be conducted on this subject.

A related fish food industry is a likely candidate for the Baranof community if the hot water is not used for the hatchery. Some exploration and economic studies should be conducted to see if this is possible within the parameters of good business sense.

Certain major issues are at hand in the Tongass National Forest and the Baranof area in particular. The Forest Service is near completion of a Forest Management Plan. The warm springs area has been recommended to be included in the national wilderness preservation system by some of the management plans being discussed at this time. Many other plans designate the area as a roadless area which would allow the fish hatchery to be built. The final outcome of this planning exercise will determine if any development can take place on the federal lands.

Local residents have expressed some reservations to outside influence. Since the springs are privately owned\*, the nature of these reservations should be explored before any plans are made for development of lands in the area.

Various property owners at Baranof have rights to certain springs. Mr. Brennan obtains his hot mineral water by a syphon. Mr. & Mrs. Albie Hofstad have rights to a spring near the trail near the springs. Mr. & Mrs. Bahovec have a spring near the building (remains) from the territorial days. The group of springs which the Sonnaburghs have the rights to are separated from these and are collected as described in this report. The others pipe the water in black plastic hose up to 1-1/2" diameter.

Land ownership and the mineral estate conveyance have not been determined to a great enough extent in the area.

## SITE DATA SUMMARY

SITE: BARANOF

### ..Physical Reservoir Data

#### ..Temperature °C:

Surface: 50

Subsurface: 125 (White, 1975)

#### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

$.2 \times 10^{18}$  Cal. (White, 1975)

#### ..Type of Overlaying Rock:

#### ..Estimated Depth to Top of Reservoir (meters):

See Geotherm file for speculative reservoir analysis.

### ..Site Land Status

#### ..Total Acres:

Federal: 28,465

Private: 35

#### ..Total Acres Leased: 0

### ..Geothermal Development Status:

Presently used by owner for space heating his home. Geothermal waters are also used in a small bath house.

### ..Local and State Attitude Toward Geothermal Development:

State of Alaska considers this site as one of the most attractive for the development of a world class fish hatchery. Personal contact with part time resident indicates area people are resistant to outside influence (Guitierrez, 1978).

### ..Land Use and Population:

Used as resort/recreational area (1,000 visitors per year, Ogle, 1976). The Forest lands are in the primary sale area for long term timber sales under existing Forest Service plans (USFS).

### ..Comments and Critical Issues:

U.S. Forest Service is now developing a Forest Management Plan for the Tongass National Forest. Numerous plans are now being reviewed, from a wilderness preservationist philosophy to a

resource development attitude. This plan should be completed by the fall of 1979 (USFS).

#### SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: BARANOF

..Latitude: 57° 05' N

..Longitude: 134° 50' W

..Rectilinear: T55S, R66W, CRM, Sitka Quadrangle

..County: Sitka Borough

..Topography:

This spring location is part of the flooded coastline of southeast Alaska. This fjord country has seen much glaciation. Alpine glaciers descended from central mountains and eroded spectacular glaciated valleys. These valleys terminate in small fjords that indent the coastline for distances of .8 to 6 miles. There has been considerable stream erosion (Soward, 1961).

..Present Land Use:

Now used by local fishermen as a resort area. There are three year round families with a half dozen or so more summer recreation cabins in the area.

..Future Land Use Plans:

State will probably build a world class fish hatchery, perhaps utilizing the geothermal resources. The area should remain the same after the construction impact. There are questions on the economics of using geothermal energy (i.e. the hatchery), but a hatchery will probably be built in any event.

..Aesthetics:

The aesthetics are truly southeastern, complete with waterfalls. The whole area is much the same as the fjords of Scandinavia.

..Historical/Archaeological Significance:

Tlingit Indians used springs for bathing. Baranof town was established as a fishing/timbering country in the 1920's. Within a few years, the springs were commercialized. A bordello was established and a rather seedy element capitalized on the development. By the 1950's, only a few old timers remained. From that time on, the town has become the recreational haven it is today (Ogle, 1976).

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: BARANOF

### ..Geologic Description:

The rocks of Chichagof and Baranof Islands lie in broad belts that strike northwest-southeast and conform with the prevailing structural trend of Southeast Alaska (Knoff, 1912). The core of Baranof Island is made up largely of quartz diorite intruded parallel to the stratified rocks. A large batholith crosses the north end of the Island. Bordering the batholith is a northwest trending belt of metamorphic rocks. In turn, this belt is bordered by another composed of greywacke and slate that forms the bedrock on the west side of the island (Soward, 1961).

The Baranof Lake area is in biotite quartz diorite to toncrite of Cretaceous age. The springs themselves are associated with faulted granite and diorite (Waring, 1965). A generally trending west-southwest fault system appears to run up the warm springs valley and is the probable structural control for it. The springs are most likely associated with this fault system.

### ..Geophysical Summary:

There has been no geophysical investigation of the area.

### ..Geologic Hazards:

This is an area of high seismicity. Mass wasting and flooding are also considerations in this area.

## RESERVOIR CHARACTERISTICS

SITE: BARANOF

### ..Reservoir Temperature:

..Surface: 50°C (White, 1975)

..Subsurface: 125°C

### ..Geochemical:

SiO<sub>2</sub>: 119 (White, 1975)

Na-K-Ca: 68

..Flow Rates: 50 to 100/gpm (Ogle, 1976)

..Fluid Chemistry:

SiO <sub>2</sub>	70
Al	0.37
Fe	---
Ca	2.5
Mg	.14
Na	51
K	1.2
Li	.06
NH <sub>3</sub>	---
HCO <sub>3</sub>	88.4
CO <sub>3</sub>	---
SO <sub>3</sub>	68
Cl <sup>4</sup>	11
F	1.2
Br	---
B	0.2
pH	9.6
Temp. °C	51

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.2 x 10<sup>18</sup> Cal. (White, 1975) (Assumed)

..Subsurface Area of Reservoir: 1,500 m (White, 1975) (Assumed)

LAND OWNERSHIP AND LEASING

SITE: BARANOF

..Land Ownership:

..Total Acres: 28,500  
..Federal Acres: 28,465  
..Acres (Other): Approx. 35

..Tentative Lease Sale Dates: None planned

..Summary of Leasing Status and Needs:

Presently, the private lands are the only ones available for development. The Forest Service is in the process of inventorying all the resources within the national forest. Out of this planning is to come an overall resource development schedule. This plan is about one year away from completion.



## GEOHERMAL DEVELOPMENT STATUS

SITE: BARANOF

### ..Present Development Status:

Water is collected from four springs in concrete cribs. The water travels through a 4" plastic pipe then a 3" pipe in a gravity powered system. The water covers about 1/2 mile before emptying into a bath house. The system is tapped along the way for the owner to utilize the hot water for space heating his home.

The heat loss in the 1/2 mile system is about 8°F in the uninsulated system. The system in the house consists of approximately 60 linear feet of 2' high radiators. Some oil is required to peak the system on cold days because of the low surface temperatures of the incoming water. The house being heated is approximately 20' x 50' in area (Ogle, 1976).

### ..Projected of Planned Development:

The State Fish and Game Department and the Division of Energy and Power Development are actively pursuing the use of the springs for a fish hatchery. This development would be one of the world's largest. There would be in the neighborhood of 50 million smolt being reared at capacity. As visualized, the facility would probably utilize the entire capacity of the spring system. Recent analysis shows that the surface manifestation is not sufficient for a total utilization system. The Fish and Game Department does not feel that it will be worthwhile in utilizing geothermal energy in the hatchery unless an economic advantage could be found. Geothermal fluids support to the hatchery could be utilizing the geothermal fluids, for a food enhancement farm for the fish. Presently, energy needs for the hatchery would be received from a proposed hydroelectric plant. Further economic studies are planned. Because of the low surface temperatures of the present system, a heat pump assist might be considered if any utilization is to be used there.

## INSTITUTIONAL CONSIDERATIONS

SITE: BARANOF

### ..Institutional Requirements:

The only requirement for private lands for development would be a State permit that should be obtained in the case of drilling to insure for water rights. The Borough of Sitka Planning Department would have to approve the plans for any construction. Federal lands using geothermal energy for development would have to comply with a cadre of Federal regulations outlined in the legal paper.

..Agency and Public Attitudes:

Local residents are resistant to any increase in population (USFS).

..Status of Requirements (i.e., EIA/EIS Requirements):

National forest is in the process of being inventoried and planned.  
No EIS for the hatchery has been started.

ENVIRONMENTAL FACTORS

SITE: BARANOF (EXTRACTED FROM SOUTHEAST REGIONAL PROFILE)

..CLIMATE: (From Kake)

..Precipitation (Annual): 77" (58" of snow)

..Average Temperature:

Summer: 44 to 62°F (7° to 17°C)  
Winter: 26 to 38°F (-3° to 4°C)  
Minimum: -4°F (-15°C)  
Maximum: 88°F (30°C)

..Degree Days (Annual): 7,800

..AIR QUALITY: No known pollutants.

..WATER QUALITY:

Mean annual runoff 16 cu.ft./sec./sq.mi. State Fish & Game has requested water rights for the proposed fish hatchery. The water would be used from the lake above the springs.

..NOISE: None.

..BIOLOGICAL:

..Dominant Flora:

Coastal and western hemlock Sitka spruce forest.

..Dominant Fauna: Sea mammals and waterfowl.

## TRANSPORTATION AND UTILITIES

SITE: BARANOF

### ..Utility or Energy Transmission Corridors and Facilities:

City of Sitka. Located 25 miles from the site. No access to right-of-way.

### ..Transportation Corridors or Facilities:

Electrical energy needs supplied by a pelton wheel. Excellent hydroelectric potential exists here.

## POPULATION

SITE: BARANOF

### ..General Description of Population:

Three families of retired to semi-retired people generally and economically coming under the concept of subsistence lifestyles.

### ..Economics:

..Present Land Use: Subsistence

..Future Land Use:

Timber sales and logging. Construction of a world class fish hatchery and related facilities.

SITE: Fish Bay

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 57° 22' N; 135° 23' W

QUADRANGLE: Sitka, B-5, T52S, R62 E, CRM

BARRIER: Forest Service management plan not completed

RECOMMENDATION: Agricultural recreation complex upon development of road.

DESCRIPTION:

A number of hot springs issue along a small stream about 3 miles (4.8 km) east of the head of Fish Bay. They are located in the Fish Bay P.G.R.A., 27,600 acres (11,169 hectares), and are the only surface geothermal manifestations known in the P.G.R.A.

The dominant rock type in the area is a Jurassic Triassic sequence of greenstone, schist, graywacke, gneiss, phyllite and limestone. To the west, major expressions of granitic igneous rocks of Cretaceous age outcrop.

The waters of the 24 springs appear to be very similar: all are mildly sulphurated, but not otherwise notably mineral in taste. More or less active bubbling is caused at several vents by CO<sub>2</sub> (Waring, 1917). The surface temperatures range from 24° to 40°C and they feed a small creek (Nava, 1975). The flow is estimated to be 1.58 l/s. The subsurface temperature best estimates is 150°C (Geotherm).

Unlike most hot springs waters, the chloride content is very low. Silica content is high, as it is in other Alaskan springs. The presence of 34 ppm of B<sub>4</sub>O<sub>2</sub> indicates the presence of volcanic emanations of intrusive volcanic rocks carrying appreciable amounts of boron (Waring, 1917).

SiO <sub>2</sub>	110
Al	1.6
Fe	0.75
Ca	13
Mg	2.4
Na	69
K	
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	43
CO <sub>3</sub>	63
SO <sub>4</sub>	24
Cl	4.5
F	---

Br	---
B	10.1
pH	---
Temp. °C	47

#### SOCIO-ECONOMIC:

This area is located within the Tongass National Forest and the Sitka Borough. At this time, the Forest Service is developing a management plan for the Tongass National Forest. This process has produced several forest-wide management plans, grading from a resource development orientation, to a wilderness preservation plan. The area around Fish Bay hot springs is classified as a multiple use area for most all management plans. One plan, however, does propose it as a roadless area. Under present management systems, the area is designated as a primary timber sale area. A proposed land transportation corridor connecting Sitka with Peril Strait would pass along the head of Fish Bay (USFS). If, in fact, this corridor were opened, some type of development would probably follow.

According to USGS maps, a couple of cabins exist at the mouth of Fish Bay, as well as a tractor trail three-fourths of the way to the spring. A foot trail continues on to the springs from this point. Springs are presently used for bathing. Aerial observation photographs suggest that the area marked as a hot spring on the topographic map of the U.S. Geological Survey has been mislocated. It has been since confirmed that the area was a mile or two closer to Fish Bay than shown on the map (Nava, 1975). There is evidence of old wooden structures around the springs.

The nearest population center is Sitka, 25 air miles (40 km) southwest and by sea, it is 60 miles (46 km). Major industries in the Sitka area are logging, fishing, tourism and government. There is a hot springs closer to Sitka to the south.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Sitka is the nearest climatological recording station. Winds for Sitka prevail from the southeast at 6.2 knots. The average precipitation is 86" (216 cm), including 35" (89 cm) snow. Average summer temperatures range from 46 to 62°F (8 to 17°C) and winter is 28 to 40°F (-2 to 5°C). Extremes are 0 to 85°F (-17 to 29°C). Heating degree days average 8,000. One might expect more snow because of the locality at Fish Bay.

The dominant flora are those of the coastal western hemlock/Sitka spruce forest. The area is identified as a key waterfowl range with Sitka deer and brown bear present in numbers. Sea mammals inhabit Fish Bay and razor clams are found along the beaches. Offshore bottom fisheries are located at Salisbury Sound. The endangered bald eagle resides in the area.

The springs are located in an area of high seismicity.

KEY CONTACT:

Borough Planner, Sitka, Alaska  
Regional Forester, USFS, Chatham area  
Tongass National Forest

REFERENCE:

Waring, "Water Resources Inventory", 1917  
Southeast Regional Profiles  
USGS Publications I-411 and I-388  
Draft, Tongass National Management Plan

SITE: Nylen

RESOURCE: Hot Springs (USFS)

LATITUDE & LONGITUDE: 57° 34' 46" N; 135° 20' 00" W

QUADRANGLE: Sitka C-5 SE 1/4 of Section 8 and NE 1/4 Section 14 T49S,  
R63E, CRM

BARRIER: Remote

RECOMMENDATION:

DESCRIPTION:

Located on Chichagof Island North of Peril Strait.

The surface springs are 2,000 feet (610 meters) from the west bank of a creek. Nine springs have been located, eight are small, one is larger flowing 8 gallons per minute, (.0304 cubic meters per minute.) The hot water flows over a 30 foot (9.15 meters) rock wall making up the creek bank and flows into the creek. The location can be found from Broad Creek's East Fork, by mosses in streams along the east bank. The temperature is 49°C. (Personal communications, Harmon, 1978).

Hardness	229.30
Zn	.18
Mg	.5
Mn	.0
Fe	.0
Cv	.011
Ni	.0
Ca	90.0
Cd	.005
Pb	.0
As	.0
Cr	.009
Mo	.3
Sr	.908
Se	.0
Zr	.006
Sb	.0
Co	.13
AL	.26
Total Phosphores	.061
Ortho-Phosphores	.032
pH	8.7
Specific Conductivity	523.832
Alkalinity Hco3C	4.05

The generalized geology of the area would indicate the springs are associated with Cretaceous granitic intrusions of the Moore Mountains. The contact between these intrusions and the sedimentary-metamorphic country rock is in the general vicinity. The granitic pluton is depicted on the geology map in the Southeast Regional Profile.

#### SOCIO-ECONOMIC:

This spring system is located within the Tongass National Forest. New development is generally discouraged at this time as the Forest Service is presently developing a management plan for the entire National Forest. This process has produced numerous forest-wide plans grading in philosophy from that of resource development orientation to wilderness preservation orientation. Most of these plans designate the area for multiple use. Under present management plans a primary timber sale designation has been placed on the land (USFS).

The nearest population is Tenakee Springs, 10 miles (16 km) to the north, across the mountains and Tenakee Inlet. The logical staging area for any development here will be Sitka.

Recreational utilization by the Forest Service is a logical course for development.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

At Tenakee Springs the summer temperatures average 45° to 61°F (7° to 16°C); winter 24° to 36°F (-4 to 2°C) with extremes of -10° to 77°F (23° to 24°C). Annual heating degree days average 8,800. Mean annual runoff is 10 ft.<sup>3</sup>/sec./mi.<sup>2</sup>.

The dominant flora is that of the coastal and western hemlock and Sitka spruce forest. The dominant fauna is bear, and Sitka deer.

The springs are located in an area of high seismicity.

#### KEY CONTACT:

Forest Manager, Chatham area USFS  
Geologist, Carl H. Harmon, USFS

#### REFERENCE:

Personal Comments from Carl Harmon Geologist, USFS  
Southeast Regional Profile  
Draft, Tongass National Forest Plan  
USGS Publication I-388



SITE: Gut Bay

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 56° 44' N; 135° 18' W

QUADRANGLE: Port Alexander, T59S, R68E, CRM

BARRIER: Forest management plan not complete

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Gut Bay P.G.R.A., 26,450 acres (10,704 hectares). The springs are located on the north shore of Gut Bay (Waring, 1965). The major structural feature in the area is the Patterson Bay fault system, which trends north-northwest through the western portion of Gut Bay. Gut Bay itself trends to the east into the Chatham Straits. The main body of rocks to the east of the fault on the north shore of Gut Bay consists of hornblende-biotite granodiorite, grading into subordinate hornblende-biotite tonalite of Cretaceous age. The main assemblage to the west of the fault is hornblende-biotite tonalite, grading into subordinate biotite tonalite and hornblende-biotite granodiorite. The pluton at Gut Bay contains a higher proportion of hornblende to biotite than does the tonalite to the west (Loney, et. al., 1964).

The rocks associated with the springs themselves are Paleozoic limestone and schist. The water emanating from the springs are sulfurous (Waring, 1965). No chemical or geophysical exploration has been conducted in the area.

Stream temperatures along both the first creek on the north side of Gut Bay and the second stream were only 1°C and 4°C when visited in 1974 (Nava, 1975).

SOCIO-ECONOMIC:

This P.G.R.A. is located within the Tongass National Forest and Sitka Borough. New development is generally discouraged at this time because the Forest Service is presently developing a new management plan for the entire national forest. This process has produced numerous forest-wide plans that grade in philosophy from wilderness preservation to resource development options. The Gut Bay area invariably is recommended for inclusion in the national wilderness preservation system. (Withdrawn November, 1978, for three years under Sec. 204, Federal Land Policy and Management Act, 43 U.S.C., Q1714(e)) This would allow exploration but not exploitation of the geothermal resource. The area is one of high scenic beauty with alpine lakes, fjords and mountain peaks adding their grandeur to the virgin forest lands.

Under current plans, the South Baranof Island area is a long term timber primary sale area.

There are no permanent residents in the Gut Bay area. There is presently no commerce. The nearest settlements are Port Herbert, Big Port Walter, south 18 miles (29 km) and the Piller Bay Cannery, across the straits on Kuiu Island. The nearest staging area is Sitka, 35 miles (56 km) by air northwest across Baranof Island.

If no timber sales occur on land available, it is doubtful that this area will be developed in the near future. Hydroelectric and wood sources of energy would compete as energy sources.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL REPORT

The nearest climatological station is Little Port Walter. Temperatures average 45° to 61°F (7 to 16°C) in the summer and 31 to 38°F (-1 to 3°C) in the winter. Extremes reach 0 to 81°F (-18 to 27°C). Precipitation is in the neighborhood of 221" (561 cm), including 123" (312 cm) of snow. These readings may be somewhat conservative. The heating degree days should be about 8,700. The mean annual runoff is very high, at 20 cu.ft./sec./sq.mi.

The dominant flora in the area is that of the coastal western hemlock and Sitka spruce forest that dominates southeastern Alaska. Notable brown bear and sea mammal ranges are noted in the Gut Bay area. There is some note of significant waterfowl ranges in the area.

Environmental hazards related to seismicity and mass wasting should be noted.

#### KEY CONTACTS:

Manager, Tongass National Forest, Chatham Area  
Sitka Borough Planner

#### REFERENCE:

Draft Tongass Land Management Plan  
Southeast Regional Profiles  
USGS Publication I-411 (Loney, et. al, 1964)  
Public Land Order #5653, BLM

SITE: Vank

RESOURCE: Reported hot spring (Waring, 1917)

LATITUDE & LONGITUDE: 56° 27' N; 132° 36' W

QUADRANGLE: Petersburg, T62S, R82E, CRM

BARRIER: Forest Service management plan incomplete

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Vank Island P.G.R.A., 2,920 acres (1,181 hectares). A hot springs was reported on Vank Island by G. Waring in his 1917 survey of hot springs in Alaska. He, however, did not visit the spring at that time.

The rocks of Vank Island are part of the belt of Cretaceous to Jurassic slate, greywacke, conglomerate and limestones, associated with the coastal foothills. The entire area has been heavily glaciated. This reported hot springs is inactive or dried up. (Personal correspondence with Dean J. Weeden, Program Manager, R&L, USFS).

SOCIO-ECONOMIC:

Vank Island is located 7 miles west from Wrangell. The area has heavy sea traffic, including the routes of the Alaska Ferry System.

The surface management agency is the U.S. Forest Service. Vank Island is part of the Tongass National Forest. The Forest Service is presently in the process of developing a management plan for the Tongass National Forest. The process has produced numerous alternative management plans. These different plans, in almost all cases, have Vank Island designated as a multiple use area. A consensus plan will be developed after public review of the existing plans. Sometime in 1979 this consensus plan will be put out for public review and eventually adopted.

Recently, an economic study was conducted by Pacific Science Research Corporation on the possibility of developing a local gradient geothermal resource at Wrangell, Alaska. This study indicated that the normal local gradient facility would be able to economically compete with the present fossil fuel system in Wrangell. This spring would indicate that perhaps a greater than average local gradient exists and perhaps the economics are better than expected.

Further exploration should be undertaken to see the extent of the resource, if any.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Summer temperatures range from 47 to 65°F (8 to 23°C) and in winter 24 to 37°F (-4 to 3°C). Extremes of -10 to 92°F (-23 to 33°C) have been recorded. Precipitation averages 82" (208 cm), including 76" (193 cm) snow. The annual heating degree days average 8,700.

The dominant flora is the coastal western hemlock and Sitka spruce forest. The island is part of one of the major migration stopovers for waterfowl in Southeast Alaska (Selkregg, 1975).

The springs are located in an area of high seismicity.

KEY CONTACT:

Forest Manager, Tongass National Forest, Stikine Area

REFERENCE:

Southeast Regional Profiles  
Draft Tongass Forest Management Plan  
Waring (1917)  
Dean J. Weeden, USFS Personal Correspondence

SITE: Bailey Hot Springs

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 55° 59' N; 131° 40' W

QUADRANGLE: Ketchikan; T68S, R89E, CRM

BARRIER: Forest Service management plan not complete

RECOMMENDATION: Prime development site - wood processing/tourism

DESCRIPTION:

Located within the Bell Island-Unuk P.G.R.A., 197,210 acres (79,811 hectares) near Bailey Bay. This area is about 50 air miles (80 km) north of Ketchikan, off the Behm Canal. The springs occur about one quarter mile up from the mouth of Spring Creek, which drains into Lake Shelokum. Lake Shelokum, in turn, drains via a steep cascading bedrock channel into the head of Bailey Bay. The valley has been glaciated and has slopes between 30° and 45°. Local elevations range from 349' (106 m) to 2,400' (731 m) (Baker, 1977).

The springs lie between 40' (12 m) to 150' (45 m) above Spring Creek. The valley bottom is flat because of alluvial infill. Bedrock at the springs and vicinity consists of granitic intrusive rocks of Cretaceous age (Biekman, 1975; Smith, et. al., 1977). When examined closely, the springs issue from a crevice in the granite. The issuance of the springs at such notably different elevations on a steep slope is unusual and indicates that the several fissures are not closely connected, or all the water would tend to flow from the lowest spring (Waring, 1917).

There are nine springs that flow with an estimated 99-108 gpm (about 350 lpm). Spring water temperatures range from 45 to 90°C (Baker, 1977). Chemical analyses are from Baker, 1977.

H <sub>2</sub> S	7*
NH <sub>3</sub>	0.2*
NO <sub>3</sub>	0.2
Phosphate, Ortho	0.25
Alkalinity, Bicarbonate	112
Alkalinity, Carbonate	11
CO <sub>2</sub>	0.2
Chloride	38*
TDS	230
Hardness (Total)	28
F	2.0*
SO <sub>4</sub>	330*
Se	0.002
Cu	0.007
Ca	0.8*

Na	93*
K	2.0
Ag	0.0002
Pb	0.002
Cd	0.0003
Cr	0.0025
SiO <sub>2</sub>	54
Al	0.01
As	0.005
B	0.3
Fe	0.05
Mg	0.1
Mn	0.003
Ni	0.007
Sb	0.005
Zn	0.001
Hg	0.001
V	0.01
Conductance (umohs/cm)	350
**Temperature (°C)	26
pH	8.8*
Date	6-7-77

- \* Exceeds ADFG water quality criteria for salmon aquaculture
- \*\* Temperature at which chemical analysis was accomplished.

#### SOCIO-ECONOMIC:

The springs were once developed as a resort with a wagon trail to the lake below. This resort closed during WWII. A 3-sided lean-to is all that remains.

The site is accessible only by float plane to Lake Shelokum. Spring Creek Valley is unsuitable for the construction of an airstrip (Baker, 1977). A Forest Service trail (in disrepair) provides foot access from the western shore of Bailey Bay to the hot springs, but is unsuitable for vehicular traffic.

Bell Island resort is 5 miles southeast of the hot springs, and could provide room, board and communications for work crews. Ketchikan, 50 miles south, would be the main logistics camp with a major airport and port.

All lands in the immediate area are located within the Tongass National Forest. New development is generally discouraged at this time because the Forest Service is presently developing a management plan for the entire Tongass Forest. This process has produced several forest-wide plans grading from one that is resource development oriented to one which is wilderness preservation oriented. Under these plans, the area would probably be placed in a roadless area.

The area has probable bedrock building conditions with plenty of wood building materials. Sand and gravel are located near the site. The temperatures of the springs are suitable for numerous direct heat applications. Those related to wood processing, aquaculture and balenology seem most likely to be utilized by the Forest Service. The elevation makes gravity feeding a likely prospect for any development.

"The temperature and flow rates are such that a small binary geothermal electric generating plant could develop perhaps 60 Kw of power", Dr. Ogle, 1976. He suggested cascading uses and a fish lodge as logical utilizations.

Resource could support a 30 Kw generator with enough energy left-over to space heat twenty cabins (Ogle, 1976).

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Ketchikan is the nearest climatological recording center for the area. Precipitation measures 154" (391 cm) including 32" (81 cm) snow. There may be less in the hot springs area because of exposure. Average summer temperatures range from 48 to 66°F (9 to 19°C) and winter ranges from 30 to 40°F (-1 to 6°C). Minimum temperature recorded is -8°F (-22°C) and maximum is 96°F (36°C).

Annual heating degree days approximate 8,400 in this area (Selkregg, 1975).

There is adequate fresh water in the area at Lake Shelokum with an annual flow rate of 150 cfs. This inlet stream presents a potential flood hazard. Ground water in the area is moderate in the valley. Mean annual runoff is 8 ft.<sup>3</sup>/sec./mi.<sup>2</sup>. Avalanches are noted on the mountain side. The area is one of high seismicity.

The dominant flora in the area is associated with the dense western hemlock, Sitka spruce forests. The fauna is dominated by fish. The area has excellent trout and salmon fishing. High density waterfowl concentrations are associated with the Behm Canal. Some Sitka deer are found in the vicinity.

The springs are located in an area of high seismicity.

#### KEY CONTACTS:

William Ogle, Consultant, Anchorage  
Forest Manager, Ketchikan Area Tongass National Forest

#### REFERENCE:

Ogle: Visit to Hot Springs  
Draft Tongass National Forest Plan  
Southeast Regional Profiles  
Baker, Aquaculture Study  
Geotherm File, U.S.G.S.

## BELL ISLAND

Bell Island hot springs is located on the western end of Bell Island, about 40 air miles north of Ketchikan in southeastern Alaska. It was picked as the site for a possible demonstration geothermally-enhanced salmon hatchery in a recent study conducted by the State Department of Fish and Game, and the Division of Energy and Power Development. The consensus was that, of the seven springs studied, the climate and logistics were most favorable at Bell Island.

The springs are located in T68S, R89E, of the Copper River Meridian. The springs issue adjacent to a creek in the floor of a narrow valley several hundred feet wide. The valley is confined by 30 to 40° slopes that rise to over 1,500 feet in elevation along southwest-trending ridges. The creek enters the sea at a narrow cove, such that the last 200 to 300 feet of the stream are tidal.

Dense spruce forest covers all of the adjacent valley slopes. The only areas of little or no vegetation are the intertidal and resort development areas.

Presently, the springs are used by owners as a fishing resort. The springs are utilized for space heating the lodge and adjacent cabins. A swimming pool using the resource is also at the resort.

The resort is the main commercial enterprise in the immediate area, although a small log mill is also sporadically in operation (probably run by the lodge owners).

The Bell Island hot springs resort, which includes 11.05 acres surrounding the springs, is owned by James and Veris Dykes. Surrounding lands are within the Tongass National Forest. Amex Mining Company has staked mining claims in the vicinity within the confines of the National Forest.

The lodge supplies its electrical needs from a diesel generator. The area does have a potential for low head hydroelectric usage. Wood is an appropriate alternate fuel source because of the dense forest. These forms of energy in close proximity give Bell Island the capability of energy self-sufficiency.

The bedrock at the hot springs site consists of granitic intrusive rocks of Cretaceous to early Tertiary age, including foliated quartz diorite. Major fractures and joint patterns are visible in the bedrock.

The topography owes its form to intense glacial scour. Even though this glacial scour produced very steep valley walls, there are no indications of slope instability and there are no avalanche scars at or in the vicinity of the hot springs.

The temperature of the hot springs is 72°C with a flow of 113 lpm. No reservoir assessment has been made to date, so its extent is purely speculative. The age of the granite would indicate that the plutons radiogenic heat is probably not the main source of heat for the springs.



The model of a deep circulating meteoric system would fit Bell Island well.

Any probable use of the resource would have to utilize the surface manifestation. That, in fact, is what the Department of Fish and Game proposes in their study of the area for a potential fish hatchery. The resource is thought to be sufficient to sustain the needs of 100,000,000 pink salmon fry. Fresh and thermal waters are sufficient in quantity and quality to meet the needs of the hatchery.

The temperature and quality of the springs allows the owners a great deal of latitude in determining what use to make of the resource. Space heating, agriculture, aquaculture, wood drying, and animal husbandry have all been proven at temperatures below 72°C. With the proximity of the forest lands, consideration of cottage industries associated with wood drying might be profitable.

The facilities proposed will be located on private lands. No special permits will be required since the utilization of the resource will be for surface manifestations.

Presently, the forest lands within the potential geothermal resource area (P.G.R.A.) are being inventoried to develop a new Forest Management Plan under provisions of the National Organic Act. The Forest Service has put out numerous management plans for public comment. The preservationist plans have Bell Island located in a roadless area with no timber production. The development-oriented plans include Bell Island in a multiple use area. The review process will produce a plan within the next year (1979). Under present management plans, there is a proposed road system corridor in the area that would someday hook up with the Alaska Highway System. There is also a contingency timber harvest area designated to the south of the site. There are no Forest Service plans to consider the geothermal resource at this time.

The basic assumption on scenario development is that funding will be arranged through the State and Federal governments for the demonstration of salmon hatcheries. The planning and time frames were developed by these management agencies.

This proposed aquaculture project was turned down by the Federal Government and the State plans to correct inadequacies in the project and resubmit at a later date.

## SITE DATA SUMMARY

SITE: BELL ISLAND

### ..Physical Reservoir Data

#### ..Temperature °C

Surface: 72°

Subsurface: 145° (White, 1975)

#### ..Estimated Non-Electric Energy Potential (MBtuh\* 30 years):

.1 x 10<sup>18</sup> cal. (White, 1975)

..Type of Overlaying Rock: Intrusive granite

..Estimated Depth to Top of Reservoir (meters):

### ..Site Land Status

..Total Acres: P.G.R.A. - 297,210 acres (120,280 hectares)

Federal Acres: 296,198

Private: 11.05

### ..Geothermal Development Status:

Bell Island Hot Springs Resort utilizes thermal waters for space heating the lodge and cabins. There is also a swimming pool that is heated with the geothermal resource (Baker, 1977).

### ..Local and State Attitude Toward Geothermal Development:

State Fish and Game Department has been actively pursuing initiating fish hatchery at the site. Concurrence has been received by owner of springs.

### ..Land Use and Population:

Used as a fishing resort. Owners and employees only true residents. The owner spends a good deal of winter in Seattle.

### ..Comments and Critical Issues:

Demonstration project rejected by Federal funding program. Resubmittal likely.

## SITE LOCATION AND PHYSICAL DESCRIPTION

SITE: BELL ISLAND

..Latitude: 55° 56' N

..Longitude: 131° 34' W

..Rectilinear: T68S, R89E, CRM

..County: None

..Topography

The topography of Bell Island owes its form to intense glacial scour imposed upon NE-SW and E-W structural grain. Some bedrock exposure on valley sides. Soil deposits in valley are thin colluvium. Valley slopes are steep but stable (Baker, 1977).

..Present Land Use:

Used as fishing lodge and resort area with swimming pool. All facilities heated geothermally.

..Future Land Use Plans:

As results of investigations by DEPD and State Fish and Game, it has been recommended for installation of fish hatchery utilizing the geothermal resource.

..Aesthetics:

As with most of southeast Alaska, the area is one of lush virgin forests. It is a wild land of inspirational beauty.

..Historical/Archaeological Significance:

No known significance other than resort. The resort itself has been utilized since around the turn of the century.

## GEOLOGICAL/GEOPHYSICAL DESCRIPTION

SITE: BELL ISLAND

..Geologic Description: (Baker, et. al., 1977)

Bedrock at the site and in the vicinity consists of granitic intrusive rocks of Cretaceous to early Tertiary age, including foliated

quartz diorite, grano-diorite, and quartz monzonite (Biekman, 1975; Smith, et. al, 1977). Major fracture and joint patterns trending east-west and northeast-southwest are visible in the bedrock from inspection of aerial photographs. Evidences of slickenslides on the rocks near the springs give indication of some faulting in the vicinity. This faulting may allow the escape of deep-seated hot water along the well-marked fissure, presumably of fault origin from which the springs rise (Waring, 1917).

..Geophysical Summary: (Pyle, 1978)

There has been a limited seismic profile obtained to determine depth of sediment and ground water characteristics. The results indicate that the sediments are much deeper than anticipated (50') and this is probably due to faulting. This has been the only geophysics conducted in the area.

..Geologic Hazards: (Pyle, 1978)

Earthquakes are common in the area. There are also some precariously balanced rocks on the canyon walls.

RESERVOIR CHARACTERISTICS

SITE: BELL ISLAND

..Reservoir Temperature (White, 1975)

..Surface: 72°C

..Subsurface: 145°C

..Geochemical (White, 1975)

SiO<sub>2</sub>: 140

..Flow Rates: 30 gpm (113 lpm) (Baker, 1977)

..pH: 8.9 (Baker, 1977)

..Total Dissolved Solids: 700

..Fluid Chemistry:

H <sub>2</sub> S	0.02*
NH <sub>3</sub>	0.14*
NO <sub>3</sub>	0.6
Phosphate, Ortho	0.1
Alkalinity, Bicarbonate	57
Alkalinity, Carbonate	0.4
CO <sub>2</sub>	0.1

Chloride	174*
TDS	700*
Hardness (Total)	17
F	3.15
SO <sub>4</sub>	1175*
Se <sup>4</sup>	0.01
Cu	0.008
Ca	6.0*
Na	300*
K	7.2*
Ag	0.0002
Pb	0.004
Cd	0.0003
Cr	0.0012
SiO <sub>2</sub>	55
Al	0.01
As	0.02
B	0.01
Fe	0.47
Mg	0.2
Mn	0.005
Ni	0.025
Sb	0.01
Zn	0.001
Hg	0.001
V	0.01
Conductance (umohs/cm)	800
**Temperature (°C)	25
pH	8.9*
Date	6-8-77

\* Exceeds ADFG water quality criteria for salmon aquaculture

\*\* Temperature at which chemical analysis was accomplished.

(Baker, 1977)

..Estimated Non-Electric Energy Potential (MBtuh 30 years):

.1 x 10<sup>18</sup> cal. (Speculative) (White, 1975)

..Subsurface Area of Reservoir: 1.5 km<sup>2</sup>

#### LAND OWNERSHIP AND LEASING

SITE: BELL ISLAND

..Land Ownership: James & Veris Dykes

..Total Acres: 297,310

Federal Acres: 297,000 (FS Lands)  
Private Acres: 11.05 (at Bell Island)

..Land Leased: 11.05 leased to State for Hatchery

..Tentative Lease Sale Dates: None

..Summary of Leasing Status and Needs:

No interest in leasing federal lands has been shown.

#### GEOHERMAL DEVELOPMENT STATUS

SITE: BELL ISLAND

..Present Development Status:

Space heating for cabins, lodge. Spring fed swimming pool. The fishing resort has been one of Alaska's most popular resort areas. The capacity of the resort is the limiting factor in its utilization. Five of the springs are presently contained in a concrete basin. There is a pipe supply system that delivers the thermal water to the end use in space heating and the swimming pool (Ogle, 1974).

..Projected or Planned Development:

State Fish and Game Department, in conjunction with the Energy Office, has been actively pursuing the development of a salmon hatchery prototype utilizing the geothermal resource. This hatchery would utilize the entire output of the spring. It would have a capacity of 10 million smolt fish.

The project would include the construction of a modular hatchery which will be mounted on an ocean-going barge. The use of the hatchery would be for incubation of 25,000 coho salmon eggs at one time. The demonstration would last six years. Total cost would be \$1.6 million under present price schedules. The entire construction phase would only take one year.

#### INSTITUTIONAL CONSIDERATIONS

SITE: BELL ISLAND

..Institutional Requirements:

If Forest Service lands are to be leased, the procedures outlined in Title 43 CFR for geothermal leasing must be followed. On private lands, such as this development, there are no special requirements at this time to develop the resource.

..Agency and Public Attitudes:

Owner of resort has worked closely with State agencies in pursuit of salmon hatchery study.

..Status of Requirements (i.e., EIA/EIS Requirements):

Forest Service is in the process of developing work scenarios for the entire Tongass National Forest. These evaluations will determine many of the answers to EIS's for the area.

ENVIRONMENTAL FACTORS

SITE: BELL ISLAND (FROM UNUK RIVER)

..CLIMATE

..Average Temperature:

Summer: 43 to 69°F (6 to 21°C)  
Winter: 14 to 36°F (-10 to 2°C)  
Minimum: -2°F (-19°C)  
Maximum: 84°F (29°C)

..Degree Days (Annual): 8,400

..AIR QUALITY: Good

..WATER QUALITY:

1. Creek runs through resort 54 cfs, annual flow.
2. Minor quantities of ground water (shallow bedrock).
3. Geothermal waters high fecal coliform count exceeds aquaculture standards (Baker, 1977).
4. Mean annual runoff: 9 ft.<sup>3</sup>/sec./mi.<sup>2</sup>

..BIOLOGICAL

..Dominant Flora: Spruce, hemlock spruce

..Dominant Fauna:

Black bear, salmon, waterfowl range near major fish stream.

..Endangered Species:

Fauna: Some eagles, but not a problem with the type of development considered.

## TRANSPORTATION AND UTILITIES

SITE: BELL ISLAND

### ..Utility or Energy Transmission Corridors and Facilities:

None at present. Potential hydro sites are noted in area (Corps of Engineers). A proposed energy corridor is located to the east end of the island under present management system. Probably negated by creation of Misty Fjords National Monument.

### ..Transportation Corridors or Facilities:

None. Proposed land transportation corridor on main islands to south that would eventually hook up with Alaska Highway in Canada. Subject to change (USFS). Probably negated by creation of Misty Fjords National Monument.

## POPULATION

SITE: BELL ISLAND

### ..General Description of Population:

The only year round residents are the owners and operators of the hot springs resort. With the limited private acreage in the area, it is doubtful that much growth will occur in population.

### ..Economics:

#### ..Present Land Use:

The Forest Service is presently considering public input on the redrafting of its Tongass National Forest Plan under provisions of the Organic and Wilderness Act. Several plans have been made available for public comment at this time. The philosophy behind the plans run from preservationist to development. The two classifications that predominate the Bell Island area are roadless area and multiple use. A final plan will be drawn together for public comment from input into these alternatives. The eventual outcome will be a new management plan for the forest that should be out in 1979. Under present management systems, a proposed land transportation corridor has been designed that would cross the Behm Canal east of Bell Island. The Forest Service has also designated a portion of Revillagigedo Island, south of Bell Island, a contingency forest sale area.

Note: National Monument has been established in vicinity, does not appear to affect the hot springs.



SITE: Barton-Saks

RESOURCE: Hot Springs

LATITUDE & LONGITUDE: 55° 52' N; 131° 05' W

QUADRANGLE: Ketchikan, T69S, R94E

BARRIER: Forest Service Management plan incomplete

RECOMMENDATION: Exploration

DESCRIPTION:

Located on the periphery of the Bell Island-Unuk River, 297,210 acres (120,280 hectares). The group of hot springs on the eastern side of Behm Canal, about 10 miles (16 km) southeastward of the mouth of Unuk River and 5 miles (8 km) southeast of Saks Cove, was reported in 1917 (Waring, 1917).

The springs are said to be similar in general character to Bell Island hot springs, yielding approximately an equal amount of scalding water that is slightly sulphurated (about 50 lpm) (Waring, 1917). The water issues in part at the rocky shore and in part directly from a fissure in granite 200 feet back from the shore. The conjecture to the genesis of the springs are that they are the result of the escape of deep-seated water along fissures in the faulted and fractured granitic rocks that cover an extensive area in the region (Waring, 1917).

The area is part of the Boundary range and the topography is that of deep U-shaped valleys and numerous fjords. The mountains are bordered by cliffs that plunge into the sea. Most streams flow to the southwest across the range.

To the east of Behm Canal, a major segment of the coast range lineament cuts through the mountains. This fault generally separates the metamorphosed Paleozoic rocks of the Behm Canal area from the granitic intrusives of the mountains to the east.

SOCIO-ECONOMIC:

The area around the hot springs is located within the Tongass National Forest. New development is generally discouraged at this time because the Forest Service is developing a management plan for the entire Tongass National Forest. This process has produced numerous forest-wide plans grading from one that is resource development oriented to one which is wilderness preservation oriented. The Barton Saks springs are in or near the area of a proposed Misty Fjords wilderness area in all the plans. The area appears to have a future management classification of at least roadless area. On December 1, 1978, this area was included in Misty Fjords National Monument under Public Land Order #5654. This was done under authority of the 1906 Antiquities Act.

The nearest population center is Ketchikan, 45 miles (72 km) by air to the southwest. Bell Island is 30 miles (48 km) to the west. There are no permanent residents in the springs area.

The general consensus of the Forest Service is that the area will not be developed in the near future. The area is just out of the jurisdiction of the Ketchikan Gateway Borough.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The nearest recording station is the Unuk River recording station. The summer temperatures average 43 to 69°F (6 to 20°C) and winter 14 to 36°F (-10 to 2°C). Extremes of -2 to 84°F (-19 to 29°C) have been recorded. The heating degree days are in the neighborhood of 7,500.

The dominant flora is that of the coastal western hemlock and Sitka spruce forests. The area has been noted as an area abundant in mountain goats and moose. This area has major anadromous fish streams and is considered a key waterfowl range (Selkregg, 1976).

The springs are in an area of high seismicity.

#### KEY CONTACTS:

Forest Manager, Tongass National Forest, Ketchikan area

#### REFERENCE:

Southeast Regional Profiles  
Draft Tongass Forest Management Plan  
Waring, 1917  
Public Land Order #5654

SITE: Unuk

RESOURCE: Reported Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 56° 08' N; 131° 00' W

QUADRANGLE: Bradfield Canal; T66S, R93E

BARRIER: Forest Management Plan incomplete

RECOMMENDATION: Exploration

DESCRIPTION:

These hot springs are reported on the north bank of the Unuk River within the Bell Island Unuk River P.G.R.A., 197,210 acres (79,810 hectares). The springs are located 6 miles (9 km) above the mouth. It is believed to have rather a small flow and is neither very hot nor notably mineralized. The water probably issues from fissures in the granitic material that constitutes the country rock over large areas in the region (Waring, 1917).

This area around the reported location of the springs consists of intrusive granitics, probably Cretaceous granitics associated with the coast range batholith.

SOCIO-ECONOMIC:

The area around the Unuk River hot springs are within the Tongass National Forest. The national forest is in the process of formulating a forest management plan for the Tongass National Forest. Numerous plans have been prepared that range in philosophy from resource development to wilderness preservation. These plans are now being reviewed to formulate a consensus management plan that should be out in 1979 for public review.

Under the plans set forth, the Unuk River has been proposed as everything from a multiple use area to recommendations to include the area in the National Wilderness System in the Misty Fjords study area. Under present management plans, a land transportation corridor proposal has been identified along the north shore of the Unuk River. The Unuk River is one of the few corridors through the coast range that a road could be built. This area now appears included in Misty Fjords National Monument. (Public Land Order #5654, December 1, 1978). This was done under authority of the 1906 Antiquities Act.

There are some private lands located at the mouth of the Unuk River. Patents USS 2667, USS 1445, USS 2629, USS 2320 and USS 2740. These are homestead patents.

The nearest logistics center would be Bell Island, 25 miles (40 km) to the southwest. The nearest settlement would be Ketchikan, 80 miles (120 km) to the southwest.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The summer temperatures range from 43 to 69°F (6 to 21°C). Winter temperatures are from 14 to 36°F (-10 to 2°C). Extremes have been recorded from -2 to 84°F (-19 to 29°C). Heating degree days approach 7,500.

The dominant flora is that of the coastal western hemlock and Sitka spruce forest. Alpine tundra is dominant above timberline.

The reported fauna of the region includes mountain goats and moose in significant numbers. The area is a key waterfowl range, as well as Unuk River being a major anadromous fish stream.

The springs are located in an area of high seismicity.

KEY CONTACT:

Forest Manager, Tongass National Forest, Ketchikan

REFERENCE:

Southeast Regional Profile  
Draft Tongass National Forest Management Plan  
Waring (1917)  
U.S. P.L.O. #5654

SITE: West Shakes

RESOURCE: Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 56° 42' N; 132° 12' W

QUADRANGLE: Petersburg, C-1, T59S, R84E, CRM

BARRIER: Forest Service Management Plan not complete

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Stikine River P.G.R.A., 137,580 acres (55,678 hectares). The springs are located on the north side of the Stikine River, 18 miles (29 km) northeast of Wrangell (Waring, 1965). The hot springs issue from alluvium overlaying intrusive granites. These granites are Cretaceous in age, and associated with the coast range batholith. Other springs are found in the area to the east (Great Stikine chief shakes hot springs). Further east in Canada, 28 hot springs are found. Normal radiogenic heat sources from the batholith are not thought to be the heat source for this spring. Conjecture by a prominent geologist is that a high heat flow might be found in the area, perhaps related to continental burial of an extension of the Juan de Fuca Rise.

The coast range lineament fault system is located to the west of the springs area. Associated faults are found in the vicinity of the springs. The immediate area has been heavily glaciated.

No exploration or assessment of the springs has been conducted to determine the geothermal potential.

SOCIO-ECONOMIC:

The land around the springs area is under the management of the U.S. Forest Service. The Forest Service is in the process of developing a management plan for the entire Tongass National Forest. Numerous management plans have been proposed and have been put out for public comment. The Stikine area has been proposed to be included in the national wilderness system in many of the plans. Other plans would have the area designated as multiple use lands which would permit development (USFS).

Under present management, there is a proposed land transportation corridor that would run in the vicinity of the springs. The Stikine River is one of the few corridors in which a road could be built through the rugged coast range. The area is also designated a high use area by the Forest Service (USFS).

There are no year round residents in the area. The obvious staging area would be Wrangell to the southwest. The economy there is based on timber and fisheries.

Balenology is an application that could be envisioned in this area utilizing the geothermal resource.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Wrangell is the nearest climatological station to the springs area. Summer temperatures range from 47 to 65°F (8 to 23°C) and winter 24 to 37°F (-4 to 3°C). Extremes have been recorded from -10 to 92°F (-23 to 33°C). Precipitation averages 82" (208 cm), including 76" (193 cm) of snow. Precipitation should be higher in the springs area according to the projection for mean annual runoff, which is 10 cu. ft./sec./sq.mi. Wind speeds average 9.0 knots in Wrangell, which has more exposure to the open waters. The annual heating degree days average 8,700.

The Stikine River system is one of the largest migration stopovers for waterfowl in southeast Alaska. The springs area has high habitate, as well as asthetic values that must be evaluated against the development potential.

The dominant flora is the coastal western hemlock and Sitka spruce forest. Moose and goats are the prominent mammals in the area.

The springs are located in an area of high seismicity.

KEY CONTACT:

Forest Manager, Stikine Area, Tongass National Forest

REFERENCE:

Draft Tongass National Forest Plan  
Southeast Regional Profiles  
Waring (1965)

SITE: South Stikine

RESOURCE: Hot Springs (Waring, 1965)

LATITUDE & LONGITUDE: 56° 38' N; 132° 15' W (Approx.)

QUADRANGLE: Petersburg, C-1, T60S, R83E, CRM

BARRIER: Forest Management Plan incomplete

RECOMMENDATION: Exploration

DESCRIPTION:

Located within the Stikine River P.G.R.A., 137,580 acres (55,678 hectares). The springs are located 8 miles (10 km) north of Wrangell on the south side of the Stikine River (Waring, 1965). The rocks associated with the hot springs are probably slate, phyllite, quartzite and schist with interlayered beds of marble and gneiss. These rocks range from Ordovician to Jurassic or Cretaceous in age. Granitic igneous rocks ranging from Ordovician to Tertiary in age outcrop both east and west of the band of Paleozoic rocks. These igneous rocks are associated or are part of the coast range batholith. The coast range linament fault system, which trends northwest the length of southeastern Alaska is located within a few miles.

The coast range batholith in this area is considered too old for a normal radiogenic heat source (Forbes). Yet, four separate springs systems are located along the American part of the Stikine River system. Numerous hot springs (28) are reported on the Canadian portion of the Stikine drainage as well. Conjecture by a prominent geologist is that a high heat flow is possible in this area, perhaps associated with a buried extension of the Juan de Fuca Rise.

The entire area has been heavily glaciated.

SOCIO-ECONOMIC:

The Pacific-Sierra Corporation recently completed an economic study on local gradient applications of geothermal energy at six towns in Alaska. Wrangell, Alaska, eight miles to the southwest, was one of the towns studied. The results of this study indicate that geothermal energy in Wrangell could economically compete with the present fossil fuel system used there. The assumption was made that an aquifer would be found at a depth based on the worldwide gradient norm. This aquifer would contain water at temperatures suitable for space heating.

There are 4,800 people in the Wrangell-Petersburg area. Wrangell itself has a population of 2,029. Unfortunately a channel exists between Wrangell and the springs area. The economic base is in the forest and fishing industries. Band and sawmills with associated

barkers, chippers, and planing mills are found in Wrangell. Principle woods are spruce and hemlock. The products are exported under the auspices of the parent Alaska Pulp Co. of Tokyo. A salmon cannery is also located in Wrangell (Selkregg, 1976).

The lands immediately around the hot springs are managed by the National Forest Service. The Forest Service is presently in the process of developing a management plan for the Tongass National Forest. Numerous plans have been put out for public comment. In these plans, the area that the springs are located in have been proposed as a multiple use area, as well as proposed inclusion in the wilderness system (USFS).

The area around the springs is classified as a high use area by the Forest Service. A proposed land corridor has been designated in the spring area under present management plans. The Stikine River offers one of the few possible corridors to the east of the coast range (USFS).

The area is generally thought to be going into the wilderness classification. Native claims are located on the same land mass as the springs area.

Serious thought should be given to the possible applications of geothermal energy before a decision is made on the future of the Stikine area. The future of the native lands could be enhanced by use of a cheap energy source. Possible wood processing utilizations could be used as well.

#### ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILES

Wrangell is the nearest climatological station to the springs area. Summer temperatures range from 47 to 65°F (8 to 23°C) and winter 24 to 37°F (-4 to 3°C). Extremes have been recorded from -10 to 92°F (-23 to 33°C). Precipitation averages 82" (208 cm) including 76" (193 cm) of snow. Average wind speed is 9.0 knots. Mean annual runoff is 8 cu.ft./sec./sq.mi. Heating degree days average approximately 8,700.

The Stikine River area is one of the largest migration stopovers for waterfowl in southeast Alaska. Moose and goats are the prominent mammals in the area. Marine mammals are located here, as well. The dominant flora is the coastal western hemlock and Sitka spruce forest.

The area has high asthetic, as well as habitat value and, as yet, is untouched. These values must be weighed against the development possibilities.

The springs are located in an area of high seismicity.



KEY CONTACT:

Forest Manager, Tongass National Forest

REFERENCE:

Draft Tongass Forest Management Plan  
Southeast Regional Profiles  
Waring (1965)

SITE: Chief Shakes Spring

RESOURCE: Hot Springs (White, 1975)(Waring, 1917)

LATITUDE & LONGITUDE: 56° 43' N; 132° 02' W

QUADRANGLE: Petersburg, (C-1), T59S, R85E, CRM

BARRIER: Forest Service Management Plan incomplete

RECOMMENDATION: Resort Area

DESCRIPTION:

The Chief Shakes hot springs are located within the Stikine River P.G.R.A., 137,580 acres (55,678 hectares). The Springs issue on the north edge of the Stikine River, about 20 miles (32 km) northeast of Wrangell. The springs are, perhaps, 150' (47 m) up a draw at the end of a small tributary of the Ketili River (Waring, 1917).

The springs issue at the base of a granite cliff that abruptly limits the Stikine Valley. Their exact point of issuance is obscured by boulders and undergrowth, but the water seems to come forth in a single stream only a few feet above the valley alluvium. Very probably, it rises through a fissure in the intrusive granitic material that forms the greater part of the coastal ranges (Waring, 1917).

The coastal range batholith consists of Cretaceous intrusive granite. The coast range lineament fault system is located to the east, which has a northwest trend. Both of these structural features play heavily in the regional tectonics of southeast Alaska. A major splinter of the lineament structurally controls the Stikine Valley in Canada at the point where it turns north.

The bedrock geology in the spring is thought to be that of the coast range batholith. Conjecture by a prominent geologist is that a high heat flow may exist in the area, perhaps related to sea floor spreading. This relationship is due to the burial of an extension of the Juan de Fuca Rise. Several other hot spring occurrences are noted along the Stikine River course, including some 28 in Canada.

The surface temperature of the spring is 125°F (52°C). The surface flow rate is 53.9 gallons/minute (380 l/min.) (Ogle, 1976). Geochemical reservoir predictions using  $\text{SiO}_2$  is 142°C and using Na-K-Ca is 175°C. The subsurface area of the reservoir is estimated at 1.5 km<sup>2</sup>. This data has been qualified due to chemical unreliability. The estimated heat content of the reservoir is  $.2 \times 10^{18}$  calories (White, 1975).

SiO <sub>2</sub>	108
Al	1.2
Fe	
Ca	13
Mg	0.4
Na	87
K	9.2
Li	---
NH <sub>3</sub>	---
HCO <sub>3</sub>	43
CO <sub>3</sub>	18
SO <sub>3</sub>	142
Cl <sup>4</sup>	6.5
F	---
Br	---
B	---
pH	---
Temp. °C	52

#### SOCIO-ECONOMIC:

The land around the hot springs is located within the Tongass National Forest. The Forest Service is in the process of developing a forest-wide management system for the entire Tongass National Forest. Numerous management plans have been put out for public review. These plans grade in philosophy from wilderness preservation to resource development. Most of the plans recommend the area for inclusion in the national wilderness preservation system. At least one plan, however, does suggest the area as a multiple use area (USFS).

Under existing management, the Stikine River canyon in the area of the springs has been designated a proposed land transportation corridor. The river system offers one of the few corridors through the rugged coast ranges. The area around the springs has been designated a high use area by the Forest Service (USFS).

There is no user at this time in the area for a major geothermal application. A small plastic A-frame has been built on the bank of the small stream, near the spring, and it contains a large wooden tub into which some of the spring water is diverted through a plastic pipe (Ogle).

The spring is quite popular with a number of people from Wrangell and there has been some conflict with the surface management agency in the area over the use it. Historically, the springs were used to some extent by Chief Shakes and his tribesmen after the turn of the century (Waring, 1917).

The area has quite a high resource temperature, if the temperature derived by chemical analysis is correct. It is recommended that some resource assessment be made in the area to determine its potential. USFS Geologists indicate chemical analysis is inaccurate. (Personal communication with Dean Weeden).

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

Wrangell is the nearest climatological recording station to the Chief Shakes spring system. Summer temperatures at Wrangell range from 47 to 95°F (8 to 23°C and in winter 24 to 37°F (-4 to 3°C). Extremes have been recorded from -10 to 92°F (-23 to 33°C). Precipitation averages 82" (208 cm) including 76" (193 cm) snow. The mean annual runoff is predicted to be much higher (12 cu.ft./sec./sq.mi.) in this area than in Wrangell, which would increase the precipitation levels. Annual heating degree days average 8,700.

The dominant flora is that of the coastal western hemlock-Sitka spruce forest. Mountain goats and moose are prevalent in the area.

The Lower Stikine River system is one of the major migration stop-overs for waterfowl in southeast Alaska. The springs area has high habitat as well as aesthetic value, that must be evaluated against the development potential.

The springs are located in an area of high seismicity.

KEY CONTACTS:

Dean J. Weeden, Program Manager R&L, USFS  
Forest Manager, Tongass National Forest, Wrangell  
Bill Ogle, Consultant, Anchorage  
Paul Statz, Wrangell

REFERENCE:

Draft Tongass Forest Management plan  
Southeast Regional Profiles  
Waring, 1917 report  
Ogle, Visit to hot spring

SITE: Craig

RESOURCE: Hot Springs (Waring, 1917)

LATITUDE & LONGITUDE: 55° 21' 00" N; 133° 38' 10" W

QUADRANGLE: Craig, T75S, R77E, Sec. 24 (Questionable) SM

BARRIER: Forest management plan, incomplete

RECOMMENDATION: Exploration

DESCRIPTION:

Waring analyzed the springs but did not include them in his Water Supply Paper in 1917.

The spring is located on Baker Island. The island's geology consists of Silurian to Ordovician sandstone and fine grained sedimentary rocks rich in calcium carbonate. The rocks are older to the southeast.

Instusive granitic rocks of unknown age outcrop along the southern portion of Baker Island. A major NW/SE trending fault traverses the island. The spring could be assumed to be associated with this fault and the igneous rocks it truncates.

SOCIO-ECONOMIC:

The land on Baker Island is within the Tongass National Forest. New development is generally discouraged at this time because the Forest Service is presently developing a management plan for the entire Tongass National Forest. This process has produced numerous forest-wide plans, grading in philosophy from one favoring resource development to one favoring wilderness preservation. A decision as to the future of this land should be made in 1979 (USFS). Under most plans, this island would be designated for multiple use to resource development.

The nearest village is that of Craig, 20 miles (32 km) to the east. The population is 467 at Craig. The energy needs are met by Alaska Power and Telephone with a 1,015 kw oil generator, and Chevron Tongass Oil Company (Rural Energy Survey). Residents of the village of Craig have previously shown interest in developing the springs for its recreational value (Geotherm, 1978).

Commercial forest interests will probably develop the island if the Forest Service leases the land.

ENVIRONMENT: EXTRACTED FROM SOUTHEAST REGIONAL PROFILE

The nearest climatological recording station is Craig. The summer temperature in Craig averages 46 to 63°F (8 to 17°C). The winter averages 29 to 40°F (-2 to 4°C), with extremes of -2 and 88°F (-19

and 31°C). Precipitation averages 110" (279 cm), including 32" (81 cm) of snow. The heating degree day averages 7,200 annually.

The dominant flora on this island is that of the Sitka spruce coastal and western hemlock forest. The dominant fauna is that of migratory waterfowl. Indigenous fur bearing animals are found here. Offshore halibut ranges are notable in the area.

This is an area of high seismicity related to the tectonic setting of the area. There are sand dunes and waterfalls on the island, attesting to its beauty.

KEY CONTACT: Forest Manager, Ketchikan Area Tongass National Forest

REFERENCE:

Waring Field Notes (1917)  
Geotherm File  
Southeast Regional Profile

It is obvious that Alaska has tremendous geothermal resources. The 104 hot spring locations and 88 volcanoes have the potential to provide a large amount of energy for the State. Local gradient and hot dry rock applications appear to have a future in Alaska as well.

The consideration of geothermal energy in a State that has the largest oil and gas reserves in the nation and largest coal reserves in the world is quite remarkable. The irony in such a situation leads one to wonder why.

The answer partially lies in the vastness of Alaska. The remote wilderness occupying the majority of the last frontier results in horrendous energy costs for fossil fuels when they have to be transported to bush sites. It is also a big untamed country and development of this land will require considerable capital investment. Capital that can be provided by sale of its natural resources such as fossil fuels. Alaskans are wise enough to consider relying on energy sources such as geothermal that cannot be exported at a profit. This will help maximize the accumulation of money through sales of fossil fuels instead of consuming them.

The answer also lies in the hearts of those who live in this land. People whose heritage or spirit have bonded them to the wilderness. A bond that necessitates self-reliance, independence and ingenuity.

Geothermal resource will be tapped in Alaska. The opportunity is there and will be taken. Electrical, space heating, agricultural, aquacultural, and freezing applications have been investigated to date. The degree to which they are pursued will depend on the availability of capital and knowledge of the resource.

Today's Alaska is a new frontier much the same as the old West a hundred years ago. However, the technology and incentives to develop used in the old West are no longer acceptable. We have asked our Government to protect the environment; to preserve our heritage; to save our wilderness and to account for all aboriginal rights, among other things. We are rightfully thinking in more holistic terms before acting, and because of it losing expediency in development.

At the same time the impetus to develop in Alaska is greater than it ever was in the old West. There are more people demanding more resources world wide. There is a serious discrepancy between Alaska bush community needs and those associated with urban life styles. It is not intended to say that rural Alaska wants and needs the same things as urban America, but that many basic necessities to modern living such as electricity, medical, dental facilities, etc. are not found in the bush. These and other needs are being pursued by Alaskans.

It is obvious that the approach to development that was used in the old West cannot work in the sophisticated worlds of commerce, regulations and compassion controlling this time period. The government has been given the responsibility to be our protector and provider in this new

world. Many of the actions it has taken such as the Antiquities Act have created serious impediments to development of Alaska's natural resources including its geothermal energy. Now that circumstance has made it in the best interest of the country, state and the people living there to develop the geothermal energy available, it seems reasonable for the government to help compensate for the impediments it has created.

The state government should put some of the money received from depletable energy resources such as oil, gas and coal back into renewable forms such as geothermal. The vehicle has been created at that the state level in the Renewable Resource Corporation.

It is also reasonable to expect the federal government to supply capital to help counter the impediments it has created, especially on Public Lands. It might be noted that the only development scenario created herein on federal lands is at Adak and that is for defense department usage of geothermal energy. The federal government should continue to support the compilation of data to give developers an idea of the potentials that exist. This report points out that reconnaissance exploration and site reservoir analysis is very remiss in Alaska.

The dollar costs for site specific reservoir analysis of each of Alaska's hot springs and volcanoes would be staggering and quite unrealistic. On the other hand, an aggressive reconnaissance exploration program to determine the surficial extent of the resources would be a reasonable alternative. Fourteen sites have been identified in this report as priority resources. Scenarios have been constructed around them. The need for site specific and reservoir analysis of these areas is critical to development of the resource. Adak, Pilgrim, Umnak Island, Kotzebue, The New Capital and Unalaska should have immediate reservoir analyses conducted because of the magnitude of the projects surrounding them. These should, of course, receive first priority for funds. Chena, Manley, Circle, Tenakee, Clear Creek, Baranof, Bell Island and Klawasi all show definite promise for development and should be considered as prime funding areas.

The costs are going to be significant but so will the benefit. Alaska now has a chance to start on the right path to energy self-sufficiency it would be a shame to miss it. With proper exposure the initial developments can be showcases for Alaska in years to come.

How Alaska develops her resources is dependent upon the state and federal government and how it reacts to its obligations. Geothermal energy can play a part in the building of a commercially strong self-sufficient Alaska. It will be up to government officials to encourage and advocate, and they will truly make or break geothermal energy on the last Frontier.

The success of the State of Alaska to utilize its geothermal resources can be measured by the amount of energy that comes on line. Presumably, this on-line quantity of energy would replace existing or planned uses of fossil fuels, a goal of both state and federal governments. This report and the following information are optimistic evaluations of possible development in Alaska.



In the case of Pilgrim Hot Springs, the State of Alaska plans to drill an exploratory well. If funding can be arranged, a successful well will be used for an agricultural experiment station. After 1983, the Btu's per year available would be  $3.4 \times 10^{10}$ . This figure was determined by making certain assumptions:

1. The well will encounter  $180^{\circ}\text{C}$  ( $356^{\circ}\text{F}$ ) temperatures. This is the expected reservoir temperature.
2. The well will flow 100 gallons per minute.
3. The useable energy level will be above  $130^{\circ}\text{F}$  ( $54^{\circ}\text{C}$ ).
4. 30% of the usable energy will be actually utilized.

If, in fact, the  $180^{\circ}\text{C}$  temperature is encountered, then the second event on the scenario will take place. This is the development of a 4000 kw power plant that would come on line in 1989. This would meet the expected electrical energy needs of the Nome area in that year.

In the case of Clear Creek Hot Springs, Dr. Bill Ogle of Energy Systems Incorporated has calculated that the surface flow of that spring could produce 20-30 kw of binary electrical power, as well as space heat for up to thirty homes. Using standard rule of thumb formulas, this would put  $3.92 \times 10^9$  Btu's of geothermal energy to use annually. It will take until 1989 to get this energy on line, according to data gathered.

The Rural Energy Survey, conducted by the State Division of Energy and Power Development, determined that 1.2 million gallons of fuel oil per year are consumed in the village of Kotzebue. This fuel oil is used primarily for space heating. If it was replaced by geothermal water,  $1.6 \times 10^{11}$  Btu's of energy per year could be achieved through geothermal utilization. This system would come on line in 1987, according to the scenario produced.

Total energy utilization at Manley Hot Springs could reach  $1.05 \times 10^9$  Btu's annually by 1983, if the agricultural uses now envisioned actually materialize. This assumes that there will be a 30% efficient use of the present surface manifestation. The calculation also assumes a  $40^{\circ}\text{F}$  Delta T.

The potential energy utilization at Chena Hot Springs will average  $1.7 \times 10^9$  Btu's per year by 1984 if the proposed development takes place. This assumes that a 30% efficiency is achieved of the Btu capacity over  $110^{\circ}\text{F}$ .

Adak is the State's leading near term geothermal potential user. The Navy plans to have 25 MW of electrical power on line by 1985. Plans also call for an elaborate space heating capability on the order of  $3 \times 10^{11}$  Btu's annually for the Naval Air Station there.

If the experience at Adak is successful, the village of Unalaska could develop a similar space heating system there. The replacement of 900,000 gallons of fuel oil yearly will require  $1.2 \times 10^{11}$  Btu's of

geothermal production. The expected on-line date for this scenario is 1990.

Umnak Island has one of the best physical resources of those likely to be developed in the State. The presence of superheated water has raised a lot of speculation about the electrical potential of the KGRA there. Fifty megawatts of electrical power will come on line in 1990 for metals processing here.

Prior to the electrical use, the aquaculture/agriculture applications planned by the Aleutian Pribiloff Native Corporation will exceed  $5 \times 10^{10}$  Btu's annually by 1985. This will replace 380,000 gallons of fuel oil.

The new State capital in Willow will require  $1.6 \times 10^{12}$  Btu's for space heating by 1994, according to Capital Site Plans. Ninety percent of this amount, or  $1.44 \times 10^{12}$  Btu's is targeted for on-line geothermal. This would be developed in increments from 1983-1994. Four separate events of somewhat equal magnitude are portrayed on the scenario.

The Klawasi geothermal project will put another 25 MW of electrical power on line by the year 2003. Other uses around the state, including those at Tenakee Springs, Baranof and Bell Island projects should add another  $1 \times 10^{10}$  Btu's per year of geothermal utilization by the year 1987.

It should be apparent that a great deal of geothermal development is in store for Alaska. As each of these projects succeed, the faith in the resource will increase, and new projects will be attempted at sites presently not being considered for development.

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## APPENDIX A

### PIPELINE CONSIDERATIONS

#### CONCLUSIONS

(Beebe in Press)

1. A million Btu's can normally be transported ten miles for less than \$1 if the load is greater than 500 MBtu/hr. If a typical house has a peak requirement of 80,000 Btu/hr. and 40,000 Btu/hr. is supplied by the pipeline, then a 500 MBtu/hr. pipeline would supply hot water for 12,500 houses. A 16 inch diameter high temperature water line with a capacity of 489 MBtu/hr. will transport a million Btu's ten miles for \$1 or less. This is true even if the pipeline costs 1-1/3 times the "normal cost" (Equation 1). Similarly, a 28 inch diameter one-way low temperature water line with a capacity of 416 MBtu/hr. will transport a million Btu's ten miles for about \$.75. The delivered cost of a Btu decreases as power increases.
2. Load factor and return (or "sink") temperature are important variables in determining the cost of energy transported by means of hot water. Even if the capital cost of the pipeline is accurately known, it is not possible to determine whether a pipeline is economically feasible without values for these variables. From the equation:

$$\text{Cost/MBtu} = \frac{\text{Annual Capital Cost} + \text{Annual Pumping Cost} + \text{Annual Heat Loss Cost}}{\text{Load Factor} \times \text{Temperature Difference} \times \text{Flow Factor}}$$

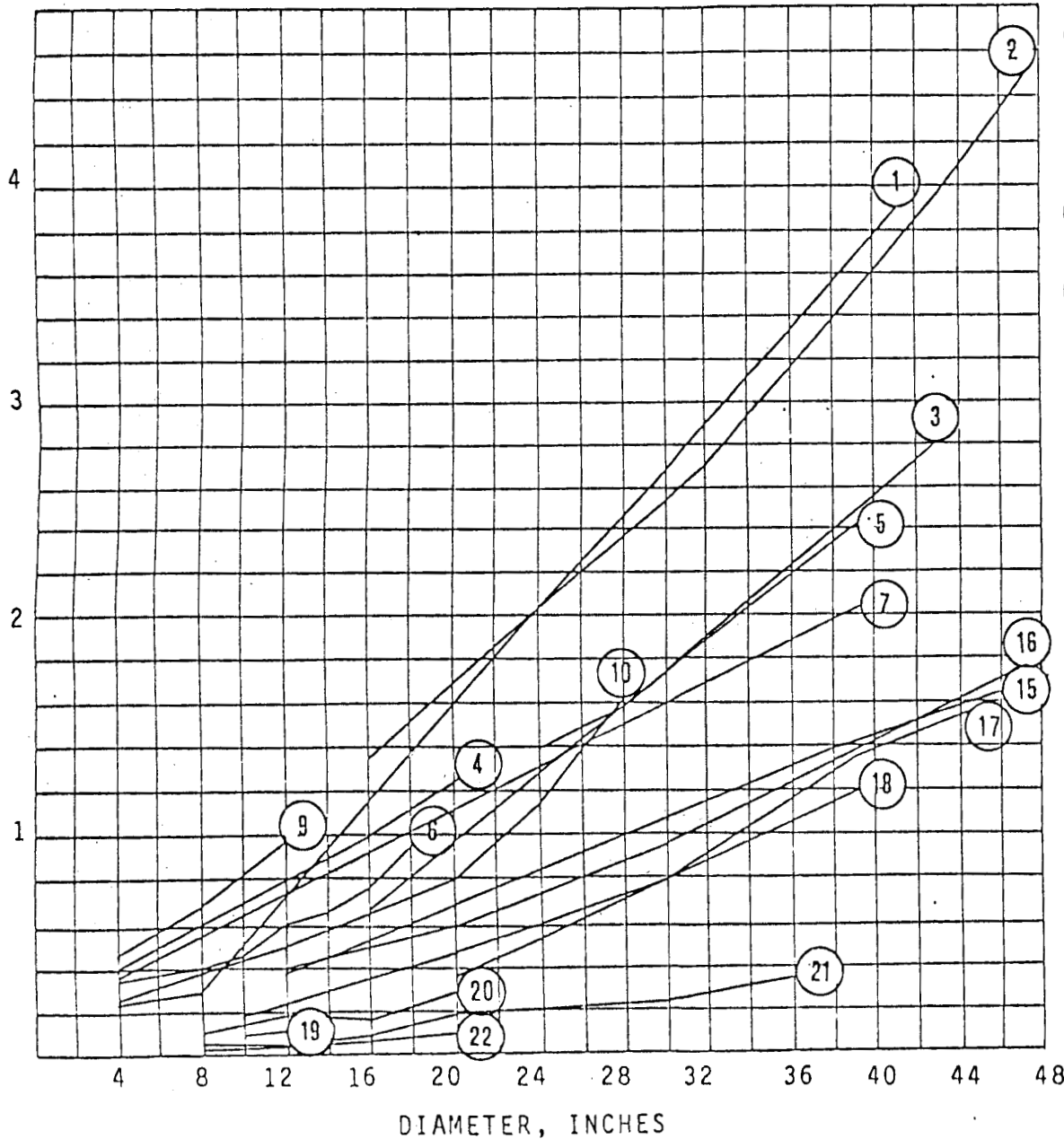
where Flow Factor = Mass Flow x Heat Capacity of Water, it can be seen that doubling the annual capital cost of the pipeline has less effect on the delivered cost of a million Btu's than does doubling the product of load factor and temperature difference. (This statement is qualified by the remark that the variables in the numerator and the denominator and of the equation above are not completely independent.)

3. There is a big difference in cost between high temperature water pipelines and low temperature water pipelines of a given diameter, as shown in Figure 1. The difference in cost between high temperature water pipelines and low temperature water pipelines with the same power is not nearly so great. As a consequence, a high temperature water dual pipeline may deliver energy at only slightly higher cost than a one-way low temperature water pipeline. This conclusion implies that normally there is not a great advantage in lowering water temperature to save money in transport. It is implicit in this conclusion that claims for new pipeline systems which promise great savings in initial capital cost must also be examined to see if they also promise long-term lower energy delivery costs.

# REPORTED COST OF HOT WATER PIPELINES

COST: U.S. \$/MILE  
(Millions)(1976)

Figure 19.



- ① Dual steel pipe in concrete envelope, HTW.
- ② Dual steel pipe in covered concrete canal, HTW.
- ③ Dual steel pipe in covered concrete canal, MTW.
- ④ Dual steel pipe in covered concrete canal, LTW-MTW.
- ⑤ Dual steel pipe in covered concrete canal, HTW.
- ⑥ Pipe-in-Pipe system, LTW.
- ⑦ Dual steel pipe in covered concrete canal, MTW.
- ⑨ Dual steel pipe in covered concrete canal.
- ⑩ Dual steel pipe in covered concrete canal, HTW.
- ⑮ Elevated single pipe, MTW.
- ⑯ Dual steel pipe, direct buried, LTW.
- ⑰ Dual polymeric concrete, direct buried, LTW.
- ⑱ Dual plastic, direct buried, LTW.
- ⑲ Transite, direct buried, LTW.
- ⑳ High cost petroleum lines.
- ㉑ Average cost petroleum lines.
- ㉒ Low cost petroleum lines.

## APPENDIX B

### I. DESCRIPTION OF THE ALTERNATIVE ACTIONS - From the Bureau of Land Management

#### A. BACKGROUND

In order to protect the national interest in the public lands in Alaska, Congress enacted the Alaska Native Claims Settlement Act (ANCSA) (43 U.S.C. Section 1601 et seq) which granted the Secretary of the Interior (Secretary) broad new classification powers to be exercised in conjunction with the Executive Branch's existing withdrawal authorities. Among other things, Congress envisioned the exercise of these powers and authorities as part of a process leading to the statutory creation of new Alaskan units of the National Park, Refuge, Forest, and Wild and Scenic River Systems.

In response to the directives and intent of Sections 17(d)(1) and (d)(2) of ANCSA (43 U.S.C. 1616 d(1) and (2)), the Secretary issued a series of Public Land Orders beginning in March of 1972, which withdrew millions of acres of public land in Alaska from the operation of most of the public land laws, including land selection by the State of Alaska pursuant to the Alaska Statehood Act (48 U.S.C. Prec. Section 21). All lands withdrawn under Section 17(d)(2) were withdrawn simultaneously under Section(d)(1); additional lands outside the "d-2" boundaries were also withdrawn under Section 17(d)(1) at this time. The "National Interest Lands" targeted in these "d-2" and "d-1" withdrawals were subsequently studied and inventoried in order to identify those with outstanding natural, cultural, scenic, historic, recreational, and scientific value. These exceptional national resource areas were to be included in a series of legislative proposals submitted to Congress.

Although the d-1 lands underlying the "d-2" boundaries were withdrawn from the operation of all the public land laws, some of the d-1 lands outside the d-2 boundaries were left open to location of metalliferous minerals; in addition, some of these lands outside the d-2 boundaries were opened up for selection under the Alaskan Statehood Act. Congress assumed that it would be able to complete its consideration of these legislative proposals relatively quickly, and accordingly it imposed in ANCSA a five year expiration date on the d-2 withdrawals. Thus the existing d-2 withdrawals expired on December 17, 1978.

In accordance with the authority in Section 17(d), Secretary Morton submitted to Congress on December 17, 1973, a legislative proposal recommending the establishment of over 83 million acres of new units of the four conservation systems (known collectively in the context of ANCSA as the National Conservation Systems). This proposal included boundary and management recommendations for each specific study area. Simultaneously, the draft environmental impact statements (EIS's) on the recommendations were released to the public. After an opportunity for public comment on the draft EIS's, the Department of the Interior in 1974, issued a 28 volume final environmental impact statement on the proposed Congressional package.

Subsequently, several other legislative proposals for conservation on federal lands in Alaska were offered by various citizen groups and legislators.

In response to a Congressional request for comment on one of these, (H.R. 39, introduced by Chairman Morris Udall of the House Interior and Insular Affairs Committee) the Department revised its 1973 recommendations. On September 15, 1977, Secretary Cecil D. Andrus recommended modification of H.R. 39 to take in 92.5 million acres of d-1 and d-2 lands in Alaska. Legislation similar to the Administration approach was passed by the House on May 19, 1978, by a vote of 277-31. In the second week of October, 1978, the Senate Energy and Natural Resources Committee reported on Alaska National Interest Lands legislation.

Despite intense efforts by Chairman Udall, Chairman Henry Jackson and others to reach a compromise agreement on the issue, there was insufficient time available to reach final agreement. The Chairman sought a one year legislative extension of the d-2 withdrawals covering all areas proposed for protection under either the House passed bill or the Senate committee bill, but due to lack of time this effort proved unsuccessful.

The Administration continues to prefer legislation as the optimum way to protect National Interest Lands in Alaska. However, since legislation no longer is possible before expiration of the withdrawals, it is incumbent on the Executive Branch to explore other avenues of interim protection until Congress can meet its responsibilities to respond to the original intent of the legislation.

The historical antecedents of the present situation should not be lost. The Alaska Native Claims Settlement Act was passed in 1971, in order to resolve claims by Alaska's aboriginal peoples (Eskimos, Indians and Aleuts) of ownership of virtually the entire State of Alaska. These claims were clouding the title to much of Alaska's lands, including the proposed right-of-way for the Trans-Alaska Pipeline. The Native Claims Act was passed by Congress after intense lobbying by a coalition of State of Alaska, oil industry and Native leaders. All of Alaska's statewide elected officials supported the legislation, including its "d-2" section.

However, subsequent questions regarding various priorities for land conveyance under both the Statehood Act and ANCSA have confused and slowed the conveyance of land to the state. This confusion can largely be traced to passage of ANCSA. Alaska National Interest Lands legislation passed by the House would have resolved much of the confusion and conveyed substantial amounts of lands to the state. Likewise, the House legislation would have resolved several continuing issues regarding Native lands.

Because of the complexity of the land use issues involved and the staggering logistical problems inherent in legislation covering millions of acres of public land, the original five year, self-imposed Congressional deadline for completion of the legislative process turned out to be inadequate. Thus the "d-2" layer of protective withdrawals covering some sixty million acres of public lands in Alaska expired on

December 17, 1978. These lands would still be protected by the underlying "d-1" withdrawals which were not subject to the same five year limitation. The National Interest lands could be retained in "d-1" status indefinitely, or depending upon the scope of the original "d-1" withdrawals, these lands could be reclassified, opening them to the use, selection, location or entry permitted under the public land laws.

The 28 volume environmental impact statement completed in 1974 was written to conform to the legislative timetable in the Alaska Native Claims Settlement Act which envisioned Congress finishing its work on this issue by December 18, 1978. Thus the final EIS's did not discuss the full array of alternative Executive Branch authorities existing in 1974, which could have been utilized to protect and preserve the national interest values in the lands covered by the 1973 proposal. That is, the "alternatives" sections of the 1974 final EIS's only discussed various legislative options and a "no action" alternative. The EIS's did not explore alternatives involving affirmative Executive Branch action. One Executive Branch alternative which was not discussed was the establishment of national monuments by Presidential Proclamation under the Antiquities Act of 1906, 16, U.S.C. Section 431 et seq.

Furthermore, two years after finalization of the EIS's, Congress enacted the Federal Land Policy and Management Act of 1976 (FLPMA), 43 U.S.C. Section 1701 et seq. This Act consolidated and imposed new procedural requirements on the Executive Branch's withdrawal authority; Secretarial withdrawals would be required to comply with the provisions of Section 204 of FLPMA. Since FLPMA had not yet been enacted when the 1974 EIS's were completed, the "Alternatives" sections of the 28 volumes are silent as to the possible use of the segregation of withdrawal provisions under Section 204 to provide added protection to the national interest lands in Alaska.

In addition, Section 22(e) of ANCSA directs the Secretary to withdraw additional public lands to replace the acreage depleted from existing national wildlife refuges by Native village selections under ANCSA. Current Fish and Wildlife Service estimates place the anticipated loss of refuge lands at over three million acres. As with Section 204 withdrawals, Secretarial withdrawals under 22(e) of ANCSA were not discussed in the "Alternatives" sections of the final EIS's.

Now that Congress has adjourned without meeting its December 17, 1978, deadline, the Interior Department supplemented the original "Alternatives" sections of the 1974 EIS's to reflect the options currently available to the Executive Branch for placing additional layers of protection on the National Interest lands, thereby guaranteeing that Congress will have sufficient time to complete the legislative process. Although the Department is confident that the existing d-1 withdrawals are capable of precluding entry, location, or selection of those lands after the expiration of the d-2 withdrawals, the natural and cultural values of the lands are so significant to the Nation that prudence dictates that they be protected as fully as possible under existing Executive authority, pending final Congressional action. In this fashion, the full range of Congressional options can be best preserved and protected.

## B. THE ALTERNATIVE ACTIONS

The potential Executive action alternatives are:

1. Antiquities Act (16 U.S.C., Sec. 43). This alternative involves the designation of the study area proposals as national monuments under the Antiquities Act.
2. FLPMA Segregation (43 U.S.C., Sec. 1714(b)). The second alternative involves the segregation of the study areas from the public domain under Section 204(b) of FLPMA.
3. FLPMA Final Withdrawal (43 U.S.C., Sec. 1714(c) or (e)). The decision could be made not to use the preliminary segregation process (Section 204(b) and instead issue a final withdrawal under Sections 204(c) or (e) of FLPMA.
4. ANCSA, Section 22(e) withdrawal (43 U.S.C., Section 1621(e)). Section 22(e) directs the Secretary of the Interior to withdraw additional public lands in Alaska to replenish the acreage depleted from the existing Alaskan refuges as a result of Native village selections under ANCSA.
5. Combination of the above. For example, some of the national interest study areas could be designated as national monuments, with the remaining lands withdrawn or segregated under Section 204 of FLPMA or Section 22(e) of ANCSA, Agency jurisdictional responsibilities would vary, of course, depending on whether the selected mix of alternative actions involve a transfer of management responsibilities away from BLM or not.

## C. EVALUATION APPROACH

In compliance with the National Environmental Policy Act of 1969 (NEPA), a full environmental evaluation was completed in 1974 for each of the areas in the 1973 legislative proposal. In effect, those 28 documents formed a single environmental evaluation of that proposal. This environmental analysis is being provided as a supplement to the 1974 evaluation so that Executive Branch options not then considered can be analyzed for their potential effects upon the human environment.

It should be stressed that the alternative Executive Branch actions evaluated in this environmental supplement are not intended to supplement the major Federal action proposed in the original 1974 environmental evaluations. The Secretary's primary proposed action remains the enactment of National Interest Lands legislation. This supplement analyzes Executive Branch options for providing additional protection to these National Interest Lands, pending completion of Congressional action on the proposals. The boundaries of the study areas set forth on the enclosed represent composite geographic maximums based upon current Administration and Congressional proposals, in order to protect the maximum range of Congressional options. Lands currently managed by the Forest Service which were proposed for wilderness status are being treated by the Department of Agriculture and therefore are not included in this analysis.

To simplify this environmental supplement, the term "study area" will be taken to mean one of the areas of National Interest land shown on the map of Alaska.

Each of the 28 environmental documents of 1974 was examined so that this latest analysis would be based on an explicit, area by area basis. The Executive Branch alternatives discussed within this supplement are to be considered as additions to the "Alternatives" sections in the 1974 statements. The relationship between the 1974 evaluation and the environmental analysis in this supplement is so close that a maximum of referencing is used in both the analytical and descriptive sections of this supplement. This is intended to reduce the documentation of an already lengthy and sound analysis in the 1974 evaluation, and to prevent unnecessary repetition, revision, printing, and reshuffling of material in accordance with the Council on Environmental Quality's guidelines and Presidential directives.

All Executive Branch alternatives and post-1973 information were analyzed to see if they substantially changed the degree of impacts described in the 1974 evaluation. Only those impacts which are substantially different from the effects described in the 1974 evaluation will be discussed in the following environmental analysis. Analysis which indicated only a minor change in impact was excluded from this presentation and will remain on file as a record of analysis and a base of information for future planning and environmental evaluation.

Since 1974, additional legislation, regulations, and policy changes have become applicable to areas managed by the Department of Interior. Of particular consequence for this analysis are: the land use planning and wilderness requirements of Sections 202 and 603 of FLPMA (see the "alternatives" section within this document for changes in the "no action" alternative created by FLPMA), Executive Order 11990 on protection of wetlands, the Clean Air Act Amendments through 1977, the Clean Water Act of 1977, Safe Drinking Water Act, subsistence use in view of Senate Joint Resolution 102, and interim National Park Service policy for Native American and National Park Service relationships. Specific regulations for the management of BLM, Fish and Wildlife Service, and Park Service lands are found in 43 C.F.R., 50 C.F.R., Chapter 1 and 36 C.F.R. Chapter 1 respectively.

#### 1. Antiquities Act National Monuments

The first alternative evaluated concerns the designation of the national interest study areas as national monuments under the Antiquities Act, 16 U.S.C. Section 431. The Antiquities Act provides for the preservation of "objects of historic or scientific interest" in national monuments, which may include the preservation of significant anthropological resources in Alaska, e.g. subsistence lifestyle. Although Presidential actions such as the issuance of Proclamations under the Antiquities Act are not subject to the provisions of NEPA, public comment on this potential option was considered desirable. It therefore has been voluntarily included within the range of alternatives discussed in this environmental supplement. Following the management responsibilities recommended by the Administration and embellished by the House in

H.R. 39, adoption of the Antiquities Act alternative would result in up to fourteen national monuments being administered by the U.S. Fish and Wildlife Service and up to thirteen national monuments under the management of the National Park Service, involving 55 million acres and 44 million acres of National Interest Lands respectively.

a. Fish and Wildlife Monuments

Under this alternative action, fourteen national monuments would protect significant scientific values associated with discrete ecosystems, or their components, in which various species are uniquely abundant. These monuments would include coastal islands and reefs, sub-arctic river deltas, and floodplain valleys of interior Alaska. Because of the preeminent importance of wildlife in the scientific values and resources protected, these monuments would be administered by the Fish and Wildlife Service.

Fish and Wildlife monuments would not actually become part of the National Wildlife Refuge System as that System is currently defined; rather these monuments would be administered in accordance with the provisions of the Antiquities Act and the Fish and Wildlife Act of 1956. Since the conservation of the unique scientific fish and wildlife values would be the primary purpose of any Fish and Wildlife monument, the Secretary, through the Fish and Wildlife Service, would be authorized to issue such regulations as would insure the conservation of those values, thereby protecting the monuments from unauthorized injury or harm.

These regulations could also authorize the use of a Fish and Wildlife monument for any purpose other than mineral leasing (see 30 U.S.C. 181), that was compatible with the conservation of the fish and wildlife values that the monument was designed to protect. This standard is virtually identical with the "compatibility test" governing the use of national wildlife refuges under the National Wildlife Refuge System Administration Act of 1966, 16 U.S.C. Section 668 *et seq.* Thus most activities which would have been allowable if the study area had been statutorily designated as a wildlife refuge, could be allowed within a Fish and Wildlife monument. That is, since the tests governing public use of wildlife refuges and Fish and Wildlife monuments would be virtually identical, (with the exception of mineral leasing), the impacts upon the public and the human environment would be very similar regardless of what label was applied to the proposed Fish and Wildlife study areas. The impacts of managing these areas as wildlife refuges were described in the 1974 EIS's. The impacts of prohibiting mineral leasing in these study areas were discussed in the 1974 EIS's under the alternatives of disallowing mineral leasing and wilderness designation. In accordance with the philosophy of permitting other resource uses that do not conflict with the preservation of historic, cultural, and scientific values, in particular those associated with the living components of the monument, subsistence uses and sport hunting would continue where consistent with preservation of the resources upon which these uses are dependent. The construction of roads would not be precluded; however, construction would occur only under terms specified in permits issued by the Fish and Wildlife Service to insure protection of values for which the monument was established. Commercial harvesting of timber, agricul-



tural use, and grazing which do not detract from values associated with wildlife or other natural features would also be permitted.

Because the impacts associated with the establishment of National monuments under Fish and Wildlife Service management would not be significantly different from those in the 1974 evaluations for the refuge proposals (including the prohibition of mineral leasing and wilderness designations alternative section), the 1974 discussion is incorporated and adopted for this alternative. Therefore, apart from a discussion of boundary modifications and insignificant changes in impacts presented mainly for purposes of reference, no additional analysis has been included within this environmental supplement.

#### b. Park Service Monuments

The remaining thirteen potential monuments would be administered by the National Park Service under the authorities generally applicable to the National Park System. The Park Service would be charged with the preservation and protection of the scientific, historic, and prehistoric resource values of these areas, including archeological sites, areas of unique geological processes and resources of significant anthropological interest. As a general rule, because of the statutory framework applicable to the National Park System, fewer activities are permitted within monuments administered by the National Park Service than would be allowable within units of the National Wildlife or Forest Systems. The Antiquities Act authorizes Presidential recognition of a broad category of significant scientific, historic, or prehistoric values, however, the preservation of these values may not always conform to the generalized management regime for units of the National Park System. In such unique situations, the Park Service possesses adequate management authority under the Park Service Organic Act of 1916, 16 U.S.C. Section 1 et seq., to fashion specialized regulations which insure the preservation of the recognized monument values.

In order to account for the broadest range of impacts and limitations which could flow from Park Service management, this analysis will assume that the thirteen study areas would be administered under the most restrictive, stringent regulations possible for a Park System monument. When combined with the alternatives in the 1974 evaluation, this "most stringent" approach completes the analysis of potential impacts and restrictions of an Executive alternative creating Park Service monuments.

The 1974 evaluations adequately discussed the impact of disallowing new mineral entry, oil and gas leasing, and Statehood Act selections. The 1974 analysis, however, assumed that existing subsistence uses would be allowed to continue and that sport hunting would be permitted within areas proposed as national preserves. In order to complete the analysis of the most restrictive land management regime allowable, therefore, the impact of disallowing subsistence uses such as hunting, trapping, fishing above sport levels and timber gathering for firewood and construction must now be considered. Similarly the impact of disallowing sport hunting within study areas proposed as preserves must be discussed.

Since the continuation of the opportunity for subsistence uses in Alaska has long been the position of the Administration, the Secretary and the majority of the Congress, and is a very sensitive issue, it needs to be stressed again in conjunction with this analysis that the prohibition of subsistence hunting is not favored by the Department but is merely one of the possible impacts flowing from the alternatives discussed in this supplement. The discussion is necessary to complete the "worst case" or "most restrictive" analysis.

## 2. Segregation Under Section 204(b) of FLPMA

The primary effect of segregating public lands under Section 204(b) would be the conservation of scenic, wildlife, and cultural resource values by temporarily removing these lands from the operation of the public land laws permitting development, such as the Homestead Acts, the Mining Law of 1872, the Mineral Leasing Act of 1920, and the Alaska Statehood Act. These lands could be kept in the segregation category for a maximum of two years.

The existing d-1 withdrawals covering the national interest study areas, however, already withdrew most of those lands from the operation of the public land laws. Since the impacts of those d-1 withdrawals were adequately discussed in the "no action" alternative sections of the 1974 EIS's, no new significant impacts would result from the segregation of the study area lands under Section 204(b) of FLPMA and the reader is referred to the 1974 impact discussion. BLM would continue to manage these areas in the interim so as to preserve the national interest values they contain. Therefore, no additional analysis beyond that contained in the 1974 evaluation is required for this particular Executive Branch alternative. Furthermore, the temporary maintenance of the status quo under the segregation process does not significantly affect the human environment, and hence is not subject to the requirements of NEPA. Thus, no separate analysis of this alternative would be required under NEPA.

## 3. Final Withdrawal Under Section 204 of FLPMA

The Secretary could forego segregating the national interest study areas and make final withdrawals of the areas under Section 204(c) or (e) of FLPMA. A final withdrawal would have the same effect of preserving important environmental values. The withdrawal could involve the actual transfer of jurisdiction over the national interest study areas from the Bureau of Land Management (BLM) to other agencies such as the U.S. Fish and Wildlife Service or the National Park Service, or it could retain jurisdiction in BLM through the designation of the study areas as "areas of critical environmental concern" recognized under Section 103 of FLPMA. All final withdrawals would overlie the existing "d-1" withdrawals for the study areas and incorporate them by reference. Without Congressional action, these final withdrawals would last for either three or twenty years respectively, depending on whether Section 204(e) or (c) is used. If the withdrawals involved the actual transfer of jurisdiction from BLM to the appropriate agency, like the Fish and Wildlife Service or the National Park Service, there would be no new significant impacts upon the environment that were not adequately dis-

cussed in the 1974 evaluation. This reflects the fact that the impacts of a refuge's creation are the same, regardless of whether its genesis is statutory or Secretarial.

If the withdrawal recognizes the national interest study areas as "areas of critical environmental concern", BLM would retain jurisdiction over the areas and would manage them so as to preserve the national interest values they contain. Also Section 603 of FLPMA wilderness classification procedures would apply (see Alternatives section). Cooperative agreements between BLM and agencies like the Fish and Wildlife Service or the National Park Service could be negotiated to insure that the natural, cultural, historic, and scenic values of the areas are maintained as they would have been if the areas had been statutorily placed into the National Conservation System.

There would be no new significant impacts from such management arrangements that were not adequately discussed in the 1974 evaluation of the Administration's legislative proposal. Therefore, no additional analysis is required for this Executive Branch alternative.

#### 4. Withdrawal Under Section 22(e) of ANCSA

This Executive Branch alternative was designed to restore the values and acreage depleted from the existing Alaskan units of the Wildlife Refuge System by Native village selections. Current Fish and Wildlife Service estimates project that over three million acres of existing refuge land will be patented to Native Village Corporations. Thus, Section 22(e) of ANCSA would allow the Secretary to withdraw at least three million acres of study area lands for addition to the National Wildlife Refuge System. Lands added to the Refuge System under Section 22(e) would permanently remain within that System unless subsequently removed by Act of Congress. The impacts of Section 22(e) withdrawal would be the same as for a final withdrawal of equal acreage under Sections 204(c) or (e) of FLPMA. The above discussion in Paragraph 3 is hereby incorporated by reference and no additional analysis is required for this Executive Branch alternative.

#### 5. Combination of the Above Alternatives

This Executive alternative recognizes that a combination of the previously discussed four alternatives could be utilized. Since an analysis of those alternatives has already been discussed in Paragraph 1 through 4 and is hereby incorporated by reference, no additional evaluation of this Executive Branch alternative is required.

#### D. PUBLIC REVIEW PROCESS

Congress has not completed the legislative process. The need for expeditious Executive Branch action and the desire for public feedback requires that the public comment process fit within the time constraints imposed by the expiration of the d-2 withdrawals. The urgency surrounding the consideration of these environmentally protective Executive Branch alternatives requires a compression of preparation and review periods. This draft environmental supplement will be issued in October

with a maximum of cross-referencing to the already exhaustive discussion of the existing environment and major environmental impacts in the 1974 environmental evaluation. This is in accord with the Presidential directives to minimize duplication of material in related environmental documents. Only new areas not described in the 1974 evaluation and significant new impacts of administrative alternatives are described in this supplement. The public will be afforded a period to review and comment on the draft supplement, with special distribution procedures to assure the prompt availability of the environmental supplement for interested parties. Public comments will be considered in the final environmental supplement to be issued in early December, 1978.

## APPENDIX C

### ALTERNATIVE ADMINISTRATIVE ACTIONS

#### Alaskan State Response Covering Impact to Geothermal Energy

Alaska's geothermal resource is one of the largest in the world. The potential space heating and electrical capacity of these resources are beyond our nation's present energy needs. There are over 100 reported hot springs and 140 volcanic expressions. The United States geologic survey has designated 88,160 acres as Known Geothermal Resource Areas (KGRA) and over 12 million acres are designated as Potential Geothermal Resource Areas (PGRA), under terms of the Geothermal Steam Act of 1971. In comparison there are nine states smaller in area than these K & PGRA's and the total acreage equals the combined areas of the States of Connecticut, New Jersey and Hawaii.

The Federal Government has stewardship to over 8,000,000 acres of this total. Many acres of this land has been considered in negotiations over d-2 and areas of ecological concern by the Department of Interior Congress of United States.

There are significantly different effects to the Geothermal Energy Potential between boundaries outlines in 1973, by Secretary Morton and those of this draft. These differences could significantly effect geothermal utilization. In the following areas the effect is significant:

#### Gates of the Arctic:

In the area around the Alatna River, additions to the area that Secretary Morton proposed as Park would now include two hot spring locations and approximately 80,000 acres of PGRA. These areas appear to have been covered by the 1974 EIS but not recommended for inclusion into the Park Systems.

#### Selawik:

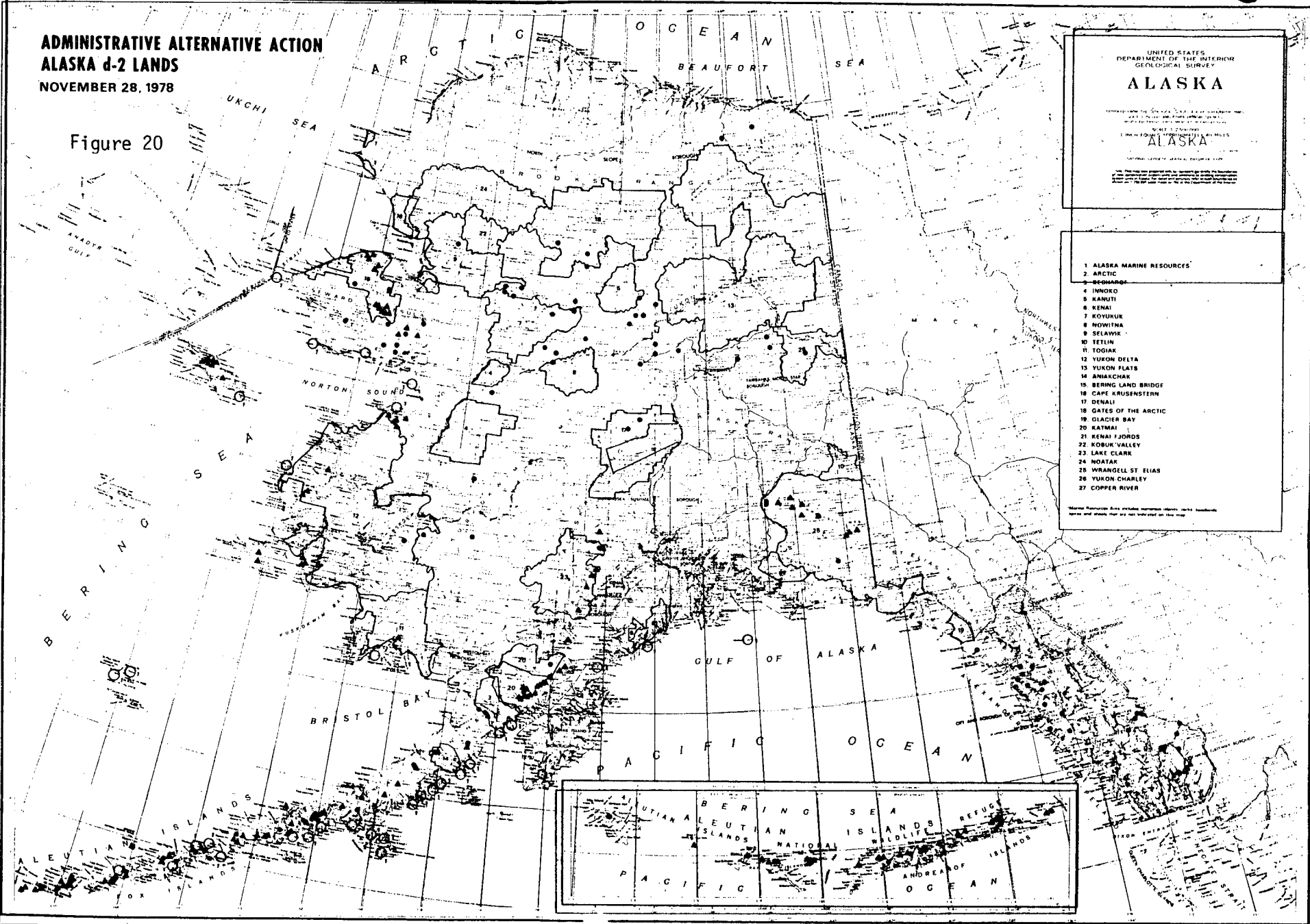
A previously unreported hot spring has been located 8 miles north of Kiana. This additional acreage between the D.O.I. 1973 parks plan and this 1978 plan appears not to have been covered by the 1974 EIS. It was not in any event recommended for any of the four systems under terms of (d)(2) at that time. Two springs in the Purcell mountains area (Purcell and Souby) are now included in the Selawik outlines and were not included in the four systems in 1973. Approximately 60,000 acres of PGRA are included that were not as well. These springs and this portion of the PGRA were covered in the outline of the 1974 EIS. It is not clear as to whether they were included however in the conservation systems.

#### Koyukuk:

The new outline area included Pochantus and it did not include this spring in the four systems under the 1973 Morton Plan. This

**ADMINISTRATIVE ALTERNATIVE ACTION  
ALASKA d-2 LANDS  
NOVEMBER 28, 1978**

Figure 20



would include 22,000 acres of PGRA as well. Hawk Hot Springs in the Purcell mountain appears to be included in the new Koyukuk boundry but not covered by the 1973 Morton recommendation included in the four systems or the EIS that covered it. South Hot Springs appears to have the same fate.

Nowitna:

Twenty thousand (20,000) acres of the Melozi-Horner PGRA appears to be included in the boundary of this study area. Under the Morton Plan these acres were not recommended for inclusion in the four systems.

Becharof:

The extension on this draft map of the study area across Becharof Lake would encompass 87,000 acres of PGRA, a hot spring and a volcano on the east shore.

These additions to the numerous springs, 33 volcanoes and millions of acres considered under the Morton Plan for inclusion in classification that would preclude development should be weighed carefully. All these resources would be added to some 18 springs and 55 volcanoes already in existing Federal restricted development areas outside of the Forest Service Lands in southeast Alaska.

Other pertinent comments on statements on the text.

Page 11-1: The draft refers to several named islands that were not discussed in detail in the 1974 evaluations. Walrus, Otter, and all of the Aleutian Islands are in areas of high geothermal potential.

On page 11-3, third paragraph: It is stated that "High potential for geothermal sources occur on Unalaska, Umnak and Akutan. The remote location of these areas is likely to preclude use or development of this resource".

This statement was made without knowledge of the State, Aleutian Pribilof Native Association and Department of Energy policies regarding these sites. The state plans on an active program to evaluate the geothermal resource on these three islands in the next few years. The State Department of Fish & Game has already completed a cursory exploration effort on Akutan for use as in geothermally enhanced salmon hatchery.

The Aleutian Pribilof Native Association has initiated a program to develop the resources at Umnak Island. The initial plan calls for agricultural and aquaculture projects to be initiated in the next two years.

The Federal Department of Energy has funded Planning activities within the state. According to scenarios produced by the planners these three islands are prime development prospects and will be developed in the next 2-5 years. Federally funded geologic exploration will be initiated

in the near future to determine the extent of the resource. Continued planning activities will determine the possible development potential of these sites.

Umnak Island is presently a Known Geothermal Resource Area. The Aleutian Pribilof Island Native Association has initiated internal measures to lease these lands from the Federal Government.

The options open to the public for review under the draft leaves no possibility for geothermal development. The Antiquities act, under the provisions set forth, (FLPMA and ANCSA) are all restrictive to geothermal considerations under present laws.

It would not be reasonable to put any of these lands under permanent designation until congress has decided which lands should be put into the four systems. Therefore, the Antiquities Act should not be used at all. If it is, it should be used only on the minimal compromise lands when agreement between State and Federal legislation and administration plans. An example is the Park core areas of the Stevens, Young, Hammond plan. These areas seem to be mutually agreed upon as park or wilderness areas. It is the boundary areas that are in contention and the Secretary of Interior and President should not permanently try to settle this dispute by invoking the Antiquities Act.

New areas added in this draft such as Akutan, Umnak and Unalaska have not been covered by an EIS and cannot be included in a National Monument until they have. If they have been technically covered the action was incorrect because of a lack of public response in these areas as the public thought these lands were not being considered.

All land in dispute between State and Federal plans should be placed under FLPMA segregation designation to allow compromise legislation to determine the future of these Federal lands. This would allow the next congress to determine the future of these Federal lands. One alternative is to allow them to revert to d-1 classification.

Lands that are not under classification in the four systems in State or Federal plans should be opened to mineral and geothermal leasing activities under d-1 designation.

If Section 22(e) of ANCSA is used, it should be used on land agreed upon as wilderness designation between all parties concerned such as Steven, Young, Hammond core wilderness areas before being used. This is because of the permanence of the action.



## APPENDIX D

### GEOHERMAL ENERGY LEGISLATION:

#### THE NATIONAL ENERGY ACT AND NEW PROPOSALS

RANDALL C. STEPHENS  
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Provisions of the National Energy Act which relate to geothermal energy are described. Further measures under consideration for a Geothermal Energy Omnibus Bill to be proposed in 1979 are discussed.

#### Introduction

The National Energy Act (NEA) is a broad-ranging measure intended to establish a national energy policy to reduce energy fuel imports, encourage conservation of depleting resources, and increase and accelerate the utilization of renewable resources and of the large national reserves of coal. The five parts of the Act include measures designed to stimulate exploration for and development of geothermal resources.

In particular, tax treatment of the sort traditionally available for other energy resources is provided for by explicitly authorizing a percentage depletion allowance and intangible drilling cost deductions. Geopressured methane is freed from price regulation. Tax credits are provided for geothermal equipment for business and residential applications.

These and other provisions of the Act resolve some of the major factors that have slowed development of geothermal resources, but there remain some deterrents, and adequate incentives for utility and industrial applications are not included.

The Interagency Geothermal Coordinating Council, a Federal interagency council charged with establishing and implementing a national program to stimulate utilization of geothermal resources, is considering additional legislative initiatives for a Geothermal Energy Omnibus Bill to be presented to Congress in 1979. This Bill will be designed to comprehensively resolve institutional problems arising from a variety of laws and regulations, and to provide incentives for those applications and users not dealt with in the NEA.

Special attention will be given to direct thermal uses. The Bill is expected to include most of the following: modifications to the Federal leasing and permitting program under the Geothermal Steam Act; improvements to the Geothermal Loan Guaranty Program; minor tax amendments; modifications to the authorities of the Small Business Administration, the programs of the Department of Housing and Urban Development, the Economic Development Administration, the Farmers Home Administration, and other Federal subsidy programs to allow and encourage support of geothermal projects; specialized wheeling and interconnection treatment; a program for use of geothermal energy by Federal facilities; and pos-

sible new financial incentive programs for heat distributors and users, such as reservoir insurance, limited recourse loans, interest subsidies, or direct grants.

The Council is presently seeking suggestions and recommendations for approaches. The objective will be permanent elimination or minimization of regulatory and legal barriers, and temporary incentives to stimulate early demonstration of the many feasible applications of geothermal resources to a wide variety of uses.

### THE NATIONAL ENERGY ACT

#### Intangible Drilling Costs and Depletion Allowance

The NEA resolves at last a major problem that has severely inhibited geothermal resource exploration for many years. The Act authorizes deduction of intangible drilling costs for geothermal wells on the same basis as for oil and gas. In addition, a full depletion allowance is permitted without the requirement for demonstrating actual depletable of the resource. The rate for geothermal resources is set at 22%, but declines to 15% by 1984 on the same schedule as for oil and gas.

The depletion allowance for geopressured methane is set at 10%, and is allowable only for wells whose drilling begins after September 30, 1978, and before January 1, 1984. Wells drilled after that date would be treated as normal gas wells. A well producing both geopressured methane and hot water would be allowed a 10% depletion allowance for income from the methane (until 1984) and a 15-22% depletion allowance for income from the hot water. There is no limit on the quantity of geothermal resource production on which percentage depletion can be taken.

For tax purposes, a geothermal deposit is defined as "a geothermal reservoir consisting of natural heat which is stored in rocks or in an aqueous liquid or vapor (whether or not under pressure)."

#### Residential Energy Credit

A residential energy tax credit is allowed for a homeowner or a member of a cooperative housing association installing "property which, when installed in connection with a dwelling, transmits or uses...energy derived from geothermal deposits...for the purpose of heating or cooling such dwelling or providing hot water for use within such dwelling...". The credit is 30% for the first \$2,000, and 20% of the next \$8,000, for a total maximum of \$2,200. The residence must be the taxpayer's principal residence, and the credit is available for expenditures between April 20, 1977, and December 31, 1985. The amount of the credit is limited to the taxpayer's tax liability, but the unused credit can be carried forward up until 1987.

The equipment must be original use equipment, and must have a reasonably expected life of five years or more. The equipment must meet any performance and quality standards specified by DOE (DOE is required to prescribe such standards, in consultation with HUD). The taxpayer need not own the equipment. He could presumably lease it and claim the credit. His basis in the equipment is reduced by the amount of the credit.

### Business Investment Credit

The Bill provides for a business investment credit of 10%, in addition to the normal investment tax credit, for "alternative energy property", including "equipment used to produce, distribute or use energy derived from a geothermal deposit, but only, in the case of electricity generated by geothermal power, up to (but not including) the transmission stage." This credit is not allowed for public utility property, defined in part as "property used in the furnishing or sale of...electrical energy,... water...or steam..." The credit is only 5% if the property is financed by tax-exempt industrial development bonds. This credit is available for equipment whose construction is completed between October 1, 1978, and December 31, 1982. The equipment must be depreciable and must have at least a 3-year lifetime. The credit also applies to "equipment for producing natural gas from geopressured brine."

The equipment must conform to standards required to be developed by the Department of Energy (DOE), once they are developed. The credit is not refundable. It can apply to 100% of tax liability, whereas the base investment tax credit is limited to 50% of tax liability. Agricultural uses qualify for the credit, as well as other business uses.

### Conversion Incentives

The NEA provides additional incentives to convert from oil and gas to geothermal resource utilization. Equipment which uses oil or gas is ineligible for the base investment tax credit, and accelerated depreciation is permitted for oil and gas using equipment which is scheduled for early retirement.

More direct measures to encourage or mandate conversion are included. New power plants and major fuel-burning installations, specifically boilers, with a design heat rate capacity of 100 million BTU/hr. or more, are prohibited from using petroleum or natural gas. Existing power plants may not use natural gas after January 1, 1990, and DOE may prohibit use of oil or gas in new non-boiler installations and in existing power plants or major fuel-burning installations which are coal capable.

Various temporary and permanent exemptions can be obtained based on unavailability of coal or other fuels (including geothermal) at a price competitive with imported oil, on environmental limitations, or on site limitations. Note that it is not sufficient in seeking an exemption to show that domestic oil or gas is cheaper - one must show that the cost of coal or other fuels exceeds the cost of imported oil. These provisions effectively require power plants and other facilities to demonstrate unavailability of geothermal resources as well as coal or other alternatives as a condition to continued use of oil or gas.

A utility seeking an exemption must demonstrate the unavailability of alternate sites as well as alternate fuels. It is noteworthy that the procedures for exemption orders require public notice and opportunity for comment by interested parties, including resource developers anxious to sell geothermal steam to a utility seeking such an exemption.

Synthetic gas from coal is not considered gas for the purposes of conversion orders. A user can also trade in synthetic gas purchased elsewhere for gas at his point of use, provided the BTU content is equivalent or better. Geopressured methane is not accorded this exemption, however.

#### Deregulation of Geopressured Methane

The NEA provides that within one year of enactment, methane produced from geopressured brine is not subject to price regulation. The cost of such "high-cost" gas is incremental, rather than rolled in. That is, the cost must be borne by industrial customers, rather than averaged out over all consumers. Rolled-in pricing would open up a larger market for geopressured methane, if the Act could be amended to allow it.

#### Interconnection and Wheeling

The NEA authorizes the Federal Energy Commission (FERC) to issue orders for interconnection; sale, exchange, or other coordination, and the expansion of transmission capacity at the request of a small power producer, cogenerator or electric utility. FERC must find to issue such an order that it will encourage conservation of energy or capital, will optimize the efficiency of use of facilities, or will improve the reliability of an electric utility system.

Small power producers are defined as persons not primarily engaged in the generation or sale of electricity who are producing electrical power from, among other sources, "renewable resources," from a site with no more than 80 megawatts of capacity. It is not clear that geothermal resources are included in "renewable resources".

A cogeneration facility is one that produces electricity and steam or other forms of useful energy (including methane). A geothermal facility producing power and using heat for industrial, heating or agricultural purposes would qualify.

Utilities (but not small power producers or cogenerators) can also seek wheeling orders from FERC. For a wheeling order, FERC must find that the order will conserve a significant amount of energy; promote the effectiveness of facilities and resources, or improve the reliability of an electric utility system. Wheeling cannot be ordered if it would replace power being provided by the utility owning the transmission facility under a contract, or under a rate schedule on file with FERC.

FERC is authorized to exempt small power producers and cogenerators with less than 30 megawatts of capacity from the Federal Power Act and the Federal Public Utility Holding Company Act.

#### GEOTHERMAL ENERGY OMNIBUS LEGISLATIVE

The NEA provisions deal with some of the major problems inhibiting geothermal energy development, but more is needed in several areas. A Bill is being prepared for submittal to Congress early in 1979 to complete the task of providing a comprehensive legal and policy framework amenable to rapid and orderly development.

## The Geothermal Steam Act

In April, 1977, President Carter promised that the Departments of Interior and Agriculture would streamline the Federal geothermal leasing and environmental review procedures. A Streamlining Task Force has developed a set of preliminary recommendations and will complete its work by early December. Some of the proposals may require legislation. In other cases, legislative authority may be desirable to prevent possible litigation. Some clarifications and changes are required to the scope and authorities of the Steam Act, as well.

Measures under consideration include an increase in limits on acreage that can be leased to an individual lessee; a conditioned leasing process, with pre-lease environmental reviews limited to exploration impacts and initial rights limited to exploration only; clarification of leasing authority for geothermal resources offshore and on withdrawn and acquired lands; access to special study areas for resource exploration; and special provisions for direct heat uses.

## Tax Legislation

The NEA resolves most of the tax problems, but some minor amendments may be needed. The minimum tax on geothermal intangible drilling costs may prevent formation of independent developers, and will be reassessed. The ineligibility of hot water distribution utilities for the 10% business tax credit may be redressed. Accelerated depreciation or research and development writeoffs for innovative industrial applications are also under consideration.

## Geothermal Loan Guaranty Program

Several possible changes to this program are being examined. A 90% guaranty for publicly-owned utility projects may be appropriate, because of the particular inability of these small systems to absorb risks. Provisions for partially forgivable loans as a form of cost guaranty may be appropriate, inasmuch as the major risks of geothermal resource dependence may be high cost, rather than outright failure. It has also been suggested that the government subordinate its interest to that of the lender.

## Expanded Interconnection and Wheeling Authority

Because of the site dependency, the small size of individual generating units, and the incremental nature of reservoir development, access to transmission lines is critical to geothermal resource development. Special, more liberal wheeling and interconnection authority for such site-dependent generation may be sought. Geothermal resources may be explicitly included in the small power producer category, eligible for interconnection orders. Wheeling orders for small power producers or cogenerators using site-dependent resources may also be authorized.

### Federal Subsidy Programs

Federal subsidy programs support a substantial fraction of the construction of new housing and public facilities. Loan limits and other policies, including basic conservation, discourage or prevent utilization of geothermal energy in such projects. Such projects are in effect forced to minimize first cost at the expense of increased life cycle costs. Corrective measures such as exemption of the costs of geothermal equipment from the Department of Housing and Urban Development (HUD) and Farmers Home Administration (FHA) loan and loan guaranty limits will be sought. Active roles for HUD, FHA, and the Department of Commerce in demonstrating space heating and industrial and agricultural applications may also be proposed as well.

### Heat Distribution Systems

Some form of incentive may be proposed for geothermal industrial parks and district heating systems. Partially forgivable loans repayable out of revenues, interest subsidies, reservoir insurance, modified loan guaranties, tax incentives, or grants are being considered.

### Other Measures

Public input is being sought especially with regard to regulatory and legal deterrents which can be corrected without sacrificing other important social goals. Suggestions for effective short-term incentives which will stimulate normal business relationships are also desired. The objective will be to make it possible for all of the necessary market sectors to consider geothermal energy as an economical alternative, including financing, exploration, development, transmission, distribution, and utilization of energy for electricity, industrial and agricultural heat use, and commercial and residential space heating. The Geothermal Energy Omnibus Bill is expected to put the finishing touches on a set of legislative authorities that includes the Geothermal Steam Act of 1970, the Geothermal Research, Development and Demonstration Act of 1974, and the NEA. The result should be a major contribution to providing clean domestic sources of energy for use throughout the United States.

## APPENDIX E

### GEOHERMAL ENERGY OMNIBUS LEGISLATION

#### RECOMMENDATIONS OF THE INSTITUTIONAL BARRIER PANEL TO

#### THE INTERAGENCY GEOHERMAL COORDINATING COUNCIL

### BACKGROUND

Three major pieces of legislation have been passed since 1970 to promote the development of geothermal resources in the U.S. These are the Geothermal Steam Act of 1970 (PL 91-581), the Geothermal Energy Research, Development, and Demonstration Act of 1974 (PL 93-410), and the five Acts that made up the 1978 National Energy Act - the Public Utility Regulatory Policies Act of 1978 (PL 95-617), the Energy Tax Act of 1978 (PL 95-618), the National Energy Conservation Policy Act (PL 95-619), the Power Plant and Industrial Fuel Use Act of 1978 (PL 95-620), and the Natural Gas Policy Act of 1978 (PL 95-621). These initiatives go a long way toward establishing a legal and regulatory framework favorable to commercial geothermal energy exploration and development, and incentives to stimulate early and widespread use by a variety of users. However, all of these Acts require improvements if the geothermal energy utilization objectives of the Council are to be met. Consequently, the Institutional Barrier Panel has developed a recommended Geothermal Energy Omnibus Bill to complete the legislative needs.

The major purposes of the legislation are to streamline Federal leasing and permitting, to provide incentives and reduce disincentives for market sectors not adequately dealt with in prior legislation (especially direct heat use market sectors), to clarify uncertainties in the National Energy Act, and to update the legislative mandate for the Council itself.

The proposed bill includes the initiatives in the following outline. More detailed descriptions of these proposals follow the outline.

#### I. Amendments to PL 93-410 IGCC Structure:

- Change name of Geothermal Coordination and Management Project to Interagency Geothermal Coordinating Council.
- Revise membership: eliminate NASA, replace ERDA and FEA with DOE, and add Commerce, HUD, and DOD
- Reflect Council, rather than Project Structure
- Authorize Active Role for Commerce Department, HUD, and Farmers Home Administration.
- Clarify annual report requirement.

## II. Amendments to PL 93-410 Loan Guaranty Program

- Authorize SBA, REA, HUD, and Farmers Home Administration to make geothermal loan guaranties.
- Authorize guaranties for 90% of project costs for publicly owned bodies (municipals and cooperatives) and for small business concerns.
- Authorize DOE to assume loans upon request of borrower, as alternative to default (panel evenly dividend on this recommendation).

## III. Amendments to Geothermal Steam Act

### Streamlining Task Force Recommendations

- Preclude KGRA designation for lands under non-competitive application.
- Authorize free use for small scale direct use applications.
- Authorize Federal agency use when it will not deter commercial development.

### Other

- Increase acreage limitation to 51,200 acres
- Clarify DOI authority to lease withdrawn and acquired lands
- Change references to "steam" to "resources"
- Authorize exploration for wilderness study areas
- Limit KGRA to electric prospects
- Provide authority to negotiate lease for mineral-severed lands
- Eliminate authority for unilateral readjustment of lease terms every 10 years.

## IV. Amendments to Energy Tax Act of 1978

- Allow 10% Alternative Energy Property credit for Public Utility Property in the case of geothermal equipment, and extend time period to completion of construction in 1990, rather than 1982.
- Eliminate minimum tax on Geothermal Intangible Drilling Costs
- Confirm eligibility of injection wells for intangible drilling cost deduction



V. Amendment to Natural Gas Policy Act of 1978

- Authorize rolled-in pricing for geopressured methane

VI. Amendment to Powerplant and industrial Fuel Use Act of 1978

- Authorize use of geopressured methane in Major Fuel Burning Installations and powerplants

VII. Amendments to Public Utility Regulatory Policies Act

- Authorize FERC to issue wheeling and interconnection orders for Geothermal Power Producers.
- Authorize exemption from Federal Power Act and Federal Public Utility Holding Company Act for Geothermal Power Producers for plants up to 60 MWe, rather than 30 MWe.

VIII. Amendments to National Energy Conservation Policy Act

- Include geothermal space heating in grants, secondary financing, and loan insurance programs.
- Include geothermal in programs for grants to hospitals, schools, government buildings, and public care facilities.
- Include geothermal in Federal buildings program
- Authorize increase in HUD and Farmers Home Administration loan limits for geothermal heating and cooling equipment.

# APPENDIX F

## LIST OF KEY CONTACTS IN ALASKA

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