SUSITNA HYDROELECTRIC PROJECT

FEASIBILITY REPORT

VOLUME 2

ENVIRONMENTAL REPORT

SECTIONS 1-4

FINAL DRAFT

Prepared for:

ACRES

Prepared by:

Terrestrial Environmental Specialists, Inc.

ALASKA POWER AUTHORITY

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ERRATA

Reference is made in various areas of Volume 2 to Appendix E3. The reader should be referred instead to Reference Report R65.

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PREFACE

Terrestrial Environmental Specialists, Inc. (TES), on behalf of the Alaska Power Authority (the Power Authority) and as a subcontractor to Acres American, Inc. (Acres), is performing environmental studies as part of a feasibility study and, depending on that study's outcome, a license application to the Federal Energy Regulatory Commission (FERC) for the Susitna Hydroelectric Project. The environmental program consists of baseline studies, impact analyses, and mitigation planning, each of which is being conducted in two phases: preceding submission of the Feasibility Report and License Application (Phase I) and following the License Application (Phase II) (Acres American, Inc. 1979, 1980). This report is a summary of the findings of the Phase I studies, which were performed over a two-year period (1980- 1981).

TES acknowledges the substantial input received from its subcontractors and consultants. Principal investigators at the University of Alaska included: Dr. J. McKendrick, Dr. W. Collins, and Dr. D. Helm (Botanical Resources); Dr. P. Gipson, Mr. S. Buskirk, and Mr. W. Hobgood (Furbearers); Dr. B. Kessel and Mr. S. McDonald (Birds and Small Mammals); Dr. E. J. Dixon and Mr. G. Smith (Archeological Resources); and Dr. A. Jubenville, Ms. J. Feyhl, and Ms. P. Powell (Recreation, Aesthetics, and Land Use). Frank Orth & Associates, Inc. (Mr. P. Rogers, Project Manager) performed the socioeconomic study. Consultants to TES included Dr. R. Taber (Big Game), Dr. F. Banfield (Caribou), and Mr. R. Williams, Mr. C. Atkinson and Mr. M. Bell (Fish Resources). Ms. A. Fazekas served as editorial consultant; Ms. C. Page and Mr. M. Goff prepared the graphics. Studies to describe the existing fish and big game ecology were performed by the Alaska Department of Fish and Game (ADF&G) under direct agreement with the Power Authority.

The environmental report sections on Water Use and Quality, Geological and Soil Resources, and Alternatives were prepared by Acres to be combined with those sections prepared by TES. Acres has also prepared Volume I, which describes engineering aspects of the proposed project. In a separate appendix (E3) along with Acres' engineering drawings, are maps prepared by TES to illustrate environmental considerations for the transmission route.

The environmental resources and impacts of transmission facilities between Willow and Healy have been addressed in an independent study by the Power Authority. The proposed route parallels the Alaska Railroad in the vicinity of Gold Creek. Therefore, the Susitna transmission line study, as presented in this feasibility report, has been limited to those areas where additional corridors would be required, namely, from the proposed dams to Gold Creek as well as Willow to Anchorage and Healy to Fairbanks.

1 - GENERAL DESCRIPTION OF THE LOCALE

1.1 - Location

The location of the proposed Susitna Hydroelectric Project is the upper Susitna River, Alaska, approximately 180 km north-northeast of Anchorage and 230 km south-southwest of Fairbanks (Figure 1.1). Two proposed dams would generate electrical power for the railbelt region of Alaska, that is, the corridor surrounding the Alaska Railroad from Seward and Anchorage to Fairbanks. The two proposed dam sites, Watana and Devil Canyon, are 266 and 216 km upstream of the river's mouth at Cook Inlet. The nearest settlements (Gold Creek, Canyon, Chulitna) are along the Alaska Railroad, approximately 18 km from Devil Canyon.

1.2 - Physiography and Topography

The Susitna River basin lies largely within the Coastal Trough province of south-central Alaska, a belt of lowlands extending the length of the Pacific Mountain System and interrupted by the Talkeetna, Clearwater, and Wrangell Mountains (Wahrhaftig 1965). In the vicinity of the proposed impoundments (Figure 1.2), the river cuts a narrow, steep-walled gorge up to 300 m deep through the Clarence Lake Upland and Fog Lakes Upland, areas of broad, rounded summits 900 to 1400 m in elevation. Between these uplands, the gorge cuts through an extension of the Talkeetna Mountains, where rugged peaks are 1200-1900 m high. Downstream of its confluence with the Chulitna and Talkeetna rivers, near Talkeetna, the Susitna traverses the Cook Inlet-Susitna Lowland, a relatively flat region generally less than 150 m in elevation. A portion of the proposed transmission facilities, between Healy and Fairbanks, would follow the narrow valley of the Nenana River through the Northern Foothills of the Alaska Range, traverse the Tanana-Kuskokwim Lowland in a flat region generally less than 200 m in elevation (the Tanana Flats), and then parallel a ridge on the edge of the Yukon-Tanana Upland.

1.3 - Geology and Soils

In its complex geologic history, the upper Susitna River region has undergone uplifting and subsidence, marine deposition, volcanic intrusion, glacial planing and erosion. The Susitna basin lies within the Talkeetna terrain, a zone of moderate seismicity (see Volume I, Section 7). Continuing erosion has removed much of the glacial debris at higher elevations, but very little alluvial deposition has occurred here. The resulting landscape consists of barren bedrock mountains, glacial till-covered plains, and exposed bedrock cliffs in canyons and along streams. Climatic conditions have retarded the development of topsoil. Soils are typical of those formed in cold, wet climates and have developed from glacial till and outwash. They include the acidic, saturated, peaty soils of poorly drained areas; the acidic, relatively infertile soils of the forests; and raw gravels and sands along the river. The upper basin is generally underlaid by discontinuous permafrost.

1.4 - Hydrology

The entire drainage area of the Susitna River is about 50,000 km^2, of which the upper basin above Gold Creek comprises approximately 16,000 km^2 (Figures 1.3 and 1.4). Three glaciers in the Alaska Range feed forks of the Susitna River, which join after about 30 km to flow south through a broad valley for approximately 90 km. The river then flows westward about 140 km through a narrow valley, with the constriction at Devil Canyon creating violent rapids. Numerous small, clear-water tributaries flow steeply to the Susitna in this middle section, several of which cascade over waterfalls as they enter the gorge. As the Susitna curves south past Gold Creek, its gradient gradually decreases. The river is joined about 60 km beyond Gold Creek in the vicinity of Talkeetna by two major rivers, the Chulitna and Talkeetna. From this confluence, the Susitna flows south through braided channels about 130 km, until it empties into Cook Inlet near Anchorage, approximately 450 km from its source.

Most of the annual flow occurs between May and September, when the Susitna is heavily laden with glacial silt. Average summer flows at Gold Creek are 20,250 cubic feet per second (cfs); winter flows average only 2100 cfs. In the winter, the river runs clear. The upper Susitna River (above the confluence with the Chulitna) contributes about 20% of the mean annual flow measured near the river's mouth.

The upper reaches of the Susitna start to freeze up in early October, and by the end of November, the lower river is icebound. Breakup begins in late April or early May, and occasional ice jams may cause the water level to rise as much as six meters.

1.5 - Climate

As in most of Alaska, winters are long, summers are short, and there is considerable variation in daylight between these seasons. Higher elevations in the upper basin are characterized by a continental climate typical of interior Alaska. The lower floodplain falls within a zone of transition between maritime and continental climatic influences (Searby 1968, cited by Hartman and Johnson 1978). From the upper to the lower basin, the climate becomes progressively wetter, with increased cloudiness and more moderate temperatures.

At Talkeetna, which is representative of the lower basin, average annual precipitation is about 71 mm (28 in), of which 68% falls between May and October, and annual snowfall is about 269 mm (106 in). Monthly average temperatures range from -13°C (9°F) in December and January to 14°C (58°F) in July.

1.6 - Vegetation

The Susitna basin occurs within an ecoregion classified by Bailey (1976, 1978) as the Alaska Range Province of the Subarctic Division. The major vegetation types in the upper basin are low mixed shrub, woodland and open black spruce, sedge-grass tundra, mat and cushion tundra, and birch shrub. (Scientific names of plants are listed in Table 3.1) These vegetation types are typical of vast areas of interior Alaska and northern Canada, where plants exhibit slow or stunted growth in response to cold, wet, and short growing seasons. Deciduous and mixed conifer-deciduous forests occur at lower elevations in the upper basin, primarily along the Susitna River, but comprise less than three percent of the upper basin area. These forest types have more robust growth characteristics than the vegetation types at higher elevations and are more comparable to vegetation types occurring on the floodplain farther downstream.

The floodplain of the lower river is characterized by mature and decadent balsam poplar forests, birch-spruce forest, alder thickets, and willow-balsam poplar shrub communities. The willow-balsam poplar shrub and alder communities are the earliest to establish on new gravel bars, followed by balsam poplar forests and, eventually, by birch-spruce forest. The major vegetation types within the proposed transmission corridor from Healy to Fairbanks are closed and open deciduous forests, closed and open mixed forests, and mixed low shrub.

1.7 - Wildlife

Big game in the upper basin include caribou, moose, brown bear, black bear, wolf, and Dall sheep. (Scientific names of these and other wildlife species are listed in Tables 3.8, 3.31 and 3.46.) Caribou migrate through much of the open country in the upper basin, and important calving grounds are present outside of the impoundment zone. Moose are fairly common in the vicinity of the proposed project, but high quality habitat is rather limited. Moose also frequent the floodplain of the lower river, especially in winter. Brown bear occur throughout the project vicinity, while black bear are largely confined to the forested habitat along the river; populations of both species are healthy and productive. Several wolf packs have been noted using the area. Dall sheep generally inhabit areas higher than 900 m in elevation.

Furbearer species of the upper basin include red fox, wolverine, pine marten, mink, river otter, short-tailed weasel, least weasel, lynx, muskrat, and beaver. Beavers become increasingly more evident farther downstream. Sixteen species of small mammals that are characteristic of interior Alaska are known to occur in the upper basin.

Bird populations of the upper basin are typical of interior Alaska but sparse in comparison to those of more temperate regions. Generally, the forest and woodland habitats support higher densities of birds than do other habitats. In regional perspective, ponds and lakes in the vicinity of the proposed impoundments support relatively few waterbirds. Ravens and raptors, including bald and golden eagles, are conspicuous in the upper basin. Bald eagles also nest along the lower river.

1.8 - Fish

Anadromous fish in the Susitna basin include all five species of Pacific salmon: pink (humpback); chum (dog); coho (silver); sockeye (red); and chinook (king) salmon. (Scientific names of fish are listed in Table 3.48.) Salmon migrate up the Susitna to spawn in tributary streams, sloughs, and side channels below Devil Canyon. Surveys to date indicate that salmon are unable to ascend the Devil Canyon rapids and are thus prevented from migrating farther into the upper basin. Anadromous smelt (eulachon) are known to migrate into the lower Susitna River, and Bering cisco have recently been discovered.

Grayling abound in the clear-water tributaries of the upper basin; these populations are relatively unexploited. Grayling as well as lake trout also inhabit many lakes. The mainstem Susitna has populations of burbot and round whitefish, often associated with the mouths of clear-water tributaries. Dolly Varden, humpback whitefish, sculpin, sticklebacks, and long-nosed suckers have also been found in the drainage. Rainbow trout, like the anadromous species, have not been found above Devil Canyon.

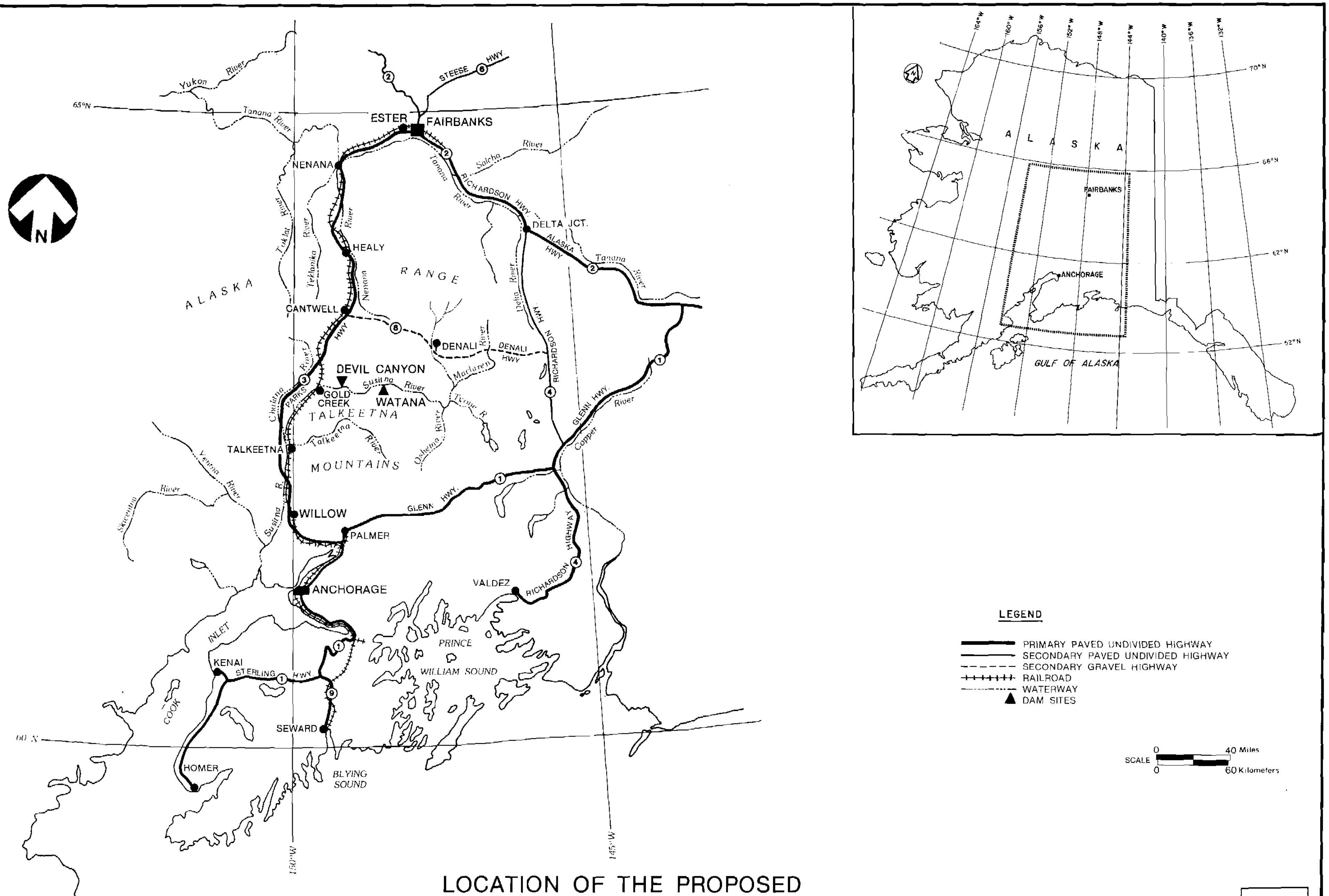
1.9 - Land Use

Because of limited access, the project area in the upper basin has retained a wilderness character. There are no roads to the project vicinity, but there are several off-road vehicle and sled trails. Although rough, dirt landing-strips for light planes are not uncommon, floatplanes provide the principal means of access via the many lakes in the upper basin.

Perhaps the most significant land use over the past three decades has been the study of hydropower potential of the Susitna River. The area is also used by hunters, white-water enthusiasts, fishermen, trappers, and miners. A few wilderness recreation lodges and private cabins, single and in small clusters, are scattered throughout the basin, especially on the larger lakes.

Most of the lands in the project area and on the south side of the river have been selected by the Natives under the Alaska Native Claims Settlement Act. Lands to the north are generally federal and are managed by the Bureau of Land Management. The State has selected some lands on the north side of the river, and there are many small, scattered private holdings in the upper basin.

The transmission corridors outside the dam and impoundment areas (Willow to Anchorage and Healy to Fairbanks) traverse lands with a somewhat higher degree of use. Most of the land within the corridors, however, is undeveloped.

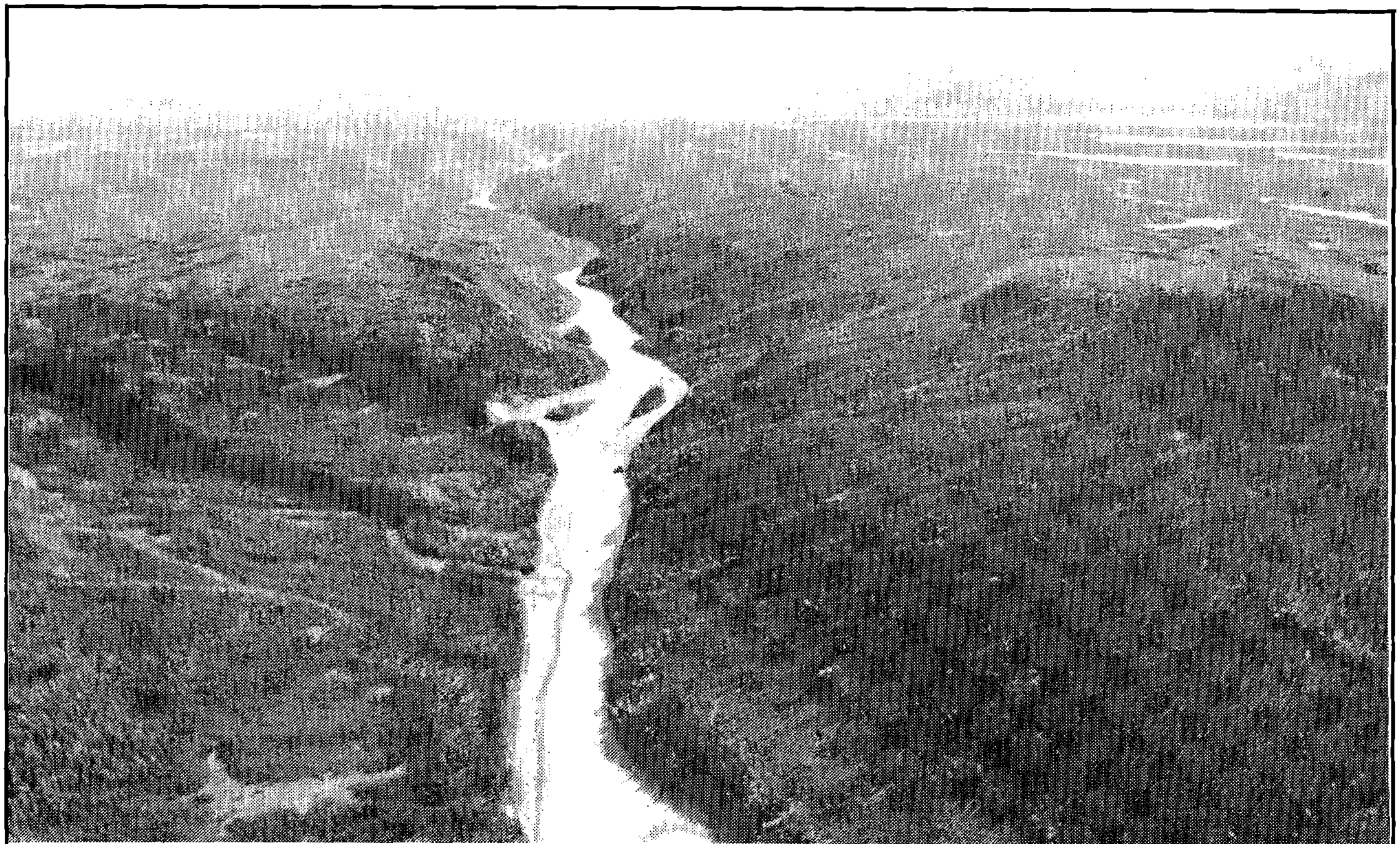


LOCATION OF THE PROPOSED
SUSITNA HYDROELECTRIC PROJECT

PREPARED BY TES / ACRES

FIGURE 1.1

ACRES



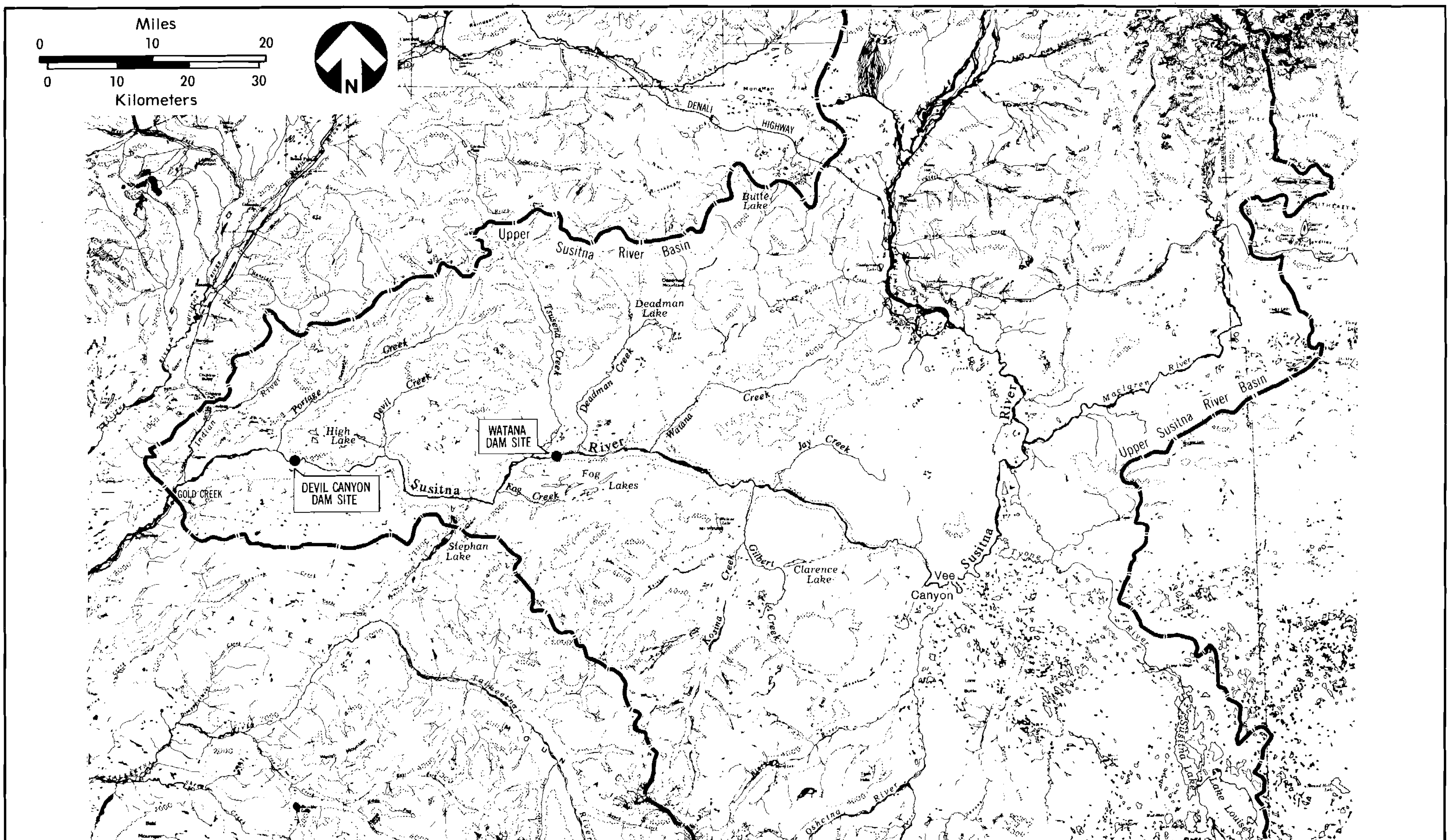
Watana, View Upstream

Devil Canyon, View Upstream

VICINITIES OF THE PROPOSED
DAM SITES, SUSITNA HYDROELECTRIC PROJECT

PREPARED BY TES

FIGURE 1.2



UPPER SUSITNA RIVER BASIN

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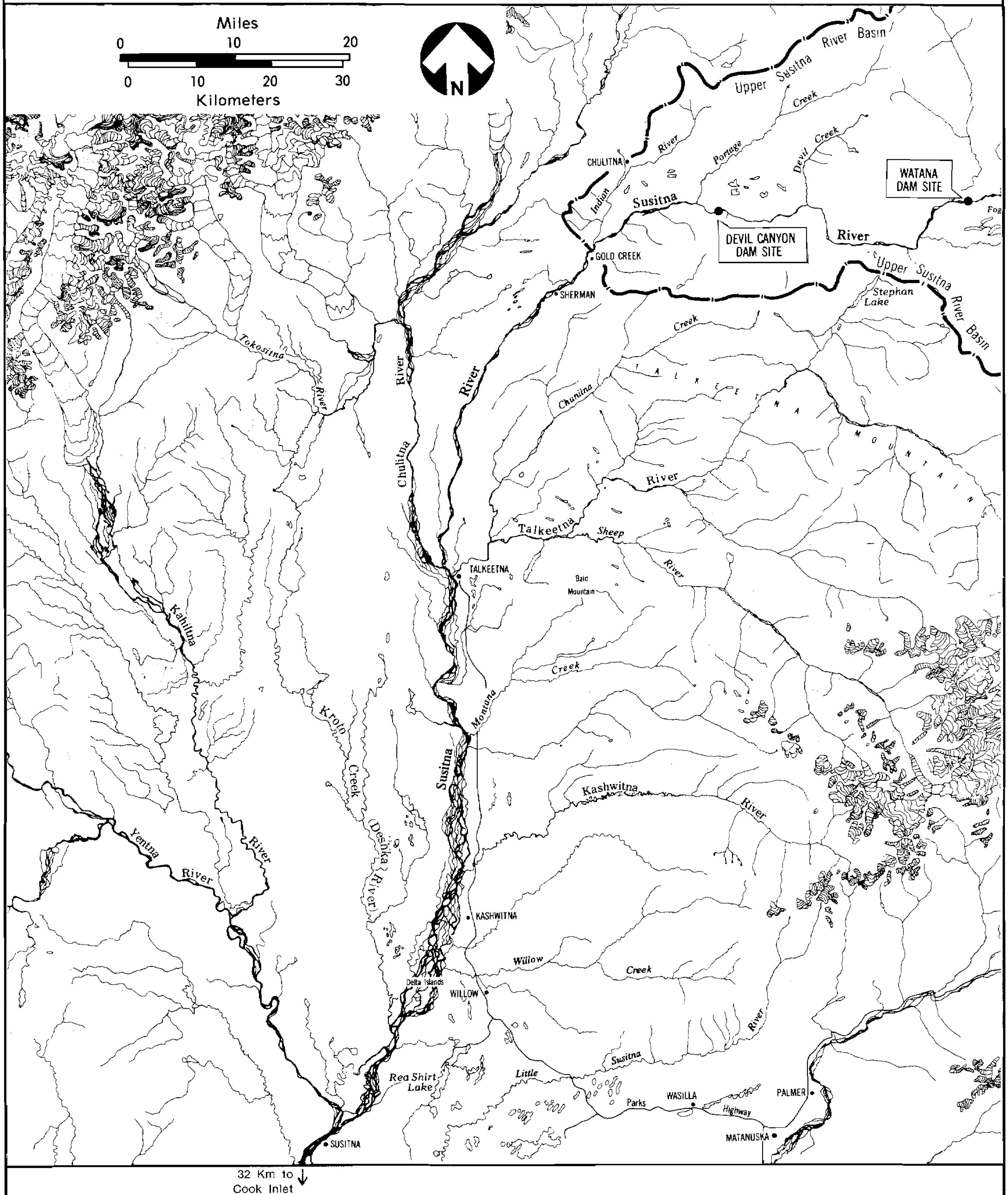
FIGURE 1.3

ACRES



LOWER SUSITNA RIVER DRAINAGE

PREPARED BY TES

FIGURE 1.4

ACRES

(i) Mainstem Susitna Corridor

The mainstem Susitna corridor encompasses 30 townships, from the proposed impoundment area at Devil Canyon downstream to the Cook Inlet estuary. Existing surface and ground water appropriations are primarily for singlefamily and multi-family' homes (Table 2.1). A small amount of water is used year-round for watering livestock. Only 0.153 cfs or 50 ac-ft/yr of surface water has been appropriated for all purposes (Table 2.2). Water appropriations in other areas are even less significant. On a seasonal basis, the greatest usage occurs during summer months for irrigating lawns, gardens, and crops. The largest single use of surface water is for placer gold operations.

As listed in Table 2.3, there are only five areas where water appropriations are located within one mile of the mainstem Susitna River. No surface water diversions are recorded that draw water directly from the Susitna River or its adjoining side channels and sloughs. Immediately downstream from the Delta Islands, on the west bank of the Susitna River, a single-family dwelling has a certificate for 650 gpd of ground water from a well of unlisted depth. The certificate includes 0.5 ac-ft/yr for crop irrigation for three months. About six miles below Talkeetna, and 0.25 miles inland from the west bank of the Susitna River, a single-family dwelling has a certificate for 500 gpd of ground water from a 90-foot-deep well. In Talkeetna, ground water from three shallow (20-, 27-, and 34-foot) wells have been appropriated for a single-family dwelling (500 gpd), the grade school (910 gpd), and the fire station (500 gpd). In the vicinity of Chase, between miles 235 and 236 of the Alaska Railroad, several unnamed streams, lakes, and creeks have been appropriated for single-family dwellings (1,250 gpd), lawn and garden irrigation (100 gpd), and crops (1 ac-ft/yr). In the vicinity of Sherman, at mile 258 of the Alaska Railroad, Sherman Creek and an unnamed stream have been appropriated for two single-family dwellings (325 gpd) and lawn and garden irrigation (50 gpd).

(ii) Other Areas

Data on existing water rights for the remaining township grids in the Susitna River basin are summarized in Table 2.2. The major uses of surface water occur in the Kahiltna and Willow Creek township grids. This water is used on a seasonal basis for mining operations. Water appropriations are 125 cfs, or 37,000 ac-ft/yr, in the Kahiltna area and 18.3 cfs, or 5,660 ac-ft/yr, in the Willow Creek area.

(c) Impacts of Susitna Project

Post-project water surface elevations for the mainstem river below Talkeetna are expected to be approximately three feet higher during winter months and from one half to one and one half feet lower during the summer months (R&M Consultants). Such a moderate range of fluctuation is not expected to adversely affect the ground water zones being tapped by the two small-capacity domestic wells in the Delta Islands and Tapper Creek areas. The surface water appropriations at Sherman are 50 to 100 feet above the present elevation of the Susitna River and would not be influenced by changes in water surface elevation of the Susitna River.

The three shallow wells (20 to 34-foot depth) recorded in Talkeetna are approximately 1.5 miles downstream from the confluence of the Chulitna and Susitna rivers and 0.13 miles downstream from the confluence of the Talkeetna River. From all visual indications the Talkeetna River appears to be upgradient and the principal recharge source for these wells. It appears that the water surface elevation of the Susitna River could be influencing the ground water level by providing the downgradient base elevation for the water table. However, the anticipated maximum decrease in average monthly water surface elevations of the Susitna River near Talkeetna will be approximately three feet. At worst, the water surface elevations of the local water table will be reduced one foot (R&M Consultants).

In the vicinity of Chase, all surface water appropriations are from small tributary streams and lakes at an elevation of 450 to 500. The Susitna River is approximately 0.25 miles from the nearest appropriation and is at an elevation of approximately 400. The anticipated changes in water surface elevation for the mainstem Susitna River near Chase are unlikely to have any effect on these surface water diversions from small streams or lakes located 50 to 100 feet above the river on the hillsides.

In summary, examination of state agency files indicated the major, although small, users of surface water occur along the Kahiltna and Willow Creek township grids. No surface water withdrawals from the Susitna River are recorded. Ground water appropriations along the mainstem Susitna River corridor are minimal, both in terms of number of users and total amount of water withdrawn. The analysis of topographic maps and overlays showing the specific locations of the appropriations along the mainstem Susitna River corridor indicated that neither surface water diversions from small tributaries nor shallow wells in the corridor area are likely to be affected by operation of the proposed project.

2.2 - Water Quality

This section presents a discussion of present water quality conditions in the Susitna River and potential impact of the proposed project.

(a) Present Conditions

The Susitna River is characterized by wide seasonal fluctuations in discharge. Breakup occurs in late April or early May, resulting in an increase in river flows with peak flows occurring in June. Discharge varies throughout the summer, depending on temperature and rainfall. Flows decline during the fall and winter and are at minimum level in March. Basin and runoff characteristics appear in Table 2.4.

The wide seasonal fluctuations in discharge, along with the glacial character of the river, have a significant effect on water quality. Suspended sediment concentrations and turbidity levels are low during late fall and winter, but sharply increase at breakup and remain high throughout summer during the glacial melt period. Dissolved solids concentrations and conductivity values are high during low flow periods and low during the high summer flows.

(i) Availability of Data

Existing water quality data have been compiled for the mainstem Susitna River from stations located at Denali, Vee Canyon, Gold Creek, Sunshine, and Susitna Station. Data from two Susitna River tributaries, Chulitna and Talkeetna Rivers, have also been compiled. The periods of record for each station are presented below:

Station	Period of Record	Agency
Denali (D)	4/9/57 - 5/19/81	USGS
Vee Canyon (V)	7/6/62 - 5/11/81	USGS
	6/19/80 - 10/8/81	R&M
Gold Creek (G)	6/22/49 - 7/21/81	USGS
	8/8/80 - 10/8/81	R&M
Chulitna (C)	4/5/58 - 3/25/81	USGS
Talkeetna (T)	4/29/54 - 10/4/77	USGS
Sunshine (S)	7/2/71 - 7/23/81	USGS
Susitna Station (SS)	8/17/55 - 8/12/81	USGS

Data have been compiled according to three seasons: breakup, summer, and winter. Breakup is usually short and extends from the time ice begins to break up until recession of spring runoff. Summer extends from the end of breakup until the water temperature drops to essentially 0°C in the fall, and winter is the period from the end of summer to breakup. Detection limits for various water quality perameters appear in Table 2.5.

(ii) Water Quality Standards

The water quality guidelines and criteria used in this evaluation were established from the following references:

- ADEC, 1979. Water Quality Standards. Alaska Department of Environmental Conservation, Juneau, Alaska, 334 pp.

- EPA, 1976. Quality Criteria For Water. U.S. Environmental Protection Agency, Washington, D.C., 255 pp.

- McNeely, R.N., V.P. Neimanis, and L. Dwyer, 1979. Water Quality Sourcebook-- A Guide to Water Quality Parameters. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa, Canada, 88 pp.

- Sitting, Marshall, 1981. Handbook of Toxic and Hazardous Chemicals. Noyes Publications, Park Ridge, New Jersey, 729 pp.

- EPA, 1980. Water Quality Criteria Documents; Availability. Environmental Protection Agency, Federal Register, 45, 79318-79379 (November 28, 1980).

The guidelines or criteria used for the parameters were chosen based on a priority system. Alaska Water Quality Standards were the first choice, followed by criteria presented in EPA's Quality Criteria for Water. If a criterion expressed as a specific concentration was not presented in the above two references, the other cited references were consulted.

A second priority system was used for selecting the guidelines or criteria presented for each parameter. This was required because the various references presented above cite levels of parameters that provide for the protection of identified water uses, such as (1) the propagation of fish and other aquatic organisms, (2) water supply for drinking, food preparation, industrial processes, and agriculture, and (3) water recreation. The first priority, therefore, was to present the guidelines or criteria that apply to the protection of freshwater aquatic organisms. The second priority was to present levels of parameters that are acceptable for water supply, and the third priority was to present other guidelines or criteria, if available. It should be noted that water quality standards set criteria which limit man-induced pollution to protect identified water uses. Although the Susitna River Hydroelectric Project is a pristine area, some parameters exceeded their respective criterion.

As noted in Table 2.6, criteria for three parameters are suggested rather than legally mandated or have otherwise been set at a level which natural waters usually do not exceed. The criteria for aluminum and bismuth have been suggested on the basis of human health effects. The criterion for total organic carbon (TOC) was established at 3 mg/l because water containing less than this concentration have been observed to be relatively clean. However, streams in Alaska receiving tundra runoff commonly exceed this level. The maximum TOC concentration reported herein, 20 mg/l, is likely the result of natural conditions. The criterion for manganese was established to protect water supplies. The criteria presented in the remaining parameters appearing in Table 2.6 are established by law for the protection of freshwater aquatic organisms. The water quality standards apply to man-made alterations and constitute the degree of degradation which may not be exceeded. Because there are no industries, no significant agricultural areas, and no major cities adjacent to the Susitna, Talkeetna, and Chulitna Rivers, the measured levels of these parameters are considered to be a natural condition. Also, these rivers support diverse populations of fish and other aquatic life. Consequently, it is concluded that the parameters exceeding their criteria have little, if any, detrimental effect on aquatic organisms.

(iii) Evaluation of Current Conditions

The results of the analyses indicate the Susitna River is a fastflowing, cold-water stream of the calcium bicarbonate type containing soft to moderately hard water during breakup and in the summer and moderately hard water in the winter. Nutrient concentrations, namely nitrate and orthophosphate, exist in low-to-moderate concentrations. Dissolved oxygen concentrations typically remain high, averaging about 12 mg/l during the summer and 13 mg/l during winter. Percentage saturation of dissolved oxygen always exceeds 80 percent but averages near 100 percent in the summer, and in the winter saturation levels decline slightly from the summer levels. Typically, pH values range between 7 and 8 and exhibit a wider range in the summer compared to the winter. During summer, pH occasionally drops below 7, which is attributed to tundra runoff. True color, also resulting from tundra runoff, displays a wider range during summer than winter.

Color levels in the vicinity of the damsites have been measured as high as 40 color units. Temperature remains at or near 0°C during winter, and the summer maximum is 13°C. Alkalinity concentrations, with bicarbonate as the dominant anion, are low to moderate during summer and moderate to high during winter. The buffering capacity of the river is relatively low on occasion.

The concentrations of many trace elements monitored in the river were low or within the range characteristics of natural waters. However, the concentrations of some trace elements exceeded water quality guidelines for the protection of freshwater aquatic organisms. These concentrations are the result of natural processes because there are no man-induced sources of these elements in the Susitna River Basin.

Concentrations of organic pesticides and herbicides, uranium, and gross alpha radioactivity were either less than their respective detection limits or were below levels considered to be potentially harmful.

It is worthy to note that the range displayed in the figures' pH and color are typical for streams in Alaska receiving tundra runoff. It is not uncommon for pH to be 6.5 (the criterion) or slightly less and color to be as high as 100 color units (the maximum reported herein). It should also be noted that the four highest levels of percentage saturation of dissolved oxygen are probably in error. If these data are eliminated, all the dissolved oxygen percentage saturation values are less than the criterion of 110 percent.

Figures 2.1 through 2.41 depict the result of the analysis for all physical parameters and inorganic and non-metallic parameters. Data summaries for metals which exceeded their criteria are also presented.

(b) Parameters Exceeding Criteria and Aberrant Data

This section presents a summary of the parameters that have exceeded their criteria (Table 2.6), a discussion of aberrant data, and a list of parameters that exhibited values less than their respective detection limits.

A number of parameters listed in Table 2.6, exceeded their respective criteria. The implications of this to freshwater aquatic organisms are related to the rationale behind the criteria and to the fact that the Susitna River is largely unaffected by man's activity.

The identification of aberrant data was considered because of the extreme values manifested by some parameters. The following parameters were suspected of having aberrant data:

(i) D.O. and Saturation

The high values measured at Gold Creek during summer exceeded the criterion. The four highest values measured by R&M (116, 115, 114, and 113 percent saturation) are probably in error because of a faulty barometer and should be eliminated from the data set. R&M's fifth highest value was similar to the USGS's highest values of 106, 104, 103, and 102 percent saturation.

(ii) Free Carbon Dioxide

The five highest values measured by R&M at Gold Creek during summer were 36, 35, 20, 16, and 16 mg/l. The two highest values may be aberrant, but there are no acceptable reasons to eliminate them.

(iii) Ortho-Phosphate

One high value, 0.49 mg/l, measured at Vee Canyon during summer appears unrealistic and should be eliminated. The next highest value was 0.1 mg/l. The high value measured at Talkeetna during breakup may also be unrealistic, but there are no data with which to compare this value, so it should stand.

(iv) Phosphorus

The high value of 0.49 mg/l measured at Vee Canyon during summer is likely to be aberrant because the next highest is 0.1 mg/l. Likewise, a high value of 0.36 mg/l is significantly different from the next highest value of 0.05 mg/l measured at Susitna Station during winter. It is recommended that both of the high values be eliminated.

(v) Turbidity

The five highest turbidity values measured at Susitna Station during summer were 790, 590, 430, 430, and 260 NTU. There is no reason to eliminate any of these values.

(vi) Total Organic Carbon

The four concentrations measured at Gold Creek during winter are 39, 34, 27, and 5.5 mg/l, and one measurement at Vee Canyon during winter was 23 mg/l. Although the four high values appear unrealistic, there is no apparent reason to eliminate them.

(c) Impacts of Susitna Project

Construction of hydroelectric dams and their reservoirs has a profound effect on the water regime of downstream river reaches. Since the rate of reservoir water outflow is controlled, the downstream reach is no longer subject to the fluctuations of a normal river regime with the consequence that the flow generally becomes less variable throughout the year (Turkheim 1975). Under currently proposed operating conditions, the Watana and Devil Canyon dams will significantly affect the average monthly flows at Gold Creek. The minimum flow regime is significantly increased and peak flows are decreased. The decrease in spring flood magnitude, especially during the initial impoundment, may result in negative effects on the downstream environment. It is reasonable to expect that the interference with natural Susitna River flows will cause some changes in streams and branches, adjacent wetlands, and ground water levels for some distance downstream from the dams.

The number of upstream hydrologic effects are few compared to at-reservoir and downstream effects. Due to an aggradation process whereby reservoir waters are backlogged or increased in an upstream direction, the reservoir can increase the amount of evaporation from a river (Turkheim 1975). However, the amount of evaporation from the river will be a small percentage of the total evaporation from the Watana and Devil Canyon reservoirs which will in itself be insignificant.

The principal impacts requiring consideration relate to sedimentation, temperature, dissolved oxygen, dissolved solids, and dissolved nitrogen.

(i) Turbidity and Sedimentation

When a turbulent, sediment-laden stream such as the Susitna River enters a reservoir, quiescent conditions will allow much of the material to settle to the bottom. Weiss and Love substantiate the reduction of turbidity by impoundment of sediment-laden waters in reservoirs (Weiss, Francisco, and Lenat 1973; Simmons 1972; Love 1961). According to reservoir sedimentation studies, 95-100 percent of sediment entering Watana reservoir would settle, even shortly after filling of the reservoir starts. The Devil Canyon reservoir would have a slightly lower trap efficiency than Watana due to its smaller volume. However, most sediment will be deposited in Watana, the upstream reservoir. Turbidity levels and suspended solids concentration downstream from the reservoir will decrease sharply during the summer months due to the sediment trapping characteristics of the reservoirs. It is likely that the turbidity of water released during winter will be substantially reduced from summer conditions as suspended sediment in near-surface waters should rapidly settle once the reservoir ice cover forms and essentially quiescent conditions occur.

Sedimentation affects other water quality parameters besides turbidity and suspended solids. Color (Drachev 1962), particulate phosphorus (Wright, Soltero 1973), dead microorganisms such as plankton and algae (Erickson, Reynolds 1969), and precipitated chemicals (Mortimer 1941; Mortimer 1942) are removed in the sedimentation process. Consequently, color levels and total phosphorus concentrations ought to be reduced in and downstream from the reservoir. Metal concentrations, such as iron, manganese, and some of the trace elements, will also be reduced as they are precipitated and settled to the bottom. Leaching under anaerobic conditions will cause some of these compounds to redissolve into the water near the reservoir bottom. However, if the deposited material is inorganic, it can form a mat on the reservoir bottom, thereby effectively blocking leachate from entering the water column (Nech 1967). This is expected to occur in the Watana reservoir but is likely to be a minor factor in the Devil Canyon reservoir.

(ii) Temperature

The range and seasonal variation in temperature of the Susitna River will change after impoundment. An impoundment study revealed that the reservoir not only reduced the magnitude of variation in temperature but also changed the time period of the high and low temperatures (Bolke and Waddell 1975). This will also be the case for the Susitna River, where pre-project temperatures generally range from 0°C to 13°C with the lows occurring in October/November through March/April and the highs in July or August. After closure, the temperature range will be reduced and low temperatures will occur in November through March. The period of highest temperature will be July and August, as is the pre-project case. Reservoirs releasing water from the surface are "heat exporter" reservoirs (Turkheim 1975), and both Susitna River reservoirs fall into this category.

(iii) Dissolved Oxygen

Thermal stratification is not likely to occur in either reservoir, but a temperature gradient will exist. It is expected that vertical mixing will occur in the spring as a result of the large input of water, wind effects, and surface water warming. This will result in the transport of oxygen from the surface, where reaeration occurs, throughout the top 60 to 100 feet of the reservoir, where biologic and chemical processes use oxygen.

(iv) Dissolved Solids

Anaerobic bottom conditions can harm aquatic life and cause the reduction and release of undesirable chemicals into the water (Fish 1959). The leaching process which is more efficient under anaerobic conditions, degrades bottom water quality by releasing such chemicals as alkalinity, iron, manganese (Symons 1969), hydrogen sulfide, and nutrients (Turkheim 1975). Also, leaching problems become more severe as the organic content in the soils increases. The potential for leaching at the Watana reservoir should decline in time as the inorganic, glacial sediment carried in by the river settles and blankets the reservoir bottom. The products of leaching are not anticipated to be abundant enough to affect more than a small layer of water near the reservoir bottoms. Also, leaching products will not degrade downstream water quality over the long-term because water will be released at or near the surface. A shortterm increase in dissolved solids, conductivity, and most of the major ions may be evident immediately after closure of the dam. Other reservoir studies have shown that the highest concentration of all major ions, except magnesium, occurred immediately after impoundment (Bolke and Waddell 1975). The increase in concentration was attributed to the initial inundation and leaching of rocks and soils in the reservoir area.

Although evaporation has been noted to cause the dissolved solids concentrations to increase (Symons 1969; Love 1961), this potential effect on water quality at the Watana and Devil Canyon reservoirs is not significant. The average annual evaporation predicted for May through September at Watana is 10.0 inches; at Devil Canyon it is 11.1 inches. There is no evaporation during the period of ice cover from October through April. The percentage of the reservoirs lost to evaporation during summer will be 0.3 percent at Watana and 0.6 percent at Devil Canyon. A less than 1 percent increase in concentration of most water quality parameters is not significant. Local effects may be noted from evaporation and sublimation may cause some water loss creating local effects. These are not anticipated to be significant.

Both Watana and Devil Canyon reservoirs will release water from at or near the surface and therefore have the potential to become nutrient traps, resulting in eutraphic conditions. The major criteria for eutrophiation to occur include nutrient concentrations, algae populations, solar radiation and the effects of reservoir processes.

(v) Dissolved Nitrogen

The critical concentration of nitrogen in a lake at the begining of the growing season above which excessive algae blooms may be expected to occur is 0.2 - 0.3 mg/l when phosphorus concentrations are from 0.01 to 0.02 mg/l (Mackenthun 1960). Phosphorus is reported to be the controlling nutrient and blooms could be expected if the level exceeded 0.01 mg/l (Symons 1969). The pre-project concentrations of nitrogen and phosphorus measured at Vee Canyon, upstream from the proposed reservoir locations, have exceeded the critical concentration levels cited above. These critical concentration levels were developed from work done in temperate regions, and may not be applicable in the subarctic. In a study of the nutrient chemistry of a large, deep subarctic lake, nitrogen and phosphorus concentration were similar to those measured at Vee Canyon (LaPerrerie, Tilsworth, and Casper 1978). The lake studied was not eutrophic, and the peak algal biomass and productivity occurred under the spring ice rather than in the summer. It was also predicted that a large number of cottages could be added around the lake without euthrophic conditions developing. Based on this work, it is likely that Watana and Devil Canyon reservoirs will be mesotrophic to oligotrophic, providing sufficient nutrients for fish life, but not so much as to become eutrophic.

Nitrogen supersaturation of water below a dam is possible at certain seasons, extending an unknown distance downstream (Turkheim 1975). This is certainly a possibility below both dams. However, the ultimate impact of nitrogen supersaturation is its effect on fish. Nitrogen supersaturation problems will be solved structurally through the use of fixed-cone valves, to dispense discharged flows, thereby eliminating plunging spills up to the 1:50-year flood. Portage Creek is essentially the upstream limit for spawning salmon. Consequently, water supersaturated with nitrogen leaving the dams must travel through Devil Canyon before reaching an important fisheries area. It is reasonable to expect that post-project nitrogen supersaturation levels will be the same as the pre-project levels at the downstream end of Devil Canyon.

(vi) Summary

Impoundment of the Susitna River will change its water quality. The following parameters will exhibit reductions in values in the reservoir and downstream reaches as compared to the pre-project levels: suspended solids, turbidity, color, nutrients, iron, manganese, and some trace elements. Both reservoirs will be heat exporters and the downstream reaches of the river will exhibit a reduced magnitude of seasonal temperature variation. Dissolved oxygen concentrations will remain high, at or near saturation, in the upper levels of both reservoirs and downstream in the river. Dissolved oxygen concentrations will likely be reduced in the hypolimnion if a stable stratification develops. The potential for eutrophication to develop in either reservoir is low.

Although water quality changes will be effected by the project, none of these changes will be significantly adverse, and many changes may be beneficial. A possible exception to this is the downstream temperature change.

TABLE 2.1: SUSITNA TOWNSHIP GRID

TYPE	SURFACE WATER APPROPRIATIONS cfs	gpd	ac-ft/yr	DAYS OF USE	GROUND WATER APPROPRIATIONS cfs	gpd	ac-ft/yr	DAYS OF USE
Certificates								
Single-family dwelling		4,500		365		5,440		365
		75		214				
2 to 4 unit housing						1,200		365
Grade Schools						910		334
Fire protection						500		365
Animals		63.5		365		94		365
Lawn and garden irrigation		200		184				
		100		153			.5	60
General Crops			12.5	153			5.5	91
Total		4,938.5	12.5			8,144	6.0	
Permits								
Single-family dwelling		250		365				
Vegetables			1	153				
Total		250	1					
Pending								
Single-family dwelling		75		365		1,000		365
						250		214
Lawn and garden irrigation		50		183				
Placer gold	.1			184				
Total	.1	125				1,250		
TOTAL	.1	5,313.5	13.5			9,394	6.0	

TABLE 2.2: SUMMARY OF WATER APPROPRIATION*

TOWNSHIP GRID	SURFACE WATER EQUIVALENT		GROUND WATER EQUIVALENT	
	cfs	ac-ft/yr	cfs	ac-ft/yr
Susitna	.153	50.0	.0498	16.3
Fish Creek	.000116	.021	.003	2.24
Willow Creek	18.3	5,660	.153	128
Little Willow Creek	.00613	1.42	.00190	1.37
Montana Creek	.0196	7.85	.366	264
Chulina	.00322	.797	.000831	.601
Susitna Reservoir	.00465	3.36		
Chulitna			.00329	2.38
Kroto-Trapper Creek	.0564	10.7		
Kahiltna	125	37,000		
Yentna	.00155	.565		
Skwentna	.00551	1.90	.000775	5.60

* Figures from Table 2.1 all converted to cfs and ac-ft/yr equivalents as follows:

1 gpd = .00000155 cfs
1 cfs = 1.98 ac-ft/day

TABLE 2.3: WATER APPROPRIATIONS WITHIN ONE MILE OF THE SUSITNA RIVER

LOCATION*	ADDITIONAL NUMBER	TYPE	SOURCE (DEPTH)	AMOUNT	DAYS OF USE
CERTIFICATE					
T19N R5W	45156	Single-family dwelling	well (?)	650 gpd	365
		general crops	same source	.5 ac-ft/yr	91
T25N R5W	43981	Single-family dwelling	well (90 ft)	500 gpd	365
T26N R5W	78895	Single-family dwelling	well (20 ft)	500 gpd	365
	200540	Grade school	well (27 ft)	910 gpd	334
	209233	Fire station	well (34 ft)	500 gpd	365
T27N R5W	200180	Single-family dwelling	unnamed stream	200 gpd	365
		Lawn & garden irrigation	same source	100 gpd	153
	200515	Single-family dwelling	unnamed lake	500 gpd	365
	206633	Single-family dwelling	unnamed lake	75 gpd	365
	206930	Single-family dwelling	unnamed lake	250 gpd	365
	206931	Single-family dwelling	unnamed lake	250 gpd	365
PERMIT					
	206929	General crops	unnamed creek	1 ac-ft/yr	153
T30N R3W	206735	Single-family dwelling	unnamed stream	250 gpd	365
PENDING					
	209866	Single-family dwelling	Sherman Creek	75 gpd	365
		Lawn & garden irrigation	same source	50 gpd	183

*All locations are within the Seward Meridian.

TABLE 2.4: BASIN AND RUNOFF CHARACTERISTICS

	Watana*	Devil Canyon*	Gold Creek**
Drainage Area, Mi^2	5,180	5,810	6,160
Average Annual Flow, cfs	7,860	8,960	9,647
Maximum Average Monthly Flow, cfs	23,100	26,200	27,900
Minimum Average Monthly Flow, cfs	890	1,030	1,100

*Data supplied by Steve Bredthauer, R&M Consultants, Inc.
**USGS 1981

TABLE 2.5: DETECTION LIMITS FOR WATER QUALITY PARAMETERS

	R&M Detection Limit(1)	U.S.G.S Detection Limit(5)
Field Parameters		
Dissolved Oxygen	0.1	-
Percent Saturation	1	-
pH, pH Units	±0.01	-
Conductivity, umhos/cm @ 25°C	1	-
Temperature, °C	0.1	-
Free Carbon Dioxide	1	-
Alkalinity, as $CaCO_3$	2	-
Settleable Solids, ml/l	0.1	-
Laboratory Parameters		
Ammonia Nitrogen	0.05	.01
Organic Nitrogen	0.1	-
Kjeldahl Nitrogen	0.1	.1
Nitrate Nitrogen	0.1	.01
Nitrite Nitrogen	0.01	.01
Total Nitrogen	0.1	.01
Ortho-Phosphate	0.01	.01
Total Phosphorus	0.01	.01
Chemical Oxygen Demand	1	-
Chloride	0.2	.01
Color	1	1
Hardness	1	-
Sulfate	1	.05
Total Dissolved Solids(2)	1	1
Total Suspended Solids(3)	1	1
Turbidity	0.05	1
Uranium	0.075	-
Gross Alpha, picocurie/liter	3	-
Total Organic Carbon	1.0	-
Total Inorganic Carbon	1.0	-
Organic Chemicals		
- Endrin	0.0002	.00001
- Lindane	0.004	.00001
- Methoxychlor	0.1	.00001
- Toxaphene	0.005	.001
- 2, 4-D	0.1	.00001
- 2, 4, 5-TP Silvex	0.01	.00001
ICAP Scan(4)		
- Ag, Silver	0.05	.001
- Al, Aluminum	0.05	.01
- As, Arsenic	0.10	.001
- Au, Gold	0.05	-
- B, Boron	0.05	.01
- Ba, Barium	0.05	.1
- Bi, Bismuth	0.05	-
- Ca, Calcium	0.05	.01
- Cd, Cadmium	0.01	.001
- Co, Cobalt	0.05	.001
- Cr, Chromium	0.05	.001

TABLE 2.5: DETECTION LIMITS FOR WATER QUALITY PARAMETERS (Cont'd)

	R&M Detection Limit(1)	U.S.G.S Detection Limit(5)
Laboratory Parameters (Cont'd)		
- Cu, Copper	0.05	.001
- Fe, Iron	0.05	.01
- Hg, Mercury	0.1	.0001
- K, Potassium	0.05	.1
- Mg, Magnesium	0.05	.1
- Mn, Manganese	0.05	.001
- Mo, Molybdenum	0.05	.001
- Na, Sodium	0.05	.1
- Ni, Nickel	0.05	.001
- Pb, Lead	0.05	.001
- Pt, Platinum	0.05	-
- Sb, Antimony	0.10	.001
- Se, Selenium	0.10	.001
- Si, Silicon	0.05	-
- Sn, Tin	0.10	.1
- Sr, Strontium	0.05	.01
- Ti, Titanium	0.05	-
- W, Tungsten	1.0	-
- V, Vanadium	0.05	-
- Zn, Zinc	0.05	.01
- Zr, Zirconium	0.05	-

(1) All values are expressed in mg/l unless otherwise noted.

(2) TDS - (filterable) material that passes through a standard glass fiber filter and remains after evaporation (SM p 93).

(3) TSS - (nonfilterable) material required on a standard glass fiber filter after filtration of a well-mixed sample.

(4) ICAP SCAN - thirty two (32) element computerized scan in parts/million (Ag, Al, As, Au, B, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Pt, Sb, Se, Si, Sn, Sr, Ti, V, W, Zn, Zr).

(5) U.S.G.S detection limits are taken from "1982 Water Quality Laboratory Services Catalog" U.S.G.S. Open-File Report 81-1016. The limits used are the limits for the most precise test available.

TABLE 2.6: PARAMETERS EXCEEDING CRITERIA BY STATION AND SEASON

PARAMETER	STATION	SEASON	CRITERIA
D.O. % Saturation	G	S	L
pH	T G	S, W, B B	L
Color	T, S	S	L
Phosphorus, Total (d)	V, G, T, S, SS	S, W, B	L
Total Organic Carbon	G, SS V, G, SS SS	S W B	S
Aluminum (d) Aluminum (t)	V, G G, S, SS	S, W S	S
Bismuth (d)	V, G G	S W	S
Cadmium (d)	T, SS SS	S, W B	L
Cadmium (t)	G, T, S SS T, SS	S W, B	
Copper (d)	T, SS T SS	S W B	A
Copper (t)	G, T, S, SS T, S, SS T, SS	S W	
Iron (d) Iron (t)	D, V, C G, T, S, SS T	S S B	L
Lead (t)	G, T, S, SS T, SS	S W, B	A
Manganese (d) Manganese (t)	D, V, G, C G, T, S T, SS	S S B	L
Mercury (d)	G, S S	S W	L
Mercury (t)	G, T, S, SS T, S, SS T, SS	S W B	
Nickel (t)	G, S, SS	S	A
Zinc (d) Zinc (t)	V G, S, SS T, S, SS SS	S S W B	A

Stations

D - Denali
V - Vee Canyon
G - Gold Creek
C - Chulitna
T - Talkeetna
S - Sunshine
SS - Susitna Station

Seasons

S - Summer
W - Winter
B - Breakup

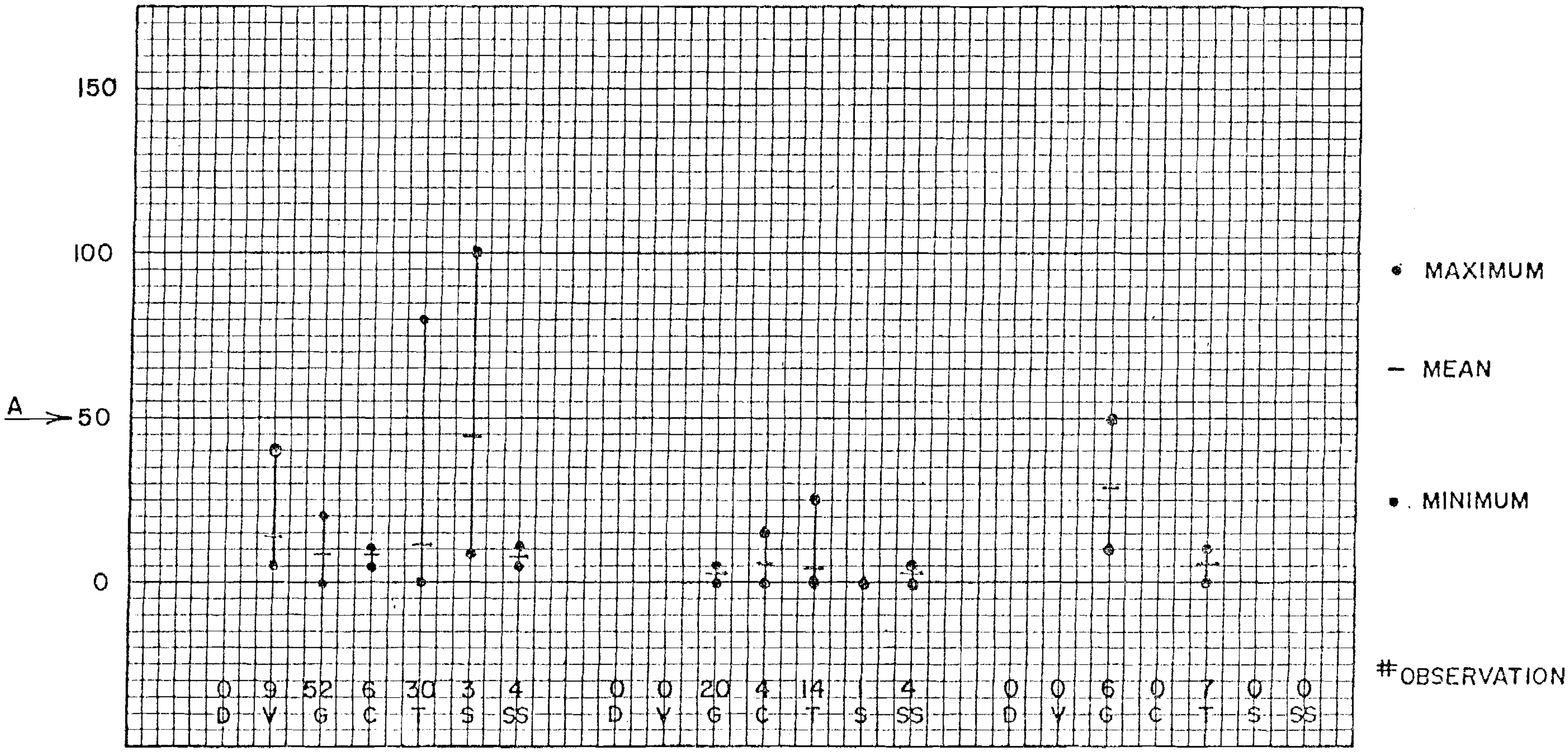
Criteria

L - Established by law as per Alaska Water Quality Standards

S - Criteria that have been suggested but are now law, or levels which natural waters usually do not exceed

A - Alternate level to 0.02 of the 96-hour LC_{50} determined through bioassay

PARAMETER: TRUE COLOR, PLATINUM COBALT UNIT



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Shall not exceed 50 units (ADEC, 1979)

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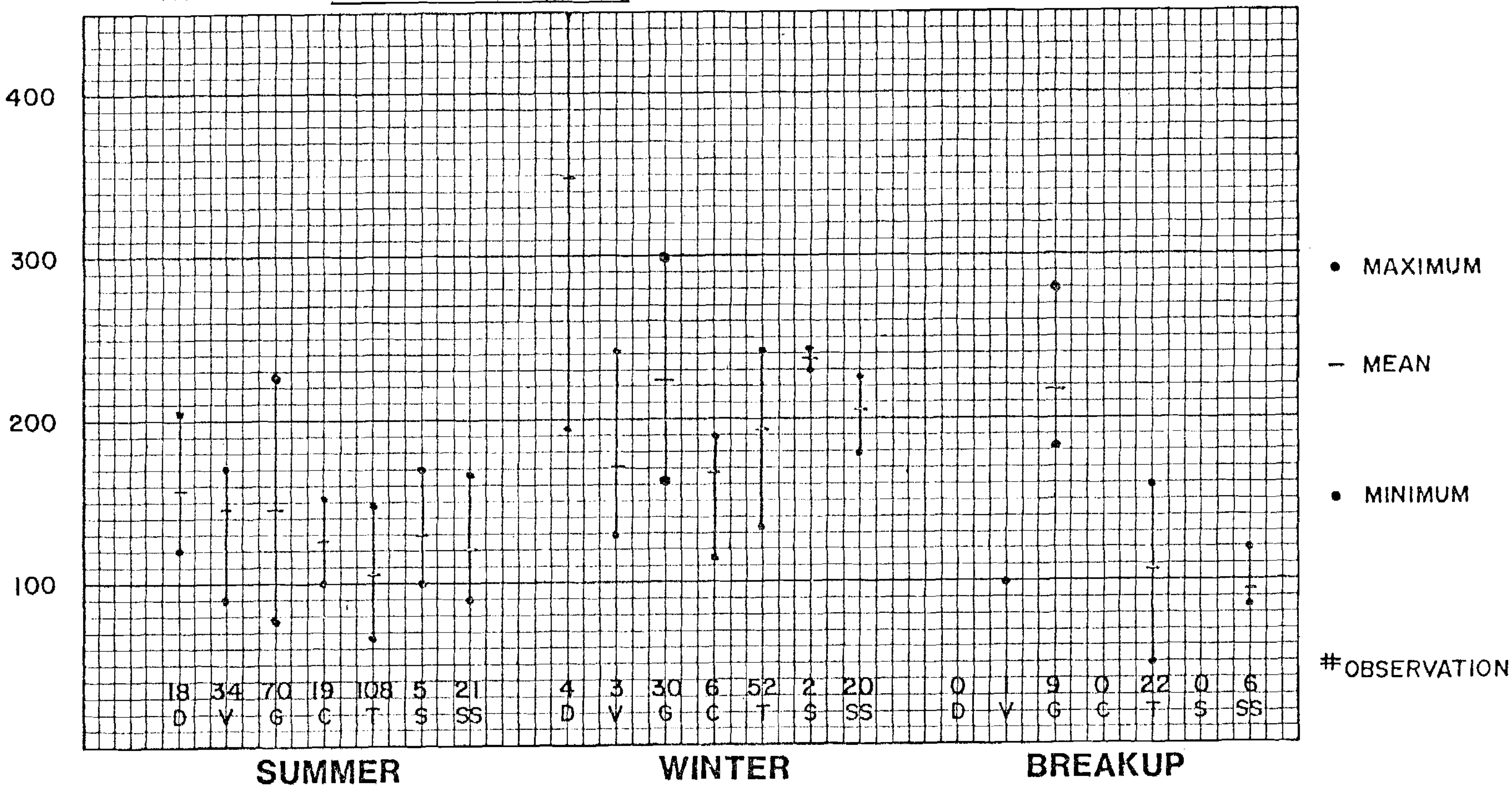
DATA SUMMARY - COLOR

FIGURE 2.1

PARAMETER: CONDUCTIVITY, μmhos/cm @ 25°C



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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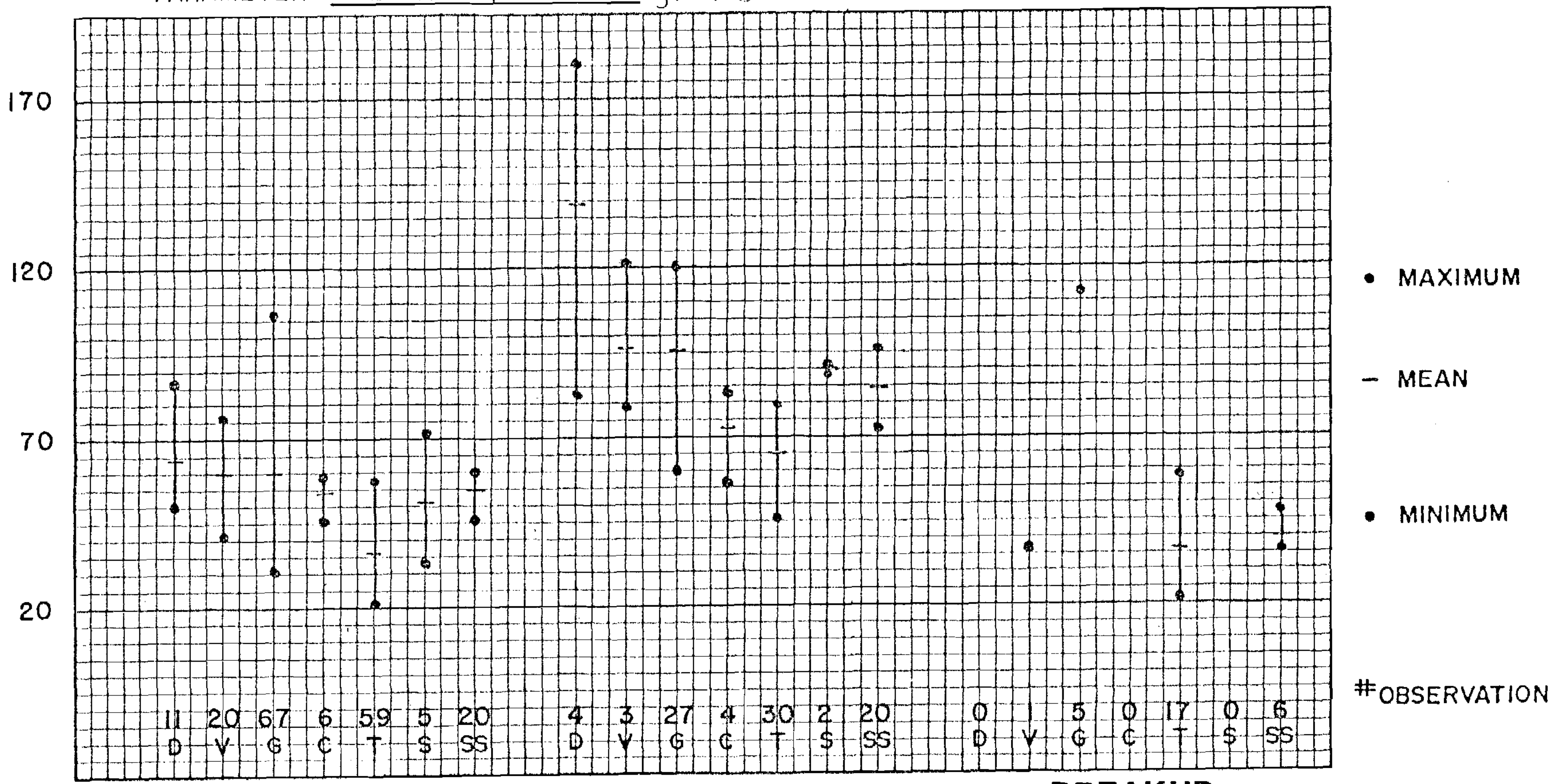
DATA SUMMARY - CONDUCTIVITY

FIGURE 2.2

PARAMETER: HARDNESS, as Ca CO_3, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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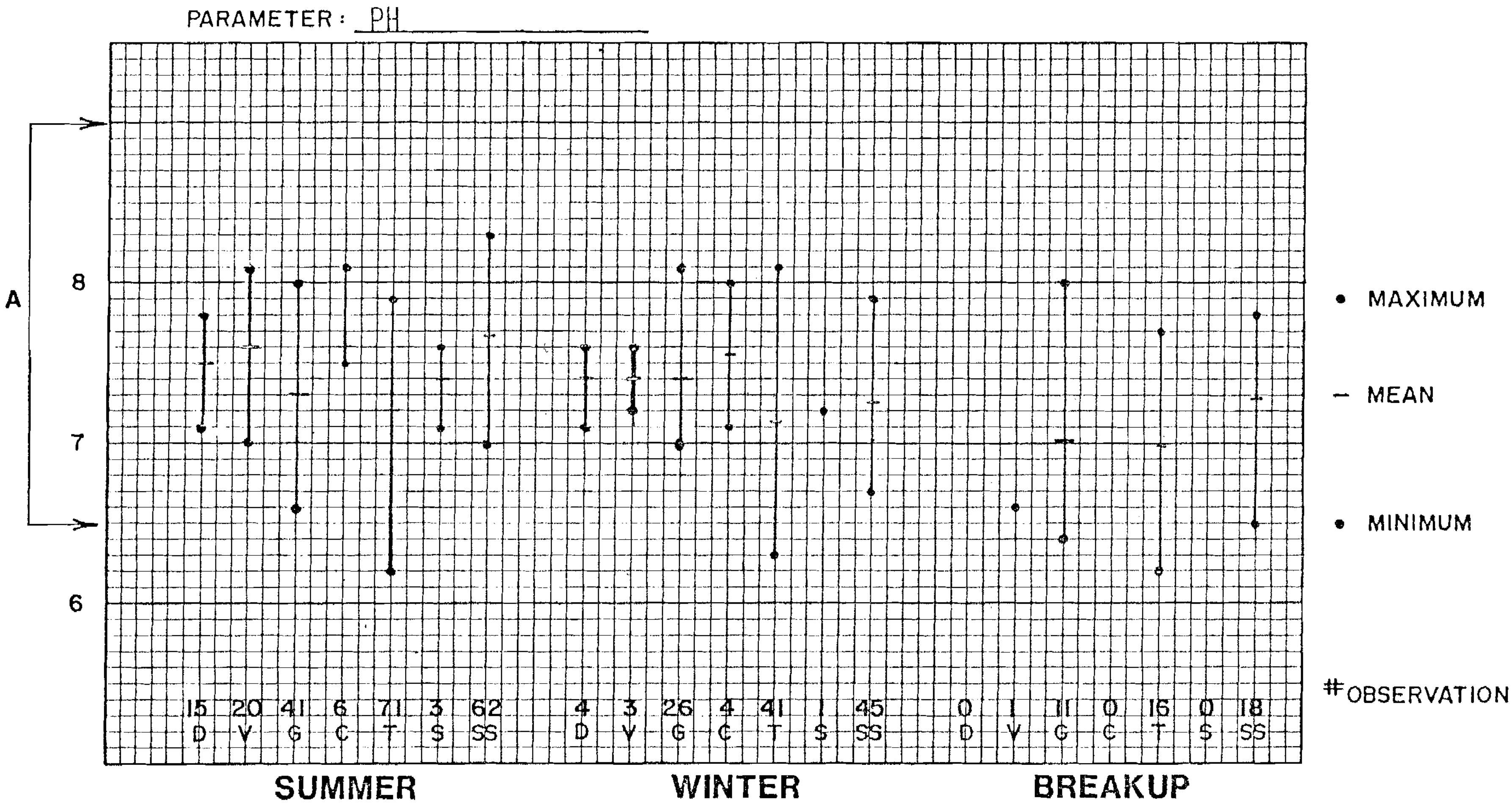
DATA SUMMARY - HARDNESS

FIGURE 2.3



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Not less than 6.5 or greater than 9.0. Shall not vary more than 0.5 pH unit from natural condition (ADEC, 1979).

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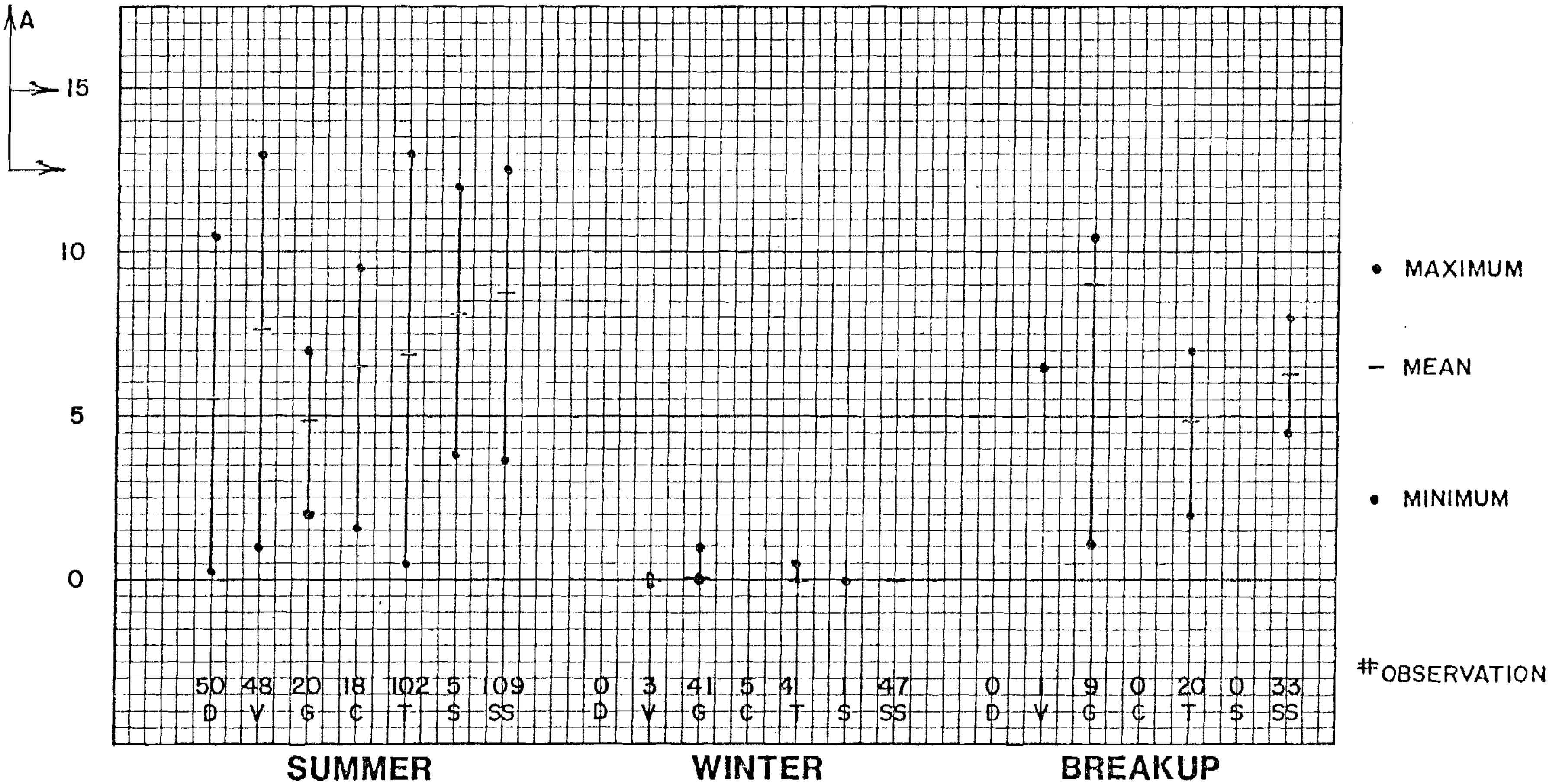
DATA SUMMARY - PH

FIGURE 2.4

PARAMETER: TEMPERATURE, °C



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Shall not exceed 20°C at any time. The following maximum temperature shall not be exceeded where applicable: migration routes and rearing areas--15°C, spawning areas and egg and fry incubation--13°C (ADEC, 1979)

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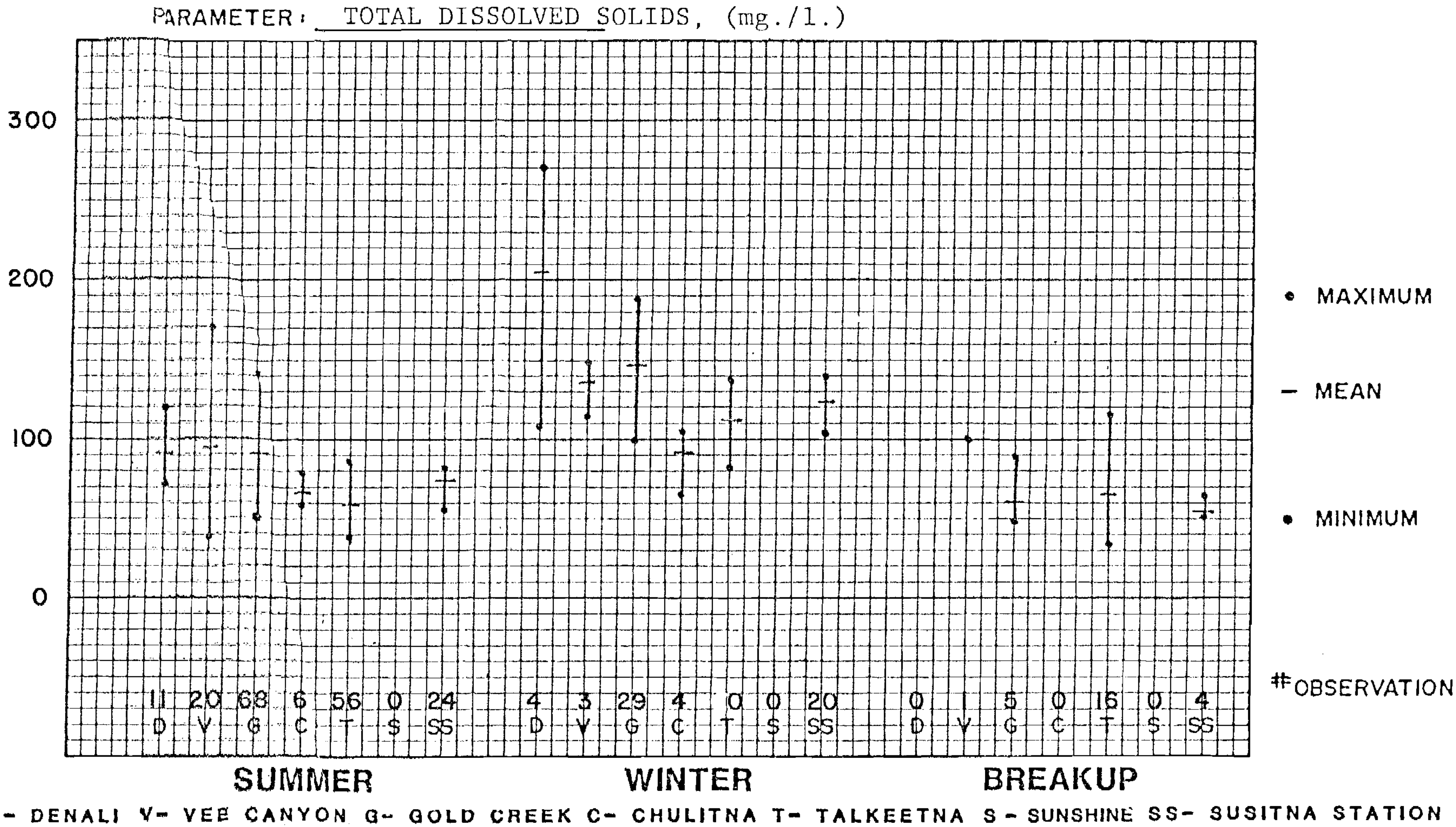
DATA SUMMARY -TEMPERATURE

FIGURE 2.5



A. 1,500 mg/1 (ADEC, 1979)

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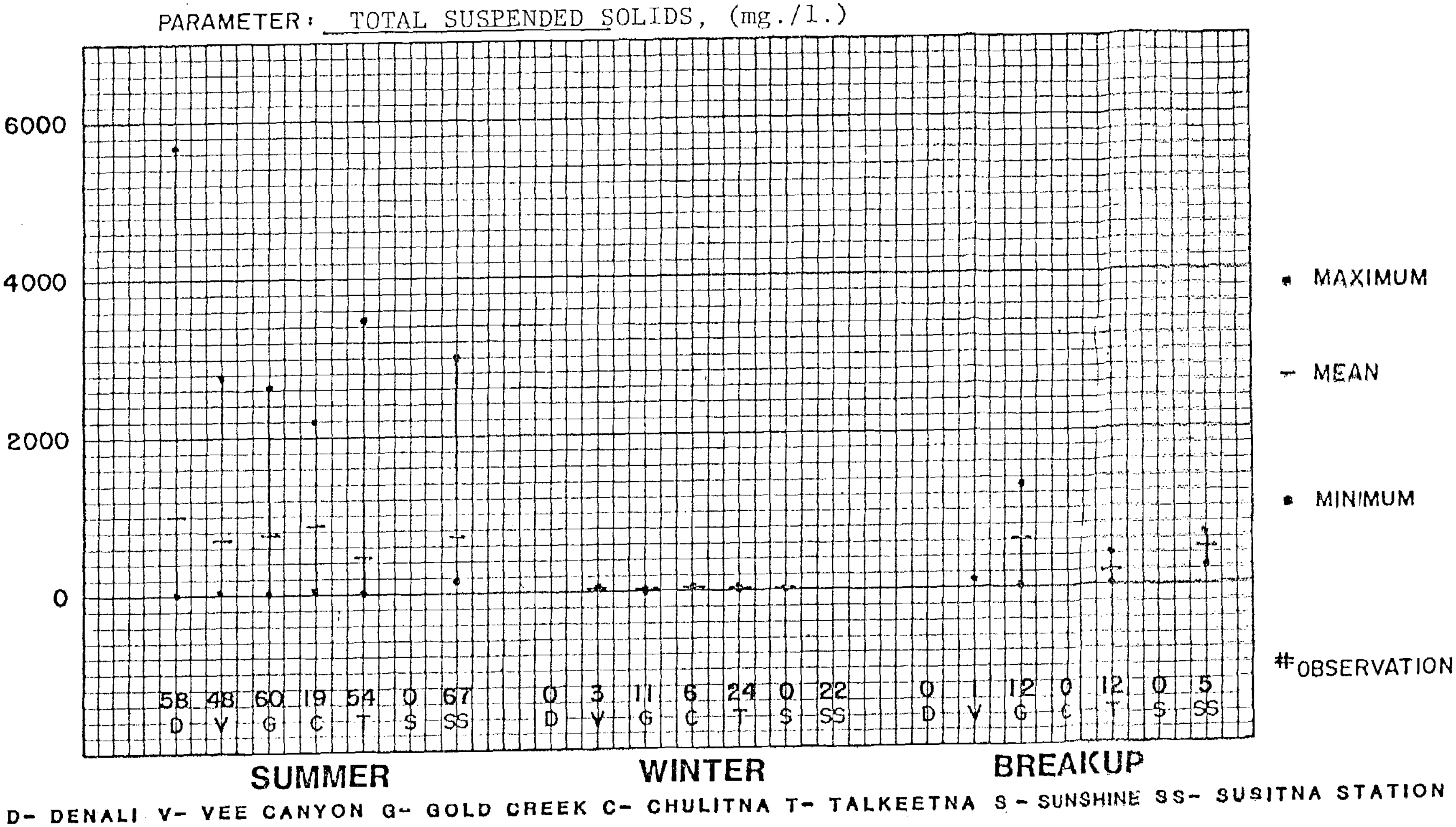
DATA SUMMARY - TOTAL DISSOLVED SOLIDS

FIGURE 2.6



No measurable increase above natural conditions (ADEC,1979).

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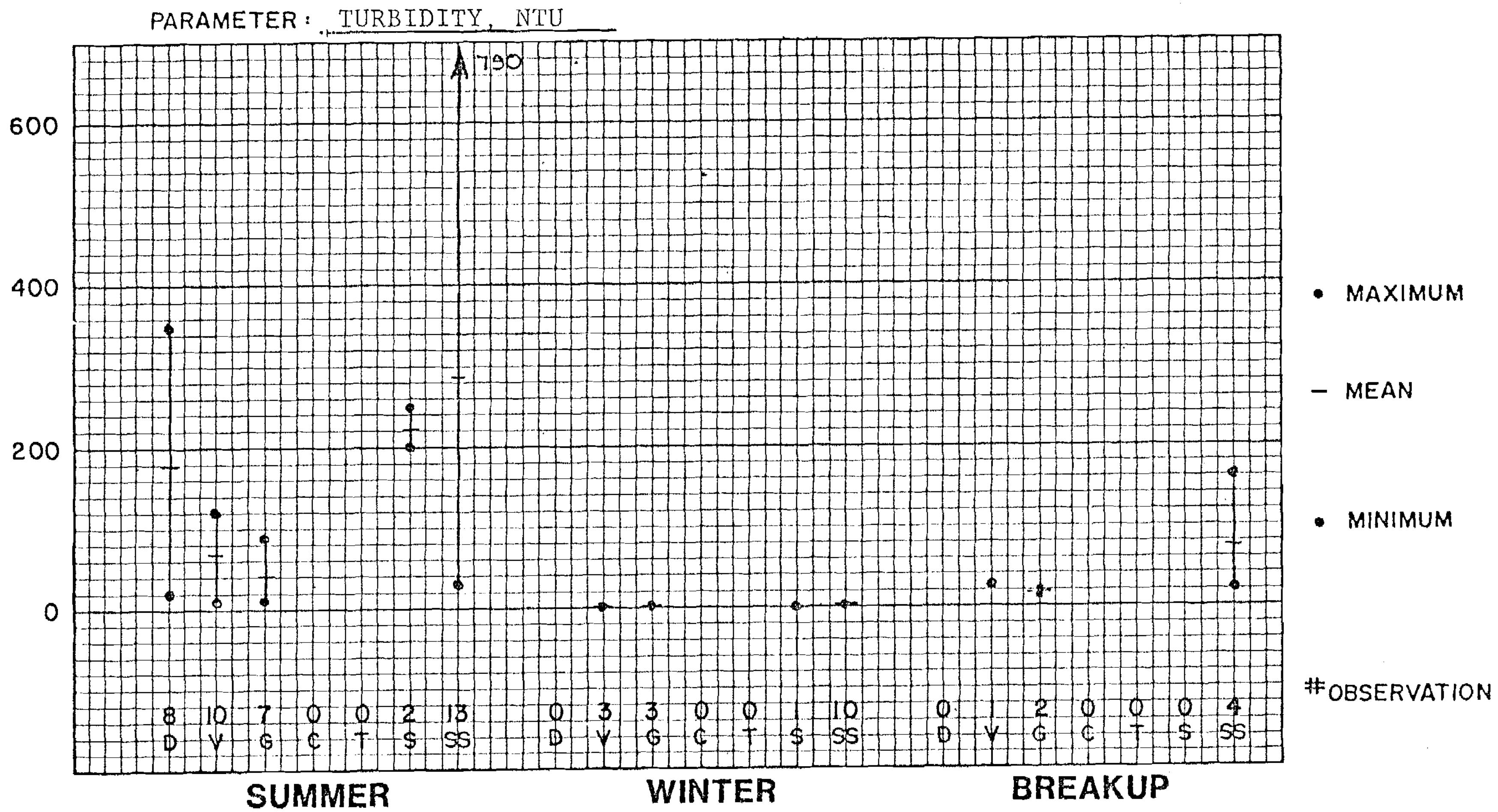
DATA SUMMARY - TOTAL SUSPENDED SOLIDS

FIGURE 2.7



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Shall not exceed 25 NTU above natural conditions (ADEC, 1979)

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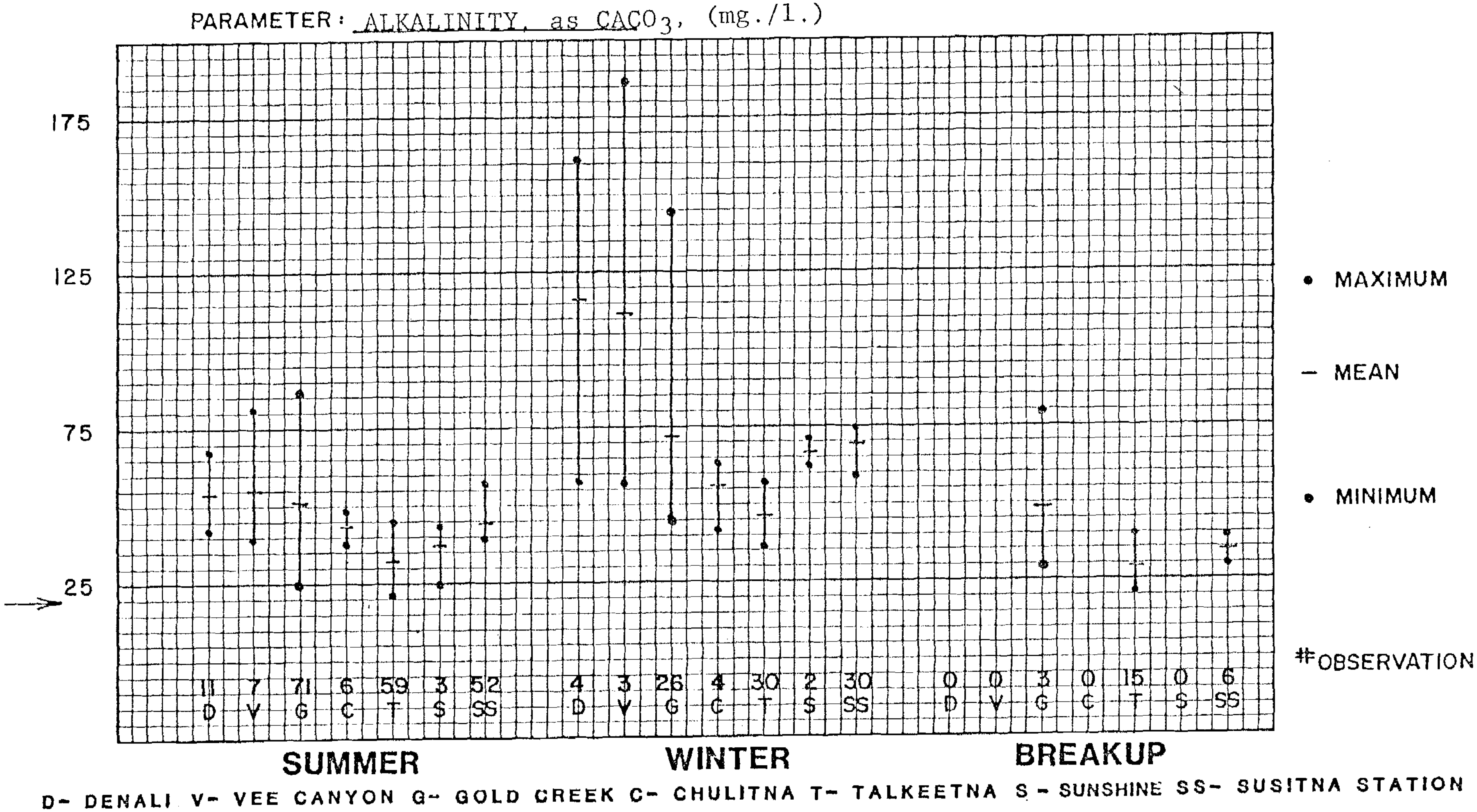
DATA SUMMARY - TURBIDITY

FIGURE 2.8



20mg/1 or more except where natural conditions are less. (EPA, 1976).

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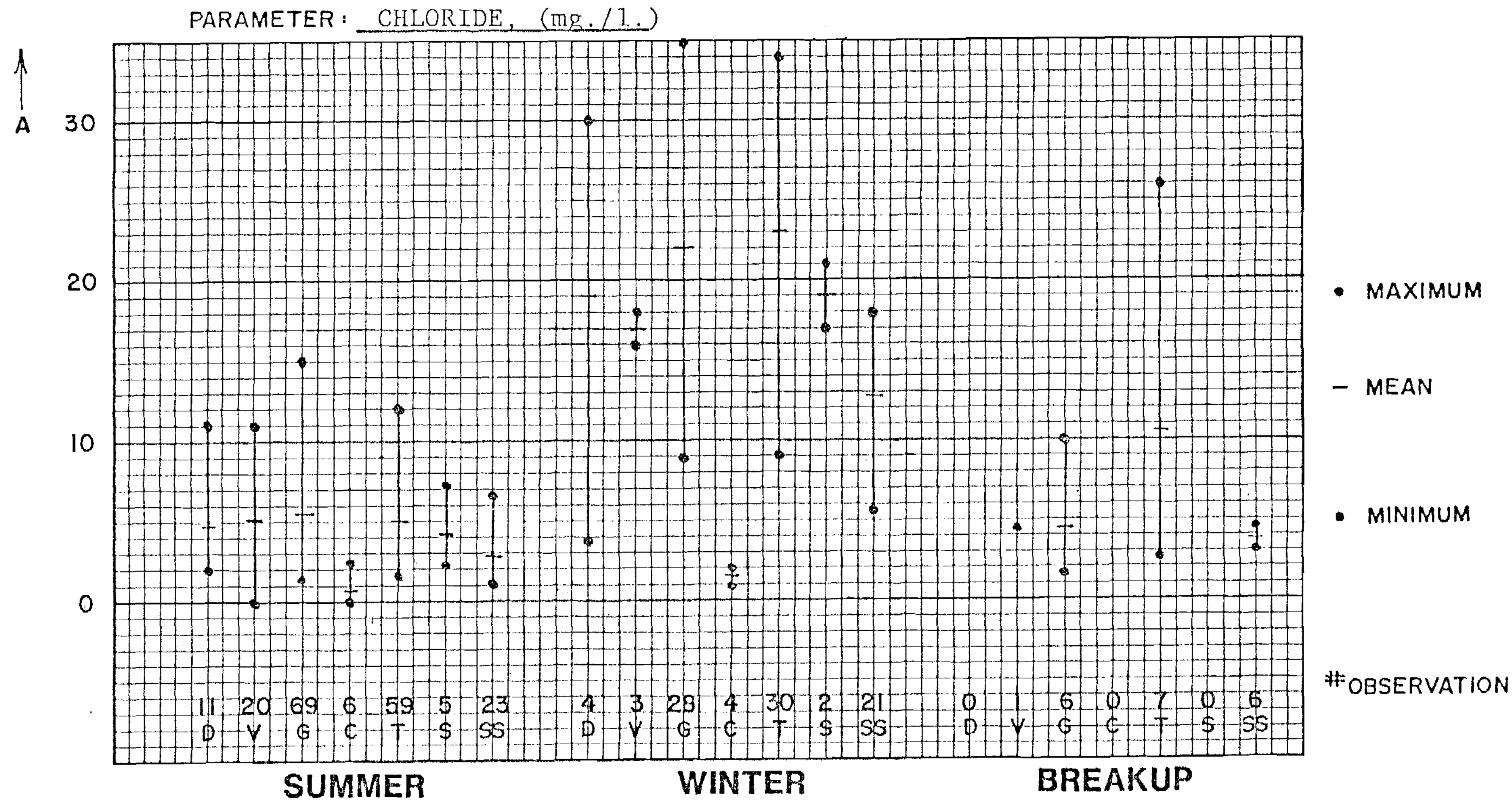
DATA SUMMARY - ALKALINITY

FIGURE 2.9



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Less than 200 mg/l$_x$ (ADEC, 1979)

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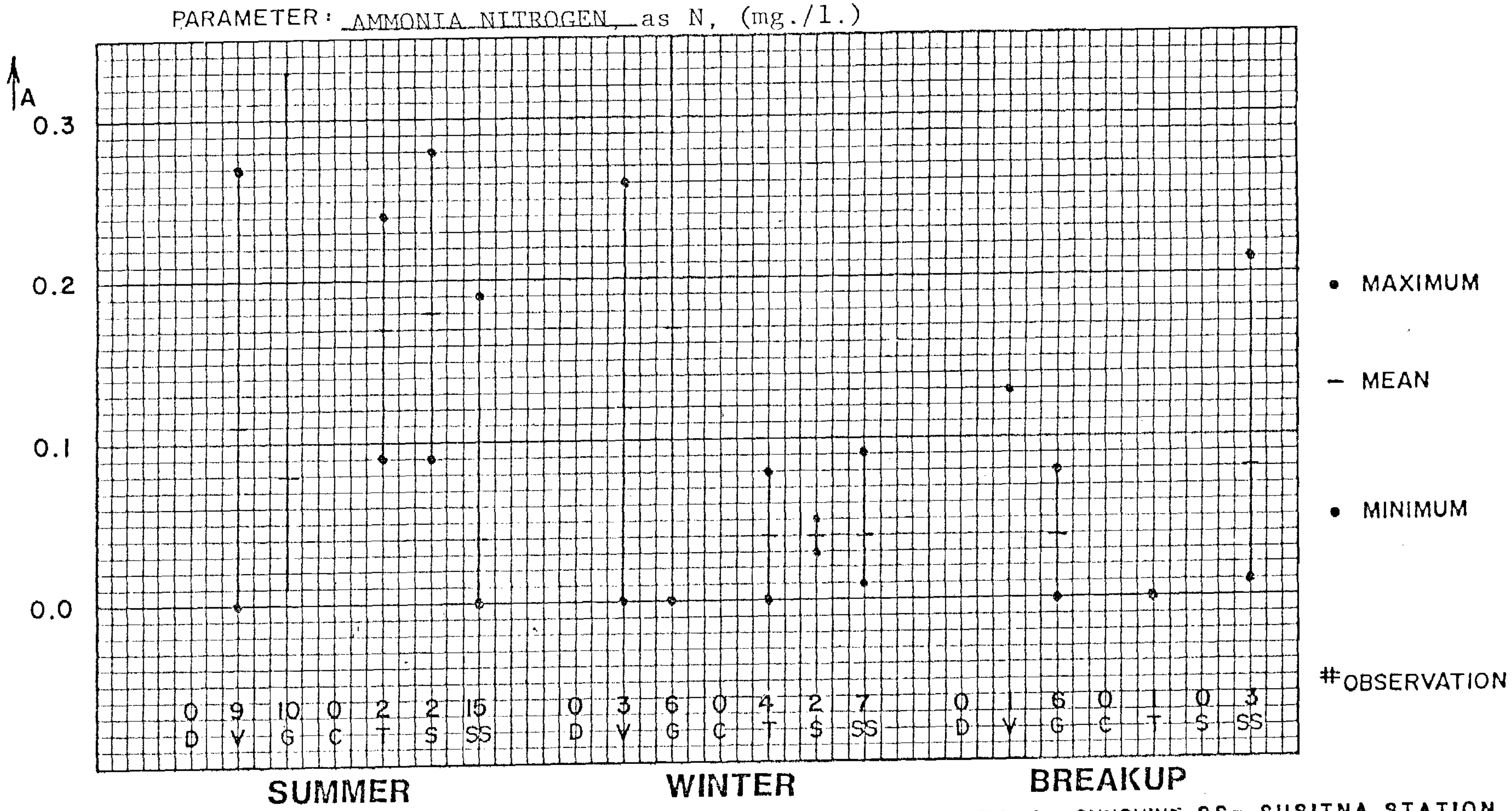
DATA SUMMARY - CHLORIDE

FIGURE 2.10



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.02mg/l as un-ionized ammonia (EPA, 1976). Data appearing above are total dissolved ammonia. The concentration of un-ionized ammonia is pH and temperature dependant. The maximum ammonia nitrogen concentration appearing in this figure is less than the stated criterion.

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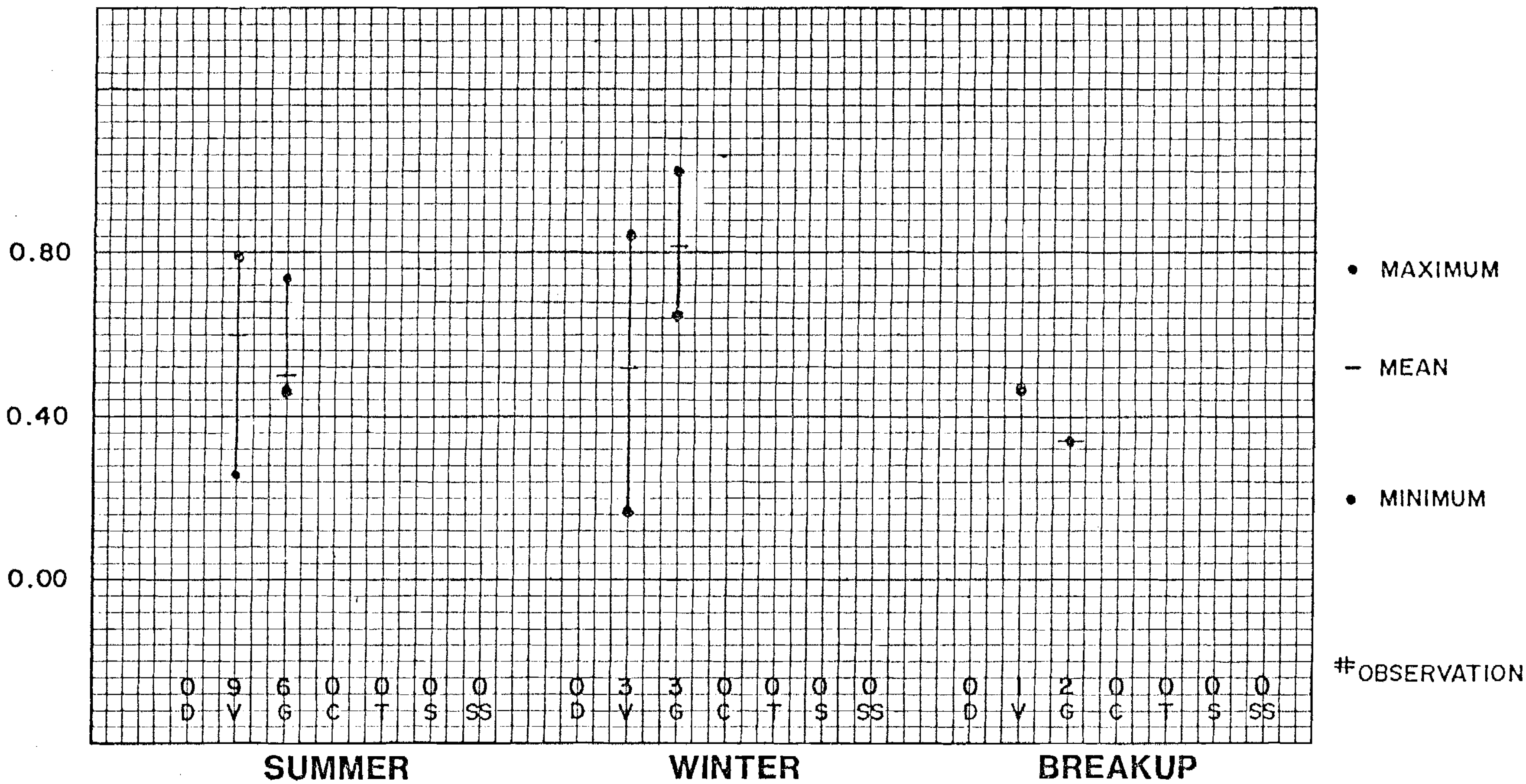
DATA SUMMARY - AMMONIA NITROGEN

FIGURE 2.11

PARAMETER: KJELDAHL NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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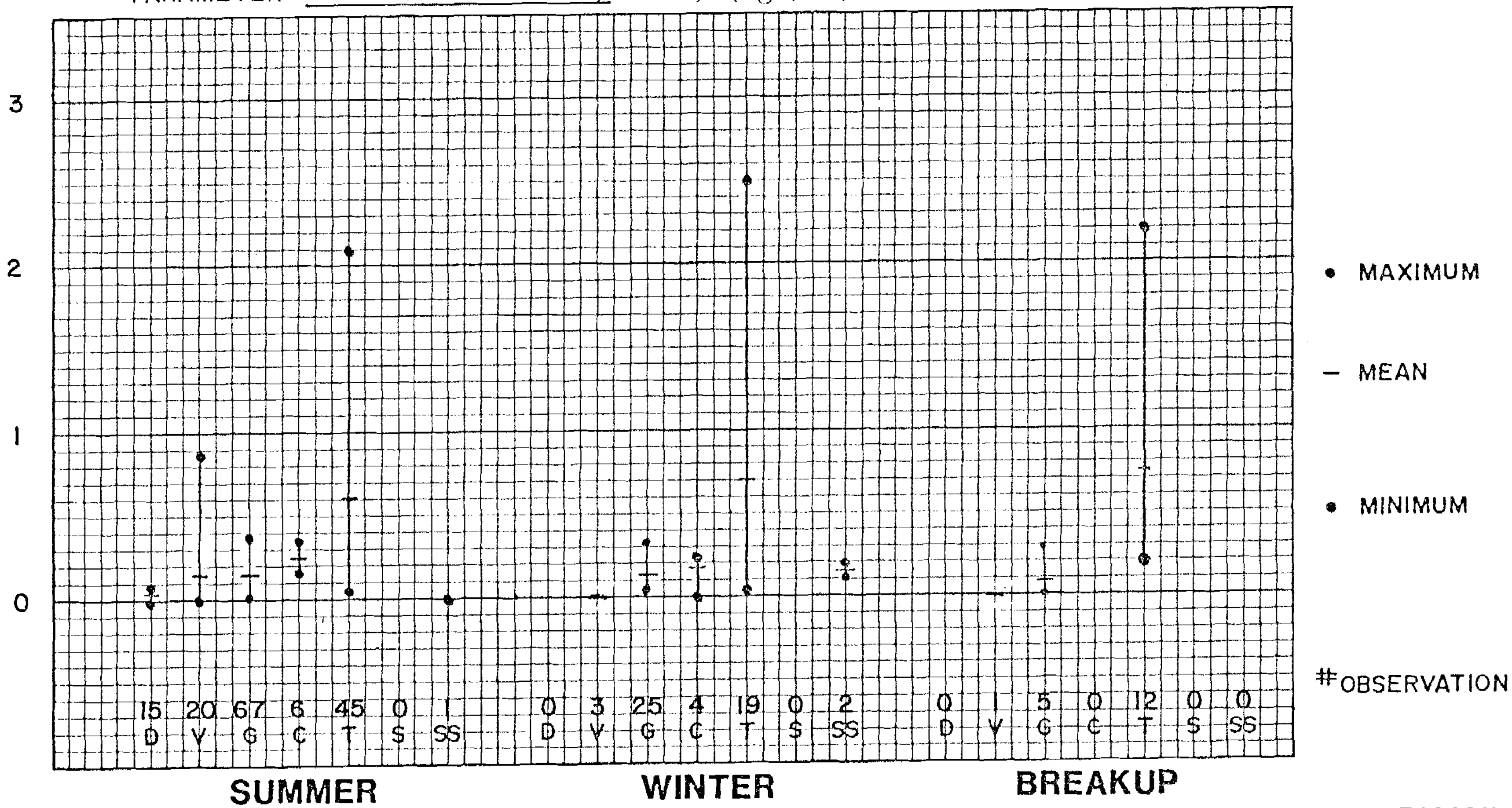
DATA SUMMARY - KJELDAHL NITROGEN

FIGURE 2.12

PARAMETER: NITRATE NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

Less than 10 mg/l (water supply). (EPA, 1976).

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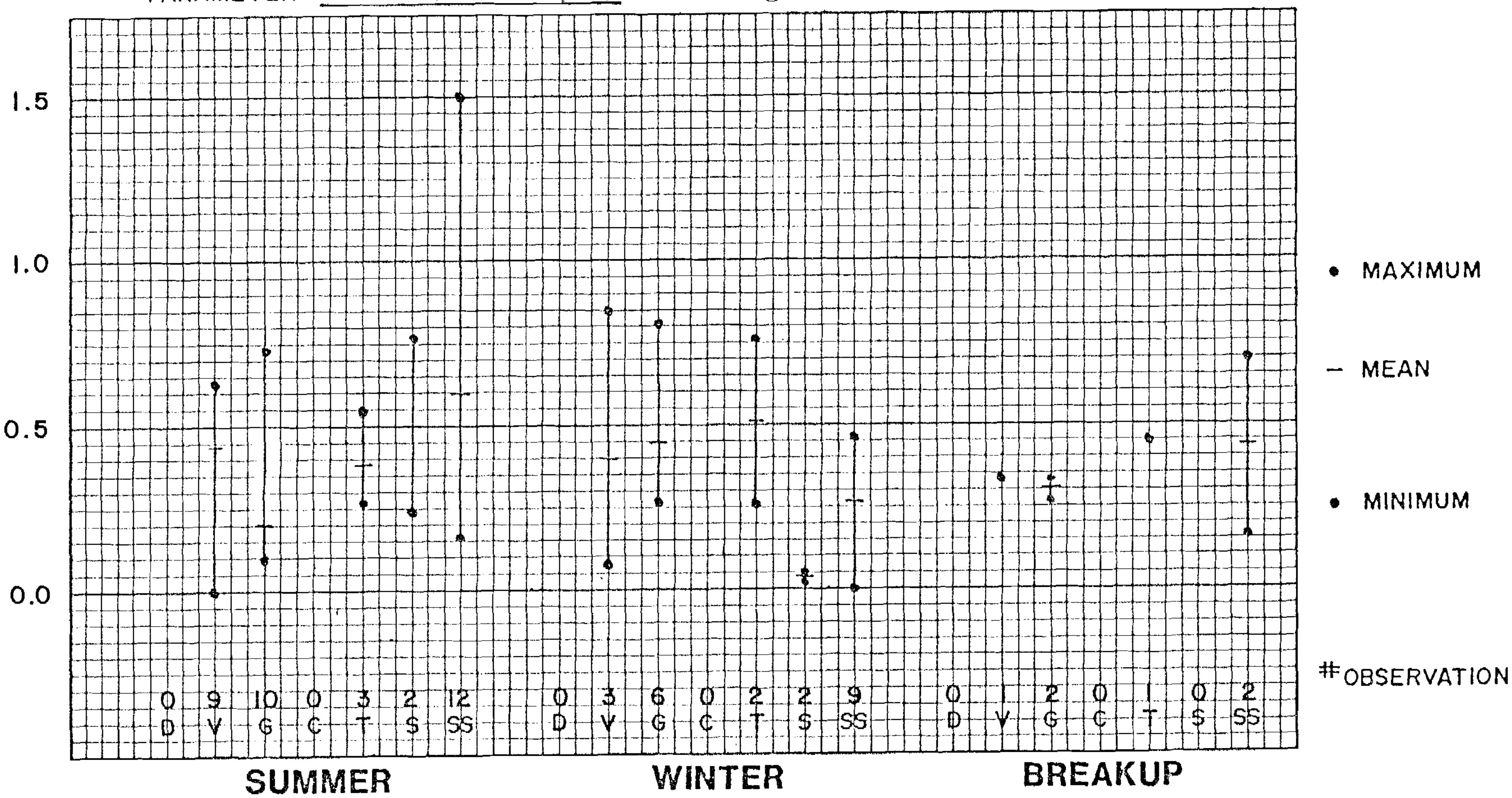
DATA SUMMARY - NITRATE NITROGEN

FIGURE 2.13

PARAMETER: ORGANIC NITROGEN, as N, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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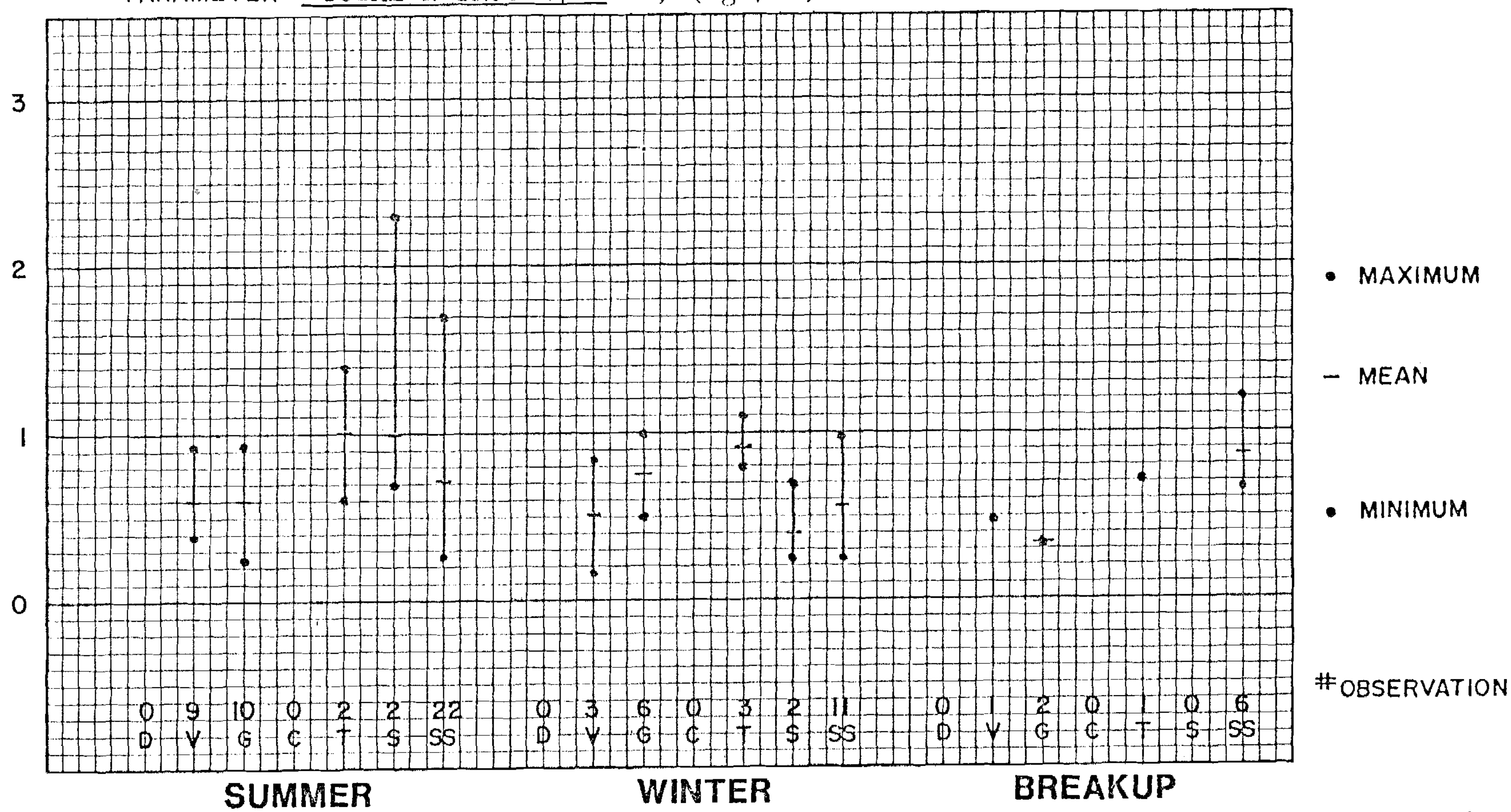
DATA SUMMARY - ORGANIC NITROGEN

FIGURE 2.14

PARAMETER: TOTAL NITROGEN, as N, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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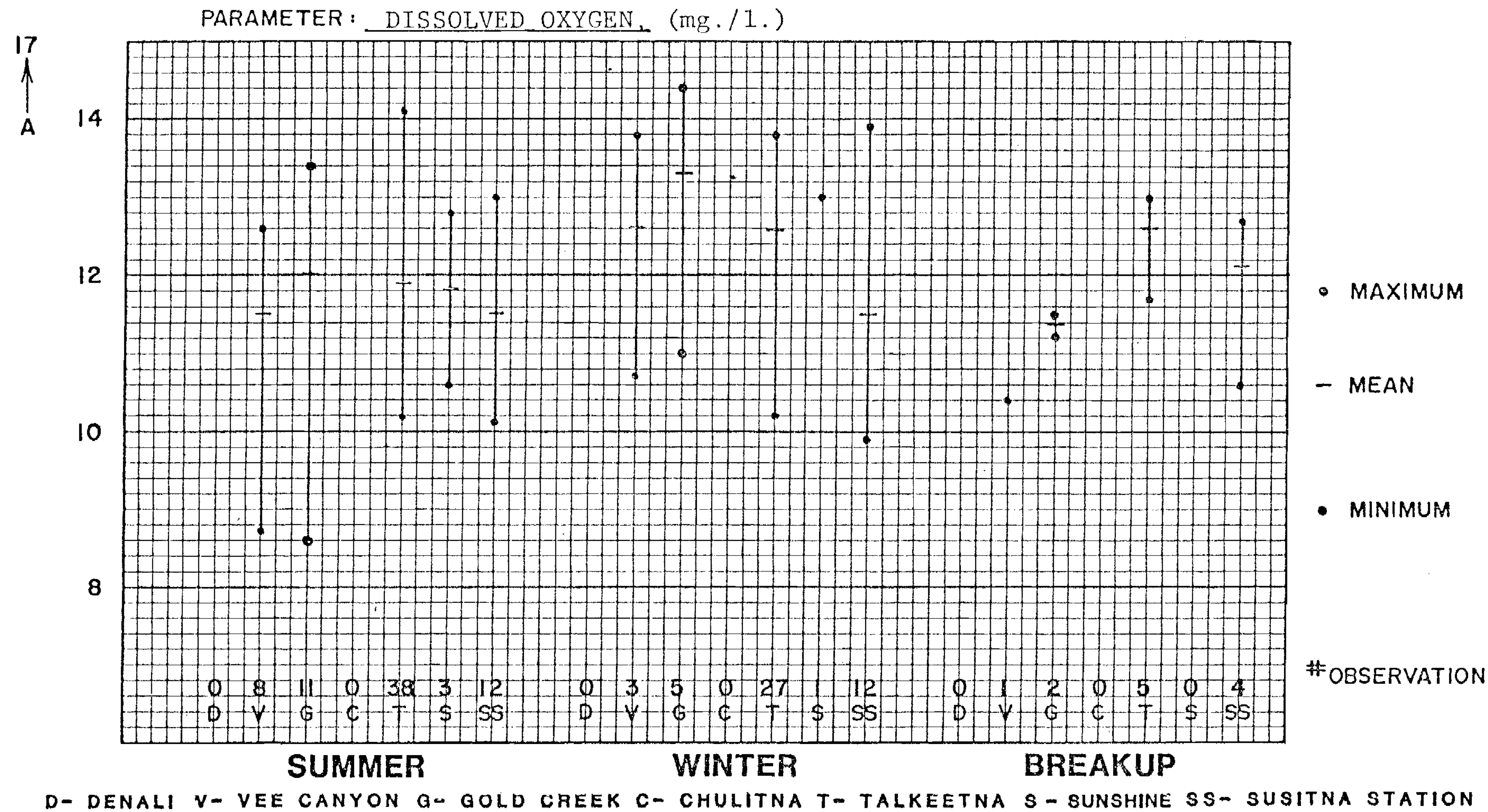
DATA SUMMARY - TOTAL NITROGEN

FIGURE 2.15



A. Greater than 7mg/1, but in no case shall D.O. exceed 17mg/1 (ADEC, 1979).

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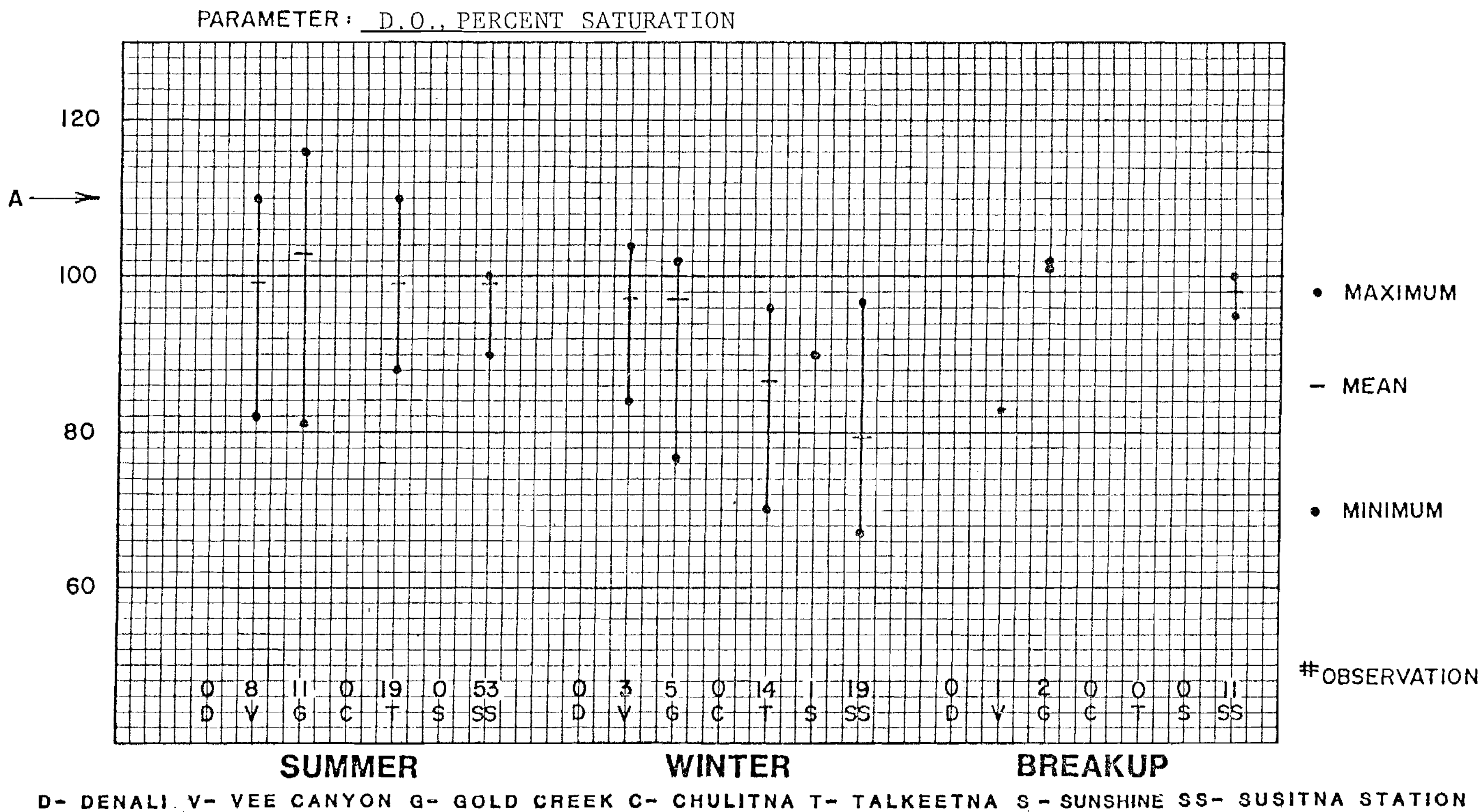
DATA SUMMARY - OXYGEN, DISSOLVED

FIGURE 2.16



A. The concentration of total disolved gas shall not exceed 110% saturation at any point. (ADEC, 1979).

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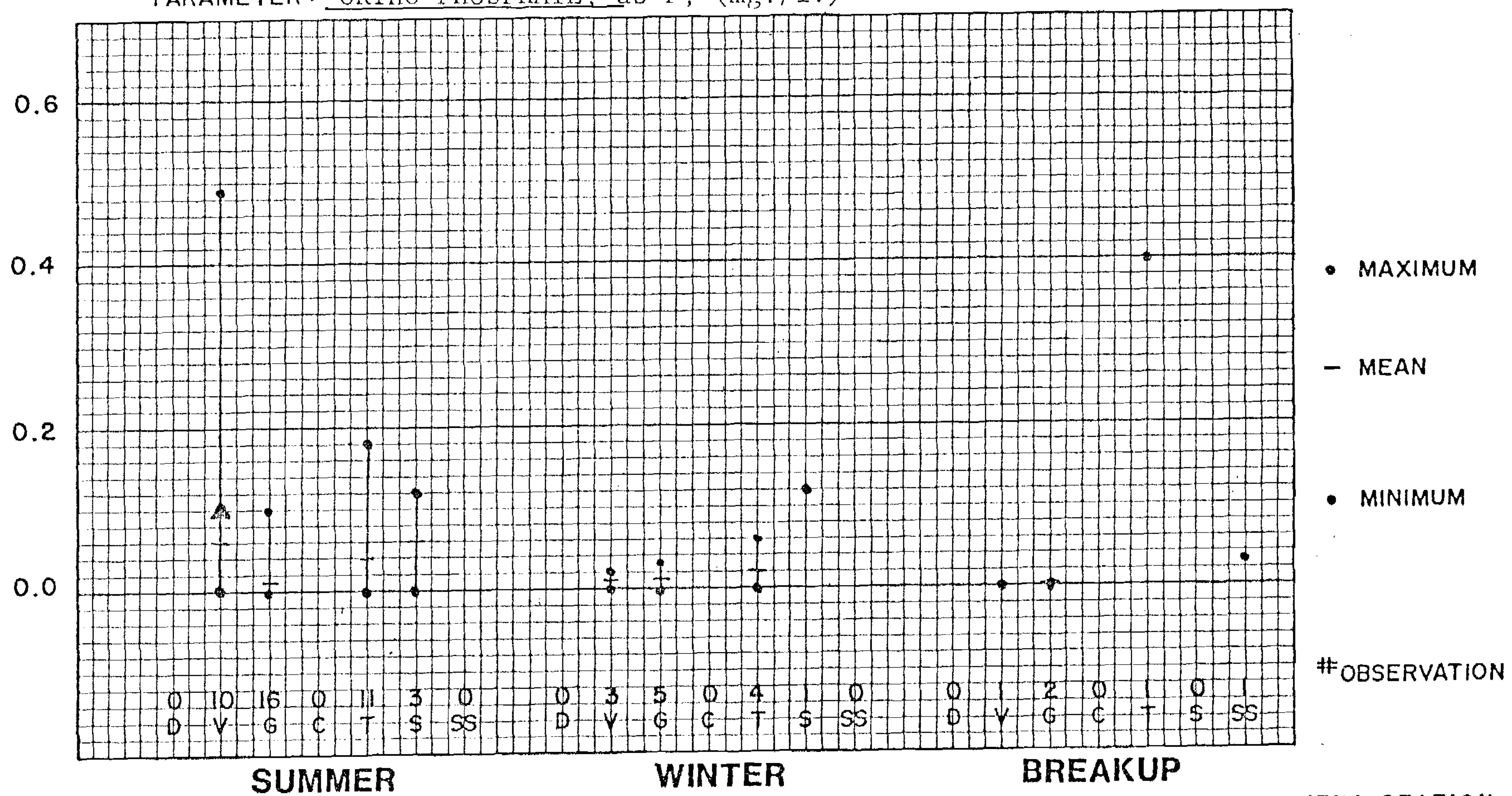
DATA SUMMARY - D.O., % SATURATION

FIGURE 2.17

PARAMETER: ORTHO PHOSPHATE, as P, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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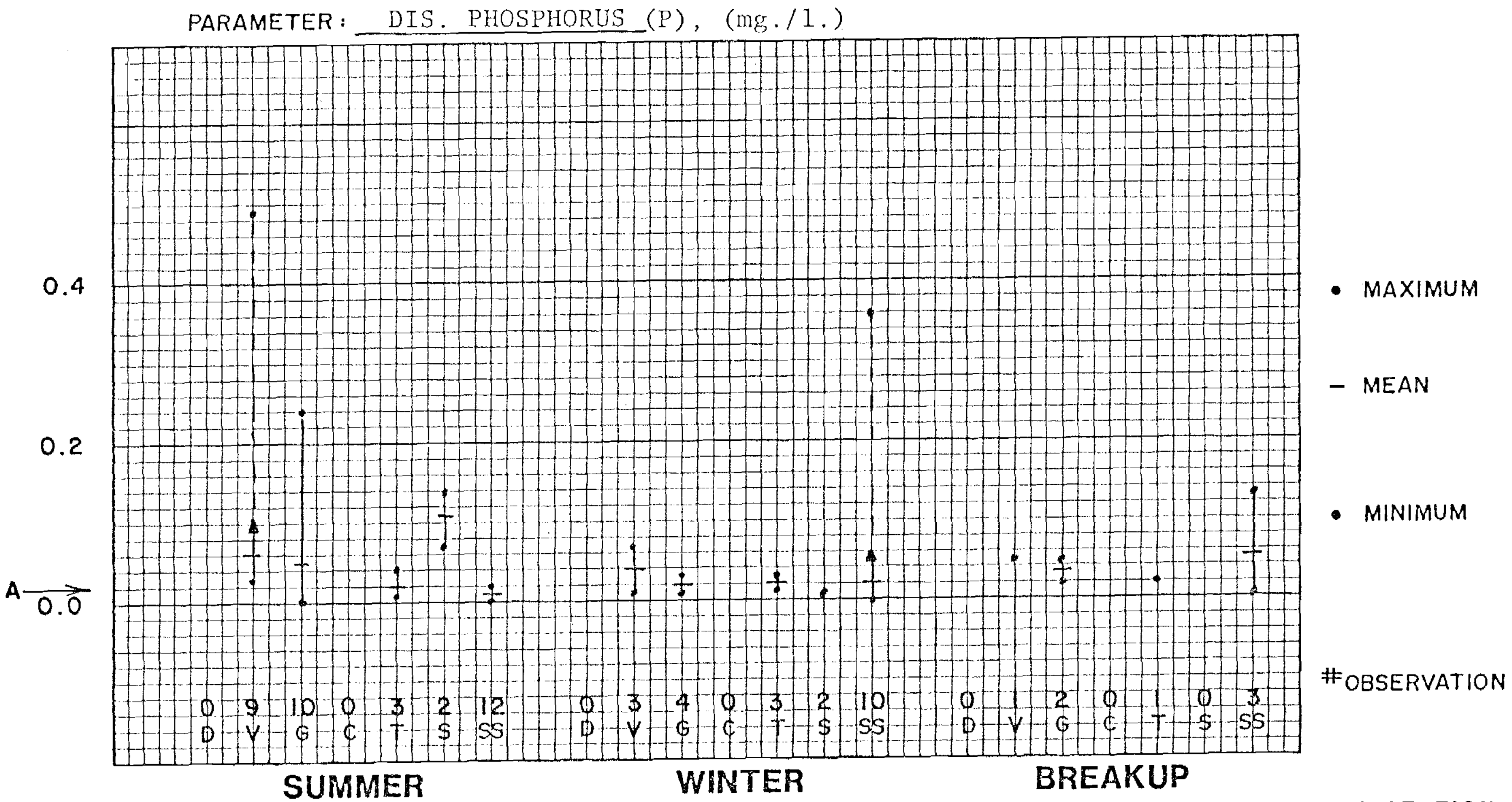
DATA SUMMARY - ORTHO PHOSPHATE

FIGURE 2.18



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.01 mg/l for elemental phosphorus (EPA, 1976)

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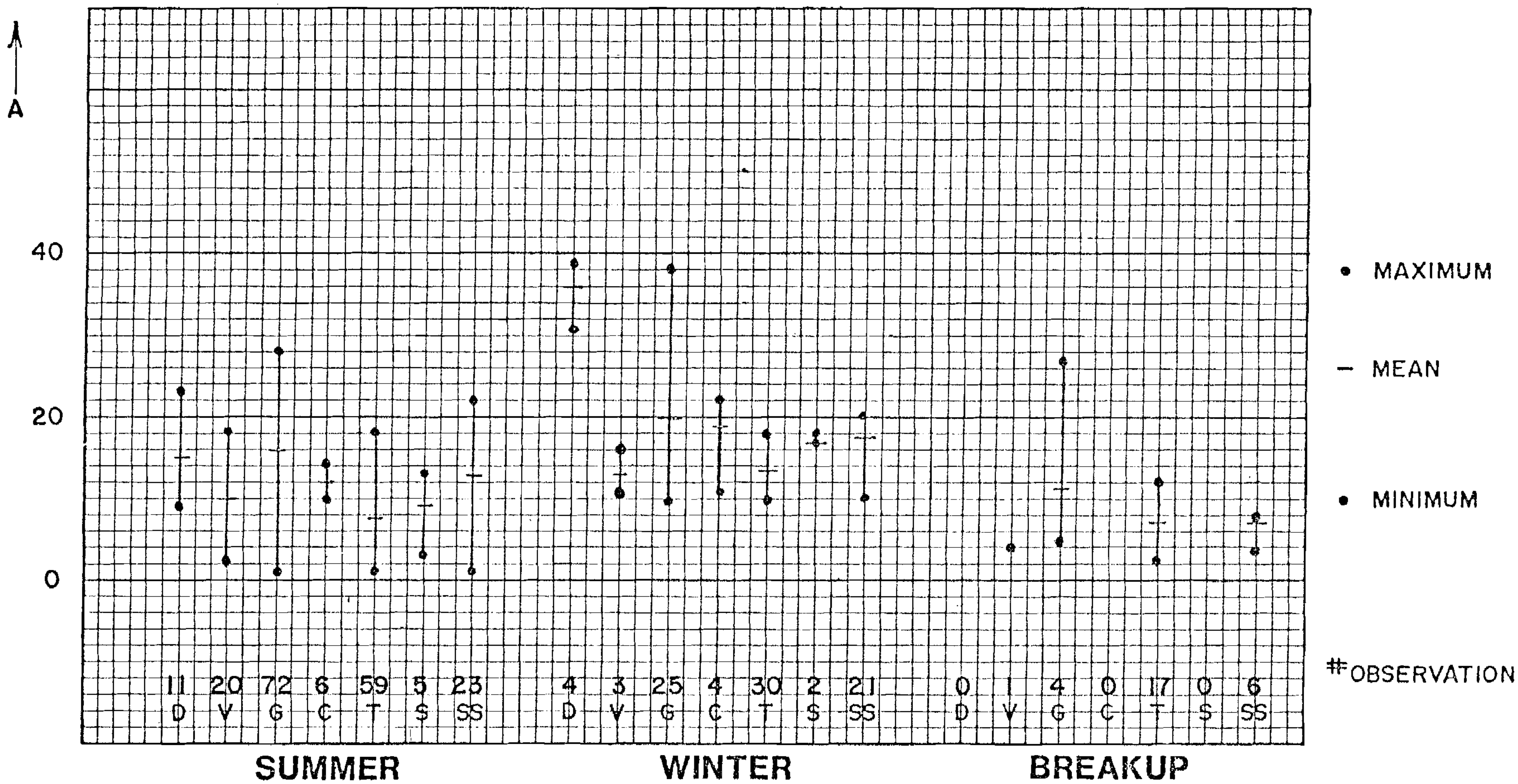
DATA SUMMARY - PHOSPHORUS

FIGURE 2.19

PARAMETER: SULFATE, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

A. Shall not exceed 200 mg/1. (ADEC, 1979).

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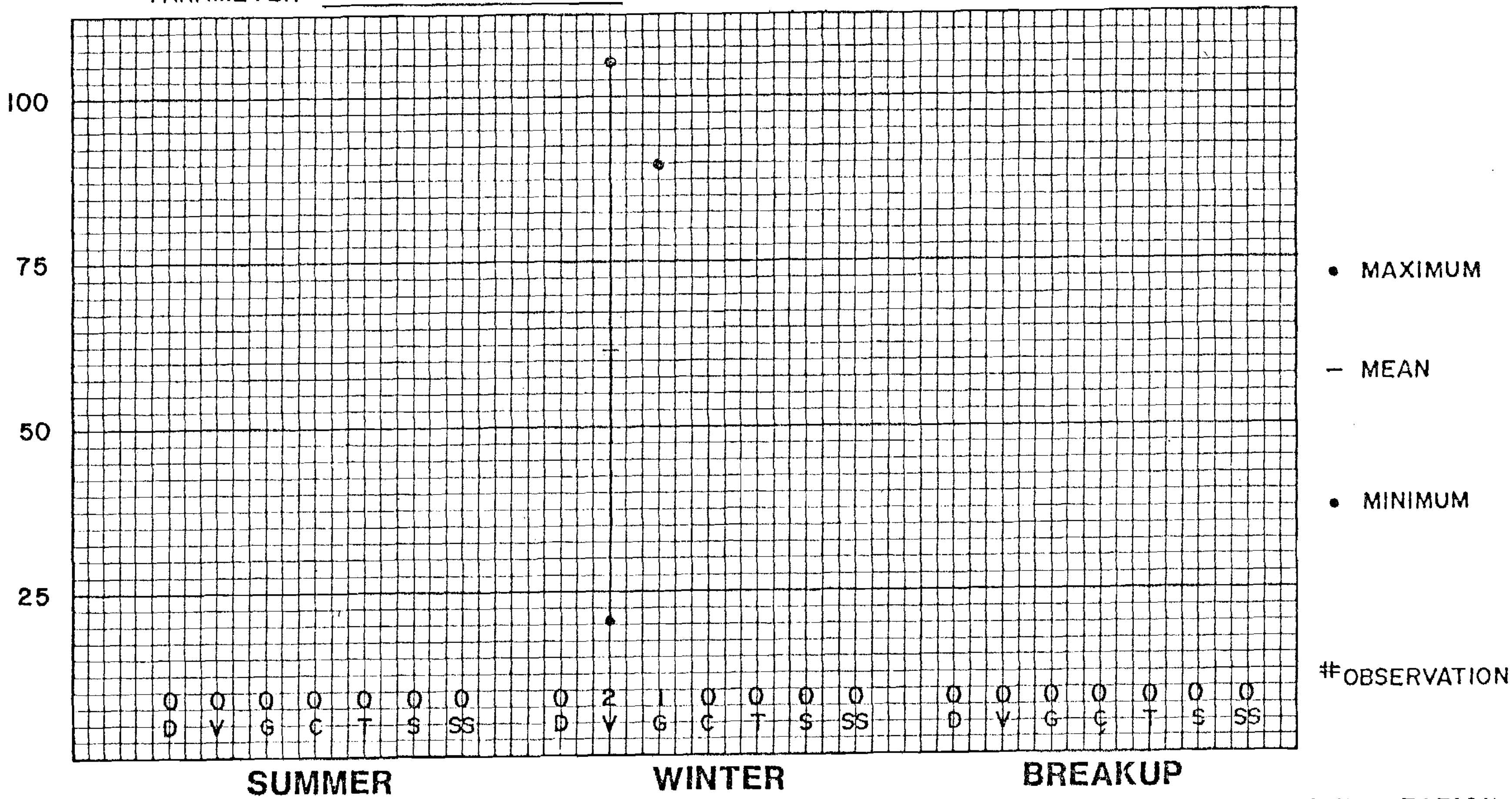
DATA SUMMARY - SULFATE

FIGURE 2.20

PARAMETER: TOTAL INORGANIC CARBON, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established.

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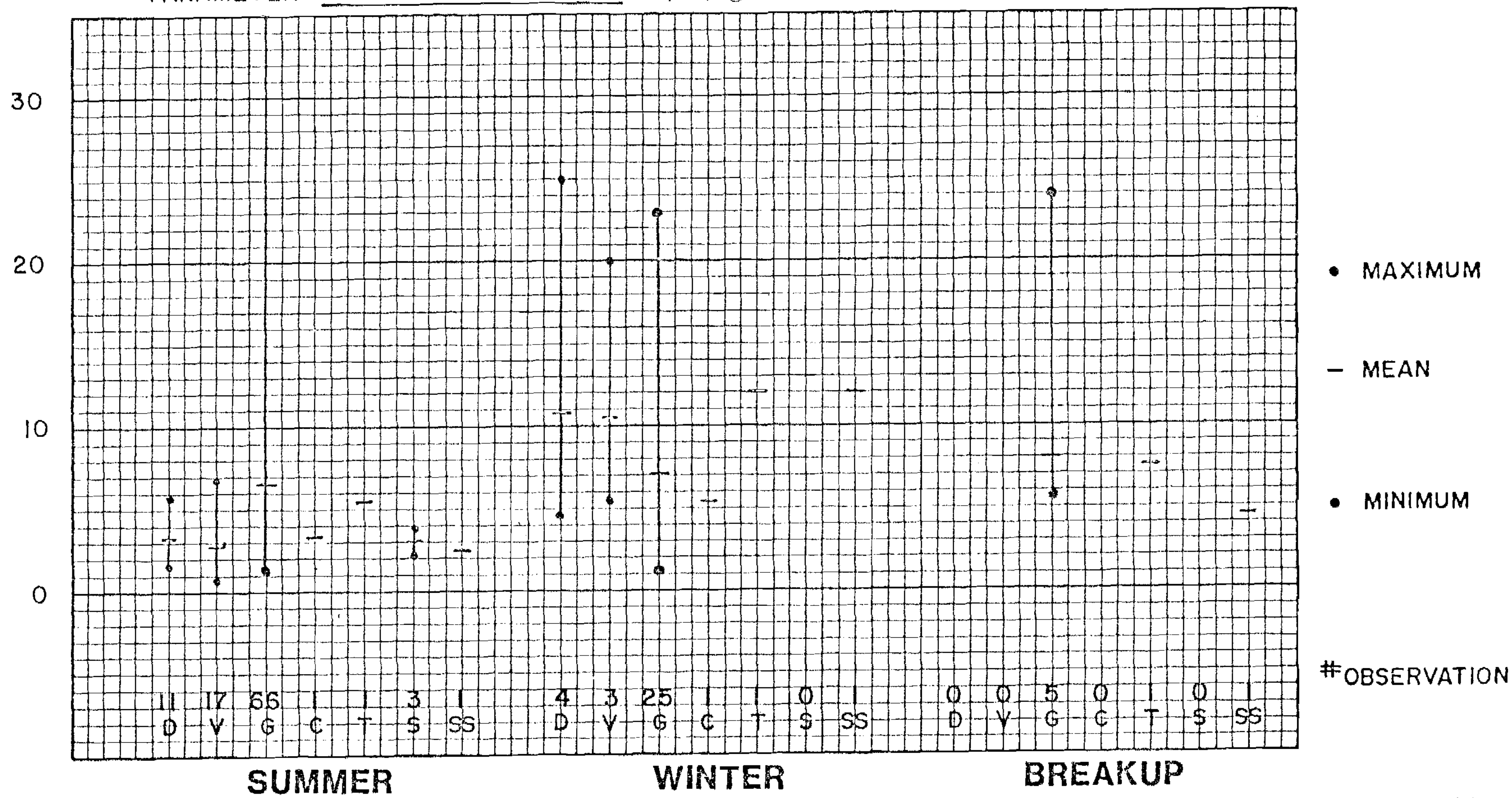
DATA SUMMARY - TOTAL INORGANIC CARBON

FIGURE 2.21

PARAMETER: FREE CARBON DIOXIDE, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

No criterion established

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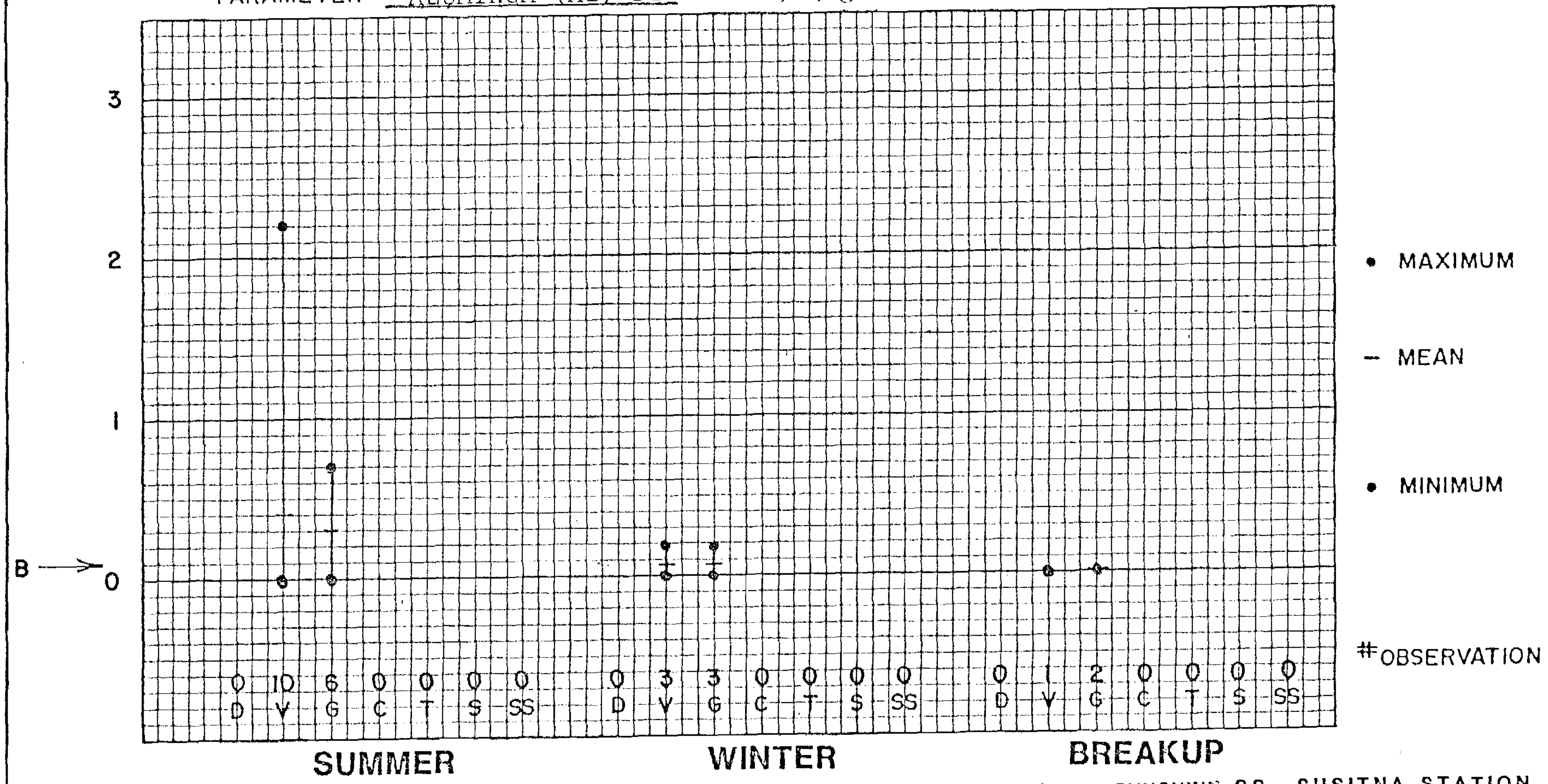
DATA SUMMARY - FREE CARBON DIOXIDE

FIGURE 2.22

PARAMETER: ALUMINUM (Al) DISSOLVED, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. No criterion established

B. A limit of 0.073 mg/l has been suggested by EPA (Sittig, 1981).

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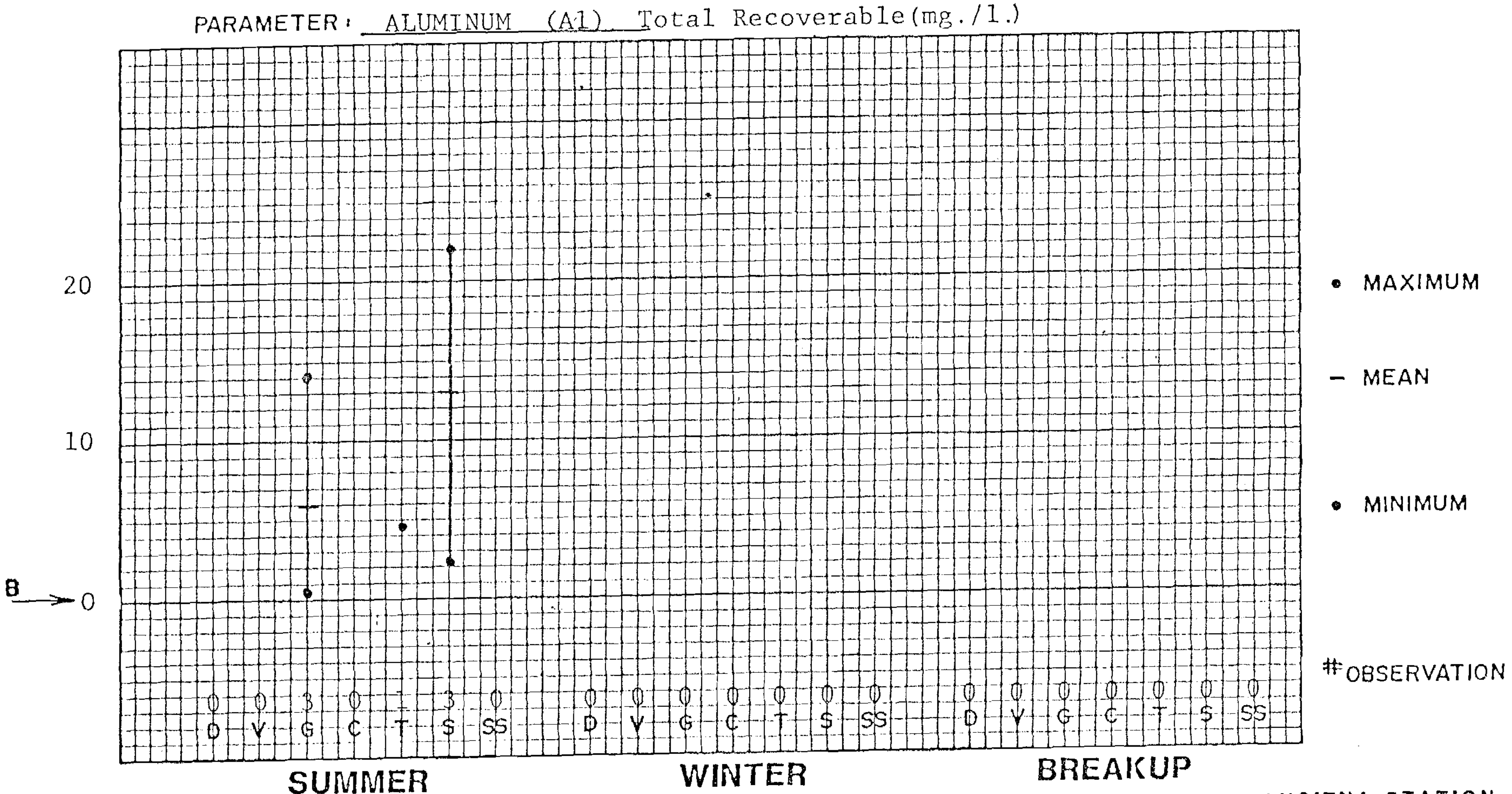
DATA SUMMARY - ALUMINUM (d)

FIGURE 2.23



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. No criterion established

B. A limit of 0.073 mg/l has been suggested by EPA (Sittig, 1981)

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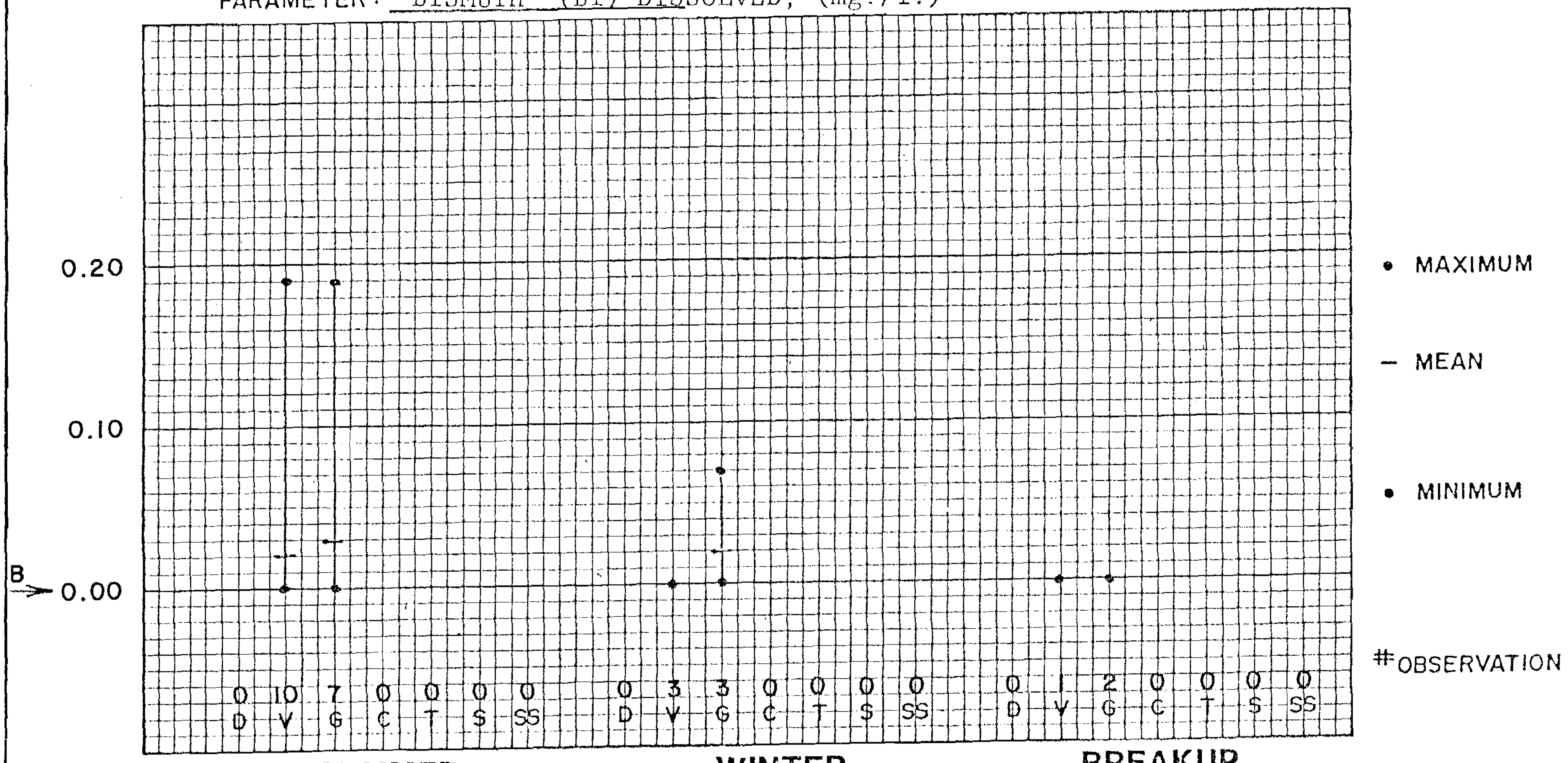
DATA SUMMARY - ALUMINUM (t)

FIGURE 2.24

PARAMETER: BISMUTH (Bi) DISSOLVED, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. No criterion established

B. EPA has suggested an ambient limit of 0.0035 mg/l. (Sittig, 1981).

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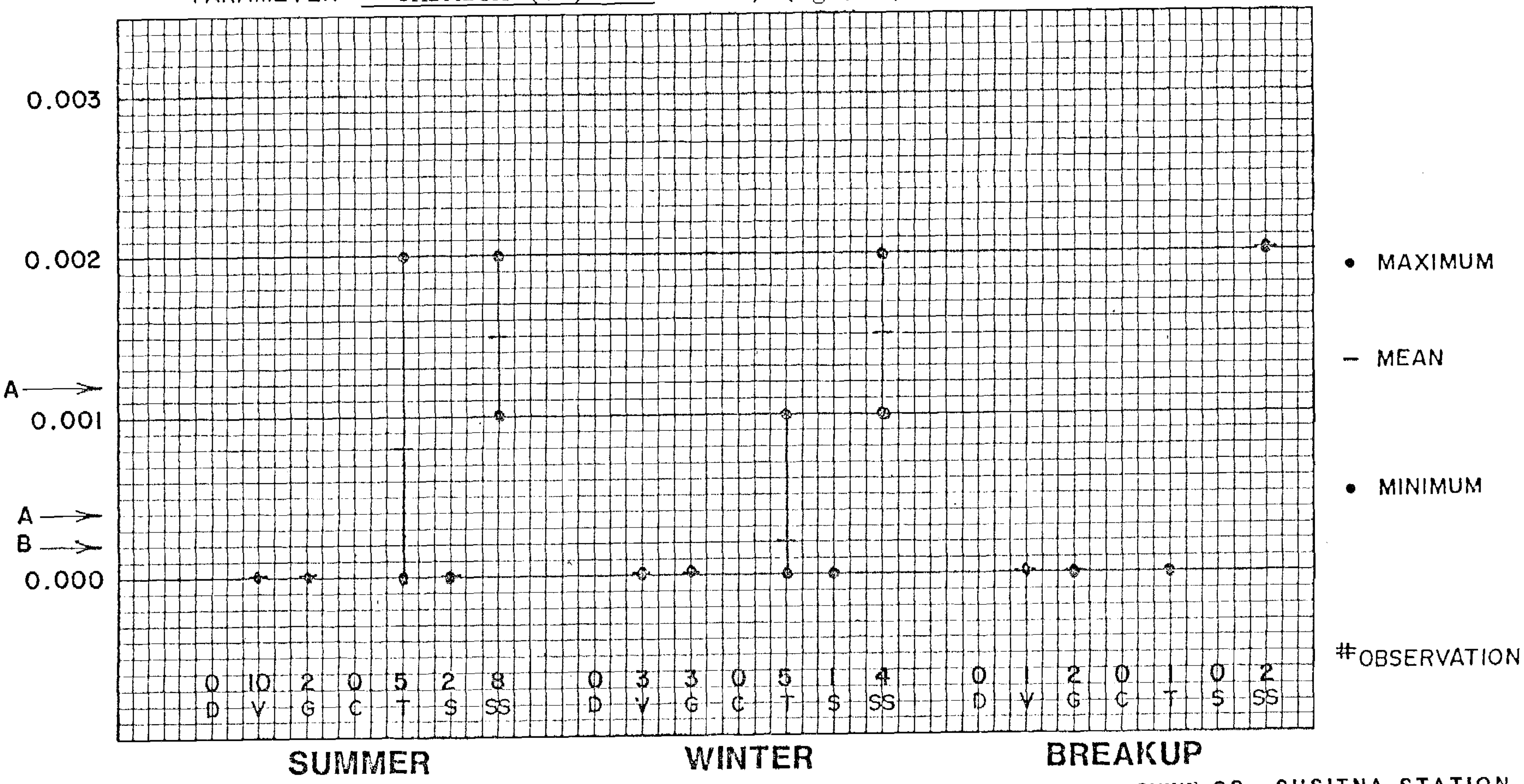
DATA SUMMARY - BISMUTH (d)

FIGURE 2.25

PARAMETER: CADMIUM (Cd) DISSOLVED, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. 0.0012 mg/l in hard water and 0.0004 in soft water. (EPA, 1976)

B. Less than 0.0002 mg/l. (McNeely, 1979)

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DATA SUMMARY - CADMIUM (d)

FIGURE 2.26

PARAMETER: CADMIUM (Cd) Total Recoverable (mg./1.)

D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. 0.0012 in hard water and 0.0004 mg/l in soft water (EPA, 1976).

B. Less than 0.0002 mg/l (McNeely et al, 1979).

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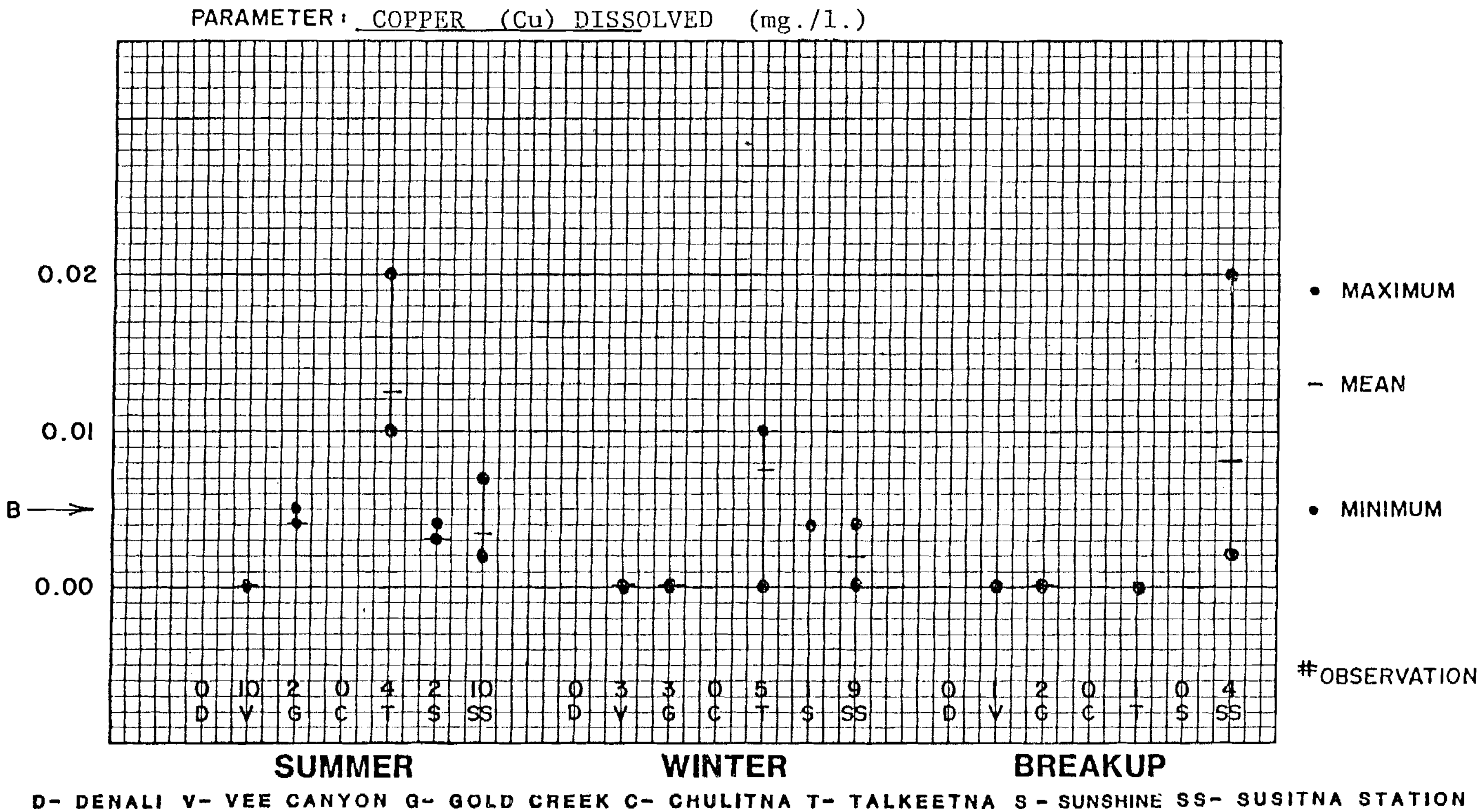
DATA SUMMARY - CADMIUM (t)

FIGURE 2.27



A. 0.01 of the 96-hour LC_{50} determined through bioassay (EPA, 1976).

B. 0.005 mg/l, (McNeely et al, 1979)

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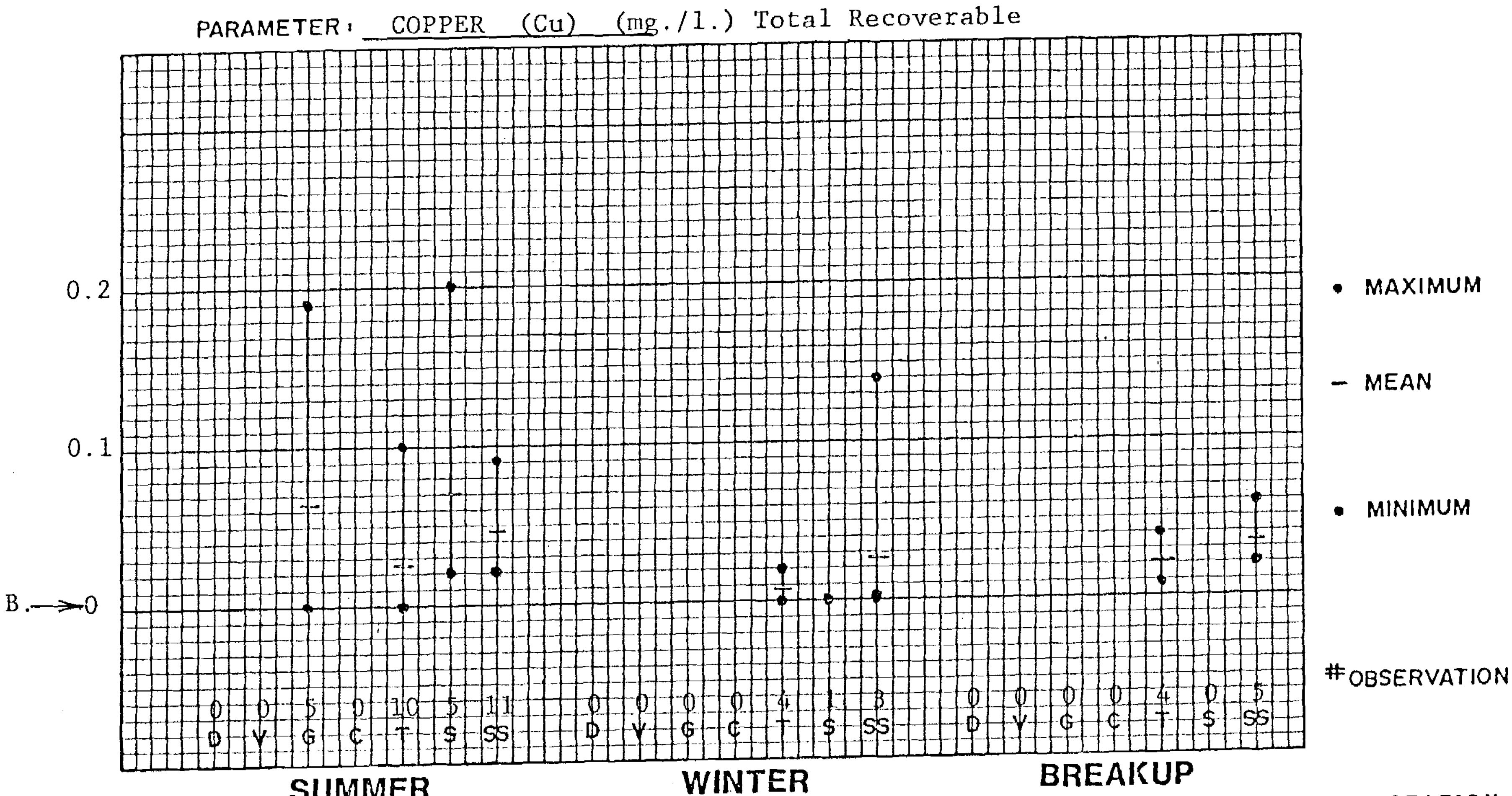
DATA SUMMARY - COPPER (d)

FIGURE 2.28



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976).

B. 0.005 mg/l (McNeely et al, 1979).

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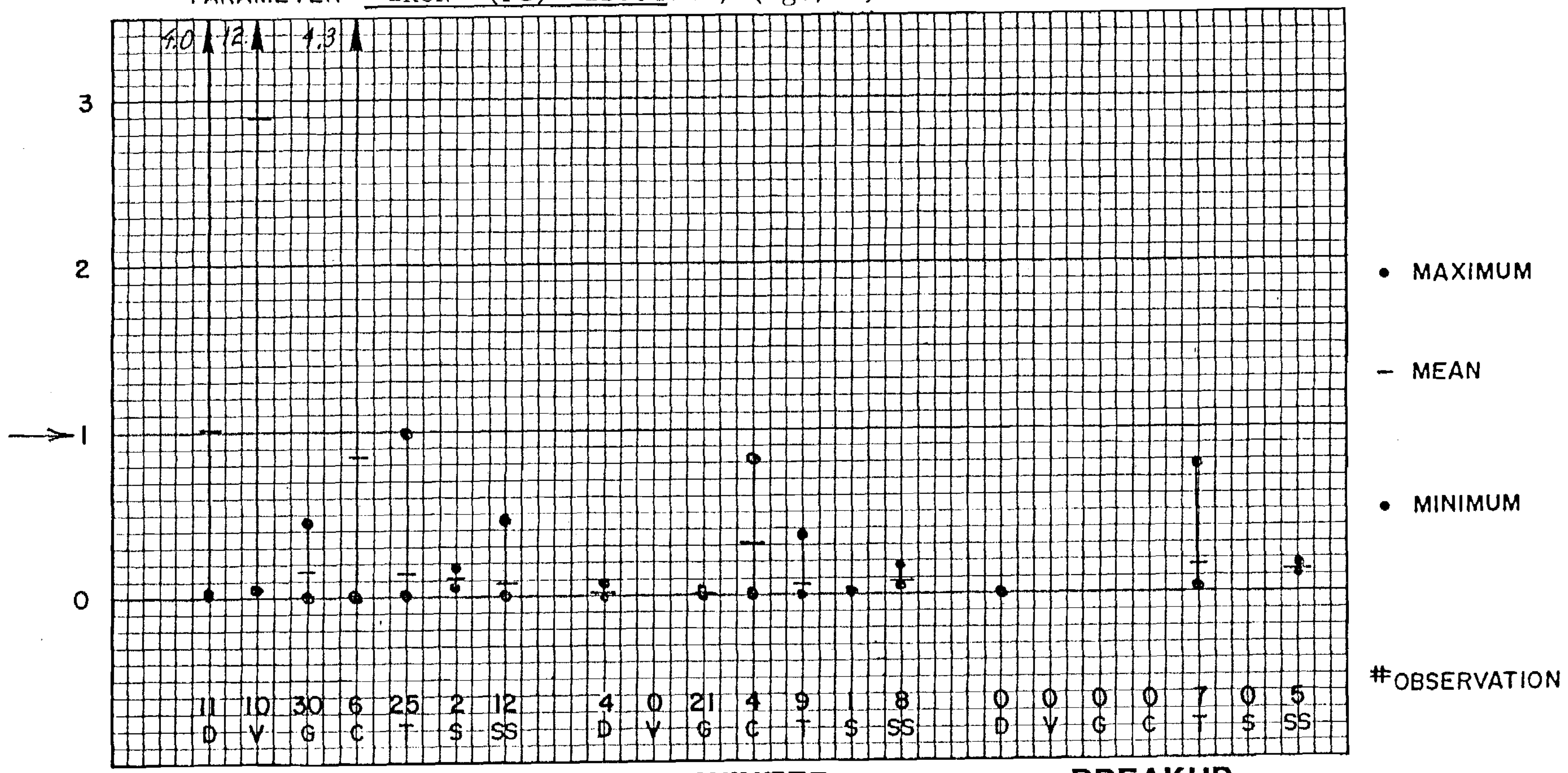
DATA SUMMARY - COPPER (t)

FIGURE 2.29

PARAMETER: IRON (Fe) DISSOLVED, (mg./l.)



D– DENALI V– VEE CANYON G– GOLD CREEK C– CHULITNA T– TALKEETNA S – SUNSHINE SS– SUSITNA STATION

A. Less than 1.0 mg/l (EPA, 1976; Sittig, 1981).

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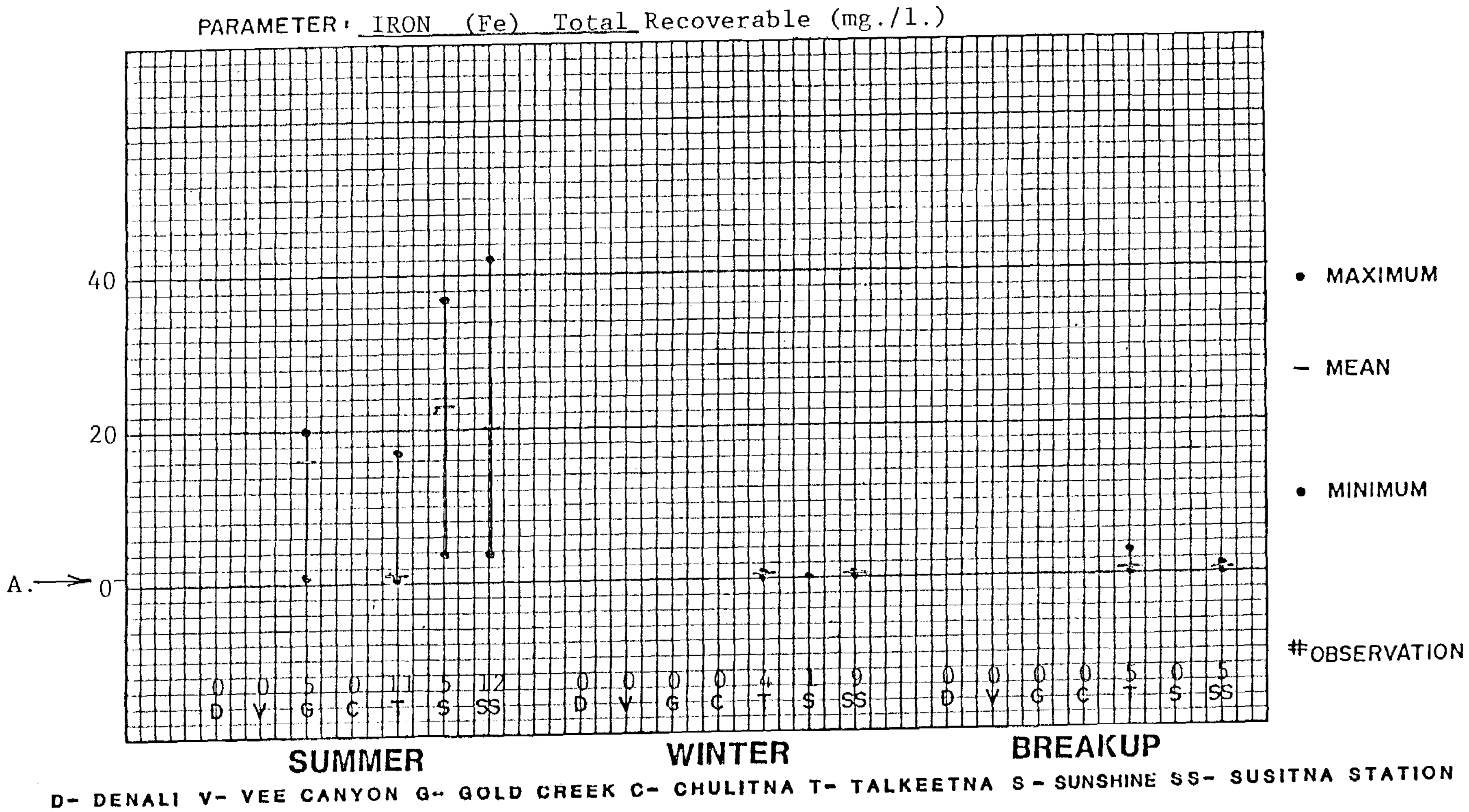
DATA SUMMARY - IRON (d)

FIGURE 2.30



A. Less than 1.0 mg/l (EPA, 1976; Sittig, 1981)

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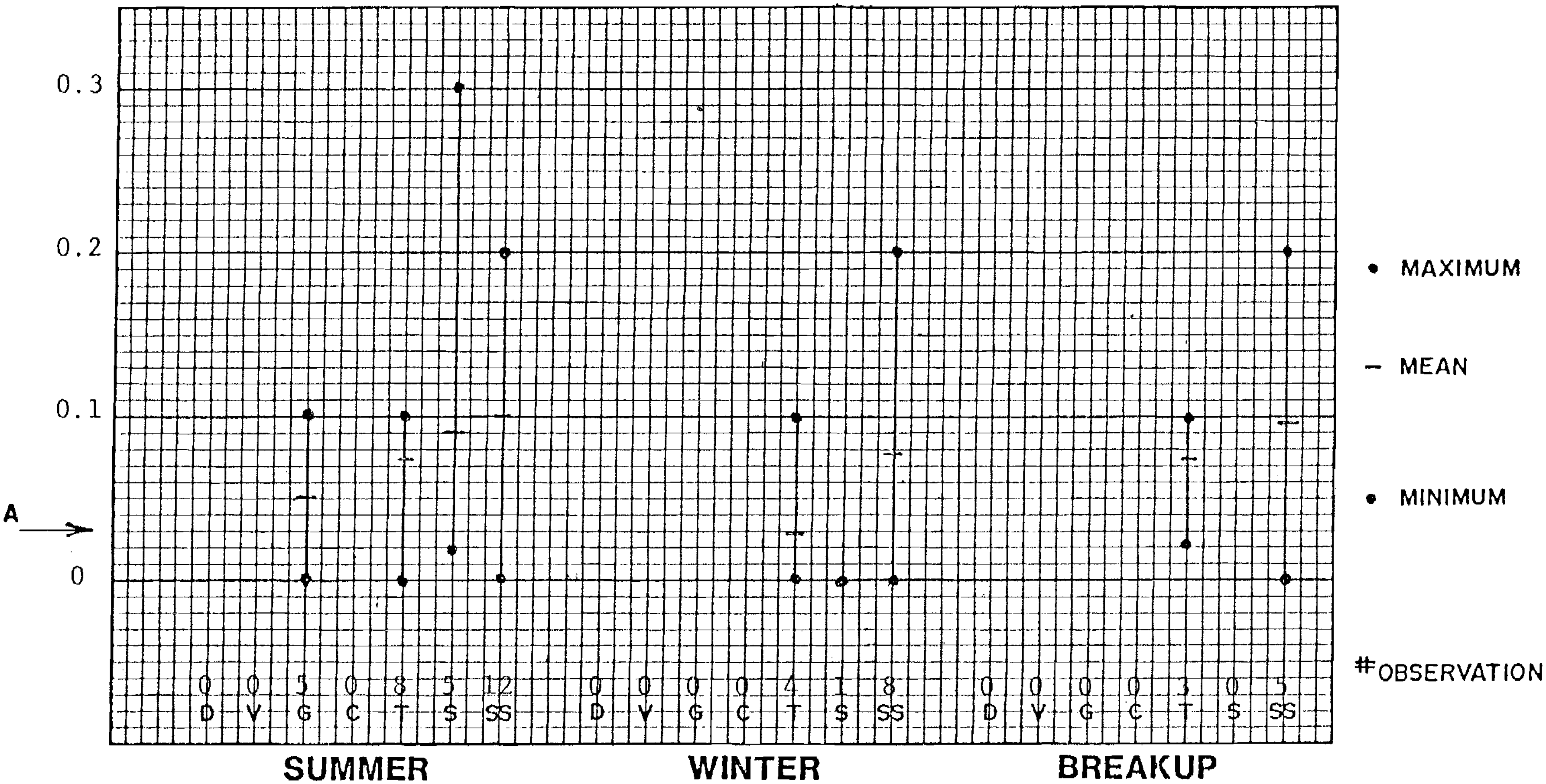
DATA SUMMARY - IRON (t)

FIGURE 2.31

PARAMETER: LEAD (Pb) (mg./l.) Total Recoverable



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.03 mg/1 (McNeely et al, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976).

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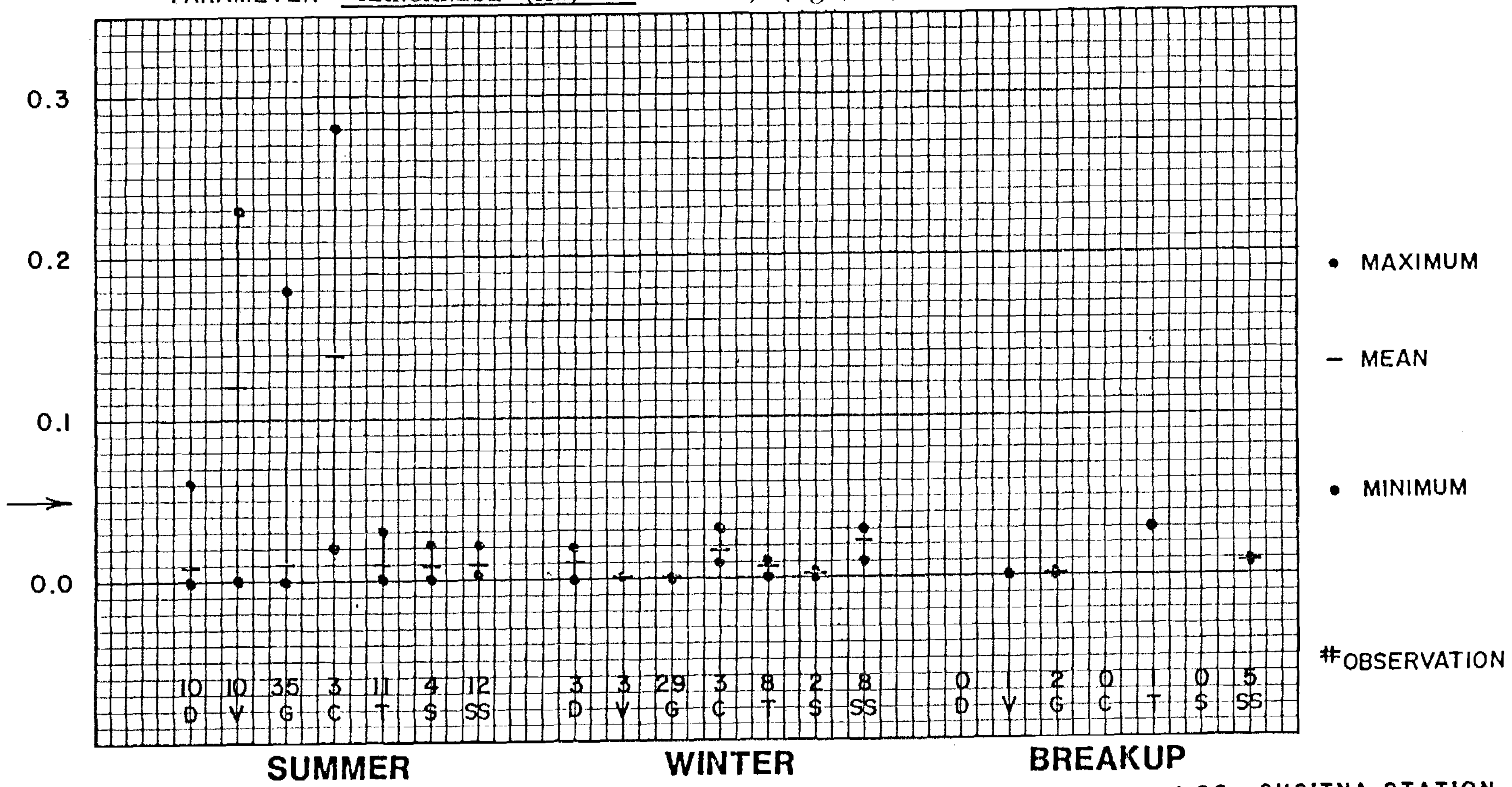
DATA SUMMARY - LEAD (t)

FIGURE 2.32

PARAMETER: MANGANESE (Mn) DISSOLVED, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.05 mg/1 for water supply.(EPA, 1976).

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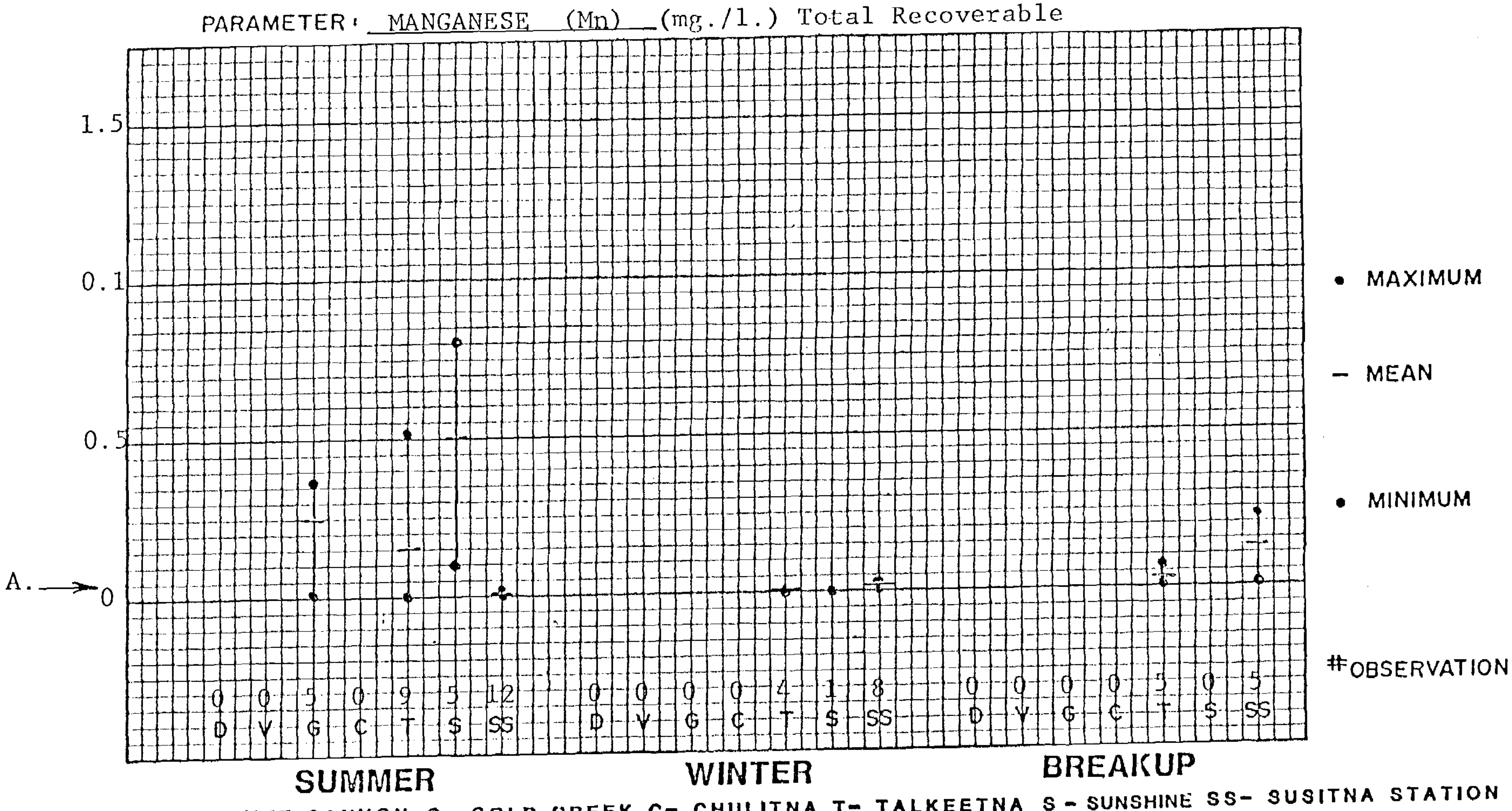
DATA SUMMARY - MANGANESE (d)

FIGURE 2.33



A. Less than 0.05 mg/l for water supply (EPA, 1976)

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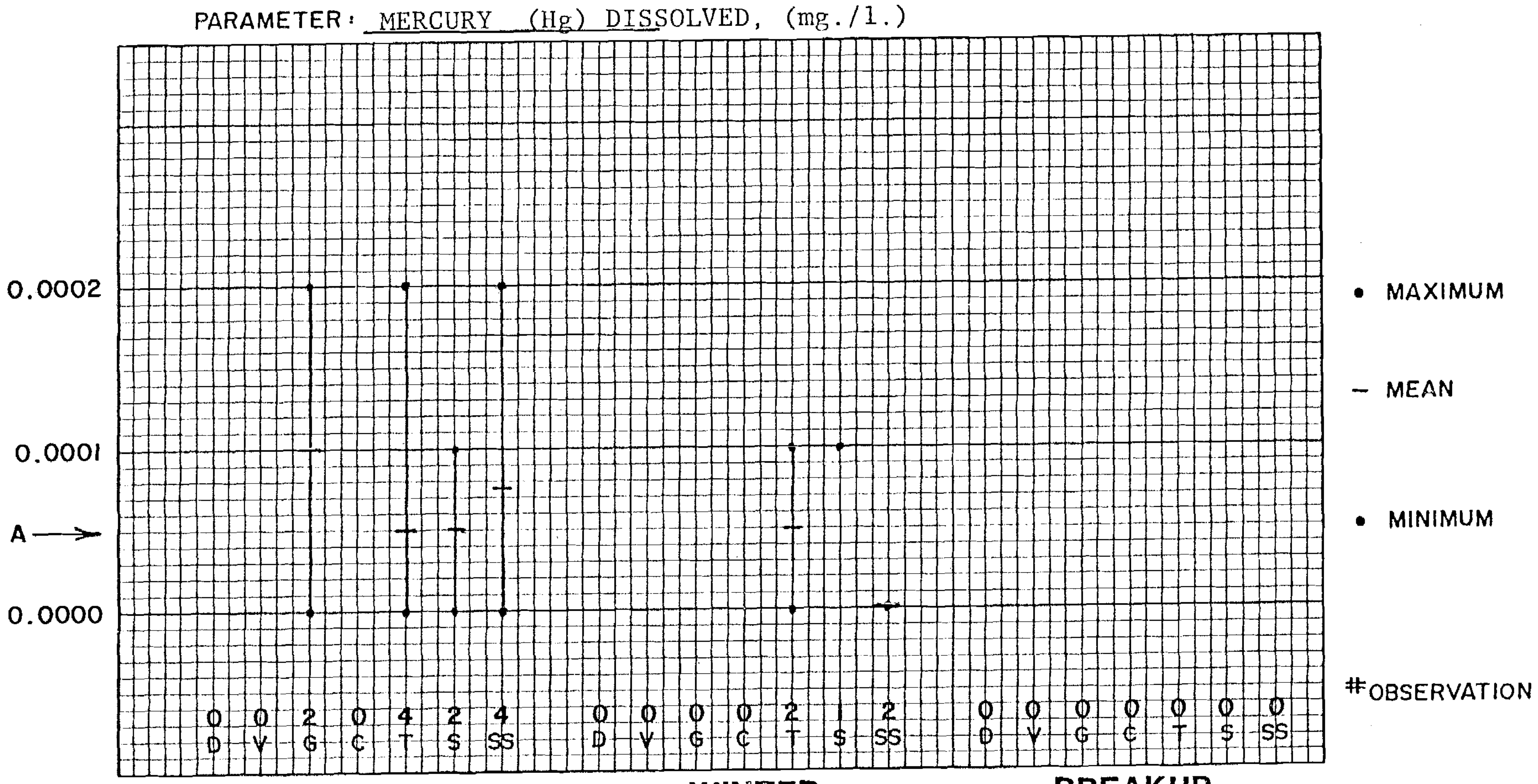
DATA SUMMARY - MANGANESE (t)

FIGURE 2.34



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.00005 mg/1. (EPA, 1976).

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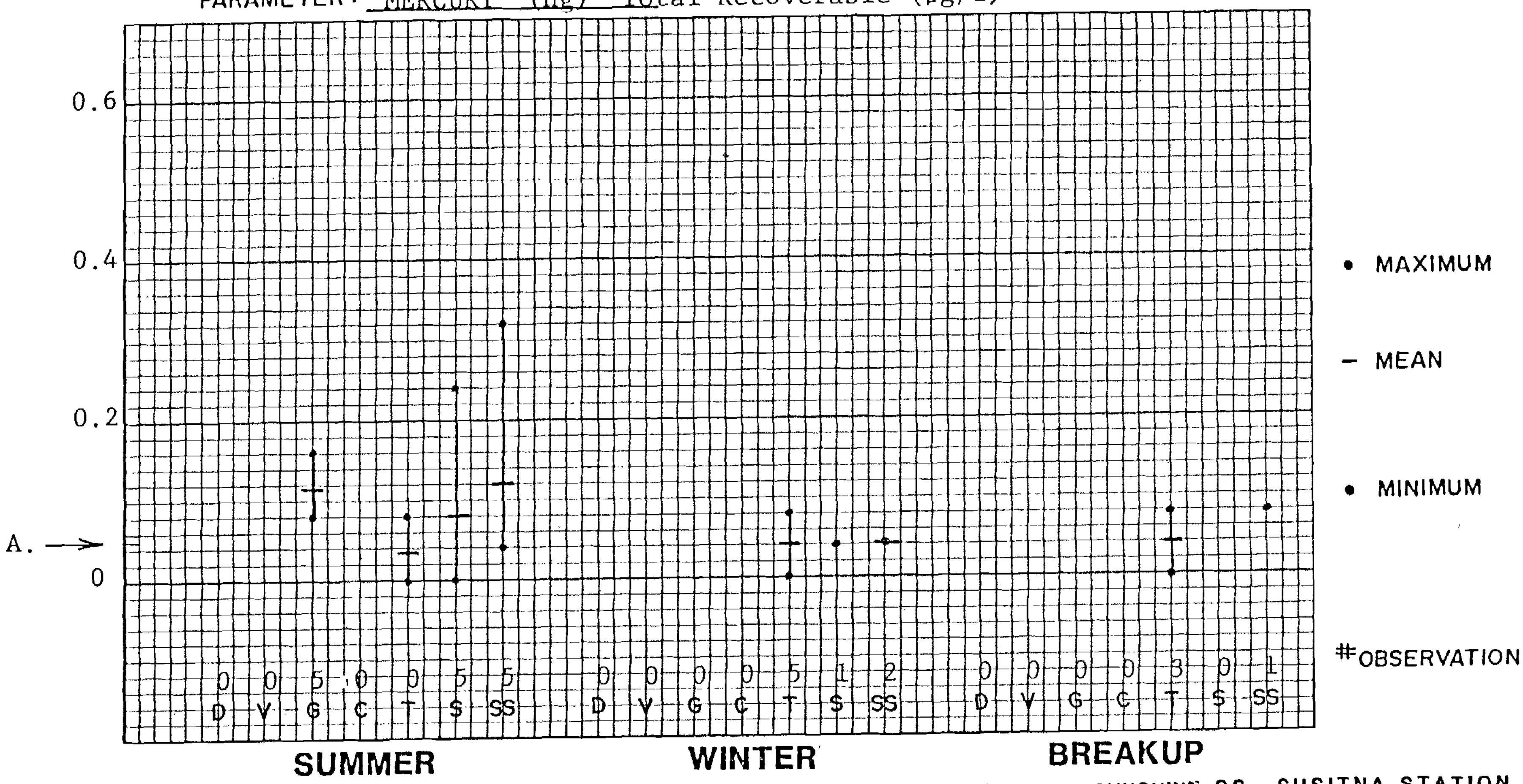
DATA SUMMARY - MERCURY (d)

FIGURE 2.35

PARAMETER: MERCURY (Hg) Total Recoverable (μg/l)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

A. Less than 0.05 μg/l (EPA, 1976)

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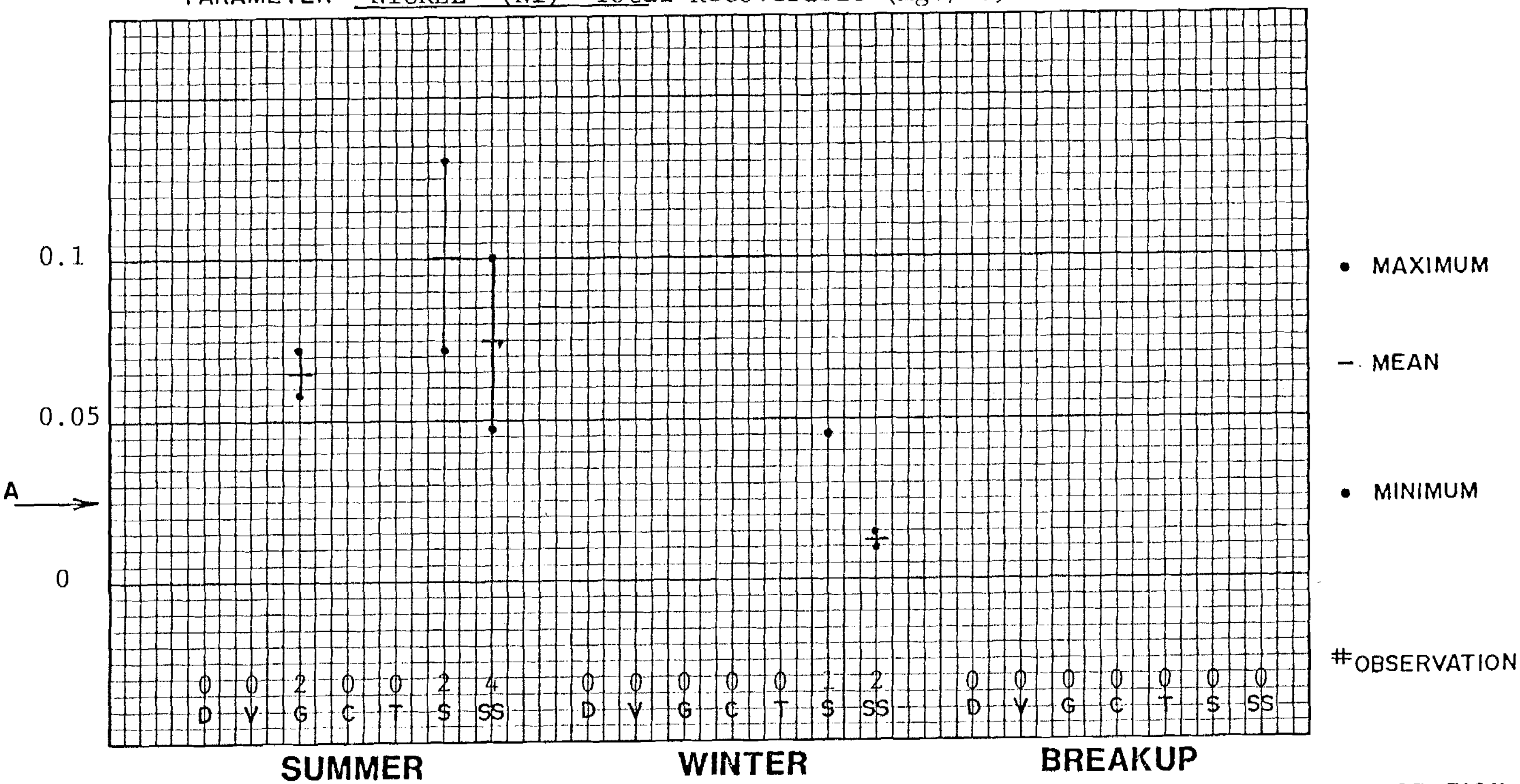
DATA SUMMARY - MERCURY (t)

FIGURE 2.36

PARAMETER: NICKEL (Ni) Total Recoverable (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S- SUNSHINE SS- SUSITNA STATION

A. Less than 0.025 mg/l (McNeely et al, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976)

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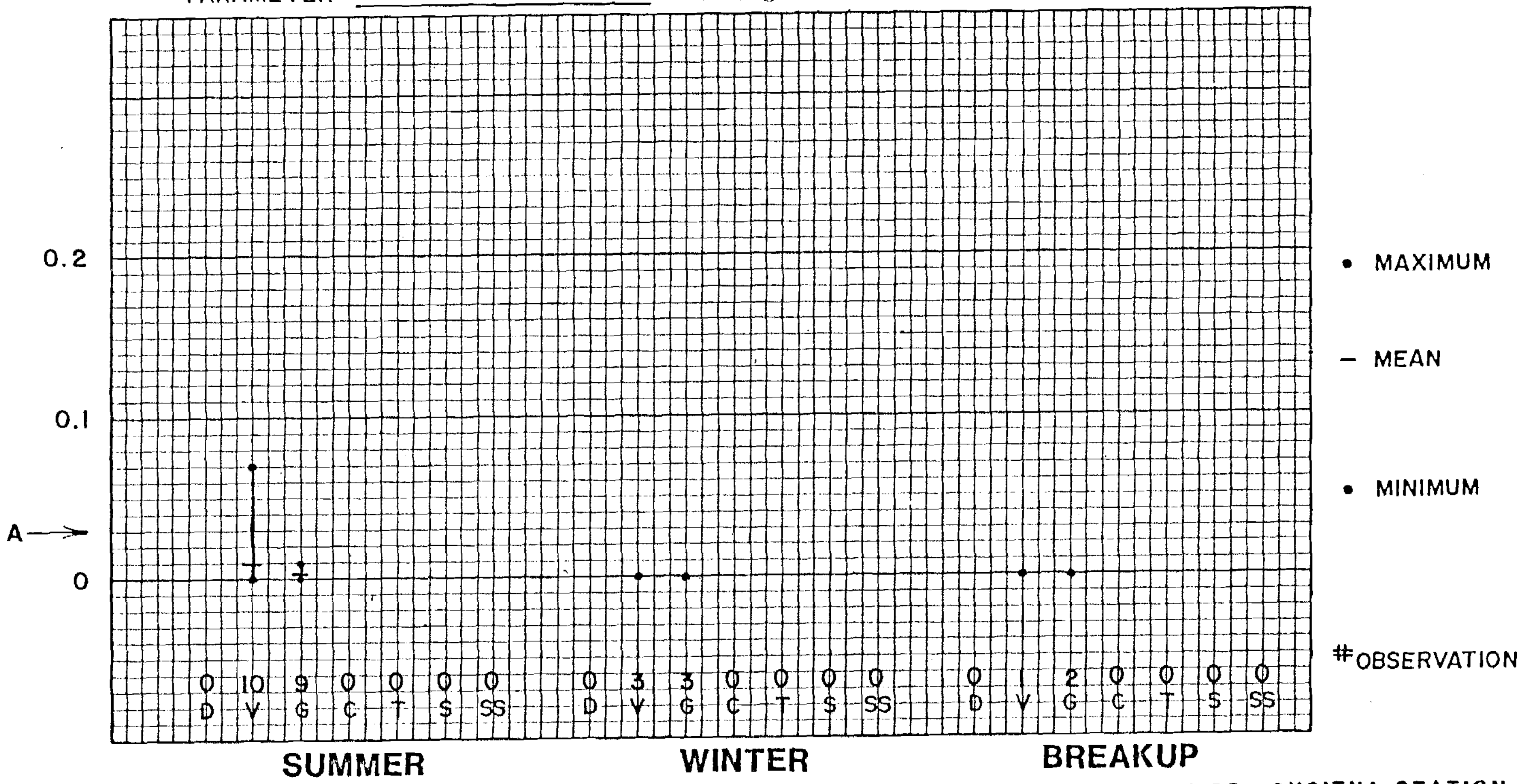
DATA SUMMARY - NICKEL (t)

FIGURE 2.37

PARAMETER: ZINC (Zn) DISSOLVED, (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.03 mg/l (McNeely, 1979)

B. 0.01 of the 96-hour LC_{50} determined through bioassay (EPA, 1976).

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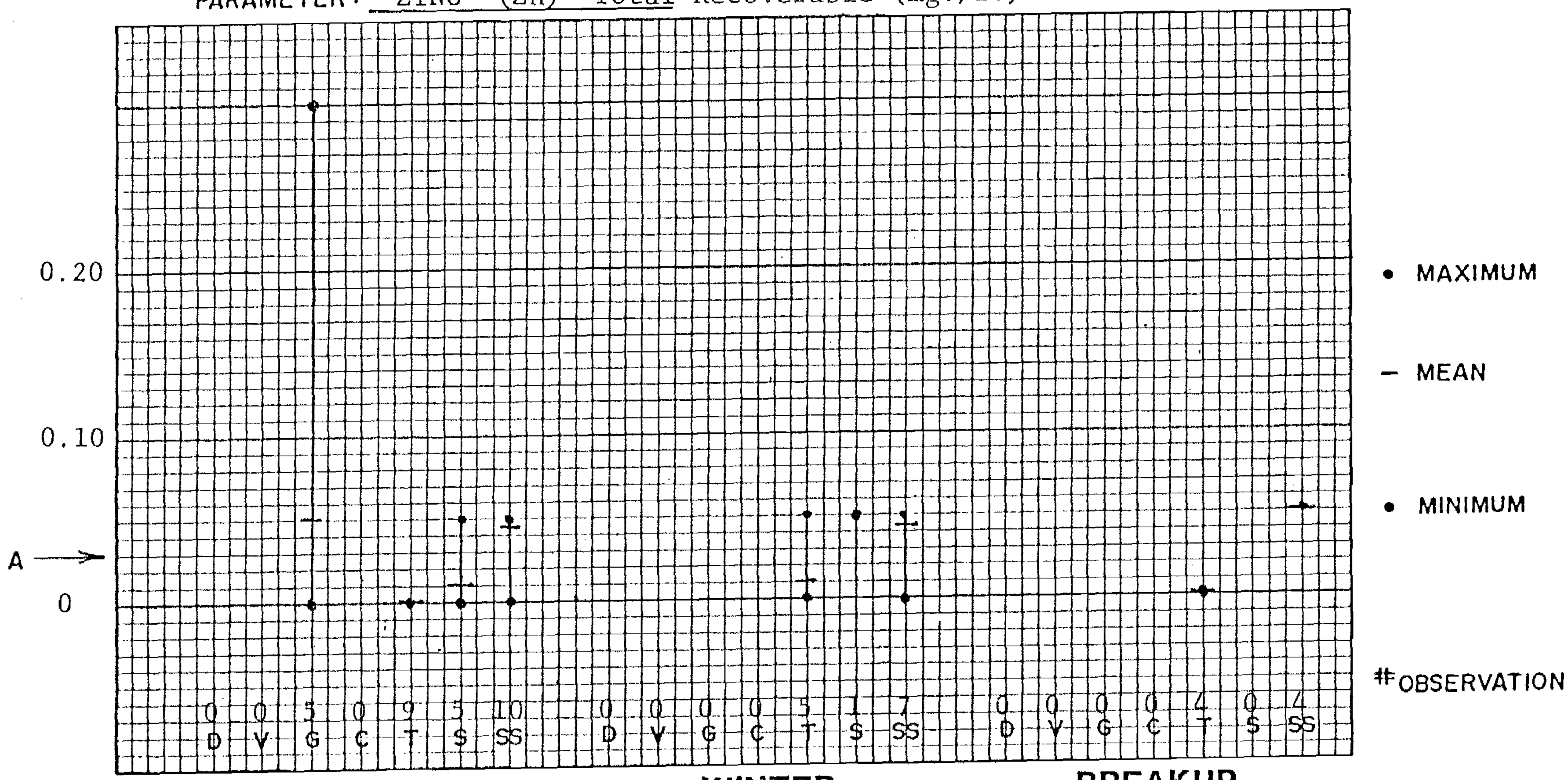
DATA SUMMARY - ZINC (d)

FIGURE 2.38

PARAMETER: ZINC (Zn) Total Recoverable (mg./l.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. Less than 0.03 mg/l (McNeely, 1979).

B. 0.01 of the 96 - hour LC_{50} determined through bioassay (EPA, 1976).

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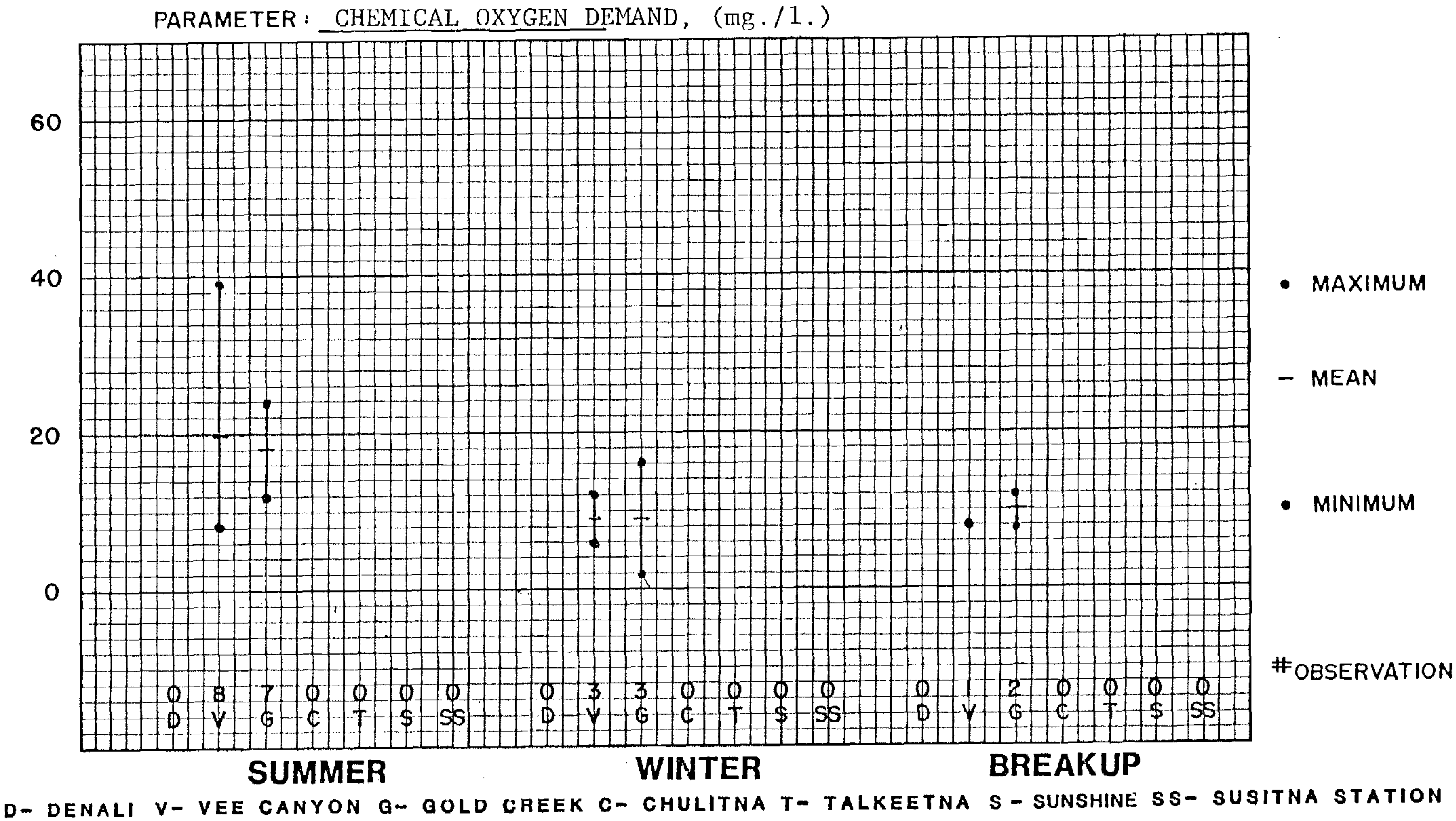
DATA SUMMARY - ZINC (t)

FIGURE 2.39



No criterion established

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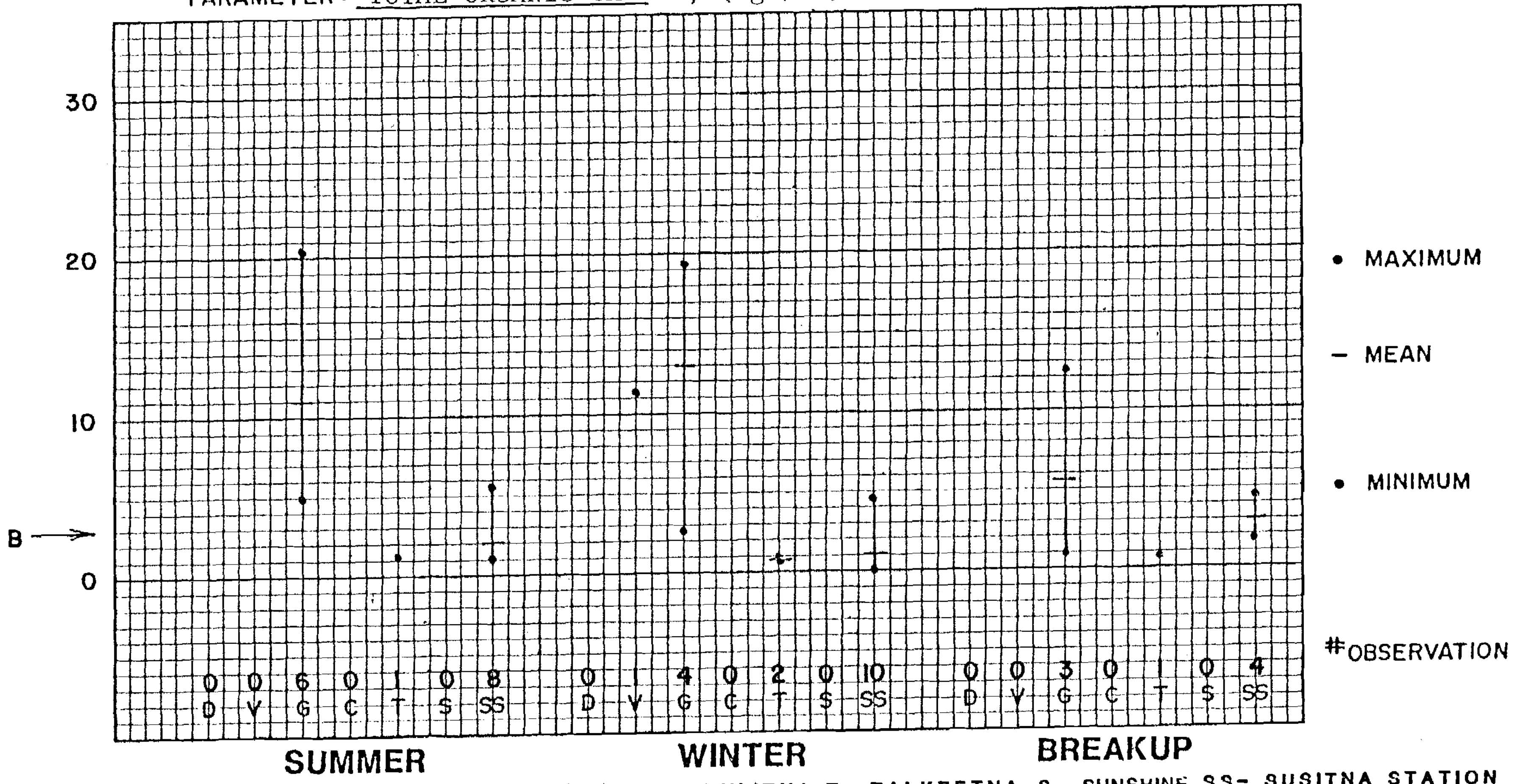
DATA SUMMARY - CHEMICAL OXYGEN DEMAND

FIGURE 2.40

PARAMETER: TOTAL ORGANIC CARBON, (mg./1.)



D- DENALI V- VEE CANYON G- GOLD CREEK C- CHULITNA T- TALKEETNA S - SUNSHINE SS- SUSITNA STATION

A. No criterion established

B. Waters containing less than 3.0 mg/l have been observed to be relatively clean, (McNeely et al, 1979).

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DATA SUMMARY TOTAL ORGANIC CARBON

FIGURE 2.41

3 - REPORT ON FISH, WILDLIFE, AND BOTANICAL RESOURCES

3.1 - Description of Botanical Resources

Descriptions of vegetation/habitat types in the upper basin and transmission corridors were based on aerial photograph interpretation and on air and ground reconnaissance. Ocular estimates of the cover of dominant species were used to classify the vegetation according to the system developed by Viereck and Dyrness (1980). High altitude (U-2) color infrared photographs and LANDSAT imagery were used to map the vegetation cover types. Vegetation of the entire upper Susitna River drainage (upstream of Gold Creek) was mapped at a scale of 1:250,000. Vegetation adjacent to and within 16 km of the upper Susitna River and within the transmission corridors was mapped at a scale of 1:63,360. The vegetation within the proposed impact areas (that is, impoundments, areas within 0.8 km of impoundments, floodplain from Devil Canyon to Talkeetna, and borrow sites) was mapped at a scale of 1:24,000. Delineation of wetlands was based on the classification of Cowardin et al. (1979).

Reconnaissance-level surveys were made of each major vegetation type. During these ground surveys, information was obtained on species composition, community structure, wildlife habitat, and physical characteristics of the site.

Descriptions of downstream floodplain plant communities were based on quantitative descriptions of 29 stands between the Deshka River and a location 11 km north of Talkeetna. Vegetation cover was estimated on four to eight randomly located 30-meter transects within each stand. Density, age, height, and diameter breast height (dbh) of trees and tall shrubs were measured along each transect; density, age, height, and width of low shrubs were also measured.

(a) Regional Botanical Setting

The upper Susitna River basin is located in the Pacific Mountain physiographic division in southcentral Alaska (Joint Federal-State Land Use Planning Commission for Alaska 1973). The Susitna basin occurs within an ecoregion classified by Bailey (1976, 1978) as the Alaska Range Province of the Subarctic Division.

The Susitna River system drains parts of the Alaska Range on the north and parts of the Talkeetna Mountains on the south (Figure 1.3). Many areas along the east-west portion of the river between the confluences of Portage Creek and the Oshetna River are steep and covered with conifer, deciduous, and mixed conifer and deciduous forests. Flat benches occur at the tops of these banks and usually contain low shrub or woodland conifer communities. Rising from these benches are low mountains covered by sedge-grass tundra and mat and cushion tundra.

The southeastern portion of the study area between the Susitna River and Lake Louise is characterized by extensive flat areas covered with low shrubland and woodland conifer communities, which, because of intergradations, are often intermixed and difficult to distinguish in the field or on aerial photographs. To the northeast, the area along the Susitna River between the Maclaren River and the Denali Highway is covered with woodland and open spruce stands. Farther east, the area has more low shrubland cover. The Clearwater Mountains north of the Denali Highway have extensive tundra vegetation. The floodplain of the Susitna River north of the Denali Highway has woodland spruce and willow stands, while the Alaska Range contains most of the permanent snowfields and glaciers in the study area.

The steep sections and some adjacent areas along the east-west portions of the river are considered in the closed spruce-hardwood forest type of Viereck and Little (1972), the moderately high mixed evergreen and deciduous forest map unit of Spetzman (1963), or the upland spruce hardwood forest of the Joint Federal-State Land Use Planning Commission of Alaska (1973). Whichever label one chooses, this type of vegetation is found mainly along rivers in the southcentral and interior regions of the state.

Both the benches bordering this same east-west portion of the river and the area around the Maclaren River are classified as moist tundra in all three of the previously mentioned references. This classification includes herbaceous meadows as well as shrub-dominated areas, both of which also occur around the Brooks Range, on the Seward Peninsula, and near the Killuck Mountains.

The extensive flats in the lower Oshetna River and Lake Louise areas, in the southeastern portion of the study area, are considered open, low growing spruce forests by Viereck and Little (1972), low mixed evergreen and deciduous forests by Spetzman (1963), and lowland spruce-hardwood forests by the Joint Federal-State Land Use Planning Commission of Alaska (1973). Viereck and Little's (1972) description appears most appropriate, since the area is covered primarily by spruce stands with treeless bogs.

The vegetation along the lower mountains, and the lower slopes of the higher mountains, was classified as alpine tundra by Viereck and Little (1972) and the Joint Federal-State Land Use Planning Commission (1973) and as barren and sparse dry tundra by Spetzman (1963). In the current study, some of these areas were mapped separately as rock, while other areas were mapped as sedge-grass tundra or mat and cushion tundra, whereas the previous maps included the rock in the alpine tundra. Some areas mapped as rock do have some important pioneering species growing in crevices, but the plants provided negligible ground cover. Alpine tundra grows on mountains throughout the state.

The downstream floodplain is a part of the Cook Inlet-Susitna Lowlands, a portion of the trough which forms a major bifurcation in the Pacific Mountain System (Joint Federal-State Land Use Planning Commission for Alaska 1973). This region is generally flat, occurs mostly below 150 m in elevation, and experiences a climate that is transitional between maritime and continental. The growing season is at least one month longer than that in the upper basin. The vegetation of this region is considered closed spruce-hardwood forest by Viereck and Little (1972), moderately mixed evergreen and deciduous forest or high evergreen spruce forested by Spetzman (1963), and the upland spruce-hardwood or bottomland spruce-poplar forest by the Joint Federal-State Land Use Planning

Commission (1973). White spruce, balsam poplar, paper birch, and alder (see Table 3.1 for scientific names of plants) are all important species in the floodplain vegetation. Additionally, willows and horsetails are dominant aspects of pioneer, non-forested communities.

(b) Vegetation/Habitat Types

The vegetation/habitat types described in this section include those in the upper basin (upstream of Gold Creek), the downstream floodplain (Devil Canyon to Delta Islands), and the transmission line corridors. Additional description information is presented in the Plant Ecology Studies - First Annual Report (APA 1980b). Vegetation cover maps for the entire upper basin and an area 16 km on either side of the river from Gold Creek to the mouth of the Maclaren River are presented in Figure 3.1 and in Figures 3.2 through 3.4, respectively.

The area covered by each vegetation/habitat cover type is presented in Tables 3.2 and 3.3. Vegetation/habitat cover maps for the transmission line corridors are presented in Figures 3.5 through 3.9; corresponding area measurements are provided in Tables 3.4 and 3.5.

(i) Upper Basin

- General Description of Forest Types

Forest vegetation/habitat types were located at the lower elevations of the upper basin (Figures 3.1 through 3.4). The average elevation of sampled areas was 523 m. These forest types were divided according to their dominant tree types (conifer, deciduous, or mixed) and then by tree crown cover percentage. Deciduous and conifer types had at least 75% of the tree cover provided by deciduous or conifer trees, respectively. The woodland type had between 10% and 25% tree cover and was only observed for conifer stands. Open stands contained 25-50% tree cover, while closed stands had over 50% tree cover. The boundary percentage between open and closed types was set at 50% rather than the 60% that Viereck and Dyrness (1980) used, since the former percentage was easier to estimate both on the aerial photographs and in the field.

Conifer, deciduous, and mixed stands with open canopies were observed in the field, while the only stands with closed canopies located in the field were deciduous and mixed. One closed conifer area that appeared on the aerial photographs near Lake Louise was not field checked. All forested stands had almost complete vegetation cover with 80-95% ground layer cover.

- Spruce Forests

Spruce stands were dominated either by white spruce (see Table 3.1 for list of scientific names) or black spruce and contained a well-developed ground layer, which itself accounted for most of the vegetation cover. The layer structure of open black and white spruce stands was similar, except that white spruce stands contained more overstory, a reflection of the generally larger size of white spruce trees. These units were mapped only at the 1:24,000 and 1:63,360 (Figures 3.2 through 3.4) scales. Another difference was that the overstory in open white spruce stands was less variable in height among stands than was the overstory in black spruce stands. Open spruce stands were usually found on slopes or flatlands along the rivers at elevations averaging 487 m. Overstory provided almost one-fourth cover in open stands which contained trees several meters tall.

While the white spruce cover was concentrated in the overstory layer, most of the black spruce tree cover was contained in the shrub layer. Black spruce stands contained low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry in the ground layer, while prickly rose and bluejoint were the most important ground layer species in open white spruce. Twin-flower was important in the white spruce stands but was not observed in the black spruce stands, possibly reflecting that ground species' preference for better-drained soils. In each of these mapping units, 30 to 35 identified species were encountered. In these open white and black spruce stands, feather mosses covered as much ground as trees did. Low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry accounted for much of the woody ground layer. Important herbaceous species included bluejoint and horsetails.

Northern Labrador tea, Labrador tea, bog blueberry, mountain cranberry, and sphagnum and feather mosses were found in black spruce forests in the upper Susitna River basin. Crowberry, nagoonberry, and woodland horsetail were also important in black spruce stands; however, these varieties were not reported along the Chenan River by Virecek (1970).

Meadow horsetail and feather mosses provided significant amounts of cover in white spruce stands along the Chena River (Viereck 1970) and in the upper Susitna River basin, but bluejoint, twinflower, and the moss Ptilium crista-castrensis were apparently more important along the Susitna River than along the Chena.

All woodland spruce stands visited were black spruce. Here, it was observed that, unlike open spruce stands, woodland stands were composed of scattered, stunted trees, and the overstory was almost negligible. One reason for this pattern is that this vegetation/habitat type was usually found on the relatively level benches where soils were poorly drained. Average elevation of sampled areas was 620 m. The resulting trees were usually too small to qualify for the overstory layer because trunks were <10 cm dbh. Maximum heights were less than two meters in some areas.

In these woodland stands, sphagnum mosses, not feather mosses, were the most important cover species; important ground layer species included sedges, woodland horsetail, and low shrubs similar to those found in the open spruce stands. Slightly over 30 identified species were encountered in the woodland spruce vegetation/habitat type.

Woodland spruce sites graded into boggy areas where tree cover might be less than 10% and where the vegetation resembled muskegs. Low birch shrub stands and woodland spruce were frequently difficult to distinguish in the field because birch stands sometimes had scattered trees which, on occasion, produced almost 10% cover. On aerial photographs, the overall pattern created by small trees produced similar textures for woodland spruce and for low birch shrub sites. This phenomenon, along with the fact that these areas took on a similar color when photographed (dark gray), made distinguishing between them difficult.

Among black spruce stands, those occupying significant slopes (8-10°) appeared to be more productive of browse species and, in fact, received noticeably greater use by moose than did other black spruce areas. Compared to other vegetation types, browse production was low, but since the browse had incurred heavy use, such stands appeared to provide important cover areas during severe weather. Open black spruce stands on the flats were generally very poor in terms of forage production, but some caribou sign was present. Skoog (1968) considered this forest type to represent a good supply of terrestrial forage lichens for caribou in winter.

- Deciduous Forests

Deciduous forest vegetation usually had a greater overstory cover than had spruce stands because individual trees had more foliage cover. These types were restricted mostly to the steep banks and floodplain along the river (Figures 3.2 through 3.4). Elevations averaged 582 m, with closed stands occurring at average elevations of 560 m and open stands at 625 m. They had almost complete vegetation cover, with an especially well-developed ground layer. While the overstory layer in closed stands covered almost three-fourths of the area, it only covered about three-eighths in open stands. Overstory was sometimes 15 m tall and, in the balsam poplar stands, even taller. Paper birch, trembling aspen or balsam poplar dominated the overstory. Neither the shrub layer nor the understory layer was of major importance. Important woody species in the ground layer in both types included crowberry, northern Labrador tea, bog blueberry, and mountain cranberry. Open stands appeared to have more woody cover in the ground layer than did the closed stands, while closed stands had more herbaceous components, such as bunchberry, bluejoint, and oak fern. Sixteen identified species were encountered in open deciduous forest types; in closed forest, 31 were found.

Closed deciduous stands were separated on the 1:63,360-scale map (Figures 3.2 through 3.4) according to the dominant species:

either balsam poplar or paper birch. Minor amounts of trembling aspen were also found but were barely large enough to sample and not large enough to map.

Closed balsam poplar generally occurred on islands in the river or on flat areas alongside the river. Balsam poplar was usually the first tree in the successional stage of vegetation development on alluvial deposits. The trees themselves provided about three-fourths cover. The ground layer was well developed and included bunchberry, crowberry, northern Labrador tea, bog blueberry, and mountain cranberry. About 14 species were encountered and identified in these areas.

Closed paper birch stands occurred on steep, usually south-facing slopes. The vertical layer structure is similar to the closed balsam poplar stands: three-fourths overstory, a well-developed ground layer, and relatively unimportant shrub and understory layers. The most important ground layer species were bunchberry, bog blueberry, bluejoint, and oak fern. Twenty five species were identified in the birch stands.

The minor, closed trembling aspen stands were usually found on the upper portions of dry, south-facing slopes. Their general structure was similar to other closed deciduous stands in that there were well-developed overstory and ground layers but insignificant shrub and understory layers.

- Mixed Conifer-Deciduous Forests

Mixed conifer-deciduous forests were usually dominated by white spruce and paper birch. Elevations for mixed conifer-deciduous forests averaged 466 m, with closed stands having a mean elevation near 425 m and open stands occurring around 482 m. Most of the larger stands occurred on slopes downstream from Tsusena Creek (Figures 3.2 through 3.4). These were probably successional stands, which developed as spruce replaced deciduous trees.

Cover in these vegetation/habitat types was almost complete with a well-developed ground layer containing important amounts of bluejoint, bunchberry, woodland horsetail, and Ptilium. The extent of overstory cover for the mixed conifer deciduous vegetation/habitat types fell between that for spruce stands and that for deciduous stands. Overstory cover in closed mixed stands was about 60%, while that in open mixed stands was 38%. The height of the overstory was sometimes up to 20 m. The shrub layer was more important in the open stands, mostly as a result of tall blueberry willow. Bog blueberry was an important ground species in the open mixed stands. Forty identified vascular plant species were encountered in open mixed stands; 29 were found in closed mixed stands.

- General Discussion of Forest Types

Forested communities in the upper Susitna River basin were similar to those described by Viereck (1975). Black spruce generally occurred in wetter sites than white spruce did, while deciduous or mixed forests as well as all closed forests occurred on warmer sites than those supporting spruce. The drier of these closed sites were usually deciduous, while the moister ones either were mixed or were dominated by spruce. Deciduous and mixed forest stands were considered earlier successional stages of the conifer stands (Viereck 1970, 1975 and Hettinger and Janz 1974).

In general, the deciduous and the mixed conifer-deciduous forests, particularly in the closed stands, appeared to represent a relatively poor forage resource for moose and caribou. Steep slopes often associated with these types might also be partially responsible for the low preference by ungulates. Natural records of browsing intensity, as indicated by the structure of paper birch suckers, suggested that these forest types may incur heavy use in severe winters. Skoog (1968) stated that these types were little used by caribou at any time of the year. The frequency of berry-filled bear scats in these types in spring suggested that these areas might be an important food resource for black bears as they come out of winter torpor. The open nature of the understory vegetation, however, made sighting of fecal piles easier in these forest types and, therefore, positively biased any comparison with other types.

- Tundra Types

Tundra communities usually occurring above the present limit of tree growth (Figure 3.1) exhibited approximately 70 identified vascular plant species. Most of the well-vegetated tundra communities occurred on flat to gently sloping areas, while sparser vegetation occurred on steep or rocky terrain. Although aspects of tundra vegetation/ habitat types were variable, four distinct subtypes occurred in areas large enough to map: wet sedge-grass tundra, mesic sedge-grass tundra, herbaceous alpine tundra, and closed mat and cushion communities.

Wet sedge-grass tundra communities occurred at an average elevation of 587 m in wet, depressed areas with poor drainage. They had almost total vegetation cover, with most of it occurring in the ground layer. Nineteen species were identified. The most important herbaceous species were sedges, especially water sedge; bluejoint; and sphagnum as well as several other unidentified mosses. The shrub layer, when it was present, contained scattered individual willows. Wet sedge-grass communities could potentially contain up to 10% cover of erect shrubs. There was usually a large amount of organic matter in these soils, and there was sometimes a thick organic layer on top of mineral soil.

Mesic sedge-grass tundra generally occurred at an average elevation of 1372 m on rolling uplands with well-drained soils. The soils were well-developed in some areas, but in others, the soil occurred as patches alternating with rocks. Nine identified species were identified, with total vegetation cover between half and three-fourths of the area. All vegetation was low in the ground layer, usually less than 30 cm tall. Bigelow sedge was the most common species and accounted for almost half of the total vegetation cover.

Two types of herbaceous alpine tundra occurred in the upper Susitna River basin, although only one herb-sedge occurred in areas large enough to map. Herb-sedge communities occurred at elevations of around 1295 m near the glaciers, particularly the West Fork Glacier, where there existed gentle slopes of fairly well-drained and relatively well-developed soils. These were basically mineral soils but contained about 5% organic matter. Some of the soil may also have developed from loess. Vegetation cover was almost complete, but cover was dispersed evenly among the many species present so that no group of species dominated the area. Because of both time constraints and the complexity of the vegetation, no estimates were made of cover. All vegetation occurred in the ground layer, and approximately 42 identified species were encountered in the one area of herb-sedge tundra visited.

The other type of herbaceous alpine community was found in small, isolated rocky areas that were too small to map or to sample. Small forbs and, sometimes, shrubs grew in the pockets of mineral soil imbedded between the rocks.

The fourth major type of tundra community was the mat and cushion tundra, which was found at high elevations (1013 m) on dry, windy ridges. Vegetation covered about three-fourths of the area and was usually less than 20 to 30 cm tall. Lichens and low mat-forming shrubs, such as dwarf arctic birch, crowberry, bearberry, and bog blueberry, dominated these areas, and soils were shallow and coarse.

Diverse wildlife occupied the high elevation tundra communities in summer. Most obvious were whimbrel, caribou, black and brown bears, ptarmigan, hoary marmots, and arctic ground squirrels. Whimbrels were frequently spotted here in early summer. Bear scat indicated over wintered berries were the major attraction for bears in June, although many squirrel dens were also found which had been excavated by bears. Caribou were more frequently sighted in the sedge-grass tundra than in any other type. In fact, Skoog (1968) considered sedge-grass tundra to be important year-round range for caribou in this region. On the other hand, he considered mat and cushion tundra to be a more important winter forage supply, since its wind-swept condition generally meant it was relatively snow-free.

Wet sedge-grass communities, more common below tree line, showed use by moose where browse was available. Otherwise, these types were more important to wading birds and, where topography allowed dam building, to beaver. In many cases, in fact, the wet sedge-grass vegetation was likely the result of beaver activity.

- General Description of Shrub Types

Shrubland vegetation/habitat types were the most prevalent types in the upper Susitna River basin (Figure 3.1 and Table 3.2). They generally occurred at higher elevations than forest communities but at lower elevations than tundra types. Most areas, particularly the low shrub, were found on extensive, fairly level benches at mid-elevations throughout the upper basin. Less extensive areas, usually tall shrub, were found on steep slopes above the river. While aspects of the shrubland vegetation/habitat types were variable, two main types, tall and low, were found, with each being further divided by the percentage shrub cover into closed and open types. Approximately 65 identified species were encountered in this overall type.

- Tall Shrub Types

Tall shrub communities were dominated by Sitka alder and were found mostly on steep slopes above the river or sometimes above the flat benches at an average elevation of 573 m. Many of these stands were two to four meters tall. Approximately 25 identified species were encountered in the alder stands, whether closed or open.

Along the slopes by the river, these stands frequently occurred as stringers through other vegetation/habitat types. Many areas also contained alder as a ring around a mountain at a certain elevation or in a strip along a river drainage, as at Portage Creek. The closed stands had almost complete vegetation cover, with the ground layer and understory accounting for most of the cover. Portions of some stands were like thickets. Again, alder provided the most cover, with bluejoint and woodland horsetail making up most of the ground layer cover.

Only one open alder stand was visited. It had less vegetation cover than the closed alder sites, and most of the vegetation was in the understory layer. Bluejoint was the most important ground layer species; white spruce was present in both the overstory and understory. This mixture of alder with white spruce indicated that this was probably a successional stand.

Hanson's (1953) description of alder types was similar to those found in the upper Susitna basin in that these thickets occurred on well-drained slopes and varied from one to four meters tall. In many cases, bluejoint was the dominant ground layer species. Hanson (1953) also mentioned Beauverd spiraea and bog blueberry as important species, which was consistent with the findings of the present study. Hanson (1953) also observed birch shrubs as an important species in alder stands, but the alder stands encountered in the upper Susitna River basin did not contain birch shrubs. In contrast, the Susitna stands contained important quantities of woodland horsetail. As in the Susitna study, Hettinger and Janz (1974) likewise observed that alder stands occurred on steeper slopes and older riparian sites.

One alder stand located on a slope of the Susitna canyon (R11E,T29N) was very heavily used by moose. Currant appeared to be highly preferred browse in this stand. Willow was important browse in all stands, and certain individuals of American green alder were heavily browsed.

- Low Shrub Types

As in earlier studies in northwestern (Hanson 1953) and northeastern Alaska (Hettinger and Janz 1974), low shrub vegetation/habitat types were common in the upper Susitna River basin. Low shrub communities were found on the extensive, relatively flat benches where soils were frequently wet and gleyed but, except for those supporting willow types, usually lacking standing water. Average elevation was about 781 m. Over 40 identified species were encountered in this vegetation/habitat type. Subtypes included birch, willow, and a mixture of the two. (Because of the gradations between them, descriptions of the subtypes are very general).

Birch shrub stands were usually dominated by resin birch about 1.0 m tall and contained several other species of low shrubs, especially northern Labrador tea. The most important associated species in these stands was bog blueberry, while mosses and lichens contributed an important amount of cover. In some stands, there was a buildup of soil and debris around the base of each birch shrub clump, creating a large amount of microrelief. Sometimes, the stands were dense, like a thicket, while others had large openings between individual birch shrubs. Scattered black spruce occurred in some stands contributing almost 10% cover. Hence, low shrub and woodland black spruce stands were difficult to distinguish on the ground and on the aerial photographs. The two species of birch shrub, resin and dwarf arctic birch, were sometimes difficult to distinguish based on leaf shape and plant height. Viereck (1966) also commented on this problem.

Willow stands were usually found in wetter areas, frequently with standing water. Diamond willow sometimes formed thickets along small streams at high elevations. Water sedge was the important herbaceous species in these stands. Because of the wetness, these communities were usually less diverse than birch shrub stands. Willows frequently also had soil and debris built up at their bases, with standing or running water in the troughs.

The birch and willow types were further divided into open and closed stands. Both open and closed stands had almost complete vegetation cover. The ground and shrub layers contributed similar amounts of cover in closed stands, while the ground layer alone provided most of the cover in the open communities.

Moreover, shrub layer cover estimates might be high because of problems in estimating cover from the ground, the same problem encountered in the forest types.

Associated species similar to those noted by Hanson (1953) and Hettinger and Janz (1974) were observed in the Susitna area and included northern Labrador tea and bog blueberry. Mountain cranberry, however, while not important in the northwestern part of the state, was important in both northeastern Alaska and in the Susitna region.

Birch shrub communities apparently received moderate use by moose most of the year. It was obvious, however, that stands with more willow were preferred. Indeed, willow stands received greater use than any other vegetation type. Feltleaf willow and diamond willow were heavily utilized in most areas.

Caribou sign, too, were frequent in birch communities. Skoog (1968) found that leaves of resin birch were important food for caribou in summer, and in winter, lichens were important. He found that caribou feed on willows in both spring and fall, and he considered willow stands important to the ecology of caribou. The present study's findings agree with this conclusion, with the exception that, in the Susitna area, apparently only those stands above the rim of the river canyon are important to caribou.

- Herbaceous Types

Two herbaceous types were found in the upper basin. Grasslands dominated by bluejoint were present on level to sloping areas at lower elevations along the river and along the Portage Creek drainage (Figure 3.2). Herbaceous pioneer communities were present on gravel and sand bars that had recently become vegetated. Soils here had little organic matter and often had a large number of cobbles. Pioneer species included horsetails, lupines, and alpine sweetvetch.

- Unvegetated Areas

Three classes of unvegetated areas are depicted on the maps: (Figures 3.1 to 3.4) water, rock, and snow and ice. Lakes and streams were included in the water category. Lakes were generally found along flat benches and ranged in size from small ponds to large lakes, such as Big Lake (approximately 450 ha). Rock incorporated those areas of bedrock or deposited geologic materials supporting little or no vascular vegetation. Rock occurred as outcroppings, either at high elevations or along steep cliffs along the river, or as unconsolidated gravel in newly deposited river bars. The category snow and ice includes permanent snowfields and glaciers. Glaciers and permanent snowfields were most common at the northern end of the study area in the Alaska Range, although some did occur near the southern boundary in the Talkeetna Mountains.

(ii) Downstream Floodplain

An intensive study of the vegetation on the downstream floodplain (Devil Canyon to Delta Islands) was conducted during summer 1981. Tabular presentation of summarized data is not practical; consequently, a general description of each vegetation type encountered is provided below.

- Early Successional Stages

Early successional communities commonly found on the floodplain were dominated by horsetail, horsetail-willow, horsetail-balsam poplar, balsam poplar, or dryas vegetation. Horsetail was generally the first to invade silty or sandy sites. Established horsetail communities had approximately 40% cover by horsetail, 2% by balsam poplar seedlings, and 4% by willow. Bare ground was 47%. Willow and balsam poplar sometimes occurred on newly formed bars but usually did not become established until after the horsetail. The mean density of willow was 22,333 stems/ha, while balsam poplar density was 13,000 stems/ha. Rockier or more gravelly sites tended to have less horsetail cover.

In most cases, alder (thinleaf and Sitka) did not appear until two or three years after the willows and balsam poplar. Its rapid growth, however, made it the highest shrub after two to four years of growth. The average ages of willow, balsam poplar, and alder in early successional stands was 4.5, 6.5, and 3.2 years, respectively.

Dryas was visually dominant on gravelly sites having little silt. Living dryas, however, accounted for only 4% cover. Balsam poplar and dead dryas covered 6% and 7.5% respectively. Dryas is a nitrogen-fixing plant and benefits other species by adding nitrogen to the soil. Even so, vegetation on these sites is of poor form and is slow-growing until sufficient soil is deposited by wind and water, at which point dryas is important for stabilizing these soil deposits. Bare ground equaled 76% of cover; of that percentage, one-third was cobbles.

- Mid-Successional Stages

Deposition of sands and silts, elevating sites above the level of frequent flooding and freeing them from disturbance by ice and fast water, appeared to be necessary for transition of early successional vegetation to mid-successional stages. Mid-successional vegetation was characterized by immature balsam poplar or by thinleaf alder which had developed into tall shrubs or trees.

Total vegetation cover in alder stands averaged 87%. Trees and tall shrubs provided 29% and 46% cover, respectively. Bluejoint grass gave 44% cover; wormwood, 5%. Thinleaf alder dominated the overstory cover (59%), with balsam poplar providing 13%. Age and dimension data indicated that, initially, balsam poplar either lagged behind or was suppressed by alder until late in the mid-successional stage. Alder canopies were typically seven meters high, with protruding balsam poplar averaging eight meters. When balsam poplar did emerge through the alder canopy, it quickly doubled its height to approximately 17 m. Thinleaf alder and balsam poplar averaged 20 and 19 years, respectively. Density of alder >4 m high was 3,557 stems/ha, whereas there were only 414 stems/ha of balsam poplar. Density of browsable willow (>0.4 m high) was 3,333 stems/ha. Highbush cranberry (>0.4 m high) averaged 466 stems/ha. Browsable balsam poplar (>0.4 m, <4 cm dbh) had a density of 1,332 stems/ha.

Balsam poplar dominated the overstory of immature balsam poplar stands, giving 62% cover; thinleaf alder provided 40% cover. Bluejoint provided 23% of the ground cover; perennial forbs gave 9% cover. Total vegetation cover was 91%.

Balsam poplar tree (>4 m height) density was 620 stems/ha. Thinleaf alder density (all sizes) was 5,049 stems/ha. Browsable balsam poplar, willow, and highbush cranberry densities were 433, 400, and 633 stems/ha, respectively.

The average height of immature balsam poplar trees was 17.7 m with an average age of 44 years. Thinleaf alder averaged 6.6 m and 22.3 years. Compared with the ages of trees and tall shrubs in alder stands, immature balsam poplar stands appeared to represent a later phase of the mid-successional stage.

- Late (Mature) Successional Stages

As the balsam poplar stands mature, white spruce may appear in the canopy (a few may become evident as early as the alder stage). Eventually, the balsam poplar becomes decadent, leaving space for development of more balsam poplar or of spruce and birch. The factors responsible for development of the birch-spruce stands versus continuation of the balsam poplar are still unclear. Geographic locations and continuity of stands suggest, however, that birch-spruce forests occur on more stable sites than do mature or decadent balsam poplar forests.

Mature and decadent balsam poplar stands, collectively, averaged 90% total vegetal cover. Trees provided 50% cover, tall shrubs 43%, low shrubs 36%, perennial forbs 23%, and perennial grasses 12%. The average height of balsam poplar trees was 26.4 m, with an average age of 98 years. White spruce growing in these stands averaged 12.6 m and 100 years; thinleaf alder was 7.3 m and 28 years.

The density of balsam poplar trees was 293/ha. White spruce density was less than seven per hectare. Density of thinleaf alder (all sizes) was 4,801 stems/ha. Browsable highbush cranberry density was 21,831 stems/ha. No browsable balsam poplar or willow were present in the understory of mature or decadent balsam poplar stands. Prickly rose, wild currant, and American red raspberry, however, occurred at densities of 12,365; 6,566; and 6,133 stems/ha, respectively.

Birch-spruce communities were characterized in the overstory by 42% cover by paper birch and 12% cover by white spruce. Tall shrubs, predominantly thinleaf alder, accounted for 14% cover. Low shrubs, forbs, and grasses provided 40%, 44%, and 18% cover, respectively. Horsetail, highbush cranberry, prickly rose, and bluejoint were the dominant understory species, providing 30%, 19%, 20%, and 18% cover, respectively.

The average height and apparent age of paper birch trees was 15.3 m and 70 years; 70 years is a low estimate, since unrotted tree trunks were difficult to find. White spruce average 16.2 m and 90 years. Thinleaf alder (>4 m) averaged 5.6 m and 28 years.

The density of paper birch trees was 227/ha. There were 147 white spruce/ha and 1,525 alder (all sizes)/ha. Browsable willow, paper birch, highbush cranberry, and prickly rose had densities of 200; 39; 17,065; and 16,932 stems/ha, respectively. Birch-spruce stands were the most diverse of vegetation types found on the floodplain. There was some evidence that these stands are self-perpetuating. That is, upon overmaturity, the birch overstory falls, making the spruce more susceptible to wind throw and, thereby, allowing a paper birch shrub-alder/highbush cranberry-prickly rose community to become established. The shrub community then advances again to the birch-spruce forest condition. The woody species composition and density of the seral brush phase makes it ideal moose habitat, especially as it is interspersed with the more mature forest.

(iii) Healy to Fairbanks Transmission Corridor

The mapping units presented on Figures 3.5 through 3.7 and in Table 3.4 are based on vegetation characteristics and are named according to Viereck and Dyrness (1980). Since the same classification system was used, transmission corridor mapping units are similar to those used in the upper basin. Deciduous mapping units consist of aspen and/or birch and contain broadleaf vegetation. Complexes of types were used where individual types existed in the field but were too small to separate on the map. Some cover classes may be under estimated, since trees had started losing their leaves when the corridors were flown for field-checking.

The northern transmission corridor consists of three basic sections: Healy to Nenana River, Nenana River to Tanana River, and Tanana River to Fairbanks. The Healy to Nenana River section contains a dissected plateau on the west side, a relatively flat area in the middle, and the Parks Highway and Nenana River to the east. Vegetation along the ridges leading from the plateau is predominantly open spruce, open mixed spruce/deciduous, and open deciduous forest. The flat area is predominantly low shrub with sedge-grass and open and closed spruce types. Except along the streams, most of the spruce trees were relatively short.

The Tanana Flats area extends from just beyond the Nenana River crossing to the Tanana River. This section is characterized by a mosaic of wet vegetation types, including open spruce (usually with larch), low shrub, and wet sedge-grass. Locations of many types appear to be controlled by old stream meanders and drainage patterns. Some patches of deciduous forests also occur. Some portions of the mosaic could be delimited on the map, while others were too intermingled to separate. Similarly, dry streambeds have stringers of other vegetation, such as low shrub, through them, and frequently these could not be delimited on the map.

The section from the Tanana River to Fairbanks passes through rolling hills covered predominantly by open deciduous forest with small areas of spruce, usually in drainages. Some low areas of spruce contained larch (tamarack) but not as much as in the previous section. The woodland mixed patches in this section are generally cutover areas. Many of the closed spruce areas have very short, scrub-like individuals and appear more like a low shrub type.

Species of spruce were not checked on the ground, but stands in low, poorly drained areas were assumed to be black spruce. Individuals in better drained locations may be either species. These species could not be separated confidently without ground-checking many stands. Therefore, this vegetation was mapped spruce.

Most spruce areas between the Tanana River and Fairbanks contain only spruce and little larch, while about half the areas in the Tanana Flats section contain larch as well. Larch was not observed between Healy and the Nenana River. The spruce-larch mixture was easily visible from the air but could not be distinguished on the aerial imagery. The black spruce-larch type, which is confined in Alaska to the interior, is generally found only on wet lowland sites with shallow permafrost (Viereck and Dyrness 1980).

(iv) <u>Willow-Cook Inlet Transmission Corridor</u>

The Willow-Cook Inlet transmission corridor passes through an area dominated, first, by closed birch and mixed conifer-deciduous forests, next, by large wet sedge-grass marshes, and, finally, by open and closed spruce stands (Figures 3.8 and 3.9 and Table 3.5). Forested stands in this particular area of the Susitna valley are characterized by generally good stocking of relatively good quality birch, white spruce, aspen, and balsam poplar. Many of the stands, however, have poor regeneration and have developed a woodland/shrubland or woodland/grassland aspect. Birch is the predominant deciduous species. Localized stands of balsam poplar and aspen are associated with active river floodplain (Willow vicinity) and drier south slopes, respectively.

Wet sedge-grass is the second most dominant vegetation type in this area. Most stands are quite extensive and associated with diverse networks of ponds, lakes, and meandering streams. These areas are generally thought to be unsupportive of other types of vegetation except for scattered islands of black spruce and low shrub along drier margins.

White spruce is dominant in stand composition for most of interior Alaska but occupies a minority position in this part of the Susitna valley. The vegetation map of this corridor is not specific as to spruce species. Most of those areas identified, however, as closed and open spruce and occurring in areas dominated by mixed conifer-deciduous forest are likely white spruce. Spruce stands skirting wet sedge-grass or low shrub areas may be either white or black spruce, while most woodland spruce stands are black spruce.

(c) Floristics

In the upper Susitna River basin and downstream floodplain combined, 254 vascular plant species, occurring in 130 genera in 55 families, were identified. Some collected specimens have yet to be identified, and others need to be verified by experts in the field. This situation is particularly true for the Carex and Salix genera. The families containing the most species were Asteraceae (Compositae), Salicaceae, Rosaceae, Poaceae (Gramineae), Cyperaceae, and Ericaceae. The Salicaceae family was important from the standpoint of canopy cover, wildlife usage, and pioneering on gravel bars, whereas the Asteraceae contributed relatively minor cover. The genus Salix contained 17 species, tentatively, while Carex had 10 species and Saxifraga had nine species.

Seven genera of lichen, which included at least 11 species, were identified, while five taxa of mosses were identified. More extensive work on lichens and mosses would undoubtedly reveal many more species.

The major floristic and botanical feature observed in the study of the upper Susitna River basin was a tendency for lowland and alpine species of the Cook Inlet and coastal region to extend into the Susitna River drainage farther than botanical records indicate. Actually, this finding is to be expected because of the paucity of collections in the upper Susitna River basin previous to this study. A list of those species discovered in the upper basin which are outside of the range reported by Hulten (1968) are listed in Table 3.6.

(d) Wetlands and Aquatic Vegetation

Apparent wetlands within the direct impact areas were classified and mapped according to that system (Cowardin et al. 1979)recently adopted by the U.S. Fish and Wildlife Service (USDI 1980a). Lakes, ponds, rivers, and streams were not specifically classified. This study's estimates of total palustrine wetland acreages (Table 3.7) were extremely liberal, since the wetlands were highly integrated with non-wetlands and because no supporting soil data were available for each of the types. Also, although the mapping was performed using the U.S. Fish and Wildlife Service system, which is acceptable to the U.S. Army Corps of Engineers for permit applications, there are several wetlands mapped under this system which are outside of the Corps' jurisdiction. Isolated wetlands, for example, with an outflow of less than five cubic feet per second are included in Table 3.7 but are not within the Corps' jurisdiction.

Most of the water bodies in the upper basin occur on the upland plateau between the edge of the river canyon and the surrounding mountains.

There are virtually countless numbers of lakes in the large flats of the upper Susitna basin, such as those in the Lake Louise area. Most of the lakes and ponds immediately adjacent to the proposed impoundment area are classified according to Cowardin et al. (1979) as: Lacustrine-Limnetic-Unconsolidated Bottom or Aquatic Bed; or Lacustrine-Littoral-Aquatic Bed or Unconsolidated Bottom.

The dominant "true" aquatic vascular species of the water bodies were: horsetail, bur reed, water sedge, yellow pond lily, mare's tail, and bladderwort. Dominant "bank" or edge species included: horsetail, bluejoint, cotton grass, water sedge, marsh fivefinger, and buckbean. The Susitna River and its fast-flowing tributaries are essentially devoid of aquatic vegetation.

3.2 - Description of Wildlife Resources

(a) Big Game

A variety of methods were employed to study the big game species associated with the Susitna project. Dall sheep was the only species which was studied without the use of radio-telemetry; sheep numbers were determined through the use of aerial surveys. Radio collars were placed on moose (upstream and downstream), caribou, wolf, wolverine, brown bear, and black bear. The resulting telemetry data were utilized to determine movement patterns, home range size, den locations, calving grounds, habitat utilization, and territory size and location.

Aerial census procedures were also employed in the case of moose (upstream and downstream) and caribou. Several different estimating techniques were applied to the census and survey data to determine the distribution and abundance of moose as well as the size of the Nelchina caribou herd.

A variety of physiological and morphometric data were collected on animals during the radio-collaring procedure. This included the analysis of blood and hair samples, teeth (for aging), and the measurement of important morphometric features.

Both bear and wolf dens were visited on the ground and their characteristics recorded. Two wolf dens were intensively monitored to determine daily activity patterns and the reaction of denning wolves to various types of human disturbance. Wolf scats were also collected from den and rendezvous sites and analyzed for food habits information. The Jay Creek mineral lick, used by Dall sheep, was visited to determine the extent of usage and to collect soil samples for mineral analysis.

A detailed survey of browse availability and utilization was conducted along the lower Susitna River from Devil Canyon to the Delta Islands. This entailed determining the relative amount of five key browse species that were available along numerous sampling transects in addition to the percentage of each species that had been utilized by moose.

The common and scientific names of the big game species are presented on Table 3.8.

(i) Moose - Downstream

Because the ADF&G Phase I report on downstream moose studies was not yet available, the following description of downstream moose is based on a compilation of information taken from previous ADF&G Susitna reports. As a result, the conclusions should be viewed as preliminary, and in some cases obvious voids exist in the data. The information that was available, however, is sufficient to develop at least a preliminary understanding of the moose resource associated with the lower Susitna River.

Prior to 1930, few moose were found in the Susitna Valley (Spencer and Chatelain 1953). At that time, moose likely utilized riparian habitats and what few browse species were available in the mature spruce-hardwood forest. It wasn't until man-caused fires and clearing of land during and after railroad construction created prime moose habitat that the moose population rapidly increased. In the early 1950's the Susitna Valley was termed "probably the most productive moose habitat in the [Alaska] Territory" (Chatelain 1951). Rausch (1958) stated that the period of peak moose abundance along the railroad between Houston and Talkeetna was February and that movement from the foothills to the railroad tracks was basically seasonal and influenced, but not necessarily caused, by deep snow. The moose population presently remains at relatively high levels.

For the Susitna studies, a total of 39 moose over a two-year period were radio-collared in an attempt to determine the movement patterns of and timing of riverine use by moose that frequent the lower Susitna River. Of these 39 moose, 10 were collared in 1980 and 29 in 1981. Some moose slipped their collars, and one was killed by a hunter, which left a total of 35 moose with functional collars during the spring of 1981. These 35 moose had been captured in the following general locations: Devil Canyon to Gold Creek - 4, Gold Creek to Talkeetna - 6, Talkeetna to Sunshine Bridge - 6, Montana Creek to Sheep Creek Slough - 9, and Kashwitna River to Delta Islands - 10. Of these 35 moose, eight were males ranging in age from 2 to 11 years, and 27 were females ranging in age from 3 to 21 years.

- Distribution and Movement Patterns

Due to differences in the number of radio-collared moose that were monitored in 1980 (6) versus 1981 (35) and the absence of a summarizing report from ADF&G, the following discussion of moose movements and distribution is broken down into the two study periods for which data are presently available: 1980 and the first 7 months of 1981.

o 1980 Study Period

During 1980, a total of 131 radio relocations were made; of these 89 (68%) were visual observations of the moose. All three types of migratory patterns [as presented by LeResche (1974)] were found in the study area: Type A, resident; Type B, migratory between two ranges; and Type C, migratory among three ranges. The bulls were either Type A or Type C. Each of the three collared cows exhibited a different type of migratory behavior.

Home range size and migration distances of moose in the area studied were likely intermediate to those found for moose in other parts of Alaska or North America. This characteristic is a function of physiography, since the availability of all life requisites between an area just west of the Susitna River eastward to the Talkeetna Mountain benches makes longer moose movements unnecessary.

From observations of the moose that winter on the river below Talkeetna, it was learned that some calve, summer, rut, and possibly winter in the flats west of the Susitna; some calve, summer, rut, and possibly winter in the forest between the river and the mountains; others spend spring, summer, fall, and possibly winter in the western benches and drainages of the Talkeetna Mountains.

Several rutting areas were documented. These were found deep into the creek and river drainages of the Talkeetna Mountains and on the benchland near timberline at the mouths of these canyons. Rutting bulls in the lowlands aggregated less and were frequently alone or in small groups of 2 to 5 moose.

No specific calving areas were recorded, but cows appeared to calve frequently on river islands. On boat trips up and down river in late May and in June, it was obvious that a fair although unknown number of cows had done so. Four cows with newborn calves were observed along the river, and the tracks of several others were seen on mud banks of islands.

The movement of moose on the river floodplain in late summer and early fall was less certain. In fall it appeared (from overflights but no quantitative data collection) that moose did not remain on the river floodplain. ADF&G biologists, however, observed them crossing the river, and hunter success along the river in September also indicated that moose were near the river in fall.

In general the home and seasonal range sizes were quite varied. Because there were some Type A moose in the study group, home ranges were as small as approximately 65 km^2 (25 mi^2). Seasonal ranges were often smaller. Type C moose had home ranges at least as large as 233 km^2 (90 mi^2). The timing and distances of migration were equally as varied. (For example, one cow moved from her summering to rutting area in early August, while another did so in late September). The longest distance traveled between summering and rutting areas was 64 km (40 mi).

o <u>1981 Study Period (January through July)</u>

Not long after the moose were captured and radio-collared, they began to emigrate from the river basin. By the end of April 1981, only four of the 35 radio-collared moose were still within the confines of the river banks.

On 28 April, 1981, of the 25 moose radio-collared within the river basin south of Talkeetna, 20 had moved to the west of the Susitna River, two were still in the river basin and only three were to the east of the river.

Of the 19 moose captured and radio-collared on the Susitna between Talkeetna and the Delta Islands, several in the Delta Island area itself remained within the confines of the river. Three of these spent a considerable amount of time on riverine islands; one of these three, which had been within the confines of the river since it was collared, moved off the river to the west only during the last week of July. Most others between Talkeetna and the Delta Islands left the river and did not return to it during calving. Only one of the 19 was east of the Susitna River at the end of July, and it was only during the last week of July that this moose moved to that location.

Moose captured on the Susitna River north of Talkeetna also left the river shortly after being radio-collared, but unlike those captured below Talkeetna, these appeared to return to the river between late May and early June, a time when calving normally occurs. Two cow moose who are residents in an area north of Talkeetna made relatively long forays [24-40 km (15-25 mi)] into apparently new range. Within a week or so, they were back in their usual range.

Several of the moose that have been monitored for more than one year have visited locations where they were found the last year. Though some distances traversed were great [25-40 km (15-25 mi)], relocations within the same hectare or so were not uncommon.

These data suggest that, for the 1980-1981 winter of relatively little snowfall, most of the moose using the riparian habitat came from the generally flat land to the west and that, because great quantities of snow did not accumulate in the Talkeetna Mountains, moose from the mountain area did not migrate to the river basin. It is also possible that migrant moose from the Talkeetna Mountains did winter in the river basin but simply spent spring and summer to the west of the Susitna before returning to the mountainous habitat in the fall.

For moose south of Talkeetna, movements of 16-24 km (10-15 mi) to the west of the river basin were not uncommon. These patterns of movement may be related to the depth of snow and the patterns of its disappearance in early spring. Areas to the west of the Susitna appeared to become snowfree before those to the east. This was particularly evident on the small knobs that rise to the elevations slightly above the general terrain and muskeg in the area. These higher sites are slightly drier and support birch in amounts equal to that of spruce. It is assumed that the disappearance of snow accelerated plant phenology on the west side of the river; it may have, in turn, attracted moose from the riparian habitats to the east.

For moose north of Talkeetna, movements to areas more than 5 km (3 mi) from the river have not occurred. Even in a year of relatively little snowfall, areas to the north of Talkeetna along the Susitna had an accumulation of 0.6 m (2 ft) or more. Because such snow depths presumably discourage lengthy movements by moose and also because forage species in that area are more confined to the riparian habitats, resident moose were relatively sedentary compared to those south of Talkeetna.

- Habitat Use

A preliminary consideration of the data revealed that during 1980, climax mixed birch/spruce (of high or medium density) was the habitat in which moose were observed in 46% of the observations. The remaining observations were made in a variety of habitats including black spruce, muskeg bogs, alder/willow, willow, alder, cottonwood/spruce and bluejoint fields.

It was surprising to find moose making so much use of mature conifer/hardwood vegetation, but an obvious bias in technique may account for the data. Most flights, and therefore most observations, were made from mid-morning to mid-afternoon. This was a time when most moose were bedded down. They may have eaten in a different habitat type earlier in the day or after the observation, but for ruminating they sought more protective cover.

On the other hand, on two separate radio-locating flights (18 June and 22 July) an unusual number of moose were observed in open muskeg/meadow habitats. It could be that particular type(s) of aquatic/semi-aquatic vegetation became available at those times and attracted moose into the relatively open habitats. Circumstantial evidence provides another possible explanation for moose using the open habitats. Several moose were observed running and shaking their necks and heads. One moose, up to its shoulders in water, was observed behaving in a similar manner. These behaviors appeared to be the result of insect harassment, and it is possible that moose were seeking relief in the open habitats where wind currents move more rapidly because of the lack of interfering vegetation.

In late May, several small groupings of moose were observed in areas on riverine islands where beavers had cut down mature cottonwood trees. It appeared that the moose had gathered to feed on the leaves and buds in the crown portions of the downed trees. Similar situations of temporary food availability probably arise when spring flood waters erode river and island banks and undermine the root systems of mature trees so they become top heavy, fall, and become available to moose.

- Food Habits

Only one study has been conducted in the vicinity of the study area to determine what moose eat. Rumen samples from railroad killed moose were collected by Rausch in 1957 and analyzed by Shepherd (1958). From 122 samples, 17 different food items were identified. Willow, birch and aspen comprised 97% of the identifiable material. These moose probably had been feeding in mixed birch/spruce habitats in several successional stages near the railroad tracks where they were killed. Along the river, few birch and no aspen were found and, therefore, moose using the river would have a different diet than that indicated by the above study.

- Browse Availability and Utilization

In 1980, in the overall study area, dense-climax cottonwood/ spruce (13.1%) and sparse-low cottonwood/willow/alder (12.3%) were the most frequently encountered habitats. In the Sheep Creek Study Site, dense-medium and dense-tall cottonwood/ willow/alder (18.4% and 15.9%, respectively) were the most abundant habitat types.

A mean of 1.4 browse plants/m^2 was recorded for all habitat types in the overall study area, and many habitats had browse densities close to that value. Browse species were most utilized in equisetum/willow (49.2%) and medium-tall cottonwood/willow/ alder (36.4%) habitats and least utilized in medium-dense climax cottonwood/spruce (6.9%) and sparse-climax birch/spruce (4.0%).

Willow and cottonwood occurred most frequently in habitats that were in early successional stages of cottonwood/willow/alder. The percentages of utilization of these two species were: willow - 36.5%; cottonwood - 16.2%. The utilization of each was greatest, however, in habitats in which it less frequently occurred. Birch was seldom found on floodplain habitats, but, where it did occur near the river, it was well utilized (26.9%). Highbush cranberry and rose were found most in tall or climax habitats. Mean densities for highbush cranberry (1.1/m^2) and rose (0.9/m^2) were higher than those for willow (0.7/m^2) and cottonwood (0.6/m^2). The mean utilization of highbush cranberry (15.9%) was similar to that of cottonwood (16.2%) but both highbush cranberry and rose had lower percentages of utilizaion than did willow (36.5%).

On the Sheep Creek Study Site, as in the overall study area, about 20% of available browse plants were utilized. Dense-medium cottonwood/willow/alder contained the greatest density (2.6/m^2) of browse plants, but medium-tall cottonwood/willow/alder had the highest percentage of utilization (35.2%) of its available browse.

Approximately one-third of the available willow on the Sheep Creek Study Site was utilized by moose. Willow was most dense (2.4 plants/m^2) in dense-medium cottonwood/alder/willow but utilized most (70.3%) in medium-climax cottonwood/willow/alder. Cottonwood was less dense than willow (1.2/m^2 vs 1.6/m^2) and utilized much less (only 8.5%). No birch was found on the Sheep Creek Study Site. As in the overall study area, highbush cranberry and rose were most abundant in climax type habitats. There were mean densities of 1.5 and 1.0 plants/m^2 for the two species, respectively. Highbush cranberry was utilized twice as much as rose (16.3% vs 8.3%).

General observations indicated that alder was seldom browsed by moose, but in some localities a small alder clump could be heavily browsed. Some islands with good moose browse apparently are not used by moose over winter: moose sign indicated heavy use of some islands in the past but no use at the time of observation.

(ii) Moose - Upstream

The history of the Game Management Unit (GMU) 13 moose population has been described by Rausch (1969), Bishop and Rausch (1974), McIlroy (1974), and Ballard and Taylor (1980). Briefly, the GMU 13 moose population increased during the 1950's and peaked about 1960. After the severe winter of 1961-62, the population began declining and continued to decline with the severe winters occurring in 1965-66, 1971-72, and 1978-79. Fall calf-cow ratios, in addition to nearly all other population ratios, declined sharply and reached a record low for the basin in 1975. Although the decline was attributed to a variety of factors, predation by wolves was suspected of preventing the moose population from recovering during mild winters.

From 11 through 23 April 1980, 40 adult moose (37 females and three males) were captured and radio-collared in the Susitna moose study area (Figure 3.10). Three of these moose represented animals that had been radio-collared during previous studies. During March and May 1981, in an effort to provide additional movement information on portions of the Susitna study area not adequately sampled in 1980, an additional 34 moose (18 adults and 16 calves) were captured and radio-collared.

- Population Biology

o Age Structure

The average age of the 37 cow moose captured in spring 1980 was 9.4 years (s.d.=3.8), while the three bulls averaged 4.3 years (s.d.=0.6). The 12 adult cows captured in 1981 averaged 7.6 years (s.d.=2.9). Mean ages of cow moose tagged in the upper Susitna River basin in 1976 and 1977 (Ballard and Taylor 1980) were compared with those captured in 1980 and were found to be significantly younger ($P<0.05$).

- Pregnancy Rates

Of the 37 cow moose captured and examined in April 1980, 23 (62%) were determined to be pregnant, while in 1981, 11 of 14 (79%) were pregnant. Observations of the radio-collared cows following capture in 1980, however, revealed that four cows which had been diagnosed as not pregnant subsequently had calves. Therefore, the actual pregnancy rate for 1980 was at least 73% and may have been higher. The 1980 and 1981 pregnancy rates may, in actuality, have been comparable to the 88% observed in 1977, which was similar to rates determined elsewhere in Alaska (Ballard and Taylor 1980).

- Calf Production and Survival

Calf moose comprised 13% of the moose observed during the distribution survey in March 1980. This low calf percentage reflects poor calf survival during 1979-80, probably a result of predation (both bear and wolf) and perhaps some winter starvation. Farther upstream, above the Denali Highway, where both bear and wolf densities had been experimentally lowered (Ballard et al. 1980), calf moose comprised 33% of the moose counted in late May 1980, reflecting increased calf survival because of the lower predator densities. During 1980, of 32 cow moose radio-collared during the Susitna studies, 19 were subsequently observed with 30 calves for an observed calving rate of 0.94 calves/cow. Fifty-eight percent of the cows producing calves had twins. These rates of calf production were quite comparable with those observed in 1977 and 1978 (Ballard and Tobey 1981).

Mortality of newborn moose calves in 1980 was high. By 1 August 1980, 23 (77%) of the calves known to be associated with radio-collared cows were missing. Rates of 1980 calf loss were compared with those observed in 1977 and 1978. Although causes of moose calf mortality were not determined in 1980, the pattern of loss was quite similar to that observed in 1977 and 1978 when predation by brown bears was responsible for 79% of the calf deaths (Ballard et al. 1981a). Calf mortality appeared to continue at a high level in 1981 as well.

During the 1981 calving season, radio-collared moose were not monitored intensively enough to document parturition dates and rates of calf loss. Of the 46 sexually mature cow moose which could have produced calves, however, only 20 (43.5%) were observed with calves. Four (20%) produced twins. The calving rate for known producers was 1.2 calves/cow. Of the 24 known calves, 14 (58.3%) were missing by 28 July. This pattern of calf loss is quite similar to that in 1977, 1978, and 1980, when predation by bears accounted for most of the losses. Overall calf survival, however, may have improved in 1981.

o Condition Assessment and Carrying Capacity

Criteria developed by Franzmann and LeResche (1978) were utilized to assess the physical status of Susitna study area moose. Analyses performed on moose tagged in 1975 and 1977 had suggested that Susitna moose were in good physical condition relative to other Alaskan moose populations (Ballard and Taylor 1980). Adult moose examined in spring 1979, however, had the lowest blood parameters of any moose examined in GMU 13 and were judged to be nutritionally stressed because of the severity of the winter of 1978-79 (op. cit.).

Blood values were determined for 34 individual moose sampled in April 1980 and 13 adults sampled in 1981. The blood data collected in 1980 and 1981 suggested that over the previous few years, the physical condition of moose had deteriorated to some degree. One reason for their condition may have been poor quality habitat. It is generally accepted that good moose habitat is closely linked with the frequency of wildfire. Since there have not been any sizeable wildlfires in GMU 13 for at least 30 to 35 years (Ballard and Taylor 1980), a gradual deterioration in habitat quality may be occurring. Even though the quality or condition of moose habitat may be gradually deteriorating, however, available evidence suggests that the population is not yet at carrying capacity.

Although no formal browsing studies have been conducted in GMU 13, casual observations along the Susitna River and elsewhere in the unit suggest that the browsing intensity may be similar to that in Mount McKinley National Park (Denali National Park and Preserve) as reported by Wolf and Cowling (1981). Even at a heavy level of browsing intensity, however, the McKinley moose herd does not appear to be limited by range conditions but, instead, by predation (op. cit.). Wolf and Cowling (1981) speculated that the McKinley herd could increase an additional 10-15% before reaching carrying capacity. It is possible that moose in GMU 13 are also below range carrying capacity, as evidenced by moose population increases following reductions in predator densities.

Studies of moose calf mortality in the upper Susitna River basin north of the Denali Highway suggested that predation by bears was responsible for 79% of the early calf losses (Ballard et al. 1981a). A bear reduction program reduced early neonatal losses from an estimated 55% to an estimated 9% (Ballard et al. 1981b).

On the other hand, if the available moose range were at carrying capacity, a significant number of calves would have been expected to have died from starvation during the first winter following the bear reduction program. Such was not the case; the first and second year winter mortality was only 6% and 4%, respectively (op. cit.). It can be inferred from that increase in the moose population that the population is not limited, at least on a short-term basis, by range conditions. Further, it is possible that a 15% increase in the moose population to reach carrying capacity is actually minimal for that area because the bear reduction program alone may have allowed the population to increase by as much as 19%. In summary, it appears that although blood data suggested that range quality in the Susitna study area has deteriorated to an undetermined degree, other evidence suggests that the range could support a larger number of moose.

o <u>Population Estimates</u>

Three previously established moose census areas are located within the Susitna study area. These are count areas 6, 7, and 14. Surveys of these count areas were used to generate an estimate of the number of moose present in the Susitna study area during fall 1980.

Count areas 7 and 14 (Fig. 3.11) were intensively censused from 5 through 8 November 1980. A total of 743 moose were censused within 26 sample areas, which amounted to 948 km^2 or 39% of the total of 2,448 km^2 for count areas 7 and 14. Based on the 26 sample areas, 35% of the 2,448 km^2 census area was classified as low moose density; 38%, as medium moose density and 27%, as high moose density. Also, based upon census data, each stratification was estimated to contain the following number of moose/km^2: low--0.434, medium--0.713 and high--1.439. Thus, the estimated fall population for count areas 7 and 14 was 1,986 $\pm$ 371 (90% CI).

Next, in an effort to generate a sightability correction factor, portions of 10 sample areas within count areas 7 and 14 were randomly chosen and were resurveyed at a greater sampling intensity. With the additional surveying effort, it was estimated that during the census, approximately 98% of the moose were being observed yielding a correction factor of 1.03. Therefore, the adjusted population estimate for count areas 7 and 14 was 2,046 $\pm$ 382 (90 % CI).

On 29 November, in an attempt to provide a gross fall population estimate for the entire study area, those portions of the Susitna study area which had not been censused were stratified. A total of 179 moose was observed during 3.6 hours of surveying time. The area stratified amounted to 2,150 km^2 of which 1,456 km^2 were classified as low moose density; 663 km^2, as medium moose density; and only 31 km^2, as high moose density. The area covered by each stratum was then multiplied by the individual density estimates derived for count areas 7 and 14 to derive a crude population estimate of 1,151 moose. This figure, added to the population estimate for count areas 7 and 14, resulted in an estimated population in early November 1980 for the study area west of the Susitna and Oshetna rivers of approximately 3,197 moose.

Using methods similar to those described in the preceding paragraph, relative moose densities in count area 6 (Figure 3.11) were also stratified. This procedure was undertaken because count area 6 has a migratory population of moose which overwinter in the vicinity of the mouth of the Oshetna River. Of the 1,217 km^2 stratified, 528 km^2 (43%) were classified as low moose density, 536 km^2 (44%) were classified as medium moose density and 153 km^2 (13%) were classified as high moose density. Extrapolating the average moose densities per stratum derived for count areas 7 and 14 to the area of each stratum in count area 6, it was grossly estimated that the fall moose population for count area 6 was 830 animals.

o Movement Pattern

Between October 1976 and mid-August 1981, over 2,700 locations were obtained on approximately 207 moose of both sex and all age classes in the Susitna and Nelchina River basins of south-central Alaska (Ballard and Taylor 1980; Ballard et al. 1981a, 1981b). Radio-collared moose exhibited all of the types of movements described by LeResche (1974) for moose in North America. For purposes of this report, however, they could basically be divided into two groups, sedentary and migratory. A sedentary moose is defined as one which confines its movements to a relatively small area and where portions of the summer and winter range overlap. A migratory moose, on the other hand, is defined as one with a relatively large home range with non-overlapping summer and winter home ranges. The latter type of moose often moves from 16 to 93 km between seasonal home ranges.

In earlier moose movement studies (Ballard and Taylor 1980, Ballard et al. 1981a), it was suggested that most of the migratory moose were located from Jay Creek and eastward. Additional information collected in 1981 suggested that a large number of migratory moose also occur in the Watana Creek area.

Movement patterns of most moose examined from 1976 through 1981 appeared to approximate the drainage patterns of the tributaries of the mainstem rivers in the area. Consequently, most movements in the upper Susitna River basin involve a north-south pattern.

From October 1976 through December 1981, 33 radio-collared moose crossed the Susitna River a minimum of 73 occasions. Of the 75 moose captured in 1980 and 1981, 15 crossed the river in the area of the proposed impoundments a minimum of 40 times. Of the 40 river crossings, all occurred during May through November. Distribution of the crossings was as follows: May - 20%, June - 7.5%, July - 12.5%, August - 12.5%, September - 25%, October - 12.5%, and November - 10%.

On 24 March 1981, the Susitna River was censused for moose crossings from the mouth of Portage Creek to the mouth of the Tyone River. A total of 73 sets of moose tracks was observed crossing the river on this date. Based upon locations of radio-collared moose and upon track sightings, crossings of the Susitna River appear to occur throughout the proposed impoundment area but appear to be relatively concentrated in the following areas: from the mouth of Fog Creek to the area opposite Stephan Lake, from the mouth of Deadman Creek upstream for approximately eight kilometers, from Watana Creek to Jay Creek, and from Goose Creek upstream to Clearwater Creek.

o Home Range

Home ranges of radio-collared moose were relatively large, averaging 224.2 km^2 and ranging from 3.8 km^2 to 2,011 km^2. LeResche (1974) reported that, regardless of how far a moose moved between seasons, seasonal home ranges of moose were consistently small. A preliminary analysis of seasonal home range data where migration points were excluded suggested that moose in GMU 13 have significantly larger home ranges than those reported in the literature (Ballard and Taylor 1980). It is suspected that a more thorough analysis of these data will demonstrate that seasonal home ranges are substantially larger than reported earlier (op. cit.). Ballard et. al. (1980) and Ballard and Taylor (1980) compared the summer home ranges of cow moose accompanied by calves with those reported elsewhere in North America and found that ranges of GMU 13 moose were substantially larger. They also determined that predator densities influenced the movements and, subsequently, the home-range sizes of the cow-calf pairs. The large seasonal and the total home-range sizes reported in the present study probably reflect an adaptation by moose to exploit habitats which are only available on a seasonal basis.

- Distribution

o Fall

The general distribution of moose in November 1980 was reflected in stratification surveys conducted as part of a census. Both count areas 7 and 14 were stratified from fixed-wing aircraft from 2 through 4 November 1980. The Devil Canyon area was stratified on 29 November and count area 6 on 9 November 1980.

Based upon relative differences in moose tracks, numbers of moose observed, and homogeneity of habitat types, moose densities were stratified as high, medium, and low. Distribution patterns exhibited by radio-collared moose (Figure 3.11) were similar to those derived from the survey; generally moose densities were greater in upland regions located away from the proposed impoundment areas west of Jay Creek but were greater closer to the Watana impoundment east of Jay and Kosina creeks because of the proximity of upland areas.

- Winter

A moose winter distribution survey was conducted from 4 through 25 March 1980 in portions of the Susitna River basin containing subpopulations of moose which could be influenced by the proposed project. In 26.1 hours of survey effort, 1,086 moose were counted. Undoubtedly, not all moose in the area were observed during this cursory survey. General distribution of observed moose is depicted in Figure 3.12.

Approximately 60 moose (6%) were observed at elevations which would be inundated at normal pool level. Only two moose were observed in the Devil Canyon impoundment area; the remainder were in the Watana impoundment, with 38 of these 58 moose (66%) concentrated at Watana Creek.

Although relatively few moose were observed along the Susitna River bottomlands, large concentrations of tracks indicated that moose had utilized these areas earlier in the winter. It is likely that heavy cover in these low areas decreased the likelihood of observing moose which were present. Among these bottomland areas, large track concentrations were observed at the mouths of Watana Lake, Watana Creek, Jay Creek, and the Oshetna River. Tracks and subjective observations suggested that most moose had moved from the lowland areas which were covered by relatively deep snow to higher windswept elevations, where snow cover was nearly absent.

On 26 and 28 March 1981, the Devil Canyon and Watana impoundment areas were intensively censused in an attempt to assess the number of moose that might be displaced during winter by the reservoirs. In the Devil Canyon impoundment (144 km^2), 28 moose (0.19 moose/km^2) were observed. It was estimated that 94% of the moose had been counted, yielding a correction factor of 1.06. Thus, the adjusted population estimate for the Devil Canyon impoundment was 30 moose (0.21 moose/km^2).

In the Watana impoundment (188 km^2), 42 moose (0.22 moose/km^2) were counted. The estimate of 42 moose within the Watana impoundment area was not adjusted. The low numbers of moose occupying the two impoundments was not surprising since radio-locations suggested that during this relatively mild winter, most moose were located away from the impoundment.

- Calving Areas

To determine if calving concentration areas occurred in or adjacent to the proposed impoundment areas, all observations of radio-collared moose between 15 May and 15 June 1977 through 1981 were plotted. Although moose parturition apparently occurs in scattered areas throughout GMU 13, several areas of concentration were evident. They included the region around Coal Creek and its tributaries, along and near the Susitna

River from the mouth of Tyone River downstream to a point several miles downstream from Clarence Lake Creek, from Jay Creek to Watana Creek, at the mouths of Deadman and Tsusena creeks, from Fog Creek to Stephan Lake, and across the Susitna at Fog Creek to Devil Creek.

- Habitat Utilization

  o Elevation

Average monthly elevations at which radio-collared moose were located from October 1976 through mid-August 1981 are summarized in Table 3.9. Generally, moose occupied relatively low elevations during late spring and early summer ($\bar{x}$=785 m for April and 805 m for May). As summer progressed, moose generally moved to higher elevations, with the highest average elevation occurring in December ($\bar{x}$=901 m). Statistical comparisons suggest that many of the average monthly values were quite similar but there were significant differences between winter and summer elevations.

In earlier studies of moose movements in GMU 13, both VanBallenberghe (1978) and Ballard and Taylor (1980) described the altitudinal movements of moose: "During summer these moose occupied areas at about 2500-3000 ft [762-914 m] elevation, and during winter habitat types at the 1800-2200 ft [548-761 m] elevation were utilized." The analyses provided in Table 3.9 do not fit this pattern. Summer elevational use appears to be quite similar, but winter elevational use during this study was different. Mean monthly elevations from December through March ranged from 818 m to 900 m, which were considerably higher than the 549 m-671 m elevations reported in earlier studies. Moreover, although portions of the data used for this analysis were derived from the earlier movements studies reported by Ballard and Taylor (1980), over half of the locations were obtained during 1980 and 1981. From October 1976 through mid-August 1981, with the exception of 1978-79, winters were relatively mild in terms of total snow depth. Since during the winter of 1978-79, only a few radio-locations were obtained, the combined data primarily represents the altitudinal movements of moose during relatively mild winters.

The altitudinal movements depicted in this study suggest that moose occupied relatively high elevations during winter. These results conflict somewhat with the commonly accepted theory that moose use lowland elevations during winter. It is generally assumed that deep snow drives moose from the highlands, forcing them to concentrate on low elevation winter range. This type of movement pattern was not prevalent during this study. It is possible that during this study, snow depths at higher elevations were reduced because of high winds and temperature inversions. This circumstance would have resulted in a greater availability of browse at the higher elevations than at lower elevations, where snow depths were likely to be greater. Consequently, moose were not forced to concentrate on low elevation winter range, which would only be used when upland snow depths become excessive. Therefore, moose winter movement and concentration patterns exhibited during this study may only reflect those of mild winters.

o Vegetation Types

Vegetation types dominated by spruce comprised the most frequently used habitats, with sparse and medium density-medium height black spruce accounting for 35% of the total observations. This finding was not particularly surprising since the classification system was based on overstory vegetation and the "spruce-moose" association is well recognized. In the upper Susitna drainage basin, spruce and shrub types combined comprise 59% of the total area but during the study received over 90% year-round use by moose.

Use of upland shrub-willow habitat types corresponded with observed elevational movements of moose. Use of this habitat type was at its lowest during the month of April, when moose were at relatively low elevations just prior to calving. Use gradually increased through summer, reaching a plateau of 43% in October and remaining at a relatively high use percentage through February. As mentioned earlier, it was suspected that the use of relatively high elevations from late fall through winter may have been the result of mild winters.

During calving in May, sparse and medium dense-medium height spruce habitats were utilized by moose. We suspect these lower elevational types are selected by cow moose because of their value as escape cover and because new foliage emerges earlier than that of other vegetation types. Based on aerial observations, several habitat types, such as birch, alder, and several spruce types did not appear to be selected by moose.

(iii) Caribou

The Nelchina caribou herd, one of 22 herds in Alaska (Davis 1978), is important to sport and subsistence hunters because of its size and proximity to population centers in southcentral Alaska. Currently, the Nelchina herd contains about 6% of the total statewide caribou population (325,000). As a measure of the interest in caribou, between 1954 and 1981, over 100,000 Nelchina caribou were killed by hunters (Skoog 1968; unpublished data Alaska Department of Fish and Game). Another indication of hunter interest is that in 1981, 6,662 people applied for 1,600 permits to hunt for Nelchina caribou.

- Distribution and Movement Patterns

The herd occupies an area of approximately 51,800 km^2 (20,000 mi^2) bounded by four mountain ranges: the Alaska Range to the north, the Wrangell Mountains on the east, the Chugach Mountains to the south, and the Talkeetna Mountains to the west (Hemming 1971). The Nelchina range contains a variety of habitats, from spruce-covered lowlands to steep, barren mountains. Human development is largely limited to the peripheries of the Nelchina range and consists primarily of the Alaska Railroad, Parks Highway, Denali Highway, Richardson Highway, trans-Alaskan Pipeline, and Glenn Highway.

Use of the Nelchina range during this study by radio-collared caribou from the main herd is portrayed by Figure 3.13. Two major areas that were used extensively at times in the past received minimal use during the study period. These areas were the northwestern portion of the range, including drainages of the Chulitna, Nenana, and upper Susitna rivers and the far eastern portion of the range, including the Mentasta and Wrangell Mountains.

During the past 30 years, Nelchina caribou have used numerous winter ranges from the Nenana-Yanert Fork drainages to the Talkeetna River and east to the Mentasta and Wrangell Mountains (Skoog 1968, Hemming 1971). During the winter of 1980-81, the Nelchina herd wintered on the Lake Louise Flat and the middle portion of the Gakona and Chistochina River drainages. Considerable use of the western foothills of the Alphabet Hills was also noted.

The primary migratory route from winter range on the Lake Louise Flat to the calving grounds in the eastern Talkeetna Mountains was westward across the flat from Crosswind Lake and Lake Louise into the Talkeetna Mountains on a front from Lone Butte to Kosina Creek.

It appeared that many animals used the frozen Susitna River between the Oshetna River and Kosina Creek as a travel route in the spring of 1981. In the spring of 1980, one radio-collared animal moved south and crossed the Susitna River near the mouth of Deadman Creek. Many animals historically used this route to the calving grounds after wintering in upper Susitna-Nenana drainages (Skoog 1968).

Since 1949, the first year for which records are available, Nelchina caribou have utilized an area of about 2,590 km^2 (1,000 mi^2) in the northern Talkeetna Mountains for calving (Skoog 1968, Hemming 1971, Bos 1974). While the precise areas utilized have varied, calving has taken place between Fog Lakes and the Little Nelchina River at about 900 m and 1400 m elevation.

Observations during the calving period (15 May - 10 June of 1980 and 1981) indicated the calving activities occurred in drainages of Kosina Creek, Goose Creek, Black River and Oshetna River (Figure 3.14). Observations of females outside this area during the calving period were of nonbreeders which reached the calving grounds later in the calving period. During the calving period, radio-collared Nelchina bulls were found in a wide variety of locations mostly in transit to summer ranges.

Historically, the female-calf segment of the Nelchina herd has primarily summered in two areas: the eastern Talkeetna Mountains and across the Susitna River in the Brushkana, Butte, Deadman, Watana, Jay, and Coal creeks complex (Skoog 1968, Hemming 1971). In most years between 1950 and 1973, varying proportions of the female-calf segment (ranging from 0-100%) crossed the Susitna River from the calving grounds to the summer range on the north side of the river. The female-calf segment of the Nelchina herd spent the summer period (11 June through 31 July) of both 1980 and 1981 in the northern and eastern slopes of the Talkeetna Mountains. Summering radio-collared males were found in many locations in the high country of the Nelchina basin.

In both 1980 and 1981, autumn (1 August through 31 September) was a time of considerable movement and dispersal by both cows and bulls. It appeared that, compared to the obvious segregation in June and July, considerable mingling of the sexes occurred. In mid- to late August 1980 a portion of the main summering concentrations moved out of the Talkeetna Mountains onto the western portion of the Lake Louise Flat, and in some cases, into the Alphabet Hills. Through September, the distribution remained relatively stable, with the main herd divided between the northeastern Talkeetna Mountains, the Lake Louise Flat, and the Alphabet Hills.

Historically, Nelchina caribou have rutted in a number of locations; however, Lake Louise Flat and the eastern Talkeetna Mountains have been the most widely used. The Deadman Lake area was also used extensively during the rut in many of the years when major segments of the herd summered in the area. During both 1980 and 1981, considerable movement from west to east occurred during the rut. In both years, a portion of the herd was in the eastern foothills of the Talkeetna Mountains in early October, but by mid-October, most animals were in the northern Lake Louise Flat. In 1980, a small group remained in the Slide Mountain area. In 1981, on the other hand, a third to a half of the herd had crossed the Richardson Highway and trans-Alaskan pipeline by 10 October.

- <u>Subherds</u>

Radio-collars were placed on animals in three suspected subherds, one in the area of the Talkeetna River, the second in the Chunilna Hills region, and the third from the upper Susitna-

Nenana drainages. Because of the changeable nature of caribou movements and the brevity of the study period, the results are tentative.

Small groups of caribou, including cows and calves, have been seen in most of the side drainages of the upper Talkeetna River. This appears to be a legitimate, resident subherd, probably composed of <400 animals. Some spatial overlap with the main Nelchina herd does occur, however.

Three caribou in this upper Talkeetna River subherd (two adult females and one adult male) were collared on 18 April 1980. These animals were relocated 50 times and were always found in drainages of the upper Talkeetna River or in the upper reaches of the nearby Chickaloon River (Figure 3.15). One female raised a calf in 1980, and both raised calves in 1981. The male spent the summer of 1980 in the mountains west of the Talkeetna River.

During late April 1980, one adult bull and one adult cow were collared in the Chunilna Hills. The cow died within a month of capture. The bull remained in the Chunilna Hills through November, when it shed its collar. Two additional females were collared in the spring of 1981, both of which subsequently gave birth to calves in the area. Relocations of Chunilna Hills caribou are shown in Figure 3.15. No overlap with radio-collared animals from the main herd or other subherds was noted, although one female did move across the Talkeetna River. The Chunilna Hills group appears to be a resident subherd numbering <350 animals.

During early May 1980, four adult females and one adult male were radio-collared from the upper Susitna-Nenana subherd (Figure 3.15). One of the females migrated to the main Nelchina calving area, summered in the Talkeetna Mountains, migrated back through the upper Susitna-Nenana area in the fall, and rejoined the main Nelchina herd on the Lake Louise flat during the rut and early winter. The other three females remained in the upper Susitna-Nenana area throughout the study period, two producing calves in 1980 and two having young in 1981. The bull summered in the Clearwater Mountains, then joined the main Nelchina herd during the rut in the Lake Louise Flat. It seems likely that a resident subherd of <1,000 caribou exists in this area; however, the situation is confounded by movements of animals from the main Nelchina herd through the area and by use of the area by summering bulls from the main Nelchina herd.

- <u>Habitat Use</u>

Habitat use by caribou was examined in the main Nelchina herd and the three identified subherds by recording vegetation type and elevation on each relocation of radio-collared caribou. The vegetation classifications were simplifications of Viereck and Dyrness's (1980) level I categories. Categories used included spruce forest (virtually no use of deciduous or mixed forest types was seen), tundra and herbaceous, shrubland, and bare substrate. For seasonal analyses, the following categories were used: calving, 20 May to 10 June; summer, 11 June to 31 July; autumn, 1 August to 30 September; rut, 1 to 20 October; winter, 21 October to 31 March; spring migration, 1 April to 19 May.

With the exception of their use of shrublands and bare substrate, habitat used by bulls and cows was significantly different ($P<0.01$). In the main Nelchina herd, bulls were found more often in spruce forest and cows in tundra and herbaceous vegetative types. Male and female radio-collared caribou from the main herd, likewise, showed significant ($P<0.001$) differences in seasonal habitat use. The main differences were heavy use of spruce forests during the rut, winter, and spring and increased use of the tundra-herbaceous type during calving and summer. Both sexes occurred with nearly equal frequency in shrublands; however, seasonal use patterns were different. Female use of shrublands occurred nearly equally in spring, calving, and summer, while male use peaked in summer and autumn.

Radio-collared caribou from the upper Susitna-Nenana, Talkeetna River, and Chunilna Hills subherds were primarily found in tundra-herbaceous vegetative type. Shrublands were also used frequently by animals from the upper Susitna-Nenana and Chunilna Hills area.

Male and female radio-collared caribou from the main Nelchina herd were located at similar elevations during autumn, the rut, and winter. During spring migration, calving, and summer, however, females were found at significantly higher elevations than males. During spring and calving, males lagged far behind the females, remaining longer on winter range and then often spending the summer period in the lower shrublands.

Mean elevations for relocations of radio-collared animals during all seasons was greater ($P<0.05$) for the Talkeetna River (1,440 m) and upper Susitna-Nenana (1,171 m) subherds than for the main Nelchina herd (1,050 m). Chunilna Hills caribou were found at slightly lower but not significantly different elevations (996 m) from the main Nelchina herd.

- Population Size and Composition

Census activities during 1980 were conducted from 2 to 5 July. A total of 17,061 caribou were counted in the primary post-calving aggregation. An additional 244 (including cows and calves) were found in peripheral areas. Therefore, the post-calving aggregation totaled 17,305 caribou with an estimated composition of 2,808 males $\geq$ 1 year; 9,285 females $\geq$ 1 year; and 5,212 calves.

Fall composition data were collected on 14 October 1980, when the main Nelchina herd was distributed on the Lake Louise Flat. The estimated 1980 fall population was 18,713 caribou. The ratio of males $\geq$ 1 year to 100 females $\geq$ 1 year was 61.9, the highest ever recorded for the Nelchina herd. An increase in the proportion of males would be expected for a herd which is increasing and previously had a relatively low proportion of males. Bergerud (1980) pointed out that a herd with good recruitment and a young age structure will have large numbers of young bulls.

The 1981 census was conducted from 23 to 25 June. The estimate of the post-calving aggregation was 19,264 caribou with 10,416 females $\geq$ 1 year, 3,035 males $\geq$ 1 year; and 5,813 calves.

Fall composition sampling was conducted on 19 October 1981 between Ewan Lake and the Chistochina River. The ratios of males $\geq$ 1 year (60.4) and calves (42.9) per 100 cows $\geq$ 1 year were nearly identical to those estimated in October 1980. Because of poor weather, the composition count was conducted about one week later than normal. It appeared that some bulls had separated from the cow-calf segment, and males may thus have been slightly underrepresented in the sampling. The estimated 1981 fall population was 20,730 caribou. The presence of all radio-collared females from the main Nelchina herd in the census area in 1981 and all but one in 1980 lent confidence in the accuracy of the population estimates.

In recent years the herd had experienced a growth phase, 1950-60; a peak, 1962-1967; a decline, 1967-1973; and then another growth phase, 1974-1981 (Table 3.10). The technique currently used to estimate herd size (aerial photo-direct count extrapolation caribou census technique) has not always produced precise estimates; however, a trend of herd growth since about 1974 is apparent when the complete series of estimates is examined.

Alaska Department of Fish and Game management objectives for the Nelchina herd include: (1) restricting the harvest until a population level of 20,000 animals older than calves is reached, (2) maintaining a minimum sex ratio of 25 males/100 females, (3) providing for the greatest opportunity to participate in hunting caribou, and (4) providing for an optimum harvest of caribou. To allow for continued herd growth, harvest of the herd is currently restricted by a permit system.

- Mortality

Three radio-collared caribou died of natural causes. Estimates of annual natural mortality rates were 0.067 $\pm$ for females $\geq$ 1 year, and 0.138 $\pm$ for males $\geq$ 1 year based on the number of observed mortalities of radio-collared caribou and the number of animal years monitored (Trent and Rongstad 1974).

These estimates were probably somewhat low as only one winter-spring period, when most mortality of caribou older than calves normally occurs (Skoog 1968), was included, while two summer periods, when natural mortality is minimal, were considered.

Calf survival from birth to 11 months of age (May 1980 to April 1981) was estimated from a theoretical birth rate of 0.66 calves per cow $\geq$ 1 year (Skoog 1968, Bergerud 1978) and an observed ratio in April of 0.30 calves per cow $\geq$ 1 year. This ratio was corrected to account for those females (0.95) who survived between May 1980 and April 1981 (Fuller and Keith 1981). Estimated calf survival was, therefore, 0.43.

Reported hunter harvest for the Nelchina caribou herd has averaged about 670 animals annually over the past 10 years (Table 3.11). Females have composed about 25% of the reported harvest. Hunter numbers have been controlled by permit since 1977.

(iv) Wolf

From 20 February 1980 through May 1981, 36 gray wolves from six individual packs were captured and radio-collared for this study. Seven wolves were recaptured on one or more occasions for re-collaring. Twenty-one (57%) of the captured wolves were males (six pups and 15 adults) and 15 (43%) were females (seven pups and eight adults). Six of the 23 were recaptured from earlier studies. From January 1980 through October 1981, individual radio locations were obtained for the 36 radio-collared wolves, yielding an average of approximately 33 locations per animal. A total of 2,255 wolf sightings were made while locating the radio-collared packs, which represented 437 pack days. (A pack day is defined as any day on which a pack was located one or more times.) Radio contact with at least four and perhaps as many as six wolf packs occupying habitats along the Susitna River near the proposed impoundments was not established during this study.

- Territories and Population Numbers

For the purposes of this report, Etkin's (1964) definition of territoriality was used, that is, "any behavior on the part of an animal which tends to confine . . . its movements to a particular location." Most definitions of territoriality assume that the territory is defended against intruders. Although wolves in the Nelchina basin apparently do, at times, defend their territories against other wolves, intrusions into a neighboring territory often occur when the home pack is not using that portion of the area.

Table 3.12 summarizes territory sizes for the six wolf packs which have been intensively investigated for the Susitna hydroelectric studies. Territory sizes for the six packs averaged 1,414 km^2, which was almost identical with sizes determined for other wolf packs in Game Management Unit (GMU)13 (Ballard _et al._ 1981c).

Figure 3.16 depicts the spatial arrangement of known and suspected wolf territory boundaries in the project area during 1980 and 1981. Based upon track counts, public sightings, and radio locations of radio-collared packs and previous studies, at least six and perhaps seven wolf packs occupy portions of the Susitna River which would be directly affected by the Devil Canyon or Watana impoundments.

Wolf territories were essentially non-overlapping during the course of any particular year (Ballard _et al._ 1981c). What overlap appeared to occur was either seasonal in nature or was the result of the manner in which territories were plotted.

Numbers of wolves estimated to occur in at least 13 wolf packs known to occur in the study area are presented in Table 3.13. Spring 1980 and 1981 estimates represent the post-hunting population while those in fall represent gains due to reproduction and dispersal prior to hunting and trapping losses.

- Den and Rendezvous Sites

General locations of both den and rendezvous sites located from 1975 through 1981 in GMU 13 are depicted in Figure 3.17. Use of these sites by wolves in GMU 13 was fairly traditional. Of the 23 sites examined, at least six have been used a minimum of three seasons. Several have been used during two seasons since 1975. The average elevation of the 23 sites was 775 m (s.d.=108 m) ranging from 610 m to 1,097 m. Most den sites were old red fox den sites which had been dug out by wolves. Most sites consisted of three to four large holes and were characterized by several small holes, which are commonly referred to as pup holes and which are rarely, if ever, used. Most sites were located on slightly elevated areas, with sandy soil providing good drainage. Although we found that holes were oriented in all directions, most were found on south to northeast exposures. Thirteen of the sites examined contained what were termed "whelping chambers" which were usually located back from the main entrance.

Table 3.14 summarizes the distances of discovered den and rendezvous sites from both the Devil Canyon and Watana impoundments. Four den sites and one rendezvous site occurred within 8 km of the reservoirs. It should be noted that the figures contained on Table 3.14 must be considered absolute minimums because they pertain primarily to the area lying east of Deadman and Kosina Creeks.

- Elevation and Seasonal Usage of Habitat Types by the Watana Pack

Because the Watana pack was intensively monitored, sufficient data were gathered with which to characterize the elevational and habitat usage of a pack. Radio location data for the Watana pack were plotted on 1:63,000-scale vegetation maps. Data points which did not specifically fall within one habitat were tallied as in an ecotone between the two types.

According to this analysis eight of 24 habitat types were not used, either singly or in combination as an ecotone by the Watana wolf pack during the study period (April 1980 through October 1981). The unused types included snow and ice, wet sedge grass, closed balsam poplar, open balsam poplar, willow shrub, grassland, disturbed, and lakes. The non-use of lakes is misleading and is a result of the sampling period's having occurred during warm months. Wolf packs frequently make kills on or at the edge of lakes and streams during winter.

Of the 18 habitat or ecotone types used by the Watana wolf pack, ten were monotypes. Assuming the radio-location data and the boundaries of the habitat types were accurate, wolves were located in the monotypes on 58% of the occasions they were located. Of the 10 monotypes, low shrub, woodland black spruce, closed tall shrub, open black spruce, and birch shrub accounted for 86% of the use. Thirty-six (43%) of 86 locations occurred in ecotone areas. Seventeen (81%) of the 21 classified ecotone areas were used only once. Twenty (56%) of 36 uses, however, involved one of the shrub habitat types. Overall, shrub habitat types accounted for 50% of all use.

The average monthly elevation occupied by the Watana pack members ranged from 673 m in April to 1,021 m in November. Sample sizes were too low to compare seasonal changes in elevational use.

- Food Habits

During 1980 and 1981, six radio-collared wolf packs were observed on 83 kills. Moose comprised 57% of the kills, while caribou comprised 33%. Other prey, such as snowshoe hare, beaver, muskrat, and other small mammals made up the remaining percentage of kills. Moose calves accounted for 51% of the moose kills, while for caribou, calves comprised 7% of the kills.

Table 3.15 summarizes wolf summer food habits as determined from analyses of scats collected at den and rendezvous sites during 1980 and 1981. Moose of all ages were the most important summer food items during both years of study. However, it is suspected that the importance of calf moose is probably over-emphasized by these data.

Studies of wolf food habits in GMU 13 since 1975 have suggested that moose are the single most important food item (Ballard et al. 1981c). This trend appears to have continued in 1980 and 1981 as well, except that caribou appear to have increased in importance as a prey item.

Based on data collected during this study and data collected in GMU 13 from 1970 to 1972 and from 1975 through 1979, it was concluded that wolves were preying upon relatively healthy calf and short yearling moose. During severe winters, wolves also preyed upon relatively healthy adult moose, and this predation was in proportion to the occurrence of that age class of moose in the total population. During average or mild winters however, wolves preyed more heavily on older adult moose.

The annual percentage of observed caribou kills has varied from 4% to 30%. Excluding 1978, when the main body of the Nelchina caribou herd wintered in the Wrangell Mountains and thus were largely unavailable to GMU 13 wolves during winter, the importance of caribou in the diet of wolves appears to have increased. (Wolf diet averaged 18% caribou for 1975 through 1977 in comparison to 26% caribou for 1979 through 1981). Some of the annual difference in percentage of occurrence of caribou could be attributed to the difference in the locations of wolf packs studied during these time periods. Caribou distribution, however, is probably, at least in part, a function of their density. The Nelchina herd reached a record low of approximately 7,500 in 1972. Since that time the population has increased so that by 1981 the herd numbered over 20,000. It is suspected that the increase in the caribou population generally has made caribou more available to wolves throughout GMU 13. If true, this pattern would suggest that as the herd grows even larger, caribou will also become more important as wolf prey. Assuming wolf populations in GMU 13 increase slightly or remain stable, a larger caribou population may have some positive benefits for moose, in that a larger percentage of the kills may be comprised of caribou, relieving the moose population from some predation mortality.

- Predation Rates

Winter predation rates were estimated for three packs, through the use of intensive radio monitoring and by back tracking. A detailed discussion of these rates follows.

From 23 January through 27 March 1980, members of the Susitna pack were observed on nine kills. These data were divided into two periods because of changes in pack numbers. The first period extended from 23 January through 12 February 1980, during which time the pack numbered seven (three adults, two yearlings, and two pups). During this interval, they preyed upon four caribou and one adult moose for a kill rate of 1/4.2 days. Caribou comprised 80% of the kills in 1980, while in 1979, all of the observed prey were moose. Differences appeared to be related to the availability of prey. In 1979 few, if any, caribou had been available to this pack, while in 1980 relatively large numbers of caribou were present.

During the second sampling period, from 12 March through 27 March 1980, this pack numbered four wolves, providing an opportunity to compare kill rates for the pack when its numbers were lower. Kills were comprised of one adult moose, one calf moose, and two adult caribou. The kill rate was 1/4.0 days, which was fairly close to the rate of kill observed when the pack included seven members.

During early 1980, the Tyone Creek pack of two adults and six pups was monitored during a 54-day period (23 January through 16 March 1980). The pack was observed on 11 kills: three adult moose, seven calf moose, and one adult caribou. The prey species used by this pack were similar to those observed in 1979. In 1979, however, when the pack was comprised of two adults, calf moose comprised only 29% of the kills, while in 1980, when the pack numbered eight wolves, calves comprised 64% of the kills. This difference could indicate a change in prey selectivity based on pack composition. This pack was observed on a fresh kill at the rate of 1/4.9 days.

From 9 January through 26 January 1981, an attempt was made to determine the predation rate of the Tolsona Pack on caribou by attempting to locate the pack every other day. During this period, the pack numbered 14 to 15 wolves and appeared to be feeding quite heavily on caribou. A total of four kills were observed--two adult caribou, one adult moose and one calf moose. Based upon these data, this pack of 15 wolves preyed upon a moose or caribou at the rate of 1/4.5 days. Comparison of this rate with other predation data (this study and Ballard et al. 1981c) reveals that the rate was well below the rate believed necessary for the pack to maintain its size and productivity. Therefore, it is believed that several kills were not detected during the study period.

Data concerning predation rates during summer were collected on the Watana Pack. At the initiation of the study, three members split off from the pack, leaving the main pack with eight members. From 10 May through 23 June 1981, the eight remaining members of the main Watana Pack were observed on only six kills. The kills were comprised of two adult caribou (one was unclassified and assumed to be an adult), two calf moose, one adult moose, and one unknown species. In addition to the kills, pack members were known to have twice visited an adult caribou which had been killed by a black bear, revisited one old moose once, and visited the unknown species kill on three separate occasions. The observed kill rate of 1/7.5 days is well below the winter rate of 1/4 to 5 days.

Peterson (1980) believed that summer wolf predation rates were lower than those of winter. Studies of two wolf packs elsewhere in GMU 13, however, suggested that predation rates in summer were equal to or greater than those occurring in winter. It is believed that the low summer rate for the Watana Pack was the result of poor visibility and of a lack of radio-contact with the alpha male.

From 10 May through 28 May 1981, the three wolves, mentioned above, that had separated from the main Watana Pack functioned as a distinct pack themselves. These three adults were observed on a total of four kills over a 19-day period, with a kill rate of 1/4.8 days. The kills consisted of two adult moose, one yearling moose, and one calf moose. This particular set of data then, does not support the hypothesis of smaller packs having lower predation rates.

Although there appear to be some inconsistencies in the data as well as variation among seasonal and pack predation rates, there is sufficient evidence to estimate a kill rate for wolves in this area. Therefore, for purposes of this report a year-round predation rate for a pack of wolves was assumed to be 1 kill/5.0 days.

An effort was made to integrate these data collected in wolf predation rates with data regarding populations of prey species in the same area. Based upon an intensive census of the study area in fall 1980, it was estimated that a portion of the wolf study area contained 1,985 moose (see Figure 3.11). The area censused roughly corresponds to an area which would be occupied by five wolf packs.

Using the census and the stratified moose data along with the estimate of five wolf packs, an attempt was made to assess the importance of wolf predation to the study area moose population. It was assumed that each pack made an ungulate kill once every five days and that from 60-70% of the kills were comprised of moose, 32% of which were calves. Based upon these assumptions, it was estimated that wolves were annually preying upon 11% to 13% of the study area's fall moose population. Percent mortality of calves present in fall ranged from 16% to 18%, while mortality on adults of both sexes ranged from 10% to 11%. It should be pointed out that these calculations are based on a prey base present in November, and thus, the mortality figures are slightly inflated. Based upon calf and yearling mortality studies conducted in and adjacent to the Susitna study area, it was estimated that between 9% and 24% of the fall calves were succumbing to wolf predation. The new estimate obviously falls within the latter range.

Determining the level of wolf predation on caribou for the study area required a slightly different approach because of the seasonal nature of caribou distribution. The impact of wolf predation on caribou was estimated by assuming that 25 wolf packs occur within the range of the main Nelchina herd and its subherds in 1981. A mortality rate was estimated for 1972, when the Nelchina herd numbered a record low of approximately 7,500 animals and approximately 45 wolf packs occurred in the range of this herd. Further, a year-round predation rate of 1 kill/5.0 days was assumed. The assumption was also that caribou comprised 20% to 30% of the annual wolf diet. No separation was made between calf and adult caribou because existing wolf data do not suggest selection of the calf age class. Based upon these assumptions, it was estimated that in 1972, wolf predation accounted for an annual mortality rate of from 9% to 13%. In 1981, with the herd at approximately 22,000 animals and with 25 wolf packs present in its range, it was estimated that current caribou annual mortality from wolf predation ranged from 2% to 3%.

- Hunting - Trapping Mortality

Wolf harvests in the study area and in GMU 13 from 1971 through 1981 ranged from a high of 128 wolves in 1977-78 to a low of 45 wolves in 1980-81. The low harvest in 1980-81 was attributed to poor weather and relatively low wolf densities.

From 1971-72 through 1975-76, ground trapping was the most common method of harvesting wolves in GMU 13, accounting for 59% of the total harvest. From 1976-77 through 1978-79 ground shooting (primarily hunting using access via aircraft) was the most common method of harvest. In 1980-81 trapping again was the most prevalent method both because poor snow conditions did not allow wolves to be tracked from airplane and because the density of wolf populations was reduced.

(v) Wolverine

Historically, very few studies have been conducted dealing with wolverine ecology or the impact of human development on this species. There is indirect evidence, however, that in Canada, wolverine populations have declined as human influence increased (Van Zyll de Jong 1975). No historical information exists regarding wolverine populations in the upper Susitna basin.

- Distribution and Movement Patterns

Relocation data for five radio-collared wolverine, sightings of unmarked wolverine or wolverine tracks, and ADF&G harvest data yielded a total of 144 point locations scattered throughout the proposed impoundment vicinity. Distribution seems to be complete throughout the study area; however, the data indicate that concentrations are generally centered in hilly topography above treeline. There are inherent biases within the data, though since most of the track sightings and the commercial harvest occurred during the spring (March-May), when wolverine generally inhabit higher elevations (Hornocker and Hash 1981).

Radio-tracking data suggest that changes in wolverine distribution occur throughout the year. Van Zyll de Jong (1975), in Canada, suggested that food availability influences changes in wolverine distribution. Three different movements by wolverine in this study seemed to be induced by food supply.

- Home Range

Radio-collared wolverine were located on 104 occasions during these studies. Home ranges were determined for five wolverine; however, only the home range of wolverine No. 040 (627 km^2) represents an annual home range. The range of a lactating female (No. 042) was 86 km^2.

Direct comparison of home range sizes of Susitna wolverine with findings for other radio-telemetry studies is difficult due to this study's sample size and the differences in sampling periods. Comparing home range sizes for males from study areas in northwestern Alaska (Magoun 1979), the Susitna River basin, and northwestern Montana (Hornocker and Hash 1981), it appears that male wolverine in Alaska have a larger home range. Home range requirements for lactating females, however, were similar for the Susitna basin, northwestern Alaska and northwestern Montana. The generally larger home ranges of wolverine in Alaska are probably related to both fewer choices and lower density of prey.

- Population Estimates

An accurate estimation of wolverine density within the impoundment area is difficult to obtain with the available data. Within the 2,727 km^2 core portion of the study area (Figure 3.18), including the two proposed impoundments, where intensive radiotelemetry studies were conducted, a minimum of nine adult wolverine occurred, providing a minimum density estimate of one adult wolverine/303 km^2. By using several different kinds of estimates, the study area can be projected to support 11 to 21 adult wolverine, giving an estimated density range of from 1/248 km^2 to 1/130 km^2. Using this range of adults, the estimated number of kits added annually to the study area's population ranges from eight to 26. These figures yield a total population estimate, of between 19 and 47 wolverine.

- Habitat Utilization

As a result of the small number of animals radio-collared, information concerning habitat use by this species was rather limited. Wolverine No. 040 was the only animal which provided sufficient data to indicate seasonal changes.

Wolverine No. 040 utilized six of the 11 different habitat types within its home range. By frequency of observation, low shrub (37.5%), sedges and grass tundra (22.5%), open spruce (20%), and mixed open spruce (10%) habitats were preferred. It should be noted that 040 utilized low shrub habitat in a lower proportion to the amount of that habitat available (37.5% vs. 55.5%), while it utilized sedge grass and open spruce habitats in greater proportion than that habitat's availability (22.5% vs. 18.5% and 20% vs. 9%, respectively). Seasonal habitat preferences were also apparent. Seventy-five percent (six of eight observations) of open spruce usage occurred between mid-December and 1 April, and 67% (six of nine) usage of sedge grass tundra habitats occurred between May and 1 September.

Wolverines 043 and 044 displayed preference for ecotone habitats, since 34.6% (9 of 26) and 61.5% (8 of 13) of their relocations were present in these transition zones. Preference for or avoidance of homogenous habitat types was impossible to separate because of these animals' preference for ecotonal areas.

All of the radio-collared wolverine displayed an increased use of lower elevation areas during winter and early spring (December through March). The mean seasonal elevation values are 760 m (summer) and 948 m (fall). Hornocker and Hash (1981) also reported an elevational decline during winter for wolverines in northwestern Montana.

- Food Habits

It is well known that wolverines are not only well adapted for carrion feeding but also that carrion is important in the wolverine diet (Hornocker and Hash 1981, Rausch and Pearson 1972, Pulliainen 1968, Haglund 1966, Krott 1959). Some authors indicate, however, that wolverine additionally use smaller prey, such as marmot, snowshoe hare, Arctic ground squirrels, microtine rodents, and birds and that this use is extensive, especially in the spring and summer (Hornocker and Hash 1981, Magoun 1979, and Krott 1959).

Data collected during the course of the Susitna studies agrees with this information on food habits. Winter food habits data of Susitna wolverines indicate the increased importance of lower elevations and forested areas. The upper reaches of the proposed Watana impoundment area support a high density of moose during the winter. From mid-December to 1 April, 75% of wolverine No. 040's locations were within that area. During March 1981, at least two wolverine were using that area and were observed using three different moose carcasses. Ground tracking during December 1980 indicated that wolverine were also preying on small mammals. The numerous locations of wolverines 043 and 044 within ecotones is probably related to an abundant food source. It is well known that ecotones are usually high in plant diversity and, likewise, support a diverse microtine population.

As previously mentioned, there is a pronounced trend of wolverines using higher elevations in spring, summer, and fall. During these times, there are large numbers of ground squirrels, pikas, and marmots throughout the high country (APA 1981). Also present in the tundra habitats are 13 species of ground-nesting birds (Cooper, pers. comm.). An excellent example of this shift from lower elevation forests during winter to alpine tundra areas during spring was demonstrated by wolverine No. 040. Similarly, wolverine 044 moved a straight line distance of 70 km from an open spruce habitat (427 m elevation) to a tundra habitat (991 m elevation) coinciding with small mammal emergence, caribou use, and bird nesting season. This wolverine remained above treeline until 26 September 1980.

- Harvest

Trappers and hunters harvested 27 wolverine from the study area during Phase I studies, 20 during 1979-80 and seven during 1980-81. The low take during 1980-81 was probably a result of poor snow and weather conditions. During the 1979-80 trapping season, an estimated 23% to 31% of the population was harvested. It is possible that the level of that harvest may have been excessive, thereby lowering the wolverine population.

(vi) Brown Bear

Brown bears are widely distributed and abundant in Alaska. Brown bears seem well adapted to open areas of tundra or grasslands, although they do inhabit a variety of different habitats in Alaska. In contrast to Alaskan populations, brown bear distribution and abundance in the contiguous United States has greatly declined over the years. One reason is that bears using relatively open habitat are considerably more vulnerable to hunters, with the result that more animals are killed. In addition, because brown bears frequently represent a danger to man, they are eliminated or confined. Brown bear abundance is usually incompatible with increasing human presence except in a few parks where bears are given a legal priority over human developmental activities. As a result, except in Alaska and parts of Canada, this species is currently classified as endangered.

In the last 20 years, brown bear populations in Alaska have increased, and the current populations appear to be abundant, young, and productive. Fall harvests in the period 1973-1980 averaged 64 bears/year (30-84 bears/year) in Alaska's Game Management Unit (GMU) 13, which includes the upper Susitna basin. This level of harvest is suspected to be less than the maximum sustainable yield of this population. Even with the recent addition of spring seasons, most of the harvest still occurs during the fall, when bears are taken incidental to moose or caribou hunts.

Recorded brown bear harvests in the Susitna hydroelectric project study area, 1973-1980, have averaged 15/year (9-24/year). Hunting in the study area largely depends upon access by air, including some hunting by guided hunters, although many bears are taken from the Denali Highway. Indeed, the largest proportion of study area brown bears are taken from subregions that include the Denali Highway.

- Population Biology

The number of brown bear captures in connection with the Susitna hydroelectric studies in 1980 and 1981 totaled 53. This total includes 11 recaptures of bears in order to replace radio-collars. Six bears, primarily males with large necks, shed their radio-collars, and four bears were known to have been shot by hunters. Four bears died during capture or recapture efforts.

Five or more radio-locations were obtained for five male and 14 female brown bears. Primarily because of large males' shedding radio-collars, the numbers of radio-locations for males (109) have been fewer than for females (422). Part of this disparity also resulted because seven females were intensively monitored in spring 1981 (114 locations), while only one male (14 locations) was so closely followed.

The age structure of bears captured for the Susitna studies is essentially equivalent to that of intensive 1979 studies in the upper Susitna, to ten years of GMU 13 harvest data, and to the subsample of radio-collared individuals (Table 3.16). As mentioned, however, the subsample of radio-collared individuals is biased in favor of females. Thus, these data indicate that the sample of study animals is reasonably representative in terms of age structure but biased in terms of sex ratios.

Brown bears in the study area appear to be healthy and highly productive. Based on nine litters with newborn cubs observed with marked adults since 1978, the mean litter size was 2.3 (range=1-3). An unmarked bear with four cubs was also observed. The mean litter size of newborn cubs is equivalent to highly productive bear populations on Kodiak island (Hensel et al. 1969) and on the Alaska Peninsula, (Glenn et al. 1976) and is higher than has been found in a relatively unproductive population in the Brooks Range (Reynolds 1976).

Of ten cubs in five litters produced in 1981, three (in three litters) were lost during the summer of 1981. Two cubs in a litter of three were lost in 1979 studies, as were two yearlings or cubs in a litter of three in the same year. No other losses from yearling or two-year-old litters were observed, suggesting that offspring mortality is concentrated on cub classes. Causes of cub losses have not been determined, although predation by male brown bears is considered most probable.

Brown bear females in the study area typically accompany their offspring through their yearling year and wean them as two-year-olds in May or June of the following year. Many of the females breed again soon after their offspring are weaned; in all three cases in which the subsequent year's data are available, this breeding was successful, with newborn cubs as evidence. For these three bears, the reproductive interval was three years, doubtless additional data will reveal a mean reproductive interval for adult females of between three and four years.

Typically, female brown bears in the study area first breed at three or four years of age and produce their first litter when they are four or five years old. The data suggest that about 44% of the four-year-old females produce litters, 33% of the remaining barren five-year-olds, and 50% of the remaining barren six-year-olds. Obviously, some of the five- and six-year-old barren females could have previously produced, but lost, litters. All seven or eight-year-old females that have been caught were either with litters or showed evidence of having had a litter previously. Based on these data, it appears that for every 100 females ($\geq$ 4 years), about 44 will produce their first litter at age four, 20 at age five, 19 at age six, and 18 at age seven [these estimates are slightly more conservative, (that is, less productive), than indicated by available data]. Based on these calculations, the mean age at which these 100 females produce their first litter is 5.2 years.

Bear population estimates are exceptionally difficult to obtain and an accurate estimate was not achieved during the Phase I bear studies. Two reasons for the difficulty are the apparent abundance of brown bears in the Susitna study area and the large home-range sizes of Nelchina brown bears [average=570 km^2, range=192-1,380 km^2 (Ballard et al. in press)].

An imprecise estimate of brown bear density was obtained, however, from intensive trapping and mark-recapture techniques conducted in the Susitna River headwaters in 1979 (Miller and Ballard 1980). Based on this density estimate of one bear/41-62 km^2, the Susitna study area of 8,473 km^2 would have a population of 100-206 brown bears. It is our subjective evaluation that brown bear density in the Susitna study area is more likely to be higher rather than lower than that estimated in our earlier study. This estimate is compared with other North American estimates in Table 3.17.

The 1980-81 den sites for 13 radio-collared brown bears were located and measured; an additional three dens were located for unmarked individuals. Brown bear den sites ranged in elevation from 710 m to 1,570 m (2,330 to 5,150 ft); the average elevation of 29 dens was 1,274 m (s.d.=231 m). Brown bears in the study area typically denned on moderately sloping southerly exposures. Their dens were dug in gravelly soil, and no evidence of reuse of the previously used den was observed.

- Home Range and Movement Patterns

Home-range sizes for brown bears radio-collared during this study are presented and compared with results of 1978 studies on nearby ranges (Ballard et al. in press) in Table 3.18. Significant differences among 1978, 1980, and 1981 data sets were obtained only for females, which had smaller home ranges in 1980 than in either 1978 ($P<0.05$) or 1981 ($P<0.10$).

In comparison with studies in other portions of Alaska, Canada, and Montana, brown bears in the study area have relatively large home ranges (Table 3.19). Only in northwestern Alaska, where a relatively unproductive population resides, have larger home ranges been reported. Canadian, Montanan, and other Alaskan populations, except the northwest group also have a greater density than that of the study population (Table 3.17). Although a clear relationship has not been established, home-range size and bear density appear to be inversely related, and both seem a function of the distribution and abundance of food resources. The relatively large home ranges and low densities of study-area brown bears may reflect, therefore, relatively low primary productivity of food items important to brown bears in the study area. In addition to or instead of low primary productivity, these data may also reflect a patchy and wide-spaced distribution of important food items. Supporting this relationship are observations indicating that in areas of Alaska where salmon represent a primary source of food, such as on Kodiak Island or on the Alaskan Peninsula, home ranges tend to be smaller and densities higher (Table 3.19). Confounding this apparent relationship, however, is the ostensibly high productivity of study-area brown bear populations. If food were limiting this population, a relatively lower reproductive potential, such as has been found in northwestern Alaska, would be expected.

Prairie Creek, which flows from Stephan Lake to the Talkeetna River is well known as an area where brown bears concentrate in July and August to feed on salmon. Local residents have reported seeing 20 bears at one time on Prairie Creek. Here, on 10 August 1980, past the king salmon peak, 13 brown bears were observed at one time, and it is estimated that 30 to 40 individual brown bears fished in this area in the summer of 1980.

During the study, in both 1980 and 1981, radio-collared brown bears moved to Prairie Creek to fish for salmon. Unfortunately, poor weather conditions in 1981 made flights to relocate animals impossible and prevented complete documentation of how many bears made this movement. A minimum of four bears (of 11 with active radio-collars) moved to Prairie Creek in 1980 and two (of 18) in 1981. The longest distance moved by a bear to Prairie Creek was 58 km (G293 in 1981). Four of these six bears were documented to have crossed the proposed impoundment areas. All of the radio-collared bears seen at Prairie Creek had portions of their home ranges north of the Susitna River and, therefore, had to cross the river en route to or from Prairie Creek. The maximum number of times an individual brown bear was known to have crossed the Susitna River was ten.

The importance of the Prairie Creek salmon run to study-area brown bears will be difficult to evaluate. Without access to salmon, moderately dense brown bear populations currently exist in the Nelchina Basin. It is possible, however, that the availability of this interior run of salmon might provide nutritional benefits that result in local bear populations that are either more dense or less nutritionally stressed than adjacent populations without access to a salmon run. In the latter case, less nutritional stress may produce larger individuals in the species.

Seasonal movements of brown bears to areas where moose or caribou congregate, such as calving grounds, are difficult to document. For one thing, moose calving areas are poorly defined. In addition, movements of bears in the spring to prey on calves cannot readily be distinguished from their movements to these same areas which may be motivated by the presence of relatively more abundant early spring forage. For four bears, however, apparent directional movements to or from caribou calving grounds were observed.

ADF&G biologists conducting caribou surveys (S. Eide, R. Tobey, and K. Pitcher, pers. comm.) regularly report seeing many brown bears associated with the Nelchina herd. For example, in early July 1980, during caribou surveys on the upper Oshetna River, these biologists made incidental observations of 22 brown bears in approximately 673 km^2 of survey area. This number represents a minimum bear density of one bear/31 km^2. Since only a fraction (perhaps a third) of the bears present were likely to have been seen by biologists concentrating on caribou, the actual local bear density in this area was doubtless much higher. In 1981, these biologists, conducting the same survey in about the same area, saw no bears, even though some radio-collared individuals were known to be present.

The available data strongly support the theory that early spring is the period when many brown bears are most intensively utilizing the proposed impoundment area (conservatively defined for this analysis as within 1.6 km of the high-water mark of the proposed impoundments). Of 12 bears radio-collared in spring 1980, six were located in the proposed impoundment area at least once (Table 3.20). The mean elevation of these observations was 605 m for the Watana area and 601 m for the Devil Canyon area (Table 3.20). The mean elevation of observation was below proposed high water lines for Watana but not for Devil Canyon.

Even without prevalent over wintering berries, the same pattern was evident in spring 1981. Excluding females with newborn cubs, which tend to remain at high elevations throughout the year, eight (62%) of the radio-collared bears were located in proposed impoundment areas in spring 1981 (47% if those females with newborn cubs are included) (Table 3.20). Of these eight bears, seven utilized the Watana impoundment area and one the Devil Canyon area. The mean elevation of the spring observations within the Watana area was 640 m, or below the high water line of the proposed Watana impoundment (Table 3.20).

These data represent minimal values for early spring use of proposed impoundment areas by brown bears in the study area.

Other bears, particularly those relocated relatively infrequently in the spring, could also have utilized these areas without having been found there during weekly monitoring flights.

- Habitat Relationships

The habitat in which a bear was found when located from the air was recorded. To facilitate interpretation, these data were lumped into five gross habitat categories. These data, by month of observation, are given in Table 3.21, which also includes 85 habitat observations for uncaptured bears observed during radio-tracking flights.

Brown bear use of spruce habitats, which are concentrated in and around the proposed impoundments, were highest in May and June. Later in the summer, bears tended to move to shrublands at higher elevations. In winter (October-April), when bears were in dens, 71% of the observations were in the "other" category of habitat (Table 3.21). These were mostly snow or rock.

These observations were lumped to contrast habitat use in the "spring" (1 May to 30 June) with that during the rest of the year. This specific observation permitted subsequent examination of the general hypothesis that brown bears use the spruce habitats near the impoundments relatively more at this time than during the rest of the year. The relatively higher use of spruce habitats in the spring was significant (Chi square=10.3, 1 d.f., $P < 0.005$). This pattern would have been even more significant if females with newborn cubs had been excluded from the analysis. As mentioned before, females with newborn cubs tend to remain at high elevations away from the impoundments throughout the year following birth of their litter; of 68 habitat points for such bears, only two were in spruce (49% were in shrublands, 35% in other, 10% in tundra, and 4% in riparian).

- Predation Rates

In a 1978-1979 study conducted in the headwaters of the Susitna River and in nearby study areas (Ballard et al. 1981a), brown bears were shown to be significant predators of moose calves. In related studies of 23 radio-collared brown bears intensively monitored twice a day in spring 1978, 14 (61%) were observed on at least 1 calf moose kill (maximum=nine calf moose kills) (Spraker et al. 1981).

The results of this 1978 study were compared with the results of intensive (daily) spring monitoring of eight brown bears in the Susitna study area. During this period totaling 102 visual observation days, one monitored, subadult, female brown bear killed three moose calves, and another subadult female killed two adult moose. In addition, three animals of unknown species were observed to have been killed by brown bears, and in three other cases, brown bears were strongly suspected to have been involved in kills. Even incorporating these suspected kills, the observed predation rate (1/10.2 days) was lower than in the 1978 study. Of the total number of brown bear observations, radio-collared bears were seen on four calf moose, four adult moose, one adult caribou, and three unknown species, and were observed in five additional cases where a kill was suspected but not observed. Because of relatively infrequent monitoring and the limited visibility of kills in the relatively thicker vegetation in the Susitna study area, these data doubtless underrepresent actual predation rates.

(vii) Black Bear

Black bears, which have a very wide range in North America and are still abundant throughout most of their original range, are similarly widely distributed and abundant in Alaska. Black bear distribution in Alaska coincides closely with the distribution of forests, with the most abundant populations occurring in open forests rather than heavy timber; extensive open areas are usually avoided, however.

The abundance of black bears combined with relatively light hunting pressure in the upper Susitna basin permits a year-long open hunting season and an annual bag limit of three bears. An annual average of 66 black bears have been taken in Game Management Unit (GMU) 13 from 1973 to 1980 (58-85 bears/year). Most of the harvest, 74%, occurs in the fall season when bears are taken incidental to moose or caribou hunts. An average of only 23% of the GMU 13 black bear harvest has been taken by non-residents.

Recorded black bear harvests in the Susitna study area, 1973 to 1980, have averaged eight per year (1-15). In the study area, as in GMU 13 as a whole, black bear harvests have been increasing in recent years, with the largest recorded annual take occurring in 1980. In the study area, the largest harvests have occurred in the region farthest downstream on the Susitna River between the Talkeetna and Indian Rivers, the only portion of the study area currently accessible by river boat or highway vehicle.

- Population Biology

The number of black bear captures in connection with the Susitna Hydroelectric Project studies in 1980 and 1981 totaled 53. This total included five recaptures of bears to replace radio-collars and one recapture of a bear that had previously shed its collar. Two bears shed their radio-collars; hunters killed six bears; four bears died of unknown causes; one died during capture efforts; and the collar was not replaced on another bear recaptured because its neck was infected.

Five or more radio-locations were obtained for 14 male and 11 female black bears. The age structure of the sample of radio-collared individuals was comparable to that of captured bears in the study area in general but was somewhat older than the subsample of black bears taken by sport hunters in GMU 13 (Table 3.22). This discrepancy probably resulted from the tendency of hunters to take younger, less experienced bears as opposed to the effort of the study's techniques to capture a random selection of study-area animals. It is also possible that black bear hunters along the road system, where much of the harvest occurs, are sampling a more heavily harvested and, therefore, younger population than exists near the proposed impoundments. Males represented a smaller proportion in the study than they did in hunter kills in GMU 13, probably because by ranging greater distances, the males become more vulnerable to hunters. These data suggest that black bears marked for Susitna studies are reasonably representative of the existing black bear population.

Black bear populations in the study area appeared to be productive and healthy. This finding was somewhat surprising because the study area is situated on the northern limit of black bear distribution south of the Alaska Range. Apparently, the habitat is adequate even though limited in extent.

Eight litters with a total of 16 cubs were observed with radio-collared females in 1980 and 1981. Five of these litters were not observed until between June and August, so they may have experienced some losses between early spring and the date of their first observation. This possibility aside, the observed litter size was 2.0 (1-3) cubs/litter. The observed litter size for seven litters of yearling black bears was 1.9. In comparison, on the Kenai Peninsula, seven radio-collared females had a mean litter size of 1.9 upon emergence from natal dens (compiled from Schwartz and Franzmann 1980, 1981).

In the Susitna study area between May and August 1981, one cub in a litter of two was lost, one was lost from a litter of three, and both were lost from another litter of two. Counting only the four litters initially observed by June, four of nine cubs (44%) were lost, all in 1981. On the Kenai Peninsula on the other hand, no cub losses have been observed (Schwartz and Franzmann 1980 and 1981).

Three black bears with apparent yearling offspring were captured in 1980 (offspring were not captured). One of these weaned its offspring in 1980 and produced new cubs in 1981, a reproductive interval of two years. The third bear relocated its den in April 1980; perhaps its original den had collapsed, killing its litter. No den relocations were observed for other bears. A two-year reproductive interval is, therefore, probably the minimum; additional data will undoubtedly indicate a mean interval of between two and three years. The mean reproductive interval for an unproductive Montana population was over three years, and the percentage of adult females accompanied by cubs was low (15.6%) (Jonkel and Cowan 1971).

Three bears produced litters at five years of age and one bear at six years of age. Assuming no previous litters and correct aging, these bears became reproductively mature and successfully bred at four and five years, respectively. On the Kenai Peninsula, seven females (aged four years) had cub litters (Schwartz and Franzmann 1980, 1981), suggesting that reproductive maturity may be reached a year earlier on the Kenai. For an unproductive population in Montana, no females were observed in estrus prior to 4.5 years of age and no bears successfully produced litters at less than between six and seven years (Jonkel and Cowan 1971).

Available data are inadequate to calculate productivity of the Susitna-area black bear population, but available data on productivity parameters suggest it does not have quite the reproductive potential of the Kenai population. The basis for this assertion is primarily the older age for reproductive maturity. The Susitna population may also have a lower recruitment rate (based primarily on higher rates of cub losses). The recruitment rate is the rate at which the adult population is increased after cub and yearling losses and other reductions in subadult population are taken into account. Relative to the unproductive Montana population, however, the Susitna population appears highly productive, equivalent to productive populations in the midwest. It should be noted, however, that these comparisons are highly speculative at this point.

No reliable black bear density estimates are available from the study area or adjacent areas. Compared to other Alaskan habitats, however, portions of the study area appeared to be very densely populated by black bears. The only available data that permit even a crude density estimate come from sightings of marked and unmarked black bears during the August 1980 tagging operation. In 1 1/2 days of spotting effort (18, 19 August 1981), 35 bears, four of which were marked, were seen in approximately 259 km^2 of search area. A radio-tracking effort on August 14 verified the presence of seven radio-collared black bears in the search area. A straightforward Lincoln Index on these observations yields an approximation of 61 bears in this area or one bear/4.1 km^2. An "adjusted" index (Ricker 1975) yields an estimate of 58 bears (s.d.=19). A highly speculative estimate of the number of black bears in the study area is possible from this density estimation. Assuming that roughly one-third (1,400 km^2) of the study area is acceptable black bear habitat, this density figure would yield a population estimate of 341 black bears in the study area. These estimates should be viewed cautiously, however, as there are many possible sources of bias in the technique of estimating densities and it covers only a small portion of the study area at a season when bears might have concentrated in search of a locally abundant food source.

Regardless, the density estimate of one bear/4.1 km^2 falls roughly at the mid-point of reported black bears densities in North America and is only slightly lower than the most intensively studied nearby population (Kenai Peninsula, Schwartz and Franzmann 1981) (Table 3.23). In fact, the above density approximation is probably too low rather than too high, at least in the habitats where black bear density is highest.

Den sites for 1980 were located and measured for 14 radio-collared black bears; two additional approximate den locations were recorded but the actual dens were not found. The distribution of known black bear den sites indicated that study-area black bears tend to den in steep terrain along the main Susitna River or its feeder streams. As one proceeds upstream through the study area, the band of acceptable denning habitat apparently becomes progressively narrower and more confined to the immediate vicinity of the Susitna River, in much the same pattern as that for overall black bear distribution.

Black bear den sites ranged in elevation from 396 m to 1,323 m; only one bear, however, denned at an elevation above 914 m. Typically, black bears in the study area denned at elevations between 457 m and 762 m elevation. Of 16 den sites found in the vicinity of the proposed Devil Canyon impoundment, the average elevation was 664 m (range =454-1,323 m; S.D.= 86 m). Two black bear dens were observed downstream of the Devil Canyon site in 1981.

Of the 14 dens used in 1980/81 that have been located on the ground, eight were in natural cavities or caves, and six were excavated. Based on evidence found at the den site, all of the natural cavity dens examined and one of the dug dens examined had apparently been utilized previously. A determination of previous use could not be made for four dens. Four of the dens examined in 1981 were apparently reused by radio-collared black bears in the winter of 1981/82, three dens by the same individual that had utilized the den the preceding year.

These data on reuse of den sites may indicate either a scarcity of acceptable denning sites in the study area or simply habituation. Of 18 den sites examined on the Kenai Peninsula, eight had been previously used and ten were newly constructed. Only one bear reused the same den in successive years (Schwartz and Franzmann 1981). In relation to this Kenai study, reuse of den sites appears higher in the Susitna area. All of the dens in the Kenai study were excavated (Schwartz pers. comm.) compared to only 43% in the Susitna area.

- Home Range and Movement Pattern

Mean home ranges and ages for bears older than 2.0 years are given in Table 3.24. The data for these two years are not completely comparable, as different individuals were observed during different seasons. In any case, it appears that these home ranges tend to be larger than has been recorded for black bears on the Kenai Peninsula, that is, 16.7 km^2 for females and 98 km^2 for males (Schwartz and Franzmann 1981). In the Kenai study, however, a more conservative method was used to calculate home-range sizes. In the Susitna study, the home range sizes reported include, for many bears, large areas where no observations were made. This situation is especially true for the 1981 data when many bears moved long distances in late summer to foraging sites; these home ranges could be viewed as two seasonal home ranges connected by a narrow transportation corridor rather than as one home range.

Larger home ranges in 1981, compared to those of 1980, were observed for all groupings of individuals but were significant only for males ($P<0.01$) and for both sexes combined ($P<0.05$). Some of this increase was doubtless caused by the greater number of observations per bear in 1981, but it is evident that home ranges in 1981 were both much more variable and larger than in 1980. The greater movements in 1981 probably reflect the apparent relatively poor 1981 berry crop, which necessitated greater movements to find acceptable foraging areas. In 1981 black bears were observed north of the Denali Highway near Susitna Lodge (R. Halford, pers. comm.), a relatively rare occurrence which also supports the theory that 1981 was a year of atypically extensive black bear movements.

In late summer of 1980 (late July-August), many black bears made seasonal movements to the tablelands between the spruce forests along the Susitna River and the mountains north of the river. It is suspected that these movements were motivated by ripening berries, which may be more abundant in these relatively open areas than in the spruce forests where black bears are more commonly found during the rest of the year. In 1981, the movements were similar, but many more bears moved much greater distances. The supposition is that the apparent scarcity of berries in 1981 in the tablelands prompted these more extensive movements, which are in turn, reflected in comparisons of annual home range sizes. These movements are likely motivated by searches for better forage or for fish as a substitute for the berries that were in short supply. For example, three males moved downstream of the main study area in fall 1981, apparently to fish for salmon downstream of Devil Canyon.

Based on available data and supposition, the pattern of black bear movements can be summarized as follows. In years of normal or acceptable berry crops, many bears in late summer move to somewhat higher country adjacent to the spruce habitats along the river, returning to their lower spring and early summer home ranges to den. Most of these late summer movements are upstream (east) and a bit north. In years of subnormal berry crops, most individuals range more extensively, and many of these move long distances upstream or downstream in search of acceptable foraging areas or areas where salmon are available. Some of the individuals making these extensive movements do not return to their former home ranges, but most do. Females with newborn cubs are exceptions to this rule, making less extensive movements, regardless of the berry crop, than other bears or than they themselves do in years when they do not have cubs. In late summer and fall, especially in poor berry years, the more extensive movements of black bears may bring them in closer contact with areas frequented by brown bears at this time, and this proximity may result in increased mortality of black bears.

- Habitat Relationships

Each black bear location was classified into one of 23 habitat classification categories for 724 observations made from the air. These data were then consolidated into five gross habitat categories; the results are presented on Table 3.25.

Black bear use of spruce habitats, concentrated in the vicinity of the proposed impoundments, was common throughout the year but was least prevalent in late summer. In August, black bears were more commonly found in shrubland habitats adjacent to the spruce forests (Table 3.25). As mentioned, it is suspected that this late seasonal movement was motivated by the relative abundance of ripening berries on these tablelands.

The hypothesis that spruce habitats were used less frequently in late summer (16 July-31 August) was tested by contrasting the percentage of occurrence of radio-collared individuals in spruce habitats during this season (36% of 251 observations) with that of the rest of the year (44% of 547 observations). The difference was significant (Chi square=4.7, 1 d.f., $P<0.05$). There was a significant difference between males and females in late summer use of spruce habitats (Chi square = 4.4, 1 d.f., $P<0.05$). In the late summer, 43% of 126 observations of females were in spruce habitats compared to 30% of 125 observations of males.

- Predation Rates

Black bear predation on moose calves is prevalent on the Kenai Peninsula (Franzmann et al. 1980). Of 23 radio-collared black bears followed in the Kenai study, five (22%) were known to have preyed on moose calves (Schwartz and Franzmann, in press). No predation occurred in areas where moose browse rehabilitation had occurred; all predation occurred in uncrushed areas of regrowth vegetation resulting from a 1947 forest fire (op cit.). If this same model holds true in the Susitna study area, which is comprised of vegetation in a relatively undisturbed state, high levels of predation on moose calves by black bears would be expected.

Daily monitoring of three black bears in the Susitna study area during the period 21 May-22 June 1981 resulted in 73 point locations. During this period, one black bear, (a five-year-old male), was observed on one calf moose kill and one adult caribou kill. This bear was also observed on a kill of an adult radio-collared moose on 22 July. No other predation was observed during the period of intensive monitoring. Subsequent regular monitoring of black bears resulted in no additional known kills of ungulates.

It is believed that calf moose are more important spring prey than indicated by these data. Many kills were likely missed because of relatively infrequent monitoring, the difficulty of spotting kills in heavy vegetation, and the low numbers of intensively monitored black bears.

(viii) Dall Sheep

The study area surveyed for Dall sheep includes all drainages flowing into the Susitna River from Gold Creek to Kosina Creek on the south and from Gold Creek to the Denali Highway on the north. Survey efforts were confined to areas of known or suspected Dall sheep habitat. The results of the sheep surveys are organized below according to well-defined sheep subpopulations.

- Portage - Tsusena Creek Area

During July 1980, a total of 72 sheep (seven legal rams, 12 lambs, and 54 unidentified) was counted in the Portage Creek and Tsusena Creek drainages. The only previous ADF&G survey in this area was a 1977 count of 91 sheep (eight legal rams, 18 lambs, 65 others). The 1977 survey included the Jack River drainage, which was not surveyed in 1980. The sheep sighted were located fairly high up in the drainages and relatively far from the proposed impoundments.

- Watana Mountain - Grebe Mountain Area

During July 1980, only eight sheep (one ram, seven unidentified) were observed in the Watana Mountain-Grebe Mountain area. Observations in 1977 suggested that at least 34 sheep were present on Mt. Watana. Numerous observations exist of sheep in the Terrace Creek area, but no sheep were observed there during the 1980 survey. Either the sheep had migrated from the area, or they were missed during the 1980 survey.

A winter distribution survey was conducted in the same area that had been surveyed in July 1980. During winter, a total of 28 to 30 sheep were observed. If data collected during these two surveys were representative of the sheep population, they would indicate that sheep were migrating into the area during winter. All sheep observations, however, were located on the southern extreme of the count area, well away from the proposed Watana impoundment.

- Watana Hills Area

The Watana Hills area was designated as a population trend count area for Dall sheep by ADF&G in 1967 and since that time has been surveyed eight times. The 1981 count of 209 sheep was the second highest number of sheep recorded for this area. The percentage of lambs was similar to past years and suggests that productivity and survival are remaining constant. Although the 1981 count was relatively high, it is believed to be accurate since the population is suspected to have remained stable or perhaps to have increased slightly.

- Jay Creek Mineral Lick

Observations recorded during the spring of 1980 strongly suggested the presence of a mineral lick on the cliffs along the lower reaches of Jay Creek near its confluence with the Susitna River. The lick is within the Watana Hills area. The possible existence of a mineral lick very close to the proposed Watana impoundment generated detailed studies in 1981.

The mineral lick at Jay Creek was examined on 9 May 1981. Portions of the lick were found to extend below the proposed average maximum pool elevation of the Watana impoundment. Sheep usage of the area ranged from the Jay Creek stream bottom to the top of the bluff and for an undetermined distance away from the bluff. On the day of examination, five Dall sheep were observed actively scraping and eating soil from this area. This further suggests that minerals are the main attraction.

A total of 34 separate observations of sheep using the mineral lick were made over a 50-day period, starting on 6 May and ending on 24 June 1981. The largest single group observed at the Jay Creek site consisted of 15 sheep. This number represents approximately 7% of the observed Watana Hills summer population and approximately 17% of the observed Watana Hills winter population.

Sheep were also observed frequenting other locations adjacent to the Jay Creek mineral site. On 23 and 25 May 1981, two groups of six and 12 rams, respectively, were observed scraping and eating soil on the ridge located on the east side of Jay Creek, directly opposite the main lick area. On seven occasions during June, sheep of different age classes were observed at an area approximately 3 km upstream from the main mineral area. This area also appears to be mineralized.

The use of the Jay Creek lick seems to be confined to May and June. An aerial summer distribution survey was conducted on 28 July 1981, and no sheep were observed at the Jay Creek area. Ten ewes and yearlings were observed, however, actively utilizing a known mineral lick in the drainage of the east fork of Watana Creek, approximately 11 km north of the Jay Creek site.

- Sport Harvest

The 1980 harvest within the Susitna sheep study area was 13 sheep. Eight of these were considered to be trophy quality rams with horn lengths greater than 89 cm (35 in). Most of the harvest occurred in the Watana Hills area.

(b) Furbearers

During 1980 and 1981, a variety of methods were employed to assess furbearer populations in the vicinity of the proposed impoundments and also downstream (Figure 3.19). The species studied included red fox, pine marten, beaver, muskrat, mink, river otter, coyote, lynx, short-tailed weasel, and least weasel. Both the common and scientific names of these furbearer species mentioned in the text are presented in Table 3.8.

Seventeen red foxes and 17 pine marten were equipped with radio collars and relocated at frequent intervals. Radio-equipped animals were relocated both from the ground and with the use of a helicopter. In addition, fox dens were located through a combination of ground and helicopter searches. The diets of both foxes and marten were studied by following trails in snow and noting feeding activity, collecting food remains at dens, and conducting gross analyses of scats and stomach contents.

Another method of assessing furbearer populations was the assignment of transects. Fourteen aerial snow transects were established between Portage Creek and the Tyone River (Figure 3.20). Each transect was oriented perpendicular to the Susitna River and extended for 4.8 km on either side of the river. The transects were then surveyed from a helicopter, and all furbearer tracks were recorded.

The extent of beaver and muskrat populations was investigated in the upper basin during 1980 by means of an aerial survey of both beaver dams and lodges and muskrat pushups. Downstream beavers were surveyed from a point 3 km above the confluence with the Indian River to a point 4 km below the confluence with the Kashwitna River. During 1980 this area was surveyed from a river boat and in 1981 from fixed-wing aircraft.

(i) Red Fox

Red foxes and their sign have been observed throughout the upper Susitna basin. In the vicinity of the proposed Devil Canyon and Watana impoundments, the population of red foxes generally increases from Devil Canyon upstream to the mouth of the Tyone River (Table 3.26). Some red foxes utilize tributaries and deltas of tributaries during autumn, then shift to alpine zones in winter, as both snow depth and the volume of water flowing over the ice increase along the river. Other foxes remain above timberline throughout most of the year. Fox numbers upstream from Vee Canyon and in alpine areas adjacent to the proposed impoundment zones appear to be comparable to those in Denali National Park and Preserve and other portions of interior and southern Alaska (Buskirk, pers. obs.).

The density of red foxes in the Susitna study area appears to be low compared to densities of red foxes in midwestern states. Pils and Martin (1978), Sargent et al. (1975), Scott and Klimstra (1955) and Shick (1952) working in Wisconsin, North Dakota, Iowa, and Michigan, respectively, estimated the density of fox families to be one family per 10 km^2. In summer 1981, six active fox dens were found on a 1,751 km^2 portion of the Susitna study area. On the basis of the sighting of two fox pups at an additional den site, it is likely that at least seven dens were occupied by fox families during 1981. This is one fox family per 250 km^2. In all probability, not all dens in the study area were found. If only half of the active dens were found, the figure is one family per 125 km^2. Correspondingly if only one-third of the active dens were found, the estimate would be one family per 83 km^2 compared to one family per 10 km^2 estimated in midwestern states. Considering the effort spent searching for fox dens during the study period, the estimate of one fox family per 83 km^2 is probably reasonable, if not slightly high.

Trappers have actively pursued red foxes throughout the region. Harvests of red fox pelts have generally been highest upstream from Vee Canyon. Emphasis has been placed on trapping red foxes along the Susitna and Maclaren rivers downstream from the Denali Highway to a few kilometers below the mouth of the Tyone River. A local trapper and fur buyer reported (pers. comm.) that during the late 1950's and early 1960's, another trapper of his acquaintance took 300-350 fox per year in this area.

The fur buyer also recalls that on an April 1959 trip down the Susitna to the Tyone River, he saw 15 to 20 foxes. It is noteworthy that these foxes were present after a heavy trapper-take of foxes occurred during the 1958-59 trapping season. While the historical estimates of red fox numbers downstream from Vee Canyon to Devil Canyon are limited, fox numbers have been low in this area since the mid-1970's; it is felt that their numbers remain consistently low. In substantiation of this belief, during the 1979-80 trapping season, two trappers working along Tsusena Creek took only two foxes; another trapper captured one fox in the Fog Lakes area; a third caught no foxes while trapping around Stephan Lake.

Principal foods of red foxes during spring and summer include Arctic ground squirrels, red-backed voles, and singing voles. Ptarmigan are taken throughout the year, but they are of major importance to foxes during the winter. Trails in snow show that foxes commonly forage in areas above timberline frequented by large flocks of ptarmigan. Murie (1944) states that ground squirrels in McKinley Park (now Denali National Park and Preserve) were abundant and much used by foxes. He has little to say relating to the use of ptarmigan, however, because at the time of his studies, populations of these birds were low in the park.

Foxes take muskrats where available, and they may be relatively important to foxes around large lakes such as Stephan, Clarence, and Deadman. Dispersing young muskrats and muskrats at pushups are particularly vulnerable to predation by foxes. A trapper reported observing foxes hunting muskrats during winter at pushups on Stephan Lake. Aerial and ground observation at Clarence Lake during this study indicates that foxes frequently visit muskrat pushups.

In parts of the study area, carrion may also be important to red foxes. Caribou carcasses appear to be the main source of carrion in the Clarence Lake area, where sport hunting is relatively heavy during fall. Two foxes near Watana Camp also fed on remains of a caribou and on a moose carcass through most of winter 1980-1981. In addition, two foxes were observed in October 1981 feeding on a sheep killed by wolves on the east fork of Watana Creek.

In general, snowshoe hares may be another important component in the red fox diet (Dickson 1938). Snowshoe hares are scarce in the Susitna study area, however, [see Section 3.2(d)] and, therefore, relatively unimportant in the diets of foxes here. No hare remains were noted either at two active fox dens found in 1980 or at six active dens observed during summer 1981. In addition, no evidence of foxes preying on hares was found during trail sampling of foxes in either 1980 or 1981. This scarcity of hares may, in part, be responsible for both the relatively low number of foxes found in the area as well as for the seasonal shifts to higher elevations where ptarmigan are available.

During the study, 19 fox dens were located, six of which were active during summer 1981. Of the 19 dens, 18 were north of the Susitna River, and one was south. Several dens were concentrated in the upper Watana Creek and upper Deadman Creek drainages. While there are probably more dens south of the Susitna River than were located, extensive searches were conducted, and no others were found. Thus, although south of the river, the Stephan Lake - Prairie Creek area appears to be well suited for red fox dens, aspect, physiography, and vegetation are generally more favorable for denning and hunting on the north side of the river. The study's findings corroborated this analysis. The extent of den use varied among these sites. Some sites were comprised of extensive burrow complexes and are probably used every year. Others appeared to be used less frequently, and in some cases, they seemed to serve only as winter resting sites.

Dens of red foxes typically occur between 1,000 and 1,200 m elevation in areas of rolling hills adjacent to mountains. A lake covering four hectares or more or a creek is usually located nearby. Vegetation surrounding den sites typically includes alpine tundra (Dryas-lichen), shrub tundra (medium and low shrub with tussocks, sphagnum dwarf birch, low willow, and ericaceous shrub-sedge) and mat and cushion tundra (Dryas-sedge, willow, and ericaceous shrubs).

Red fox dens are found on prominences up to 5 m higher than the surrounding area. The soil type is usually silt and relatively rock free. Murie (1944) reported: "Red fox dens in McKinley Park [Denali National Park] were in the open and in the woods, on sunny knolls far up the slopes, and on the flats. Most of them were dug in sandy loam . . . . "

Murie's findings are similar to those of this study except that ground and air searches did not reveal fox dens in the woods. Allison (1971), working in Denali National Park, recorded dens in habitats similar to the denning habitats observed during this study. Except for alder, Allison mentioned no plants over four feet (1.2 m) high near dens. On the other hand, some fox dens have been seen in the woods in Denali National Park (Buskirk, pers. obs.).

Red fox dens usually had a complex of burrow entrances, most oriented to the south but some facing west. The number of entrances present per den ranged from three to 27, with one alternative den generally located within 200 m of the main den.

All active dens located were in or near areas of medium to high ground squirrel density. As noted above, ground squirrels are an important food item during the denning season.

Red foxes begin denning activities in the Susitna basin during late April or early May. One female in the study, over a two-day period, moved almost 16 km from her winter range to a den site. In another instance, an adult female reared pups in 1981 at a den where she had been a pup in 1980.

Ranges remained constant throughout the summer. An adult male occupied a minimum summer range of 36.8 km^2 in 1981. Another male occupied a range of approximately 20 km^2. From late August into October, juveniles utilized progressively larger areas around natal dens.

Dispersal occurred in early to mid-October. Allison (1971) reported that in Denali National Park, fox families vacated dens by mid-August. Storm (1972) found that foxes in Iowa and Illinois used den sites until late July and remained together as a family unit into October. Sheldon (1950) observed that some fox families in his central New York study area stayed together until September and that the latest date for an occupied den was 10 July 1947. The latest date reported for foxes at dens in Alaska is 11 August (Magoun, pers. comm.). Findings in the Susitna area suggest that a period of roughly one month may pass between abandonment of the den site and dispersal of the young. This period contrasts with the three months between abandonment of the den site and dispersal in Storm's study area in Iowa and Illinois.

Recorded dispersal distances ranged from 16 km to 64 km. Of ten juvenile red foxes collared in 1981, nine have completely left the area. Extensive aerial searches with radio receivers failed to produce signals from any juvenile foxes within 80 km of their natal dens.

Large creeks as well as the Susitna River appear to present no barrier to foxes intent on crossing them. For example, one adult male regularly crossed Deadman Creek, and two juvenile red foxes crossed the even larger Susitna River in October, when slush ice was flowing down the main channel.

(ii) Pine Marten

Pine marten are locally abundant in the vicinity of the proposed Devil Canyon and Watana impoundments. Information from former and present trappers indicates that marten have historically been important to trappers and are presently the most economically important species to trappers in the vicinity of the impoundment zones.

Data from aerial transects flown in November 1980 (Table 3.26) indicate that marten are present along that portion of the Susitna River that was surveyed (Portage Creek to Tyone River), with the highest concentration of marten tracks between Devil Creek and Vee Canyon. In terms of elevation, marten were most numerous below 1,000 m, probably because forested vegetation communities (coniferous, deciduous, and mixed) are likewise restricted to elevations below 1,000 m.

Diets of marten were studied by identifying food remains in scats and in the gastrointestinal tracts of animals caught locally by trappers. Over 450 gastrointestinal tracts and scats were collected. Data from an earlier study in Alaska (Lensink 1954) indicated that mice were the principal food of marten south of Lake Minchumina. Similarly, gross examination of scats at the time of collection suggests that mice are the principal food of Susitna marten; however, major seasonal shifts in the diet of Susitna marten are suspected. The results of scat examination and snow tracking also indicate that the fruits of bog blueberry, mountain cranberry, crowberry, and prickly rose are eaten in autumn and winter.

Based on data collected during 1980, the home ranges of three male marten covered a minimum of 4.74 km^2, 5.44 km^2 and 4.87 km^2, respectively. These estimates assume the following:

1. Creeks and the Susitna River form home range boundaries during summer.

2. Marten home ranges do not extend above treeline during summer. Movements of marten beyond the home ranges depicted by some resting locations may be significant and could indicate considerably larger home range sizes.

Many estimates of North American marten home ranges reported in the literature (for example, Hawley and Newby 1957 and Lensink 1954) are based upon capture-mark-recapture methods. Archibald (1980) has shown that, for the same animals, home range sizes determined by telemetry are greater than home range sizes determined from trapping grid methods. Archibald found that telemetry-based home ranges for five marten over one year in age (two males, three females) averaged 4.1 km^2. Also using radiotelemetry, Mech and Rogers (1977) found four marten (three males, one female) in Minnesota to have an average home range size of 12.8 km^2.

Data from radiotelemetry work show that fidelity to home ranges varies considerably. For instance, while home ranges of adult male marten appear to be mutually exclusive, overlap with home ranges of other sex/age class marten does occur. In addition, marten do not readily cross bodies of water which require them to swim. Thus, the Susitna River and larger tributary creeks form home range boundaries for many marten. Home range data on four male marten captured during 1980 are presented on Table 3.27 and Figure 3.21.

A female marten of unknown age and a juvenile male both possessed home ranges with two centers of activity separated by several kilometers. The highest elevation of any marten radiolocation was 810 m, but in one instance, marten scats were found at an elevation of 970 m. As noted above, however, it appears that marten seldom travel higher than 1,000 m.

In general, marten rest above ground during summer months and below ground in winter. Winter resting sites of marten consist almost exclusively of active red squirrel middens. Consistent with this behavior, of 34 marten resting sites found during the study, 26 were active red squirrel middens, two were inactive red squirrel middens, three were red squirrel grass nests in white spruce trees, and three were burrows or holes of unknown origin in soil. All of these resting sites were in forest or woodland vegetation types.

(iii) Beaver and Muskrat

Beavers and muskrats occur throughout the Susitna drainage from the delta of the Susitna River on Cook Inlet upstream along the river and its tributaries to elevations above 1,000 m. Both species occur in lakes and marshes from sea level to above 1,000 m. Populations of beavers or muskrats or both are present along slow-flowing sections of most larger creeks, particularly where lakes drain into streams. Examples include the Stephan Lake/Prairie Creek drainage and the Deadman Creek/Deadman Lake drainage.

During early winter, muskrats construct small lodges, or pushups, in the forming ice cover on ponds. These pushups are used as feeding sites, resting areas, and defecation sites. They remain intact until breakup and can be used as an indication of muskrat presence and general abundance. During the spring 1980, aerial surveys for pushups upstream from Gold Creek showed muskrats occurred in only 27 of the 103 lakes and ponds sampled.

Trapping for beavers and muskrats has historically been common along the Susitna below Devil Canyon, along major tributaries, including Indian River and Portage Creek; and around larger lakes, such as Stephan Lake.

Sign of both species is also common in suitable aquatic habitats above timberline. Trappers' reports suggest that they seldom pursue beavers or muskrats inhabiting alpine streams and lakes because the reward does not justify the effort involved. While these animals do represent an important fur resource, both species, at higher elevations, are also particularly vulnerable to environmental alterations and/or to overharvest because of their dependence upon small, isolated riparian habitats.

The farther downstream from Devil Canyon one moves, the greater is the beaver and muskrat use of riparian habitats along the Susitna River. Surveys of their sign, conducted from river boats during summer 1980 (Table 3.28) and from fixed-wing aircraft during summer 1981, indicate that between Devil Canyon and Talkeetna, beavers are limited to occasional foraging sites and lodges along protected banks of the river, sloughs, and lower reaches of feeder streams. No sign of muskrats was noted along this section of the Susitna. Between Talkeetna and Montana Creek, sign of beavers is common along sloughs, in deltas of tributaries, and along stable banks of braided river channels. Sign of muskrats in this stretch is limited to sloughs and marsh areas near the mouths of feeder streams. From Montana Creek to Delta Islands, sign of beavers is present almost continuously. The numerous islands and sloughs provide ideal habitats for foraging, caching food, and building lodges.

Results of this survey agree with the findings of Boyce (1974) and Hakala (1952), who reported that beavers in Alaska favor lakes or slow-flowing streams bordered by subclimax stages of shrub and mixed coniferous and deciduous forests. This description fits the area between Montana Creek and the Delta Islands, and the earlier findings were corroborated by this study. Similarly, this study and an earlier study (Retzer 1955) confirmed that large rivers with narrow valleys and high velocity flows, such as the area between Devil Canyon and Talkeetna, are generally sparsely populated by beavers.

(iv) Mink

In the upper basin, mink tracks were observed along all major tributary creeks below 1200 m in elevation and near some streams and lakes. A total of 34 mink tracks were counted along aerial transects in November 1980 (Table 3.26). Of these, 27 were in riparian or lake shore habitats. In addition, mink tracks were noted along the lower Susitna River during the downstream beaver survey.

(v) River Otter

Tracks of river otters were often sighted along the river, on tributary creeks to 1200 m elevation, and around Stephan and other large lakes. In November 1980, an unusually high incidence of otter tracks was noted on shelf-ice along the Susitna River in the proposed impoundment zones. A survey was carried out in which 37 points on the river between Portage Creek and the Oshetna River were examined for the presence of otter tracks (Figure 3.20). Forty-three otter tracks were present at 17 of these points (Table 3.29). Although the significance of these tracks is not clear, they may represent upriver or downriver movements of otters prior to freeze-up. Another possibility is that otters were concentrated along the river to feed on grayling leaving tributaries at freeze-up to overwinter in the Susitna River.

Other trails observed were of otters traveling cross-country, away from bodies of water. Such tracks may represent dispersal of subadult animals and have been noted by members of the furbearer study team in other areas of southcentral Alaska. Local trappers seldom take river otters because they are relatively difficult to trap and their pelt values have usually not been high enough to justify the effort.

(vi) Coyotes

Coyotes occur in the study area, but their distribution is generally restricted to areas downstream from Devil Canyon. No coyotes or their tracks were observed by the furbearer team. On 12 September 1980, a coyote was heard howling a short distance southwest of the Stephan Lake Lodge. An employee of the Alaska Railroad at Gold Creek reported trapping one coyote and seeing tracks of others during the winter of 1979-80. During the past several years, coyotes have been commonly noted in the Indian River-Canyon area, their howling heard often. Upstream from Devil Canyon, however, coyotes are less common. None of the trappers contacted during the course of this study reported seeing or trapping coyotes upstream from Devil Creek. The distribution and abundance of coyotes in the region is probably limited by wolves rather than by habitat and/or food availability. Within their home range, wolves are usually aggressive toward coyotes.

(vii) Lynx

Lynx occur in the study area, but their distribution is very limited. On 19 November 1980, probable lynx tracks were observed on the Susitna River bar across from the mouth of Goose Creek. On 22 October 1981, this area was visited by members of the furbearer study team, and a dense concentration of lynx tracks and scats was discovered. On 30 October 1981, two team members also found lynx tracks at the mouth of Jay Creek, and on 3 November 1981, lynx tracks were noted along Goose Creek 1.6 km from the mouth. Two trappers from Glenallen reported taking lynx in the vicinity of the mouth of the Oshetna River during winter 1976-77. Their impression was that lynx had not been numerous before or since that time. In the vicinity of the proposed impoundments, trappers reported no sightings of lynx or their tracks. Reports from trappers in the Gold Creek area suggest that in recent years, lynx have been uncommon downstream from Devil Canyon.

Although, with the exception of the upper reaches of the proposed Watana impoundment, lynx appear to be uncommon in the study area at present, populations may have been significantly higher in the past. The historical frequency of natural fire appears to increase between Portage Creek and the Tyone River. It may be that in these burned areas in the past, snowshoe hares, upon which lynx feed, have periodically been numerous and that at those times, lynx numbers were correspondingly higher.

(viii) Short-tailed Weasel

Short-tailed weasels are locally abundant in the study area. Their tracks have been observed in a variety of habitat types from the banks of the Susitna River to elevations over 1500 m. Seven hundred and forty-six tracks of short-tailed weasels were observed during transect surveys in November 1980 (Table 3.26); 328 (44 %) were counted on a single transect near the Tyone River. Four hundred and eighty-nine (66%) of the tracks were observed in woodland white or black spruce vegetation types, and an additional 190 (25%) were counted in medium (Betula) shrub types. Trappers on upper Tsusena Creek, in the Fog Lakes area, and elsewhere in the study area take short-tailed weasels both intentionally and incidentally to the trapping of other species.

(ix) Least Weasel

Observations suggest that least weasels occur sparsely throughout the study area. Several sets of tracks believed to be those of least weasels were observed on lower Watana Creek in March 1980. The carcass of a least weasel taken by a trapper at Fog Lakes was obtained in February 1981, and a live least weasel was observed near the southeast edge of proposed Borrow Area A on 25 October 1981. While not abundant throughout the study area in general, least weasels may be locally common; however, their small size and secretive behavior make confirmation of their presence difficult.

(x) Furbearer/Habitat Relationships

Over 800 fox-habitat sample points obtained through trailing in winter, aerial surveys (Table 3.30), and radio-tracking show that foxes prefer two basic habitat groups: a combination of black spruce woodland and medium shrub tundra and a combination of alpine tundra, low shrub tundra, and mat and cushion tundra. The vegetation types in each group were found to be in close association in the study area.

Habitat preferences of foxes were sampled throughout the year. The black spruce woodland and medium shrub tundra group accounted for 46.5% of all sampled locations, and the alpine tundra, low shrub and mat and cushion tundra group covered 48% of all locations.

Pine marten favor conifer-dominated forest and woodland habitat types for foraging and resting. Of 1,353 marten tracks located in identified habitat types in November 1980, 605 (45%) were in woodland black spruce, 525 (39%) in woodland white spruce, 54 (4%) in mixed forest, and 29 (2%) in mixed woodland (Table 3.30). Of 34 marten resting sites located by radiotelemetry, 13 (38%) were in mixed forest, eight (24%) in white spruce forest, eight (24%) in mixed woodland, and five (15%) in other woodland types. Although marten do make occasional forays into shrub tundra and marsh types, the proximity of trees is clearly important. In late summer and autumn, bogs and Carex marshes are important foraging sites. Vegetation types avoided by marten include higher alpine types and large, pure stands of deciduous trees.

In the vicinity of the proposed impoundments, beaver dams, lodges, food caches, and foraging sites were noted to elevations above 1,000 m on many slow-flowing sections of creeks and near the outlets of lakes. In alpine areas, willow appears to be the major food, but some dwarf birch and alder are utilized. Along forested banks of creeks in the impoundment zones and along the Susitna River below Devil Canyon, beavers prefer aspen and cottonwood where available, although willow and some birch are utilized. Sign of beavers is increasingly abundant along sloughs and slower-moving channels of the Susitna River downstream from Gold Creek to Delta Islands.

Muskrats occur in lakes, ponds, small streams, sloughs, and marshes throughout the study area. Shallow areas with aquatic vegetation, particularly sedges, are preferred foraging sites.

Data from aerial transects and direct observation of sign confirm that habitats most important to mink in the study area, as elsewhere, are creek and river banks, lake shores, and marshes. For most of the winter, mink utilize areas under ice.

Results of aerial transects and direct examination of otter sign show that otter forage almost exclusively in riverine and lacustrine habitats. Otters make use of under-ice habitats during winter, although the extent and nature of this utilization is unknown.

Short-tailed weasels exhibit much broader habitat preferences than other small mustelids. Of 746 weasel tracks classified during November 1980 aerial transects (Table 3.30), 401 were found in black spruce woodland, 190 in medium (primarily Betula) shrub tundra, 88 in white spruce woodland, and 29 in mat and cushion tundra. Direct observation of sign supports the inference that short-tailed weasels can meet their food and cover needs in a variety of structurally and phytologically diverse habitat types.

Lynx appear to be concentrated in the limited riparian communities and the recently burned areas where hares are present.

(c) Birds

Field studies were conducted during the following periods: 6 July to 4 October 1980, 8 to 10 February 1981, and 17 April to 23 October 1981. Activities included helicopter surveys of raptor cliff-nesting habitat and, during waterfowl migration, of selected waterbodies; 385 party-hours of breeding bird censusing; 53 party-hours of ground censusing of water-birds; 44 party-hours of ground observations of raptor/raven nest sites; and more than 630 party-hours of general bird surveys. The common and scientific names of birds mentioned in the text are presented on Table 3.31.

(i) Species Composition and Relative Abundance

To date, 135 species of birds have been recorded in the upper Susitna River basin study area. The relative abundance of these species (see Table 3.32 to 3.35) is largely a function of habitat availability, with common redpoll, savannah sparrow, white-crowned sparrow, lapland longspur, and tree sparrow the most abundant species. Redpolls are habitat generalists, while the other abundant species are birds of the shrublands (dwarf, low, and medium shrubs), vegetation types that cover 67% of the region (APA 1981).

On the basis of current information, 13 species are ranked as rare in the region: three raptors (osprey, American kestrel, boreal owl); three species of prairie ducks (gadwall, blue-winged teal, ring-necked duck); three sandpipers (upland sandpiper, surfbird, sanderling); three small land birds (black-backed three-toed woodpecker, western wood pewee, yellow warbler); and ruffed grouse. Most of these birds are at the periphery of their geographic ranges, although lack of appropriate habitat may limit a few. All, however, are represented by larger, healthy populations in other portions of Alaska.

An eastern kingbird, spotted on 11 July 1980, is considered accidental in the region. In Alaska this species is a regular visitant only in the southeast; it is casual elsewhere in the state (Kessel and Gibson 1978).

(ii) Breeding Bird Densities

Breeding bird censuses, using the territory mapping method (International Bird Census Committee 1970), were conducted between 20 May and 3 July 1981. Twelve square, ten hectare (25-acre) census plots were selected in relatively uniform patches of vegetation that represented each of the major woody avian habitats (after Kessel 1979) present in the region. Eight early-morning censuses were taken on each plot to determine the avian population levels supported by the different habitats and the density of territories of each bird species in each habitat.

Avian population levels varied greatly among the different habitats (Table 3.36), as, of course, did the level of use of each habitat by different species (Table 3.37). The presence or absence of a given species in a habitat is largely a function of species' habitat preferences (see below), but habitat occupancy levels are affected by a number of factors, including in interior Alaska, habitat structural complexity and primary productivity (Spindler and Kessel 1980).

Generally, in the upper Susitna River basin, the forest and woodland habitats supported higher densities and/or biomasses of birds than did the shrub communities. Highest densities in forests were found at the downstream (Sherman) balsam poplar forest plot, which supported 60.9 bird territories/10 ha, and lowest densities were found in the white spruce forest plot at the mouth of Kosina Creek (15.7 territories/10 ha). Of the shrub habitats, low-medium willow shrub had the highest densities (45.4 territories/10 ha), and the dwarf shrub-alpine tundra the lowest (<11 territories/10 ha). Tall alder shrub was also low (12.5 territories/10 ha). Alpine tundra areas of upland cliffs and block-fields and of mat and cushion tundra had the lowest bird usage but supported some bird species not generally found in other habitats. Species in the alpine tundra included white-tailed ptarmigan, horned lark, wheatear, water pipit, gray-crowned rosy finch, and snow bunting.

Preliminary comparisons between occupancy levels in habitats of the upper Susitna River basin and those in similar habitats in the upper Tanana River valley (Spindler and Kessel 1980) show many parallels. In both regions, white birch forest and the mixed deciduous-coniferous forest supported intermediate levels of bird populations and coniferous forest the lowest levels. The scattered woodland and dwarf forest habitats, with their openness and added shrub components, however, also supported intermediate occupancy levels, even with major coniferous components. The lower-height shrub thickets had low numbers of species, apparently because of relatively simple habitat structure, and there were differences in occupancy levels between plots with a dry substrate and ones with high substrate moisture. Habitat diversity and a wet substrate probably allowed higher occupancy levels on the Susitna low-medium willow shrub plot compared to other shrub plots.

The most conspicuous difference between the upper Susitna and Tanana valleys was in the tall shrub thickets. Tall shrubs in interior Alaska supported the highest avian occupancy levels of any habitat (Spindler and Kessel 1980), but unlike the Susitna study area, these thickets were dominated by willow, thinleaf alder, and balsam poplar, which have average to above average levels of primary productivity. The tall shrub thickets of the Susitna study area were composed almost entirely of American green or Sitka alder, which have relatively low levels of primary productivity (Spindler and Kessel 1980) and which, in interior Alaska and on the Seward Peninsula, also support relatively few birds (Kessel pers. obs.).

(iii) Waterbird Use of Wetlands

- Summer Populations

In respect to both numbers of species and numbers of individuals, the wetlands of the region supported relatively few waterbirds during the summer. The relative abundance of loons, grebes, and waterfowl determined from all observations is shown in Table 3.32. The number and density of adults and broods of waterbirds observed during the intensive ground surveys of 28 ponds and lakes during July are shown in Table 3.38.

The density of adult birds derived from the intensive ground survey of 20.5 km^2 of wetlands was 23.8 adults/km^2. By comparison, a similar census of 13 of the more productive waterbodies of the upper Tanana River valley, east-central Alaska, in 1977 and 1979 showed 183.3 and 110.9 adults/km^2 of wetlands, respectively (Spindler et al. in press). Regional comparisons of densities obtained by the waterbody census method can only be made if the distribution of waterbody size classes is similar between regions (ibid)., which was the case for the sets of sampled waterbodies used here. The number of broods directly corresponded to the low bird density, with 2.9 broods/km^2 of wetlands in the upper Susitna River Basin in 1981, compared to an average of 6.2 broods/km^2 in the upper Tanana River valley (ibid.). In 1979, productivity in the eastern portion of the upper Tanana River valley study area was 30-40% lower than historical levels at some of the most productive Alaskan wetlands, like Minto Lakes and the Yukon Flats (J. G. King, U.S. Fish and Wildlife Service, pers. comm.). Thus, during the summer, the waterbodies of the upper Susitna River basin appear to support a relatively impoverished waterfowl population.

The species composition of waterfowl in the region showed some differences from that of central Alaska as a whole, in part reflecting the subalpine nature of much of the study area. Oldsquaw and black scoter were the most productive of the waterfowl in 1981 (Table 3.38). Both species are primarily tundra nesters, and the Alaska Range is the only inland nesting location known for the black scoter in Alaska (Gabrielson and Lincoln 1959). On the other hand, the pintail, which is one of the most numerous ducks in central Alaska, occurred in relatively small numbers in the study area, in spite of the fact that because of severe drought in the Canadian prairie provinces, both 1980 and 1981 were high population years for pintails in Alaska (King and Conant 1980, Conant and King 1981).

Trumpeter swans bred commonly at the eastern end of the study area, from the vicinity of the Oshetna River at least to the MacLaren River. On a random flight over the ponds of this area on 4 August 1981, 19 observations of trumpeter swans were made. Forty adult birds were counted, including nine pairs with broods, totaling 28 cygnets. This area is the western edge of the Gulkana Basin trumpeter swan population, which has more than doubled during the past five years (J. G. King, U.S. Fish and Wildlife Service, pers. comm.).

- Populations During Migration

Studies covered one spring and two fall migratory periods. Aerial surveys were begun earlier and conducted more frequently in fall 1980 than in 1981 because during the first year, it was necessary to learn the use patterns in the region. The fall 1981 surveys were begun later in September than those of 1980 and continued until most of the waterbodies were frozen. An attempt was made to time the first 1981 survey to catch the peak of waterfowl migration, but that effort apparently failed because of a somewhat earlier movement of wigeon, pintail, and scaup that year. During both fall periods, however, the patterns of migration and of waterbody use were similar.

Summaries of the numbers and species composition of loons, grebes, and waterfowl enumerated in the upper basin during aerial surveys in fall 1980 and 1981 and spring 1981 are given in Tables 3.39 to 3.41. Relative abundance rankings for species in fall and spring appear in Table 3.32. Based on these data, the upper Susitna River basin, which is on a high plateau between the Alaska Range and the Talkeetna Mountains, does not appear to be a major migration route for waterbirds (contra U.S. Army Corps of Engineers 1977).

Scaup, including both lesser and greater scaup, were the most numerous species group during both spring and fall. Relatively large numbers of mallards and American wigeon also moved through during both seasons (although the fall 1981 surveys missed the peak wigeon migration). Pintails were common during spring migration but uncommon in fall. Few geese or cranes were seen at either season.

The upper Susitna River basin was less important to migratory waterfowl in spring than in fall. The difference was probably due largely to the ice breakup, which occurred after the main spring migratory movement of many species, especially the dabbling ducks and the common goldeneye.

During their migration, early migrants used both the Susitna River itself and the thawed edges of lakes. Use of the region's waterbodies increased toward the end of May, concurrent with more open water and with the influx of the later-arriving loons, grebes, scaup, oldsquaw, scoters, and mergansers.

On 7 May 1981, an aerial survey was done along the Susitna River from Devil Canyon to Cook Inlet to ascertain the magnitude of waterfowl use during spring migration. The results are presented in Table 3.42. In general, comparatively few waterfowl were noted using the river. Waterfowl abundance appeared to increase as one progressed downstream from Devil Canyon, probably because of changes in river morphology that correspond to various reaches of the Susitna River. That portion of the river between Cook Inlet and the Delta Islands is highly braided and is characterized by slow-flowing sloughs and, thus, provides a greater area of water suitable for waterfowl use. The upper reaches of the river, near Devil Canyon, are more channelized, faster flowing, and, therefore, less suitable for resting migrants.

(iv) Breeding by Cliff-nesting Raptors, Ravens, and Eagles

Information on use of the region by breeding raptors and ravens was derived from 1) helicopter surveys on 6 July 1980 and on 16 and 17 May 1981, of all cliff habitat along the Susitna River and its tributaries, from Portage Creek (1980) and Indian River (1981) to the mouth of the Tyone River, and on 3 and 5 July 1981, of habitats along the proposed access routes; 2) ground visits between 20 May and 13 July 1981 to all 1980 and 1981 active nest sites; 3) special ground and aerial searches of vegetated cliff habitat to discover potential peregrine habitat; 4) supplemental observations made whenever flying over or working near raptor habitat, and 5) miscellaneous observations made throughout the study period.

During the ground visits, photographs as well as verbal descriptions were obtained for each active nest site, and all the cliff habitat along the river system was classified according to its apparent quality for nest sites. "A" cliff habitat had cliffs large enough to support a nest, had ledges and nooks for nest placement, and had little loose material; "B" cliffs had these same attributes but were smaller and perhaps not large enough to support a nest; and "C" cliffs had loose substrates (dirt and rock banks or loose talus) and probably would not have been used by raptors.

- Summer Populations

In all, 43 raptor/raven nest sites were located during 1980 and 1981, 20 of which were inactive in both years. Presumably, these inactive sites function either as alternative sites or are used in years of higher population levels. Of the 23 nests that were active in at least one year, at least five were used both years, each by the same species (Table 3.43). Active sites during the two years of study included those of ten golden eagle, six bald eagle, four common raven, one and perhaps two gyrfalcon, and one goshawk.

In 1974, White (1974) found ten active nests within this same geographic area: two gyrfalcons, one bald eagle, and seven common ravens. He reported 14 inactive nests, ascribing eight to ravens and three each to golden and bald eagles. The reason for the substantially different species composition between the two sets of surveys, that is, more ravens and fewer eagles in 1974, is unknown.

The density of active golden eagle nests in both 1980 and 1981 (one pair per 14.8 km) was similar to that along the Dalton Highway through the Brooks Range in 1979 (one active nest per 15.7 km) (D. G. Roseneau, pers. comm.)--the Brooks Range having one of the highest populations of golden eagles in Alaska. Murie (1944), in Mt. McKinley (now Denali National Park) National Park, found active nests as close as 1.6 and 2.4 km to each other in 1941 and 1939, respectively. Pairs of golden eagles regularly build and maintain a number of simultaneous nests, which they use as alternative sites in various years (Brown and Amadon 1968), some several kilometers apart (D. G. Roseneau, pers. comm.). It has been suggested (White et al. 1977) that local populations increase during years of high hare populations, but hares were relatively scarce on the upper Susitna in 1980 and 1981. Murie (1944) also found that ground squirrels were a major prey of golden eagles in Mt. McKinley National Park in 1939-1941, and this species was abundant in the Susitna area during our study.

Bald eagle densities in the upper Susitna River drainage appear slightly lower than those of interior Alaska, where Roseneau et al. (1981) reported 44 nests, 25 active in 1980, in the vicinity of the Alaska Highway and Tanana River between Fairbanks and the U.S.-Canada border, a distance of approximately 480 km.

On 26 June 1981, an aerial survey was taken along the Susitna River from Cook Inlet to Portage Creek in order to ascertain the use of the lower river by nesting bald eagles. A similar survey was done in early April 1980 by the U.S. Fish and Wildlife Service (USF&WS). An attempt was made during the 1981 flight to locate all nests previously reported by the USF&WS. During the 1981 survey, nine active eagle nests were found (Table 3.44), five of which had previously been noted by the USF&WS. In addition, 13 bald eagles (ten adults and three immatures) were sighted. Based on the discovery of nine nests and on the sighting of five adult birds in the vicinity of nests which, although reported by the USF&WS, were not located during this survey, it is likely that a minimum of 14 to 15 active nests are present between Cook Inlet and Portage Creek. Since weather conditions impaired the effectiveness of the 1981 survey and thus limited the total number of nests located, it is reasonable to speculate that the actual number of active nests could be closer to 20.

Compared to eagle abundance, gyrfalcons are uncommon in central Alaska, but they nest throughout the Alaska Range. Cade (1960) estimated the total Alaska population at about 200-300 pairs, whereas Roseneau et al. (1981) thought there were more, but fewer than 500 pairs. Numbers in a given area may vary considerably from year to year (Cade 1960, Roseneau 1972) but probably not over large geographic regions (Roseneau 1972). For example, gyrfalcons in northern and western Alaska have low site fidelity from one year to the next (Cade 1960, Roseneau 1972). In the Alaska Range, however, most sites are used every year (Bente 1981).

There were no confirmed sightings of peregrine falcons in the region during our study, in spite of the many hours spent in ornithological field work and in raptor habitat. White (1974), however, saw two individual peregrines during his June 1974 survey but found no sign of nesting. One bird was a "single adult male. . .roosting on a cliff about 4 miles upriver from the Devil Canyon Dam axis," and the other was a "sub-adult . . . about 15 miles upriver from the Devil Canyon Dam axis." White (ibid.) stated that the Yentna-Chulitna-Susitna-Matanuska drainage basin "seemingly represents an hiatus in the breeding range of breeding peregrines. . .," and Roseneau et al. (1981) stated that "the Susitna and Copper rivers both provide . . . [very few] . . . potential nesting areas for peregrines."

Only one osprey was observed during the two seasons of study, on 23 May 1981 (John Ireland, pers. comm.) at one of the lakes near Stephan Lake.

- Breeding Chronologies

No special effort was made to obtain data on the breeding biology of raptors and ravens in the Susitna study area. Because the breeding season is a period when most birds are relatively sensitive to disturbance, attempts were not made during this study to establish breeding chronologies for nesting species. Table 3.45, however, shows the breeding chronologies of eagles, gyrfalcons, and common ravens in interior Alaska.

(v) Avifauna/Habitat Relationships

A general overview of bird habitat preferences can be obtained from the density of territories of various species in the habitats represented by the bird census plots (Table 3.37), the assumption being that species occur in greatest densities in their preferred habitats. Similarly, some information on habitat preferences can be obtained from our general surveys, in which we recorded the number of individuals of each species seen per kilometer in various habitats (data not shown).

The following, based on data from the bird censuses and the general bird surveys, is a list of the most abundant species found during the summer in each of the major avian habitats of the upper Susitna River basin:

- Lacustrine waters and shorelines: Arctic tern, mew gull, lesser and greater scaup, common loon

- Fluviatile waters, shorelines, and alluvia: spotted sandpiper, mew gull, violet-green swallow, harlequin duck

- Upland cliffs and block-fields: gray-crowned rosy finch, common redpoll, horned lark, American golden plover, water pipit

- Dwarf shrub mat: water pipit, American golden plover, horned lark, lapland longspur, rock ptarmigan

- Low shrub: savannah sparrow, tree sparrow, lapland longspur, white-crowned sparrow

- Medium shrub: tree sparrow, white-crowned sparrow, savannah sparrow, Arctic warbler, Wilson's warbler

- Tall shrub: hermit thrush, Wilson's warbler, fox sparrow, white-crowned sparrow, tree sparrow

- Scattered woodland and dwarf forest: white-crowned sparrow, American robin, Bohemian waxwing, tree sparrow, ruby-crowned kinglet

- Mixed deciduous-coniferous forest: hermit thrush, dark-eyed junco, yellow-rumped warbler, Swainson's thrush, varied thrush

- Deciduous forest: yellow-rumped warbler, common redpoll, Swainson's thrush, blackpoll warbler

- Coniferous forest: ruby-crowned kinglet, varied thrush, dark-eyed junco, yellow-rumped warbler, Swainson's thrush

(d) Non-game (Small) Mammals

(i) Species Composition and Relative Abundance

Sixteen species of small mammals were recorded in the upper Susitna River basin during the two years of study (Table 3.46).

Trapline surveys conducted during one spring and two fall periods involved a total of 16,776 trap-nights of effort and resulted in the capture of 1,753 microtine rodents (six species) and 1,747 shrews (four species). The two most abundant animals, constituting 67% of total captures, were northern red-backed voles, represented by 1,382 specimens, and masked shrews, represented by 1,286 specimens. Other shrews captured were Arctic shrews (297 specimens), dusky shrews (153), and pygmy shrews (11). Microtus specimens included 203 tundra voles, 68 meadow voles, and 75 singing voles. Brown lemmings (20) and northern bog lemmings (4) were also taken.

Capture results from 12 sites sampled during all three trapping periods indicated a pronounced temporal difference in small mammal abundance (Fig. 3.22). Trapping in fall 1980 resulted in 941 captures, compared to 125 the following May and 1,231 in fall 1981. Comparison of fall numbers shows that tundra voles were twice as abundant in 1981 as in 1980, red-backed voles 1.7 times more abundant, and masked shrews 1.3 times more abundant. Fall capture numbers of meadow voles, Arctic shrews, and pygmy shrews were about equal, while dusky shrews were sharply lower. Brown lemmings (six specimens) and bog lemmings (three) were taken in 1981 only. The low number of captures in May 1981 probably resulted from cessation of breeding in late fall and from overwinter mortality. Regardless of the temporal differences in population levels, the relative abundance ranking among species remained the same, that is, the common species remained common and the rare continued to be rare.

Six additional small mammal species occurred in the study area but were not caught on trapline surveys. For example, Arctic ground squirrels were abundant and widespread in the high country, while two other alpine species, collared pikas and hoary marmots, were only locally common. At lower elevations, red squirrels were fairly common. Porcupines were uncommon. Snowshoe hares, nowhere numerous, were generally restricted to areas east of Watana Creek. Localized "pockets" of hares were reported in the vicinities of Jay Creek, Goose Creek, and the Oshetna River. The scarcity of hares in the study area was probably due more to a scarcity of suitable habitat than to a low stage of a population cycle. Noticeably absent from the Susitna basin were recent burns and riparian shrub thickets, habitats most preferred by hares in other areas of central Alaska.

(ii) Small Mammal/Habitat Relationships

Standardized trapline transects were established on sites representing the small-mammal habitats of the region. Using a cluster analysis technique (Dixon and Brown 1979), 42 trapping sites were classified on the basis of their floristic similarity into three main vegetation types: 1) herbaceous dwarf and low shrub sites; 2) coniferous forest sites; and 3) mixed deciduous-coniferous forest, deciduous forest, and tall shrub sites. Figure 3.23 shows small mammal abundance patterns across this spectrum of habitat types.

Shrews and red-backed voles occupied a broad range of habitat types. Masked shrews, the numerically dominant shrew species, were caught on all 42 sites, while Arctic shrews were taken on 29, dusky shrews on 23, and the locally rare pygmy shrew on only four (not shown on figure). Generally, shrews were most abundant in balsam poplar forest, grassland, and alder shrub communities.

Red-backed voles, the dominant microtine of the region, were found on all but five sites, indicating this species' ecological flexibility. Across this broad range of occupied sites, red-backed voles were most numerous in forest and shrubland communities, particularly open and woodland spruce, and balsam poplar forest. Herbaceous meadows, especially wet sites, were generally avoided.

Microtus species had a more restricted habitat distribution. Tundra voles and meadow voles occurred primarily in herbaceous meadows and bogs dominated by sedge and grass vegetation. Such sites included wet sedge-grass, riverine herb/low shrub meadows, and sedge tussock seepages in black spruce woodland. Tundra voles occurred on 22 sites, compared to ten for meadow voles, suggesting the former species had greater habitat tolerance. Colonies of singing voles were found only above treeline in tundra and shrub habitats. They were most abundant in open willow-birch shrub communities on relatively dry sites.

Brown lemmings were trapped irregularly at or above treeline in herbaceous and shrub communities. Bog lemmings (not shown on figure) were caught at lower elevations in wet sedge-grass/low shrub sites (two captures), grassland (one), and near a seepage in white spruce forest (one).

Arctic ground squirrels dominated well-drained herbaceous and shrub tundra habitats above treeline, while collared pikas and hoary marmots were more restricted to rock habitats at the higher elevations. Red squirrels were confined almost exclusively to coniferous and mixed coniferous-deciduous forests and to woodlands within the river basin. Porcupines were encountered in a variety of forest and woodland communities. Snowshoe hares were in forest, woodland, and tall shrub habitats.

3.3 Description of Fish Resources

The baseline information described in this section is based primarily on reports prepared by the Alaska Department of Fish and Game (ADF&G) on Susitna River investigations conducted during the winter of 1980-81 and through 1981. These reports included studies on the adult anadromous species and on juvenile anadromous and resident species as well as on aquatic habitat and instream flow. Previously completed ADF&G reports and other pertinent literature have been used, where possible, to supplement this information.

The contribution to Cook Inlet of the Susitna River above Talkeetna can be estimated using the ADF&G 1981 salmon studies, the Cook Inlet commercial fishery harvest information, previous ADF&G salmon studies on the Susitna River, and standard harvest to escapement ratios for the five Pacific salmon species.

In the adult anadromous studies, the locations of the sonar counting and fishwheel field stations are shown in Figure 3.24. The locations of the primary tributaries and sloughs in the Susitna River downstream of Devil Canyon are shown in Figures 3.25 through 3.30.

For the lower Susitna juvenile anadromous and resident fishes investigations, the study area was divided into two reporting reaches: Cook Inlet to Talkeetna, which was the first 157 km of the Susitna, and the Talkeetna to Devil Canyon segment, which was approximately 86 km in length. Thirty-nine habitat locations and 44 sampling sites were located. These are listed in Table 3.47.

Based on a preliminary reconnaissance of the upper Susitna River basin, eight major tributaries were selected for more detailed fisheries studies. These tributaries were: Fog and Tsusena creeks in the vicinity of the proposed Devil Canyon impoundment and in the proposed Watana impoundment, Deadman, Watana, Kosina, Jay, and Goose creeks and the Oshetna River. For the purpose of this study, the first 1.6 km of these streams from their confluence with the Susitna River were designated as habitat locations. Sampling at the confluences included areas 90 m upstream and downstream of the respective confluence to assess mainstem utilization. Sampling evidence was placed on the tributaries, however, and not on the Susitna mainstem because it was thought that the tributaries contained the major fish resource in this region during the summer.

The aquatic habitat and instream flow studies during the summer field season involved data collection and analyses on water quality and hydrologic conditions in addition to the mapping of designated habitat sites between Cook Inlet and the Oshetna River. These areas included mainstem regions, sloughs, tributary confluences, and some upstream tributary localities. In all references to river kilometers in the text, it should be noted that distances are measured beginning with the river mouth as river kilometer 0.

Several sites in the study area were examined in greater detail than were other areas in order to evaluate the relationships between mainstem hydraulic and water conditions and fisheries habitat in slough areas between Talkeetna and Devil Canyon. The study was divided into two segments: 1) water quality and discharge data collection and (2) surveying and discharge measurements.

In order that impact analyses and mitigation assessments be made, a substantial amount of information and data generated by other project participants was utilized. Engineering and hydrological information provided by Acres American as well as hydrological and water quality information supplied by R&M Consultants and the United States Geological Survey (USGS) were used in conjunction with the available baseline fisheries data.

Since the above studies did not deal with the fish resources of the proposed northern transmission corridor from Healy to Fairbanks, a description of those resources is presented here. The Tanana River probably possesses the most valuable fish resource, with chinook, chum, and coho salmon found in the system. Throughout this northern region, several resident fish are known to occur. These include Arctic grayling, Dolly Varden, sheefish, burbot, northern pike, and several species of whitefish (ADF&G 1978). Fish resources in the southern segment of the transmission line corridor are essentially the same as those discussed in the following fish ecology report.

(a) Anadromous Species

(i) Salmon

In the following discussion of Pacific salmon species, the common names of chinook, sockeye, pink, chum, and coho salmon have been used. There are many other common names used throughout the geographic ranges of these species, and their indiscriminate use can result in a good deal of confusion.

For chinook salmon, the other most frequently used common name is king salmon. Sockeye salmon are also referred to as red salmon. It should be mentioned that the land-locked form of the sockeye is called kokanee. For the pink salmon, other frequently used common names are humpback salmon or simply, humpback. Chum salmon are also referred to as dog salmon, and coho salmon can be called silver salmon. The scientific names for the salmon species mentioned above and for all other fish species discussed in the fish ecology report are listed in Table 3.48.

Throughout the discussion of salmon, reference is made to Devil Canyon's being a natural barrier to salmon migration, a phenomenon which had previously been assumed but with little investigative support. Fisheries and hydrologic studies conducted during the past year have confirmed that salmon do not migrate through Devil Canyon, despite the fact that fish were reported to exhibit milling or holding behavior in the lower portion of Devil Canyon.

In the following discussions on salmon migration periods, reference is made to the peak migration periods. This was usually determined by plots of fishwheel catches per hour throughout the sampling season. The time period in which the catches of individuals was the greatest was determined to be the peak migration period. In discussing migration time rates, these rates are valid only if there is no fundamental variation in migrational timing between Susitna River stocks of the various salmon species.

It is known, at least in some cases, that salmon migration rates are influenced by variations in river discharge patterns. This phenomenon was seen in the fishwheel and sonar counting studies made on chinook salmon. Comparisons of catch rates and provisional USGS discharge data indicated a resumption of upstream migration following periods of high water.

- Adult

  o Chinook Salmon

In the lower Susitna River, the adult chinook salmon migration begins in late May and ends in early to mid-July. Historically, by 1 July, 90% or more of the escapement have migrated past the Susitna Station region, 41 km upstream of Cook Inlet (ADF&G 1972).

Field studies conducted during the 1981 season substantiated that the migration run had already begun before fishwheel sampling was operational on 19 June. As a result, the precise onset of migration in the lower Susitna River could not be determined. At Yentna Station, mean hourly fishwheel catches indicated that the migration was over by 9 July.

Similarly, sonar counts made during the initial days of operation at Sunshine Station suggested that a significant segment of the escapement had already migrated past this location prior to the 23 June sonar counter installation. This occurrence was also the case at the Talkeetna site, where a sizable portion of escapement had already passed before 22 June, when the sonar counters were initially operational. Migrating chinooks were already found to be present at Curry, upstream of Talkeetna, on 16 June.

Fishwheel catches and sonar counter data indicated that the peak of upstream migration at Sunshine Station occurred on 23 June and that migration ceased about 10 July. No peak migration period could be determined at Talkeetna, but migration had stopped by 7 July. The peak of the migration at Curry occurred on 23 June, while the run was essentially over in this region by July 4. Sonar counter data for chinook salmon is shown in Table 3.49.

The majority of Susitna Station fish sampled for age analyses were found to be three- and four-year-old individuals. Five- and six-year-old fish were present but in smaller numbers. At the Yentna Station, four-year-old fish, followed by six-year-olds, were the two dominant age classes in the migration run.

Age samples collected at Sunshine, Talkeetna, and Curry Stations can be considered characteristic of the chinook escapement. There was a higher percentage of younger fish, mainly three-year-olds, sampled at Sunshine Station than at either the Talkeetna or Curry Stations. Four-year-old individuals were dominant in the samples, except at Talkeetna, where six- and four-year-olds were equally abundant. Seven-year-old fish were relatively scarce at Sunshine and Talkeetna. None was identified from the Curry Station sample.

Radio telemetry studies indicated that the confluence of the Talkeetna, Chulitna, and Susitna rivers may be a milling area for migrating adult chinook salmon. All of the fish tagged at the Talkeetna site (which is 165 km upstream of the confluence) moved downstream and remained either at the confluence or downstream of this area for several days or weeks before moving upstream. This downstream movement was not seen in fish radio tagged at the Curry site.

Some fish were found to enter one or more tributaries on their migration run to their natal stream. Also, two radio tagged individuals were found milling in lower Devil Canyon, approximately 240 km upstream of Cook Inlet, and later entered tributaries downstream of Devil Canyon.

Chinooks spawn in the tributaries of the Susitna River system and do not utilize the mainstem Susitna for spawning purposes. Some of the more notable spawning tributaries include: Alexander Creek, Deshka River (Kroto Creek), Willow Creek, Clear Creek (Chunilna Creek), Chulitna River, Peters Creek, Lake Creek, and Talachulitna River. In the Susitna system upstream of Talkeetna, Indian River and Portage Creek are important spawning tributaries. Essentially, July and early August constitute the spawning period for chinooks in the Susitna River system.

The escapement counts for the east side Susitna River tributary streams between 1976 and 1981 were rated as only "fair" to "poor." Surveys conducted in 1981 on Indian River and Portage Creek, however, rated the escapements for these two streams as above average.

Given the lack of total Cook Inlet escapement data, the Susitna River contribution of chinook salmon is not known. The basis for estimating chinook salmon escapement is primarily index counts of clear water tributary streams. The Susitna drainage estimate for chinook production is in the range of 105,000 to 115,000 salmon. Between one and 2% of the Susitna escapement use the Susitna River above Talkeetna, the area of most profound impact.

- <u>Sockeye Salmon</u>

Apportioned sonar counts and a summary of fishwheel catches discussed below for sockeye salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52.

At Susitna Station, the sockeye salmon migration principally extended from 29 June to 24 August, with the midpoint of the run occurring on 17 July. A total of 340,232 individuals were counted by Side Scan Sonar (SSS) counters, while 75% of the escapement passed during a 13-day period from 11 July to 23 July. Fishwheel operations indicated that the peak migration occurred between 10 and 19 July.

A total of 139,401 sockeye were counted at the Yentna Station. The migration commenced on 1 July, and the midpoint of the run was determined to occur on 16 July. The migration run had ended by 3 August. The majority of the total fish count was made between 12 and 23 July. Fishwheel catches indicated that the migration peak was between 13 and 15 July.

Sonar counts at Sunshine Station totaled 89,906. The migration began on approximately 16 July, reached a midpoint on 23 July, and ended on 20 August. Seventy-five percent of the sockeye migrated past this location between 19 and 28 July. Based on fishwheel catch records, the peak of the migration occurred between 18 and 23 July.

At Talkeetna Station, 3,464 sockeye were counted. The migration commenced on 23 July and was completed by 8 August. The midpoint occurred on 31 July. A significant majority of the total count was made between 23 July and 6 August. It appeared from fishwheel catch data that the migration peak occurred between 27 July and 1 August.

The Curry Station fishwheel counts totaled 470 sockeyes. Results indicated that the migration commenced on 18 July, reached a midpoint on 5 August, and was not over until 29 September.

From the sonar data, the migrational timing of sockeye salmon indicates that those fish passing Susitna Station enroute to the Yentna River made the 10 km trip in one day or less. Individuals migrating past Susitna Station toward Sunshine Station covered this distance in an average of 8 days (11 km/day) and reached Talkeetna Station in an average time of 13 days (7.4 km/day).

Tag/recapture data indicated that the minimum travel time between Sunshine and Talkeetna Station and Curry Station was approximately five days or a travel speed of approximately 5.6 km/day.

Based on tagging operations, population estimates were calculated; these estimates may not accurately reflect the actual number of fish utilizing the various portions of the Susitna system. Sockeye population estimates derived from tagging operations indicated that approximately 130,489 sockeye were present at Sunshine; 4,809 at Talkeetna; and 2,804 at Curry Station.

Sockeye salmon age composition analyses indicated that a significant majority of the sockeye samples at each station were age 5_2 that is, five years old with two years in fresh water. The second most abundant age class was 4_2, followed by age 6_2. Five-year-old fish comprised approximately 86% of the return at Susitna Station and Yentna Station, 73% at Sunshine and Talkeetna Station, and 70% at Curry Station.

In the Talkeetna to Devil Canyon reach, adult sockeyes were observed in Sloughs 3B, 3A, 6A, 8A, 9, 9A, 9B, 11, 17, 19, 20, and 21 and in lower McKenzie Creek (Figures 3.25-3.30). Peak spawning occurred during the last week of August and the first three weeks of September. Of the locations listed, sockeyes were most numerous in Slough 8A, 9B, and 11, where peak spawning ground counts were 177, 81, and 893 sockeye salmon, respectively.

The 20-year average Cook Inlet harvest for sockeye salmon was 1,168,198. Sockeye salmon escapement and stock separation information for Cook Inlet show that approximately 23% of the 1979 Cook Inlet run and approximately 19% of the 1980 run were classsified as originating from the Susitna River. Approximately 5% of the Cook Inlet sockeye run escapes at Susitna Station and approximately .05% in the reach above Talkeetna.

o Pink Salmon

Apportioned sonar counts and a summary of fishwheel catches discussed below for pink salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52. The adult migration for pink salmon in the Susitna River system was found to begin essentially around 10 July and to terminate during the third week in August. In the vicinity of Talkeetna and Curry stations, the peak migration period lasted from the last week of July until the middle of August.

Sonar counts at Susitna Station totaled 113,349 pinks. The migration period started approximately on 10 July, with the midpoint occurring on 25 July. The migration run at Susitna Station terminated on 21 August. Seventy-five percent of the escapement passed this region between 15 July and 29 July. Fishwheel catches indicated that the migration peak had occurred between 21 July and 3 August.

At the Yentna Station, 36,053 pink salmon were enumerated by the sonar counters. The migration began here on approximately 14 July; the migration's midpoint was 27 July; and its cessation date was 20 August. Between 21 July and 2 August, a significant percentage of the total pink salmon run counted at the Yentna Station had passed this station. Fishwheel catches indicated that the migration peak lasted from 21 July to 6 August.

The number of individuals counted at the Sunshine Station sonar site totaled 72,945. The migration run did not begin at

Sunshine Station until approximately 23 July, essentially two weeks later than at Susitna Station. The midpoint date for the run was 1 August, with completion on 20 August. Seventy-five percent of the migration was counted between 28 July and 9 August. Fishwheel catches showed the migration peak to have occurred between 29 July and 9 August.

Talkeetna Station counts totaled 2,529 pink salmon. The migration period was found to be similar to that at Sunshine Station: the migration run at Talkeetna essentially began on 27 July, reached a midpoint on 6 August and had ceased on 20 August. Seventy-five percent of the escapement passed Talkeetna Station between 29 July and 9 August. Peak fishwheel catches occurred between 1 and 10 August.

At Curry Station, the pink migration began on 31 July, reached a midpoint by 8 August, and terminated approximately 19 August. Between 4 and 19 August, 75% of the escapement passed Curry Station.

Population estimates derived from tag and recapture data indicated that approximately 53,101 pink salmon were present at Sunshine Station; 2,335 at Talkeetna Station; and 1,146 present at Curry Station. It should be emphasized that these results are from the odd-year pink run, and population estimates would be substantially higher during the even-year run.

The migrational rates based on plots of sonar and fishwheel catch data indicated that pink salmon took an average of three days to reach Yentna Station from Susitna Station, a distance of approximately 10 km. This represents an average travel speed of roughly 3 km per day. Between Susitna Station and Sunshine Station, the average travel time was 9 days with a travel rate of 10km/day. Travel time between Susitna Station and Talkeetna Station was approximately 12 days with a travel rate of around 10 km/day. Tag and recapture data on pink salmon indicated that travel time between Sunshine and Talkeetna Station ranged from .2 to 30 days. Pink salmon averaged three days of travel time or 10 km/day between Talkeetna and Curry Stations with a range of travel time between one and 13 days.

Spawning pink salmon were found in Sloughs 3A, 8, and A and also in Whiskers Creek, Chase Creek, Lane Creek, Fourth of July Creek, Fifth of July Creek, Skull Creek, Sherman Creek, Indian River, and Jack Long Creek (Figures 3.25-3.30). The highest peak spawning count within an index area was in Lane Creek, where 291 fish were recorded. Peak spawning occurred in a ten-day period from 19 August to 28 August. The stream survey counts are index counts and do not reflect total number of spawning fish present in the stream surveyed.

The average even-year pink salmon Cook Inlet harvest for 20 years is approximately 1,671,194. It is also estimated that 85-90% of the Cook Inlet harvest originates in the Susitna. In 1981, odd-year pink salmon data were collected by ADF&G. The 20-year average for odd-year pink salmon harvest from Cook

Inlet is 148,073 fish, but with a range of 23,963 to 554,184. The harvest to escapement ratio of 3.8 to 1 for pink salmon indicates that 19% of the Cook Inlet run escapes back to the Susitna River drainage for spawning and rearing. This 19% of the Cook Inlet run is equal to 100% of the odd-year Susitna pink salmon that pass Susitna Station. Roughly 3% of these fish use the area above Talkeetna for spawning. Thus, 97% of the Susitna pink salmon run use other reaches of the river for spawning.

o Chum Salmon

Apportioned sonar counts and a summary of fishwheel catches discussed below for chum salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52.

The chum salmon migration began during the second week of July and ended during the beginning of September. In the Susitna River upstream of Talkeetna, the period from late July until the end of August was the peak migration period. Unlike the pink salmon, a peak migration period of seven to ten days could not be established for chum; rather, the chum migration seemed to be distributed over a longer period of time.

A total of 46,461 chums were counted at Susitna Station by the SSS counters. The migration arrived at Susitna Station on 10 July, reached a midpoint on 27 July, and ended on 25 August. Seventy-five percent of the escapement was counted between 15 July and 6 August. Fishwheel catches indicated that the migration peak occurred between 3 August and 7 August.

The Yentna Station enumerated 19,765 individuals. The migration run essentially began at Yentna Station on 13 July, reached its midpoint on 29 July, and ceased on 24 August. A significant majority of the fish were counted between 18 July and 15 August. Fishwheels operated at Yentna Station indicated that the migration run reached its peak between 20 and 23 July.

Counts at the Sunshine Station totaled 59,630 chums. The migration run at this location commenced on 22 July, reached a midpoint on 6 August, and ended on approximately 6 September. Seventy-five percent of the fish were counted between 27 July and 24 August. The peak of chum migration at Sunshine Station, as indicated by fishwheel catches, occurred between 17 and 19 August.

A total of 10,036 chum salmon were counted at Talkeetna Station. The beginning of the migration was approximately 28 July. The midpoint was reached on 8 August, and the migration ended on 29 August. The majority of the escapement was counted between 30 July and 29 August. No narrowly defined peak period was ascertained from the fishwheel catches.

Fishwheel catches at Curry Station indicated that the chum migration began approximately 29 July. The run's midpoint was 16 August, and the migration terminated on 2 September.

Chum salmon averaged four days of travel time between Susitna Station and Yentna Station for a travel speed of 2.5 km/day. Average travel time between Susitna Station and Sunshine Station was 10 days, which is a travel rate of 9 km/day. The migration period between Susitna Station and Talkeetna Station averaged 14 days or approximately 9 km/day.

Chum salmon tagged at Sunshine Station took between two and nine days to reach Talkeetna Station. Between Talkeetna Station and Curry Station the number of travel days ranged from one to 24 days with an average travel time of approximately 4.5 days and a travel rate of aproximately 6 km/day.

Tag and recapture data determined that approximately 262,851 were present at Sunshine; 20,385 at Talkeetna Station; and 13,068 at Curry Station. Although these are estimates, the relative abundance at the various river regions can be seen.

At each site, age 4 chum salmon from the 1977 brood year dominated the catch, comprising, on the average, 86% of the sample. Second in abundance were age 5 fish, followed by age 3 individuals. The most noticeable difference in age class structure occurred among the chums sampled at Curry Station. At this site, the percentage of age 5 fish was higher than at other locations, while the percentage of age 3 fish was lower.

Another result of this study is that chums were found to spawn in the Susitna mainstem. Of the 12 mainstem sampling sites, evidence of chum spawning was found at ten. Several of these sites were located in the river mainstem of the Curry Station.

Chum salmon were present in Sloughs 1, 2, 6A, 8, 8B, Moose, A^1, A, 8A, 9, 9B, 9A, 11, 13, 15, 17, 19, 20, 21, and 21A (Figure 3.25-3.30). They were also found within the survey reaches of Whiskers Creek, Chase Creek, Lane Creek, Lower McKenzie Creek, Skull Creek, Sherman Creek, Fourth of July Creek, and Indian River. The peak spawning activity in the sloughs occurred during the last two weeks of August and the first two weeks of September. The highest counts were recorded in Sloughs 8, 8A, 9, 11, and 21, where 302, 620, 260, 411, and 274 chums, respectively, were found spawning. Based on the limited stream survey data, the peak spawning period was approximately one week earlier than that observed in slough spawning areas. The highest peak count in an index area was registered in Lane Creek, where 76 chums were counted on 23 August.

Eleven chum salmon were radio tagged between 30 July and 12 August. Their movements were monitored from 30 July through

August 1981. Ten of the 11 fish were tagged between 6 and 12 August. Seven fish were tagged at Curry Station, and four were tagged at Talkeetna Station; five were females, and six were males.

The primary destinations of radio tagged chums were Susitna River sloughs, clear water tributaries, and the confluence zones of tributary streams. Four fish entered Susitna River sloughs 21, 11, Moose, and an unnamed slough near rkm 156, respectively (Figures 3.25, 3.29 and 3.30). Three fish entered the Indian River. One fish entered Sherman Creek before returning to the mainstem Susitna River, where it held within 4.8 km of the Fourth of July Creek confluence zone. Another fish stayed in the mainstem Susitna River at river kilometer 191. One individual swam down the Susitna River and entered the Chulitna River, while another fish was last detected at river kilometer 203.2 in the Susitna River. Radio tagged chums entered spawning areas between 8 August and 23 August.

Maximum sustained yield total run for Cook Inlet chum salmon harvest are estimated at approximately 1,000,000, based upon a historic sustained harvest of 700,000 fish and a harvest to escapement ratio for chum salmon of 2.2 to 1. The Susitna River proportion of the harvest, based upon historic data and assuming that 90% of the Cook Inlet chum salmon harvest originates from the Susitna, totals apprixmately 630,000 fish. Thus, it is estimated that on the average, 280,000 ± chum salmon return to the Susitna River to spawn each year. This figure means that approximately 28% of the Cook Inlet run of 1,000,000 chum salmon escapes to the Susitna. For a worst case estimate, using 1974 data, the estimated Susitna escapement would be approximately 160,000. Based upon available data and ADF&G's 1980 study program, the best estimate of chum salmon escapement in the reach of the Susitna River above Talkeetna is in the 20,000 to 30,000 range. This number is approximately 20% of the total Susitna run, which is considered a fairly liberal percentage.

o <u>Coho Salmon</u>

Apportioned sonar counts and a summary of fishwheel catches discussed below for coho salmon are shown in Tables 3.50 and 3.51, respectively. Tag/recapture estimates are shown in Table 3.52.

For the Susitna River system as a whole, the adult coho migration period runs from approximately the third week of July until early October. The coho are the last species of Pacific salmon to migrate up the Susitna. Late July through August is the major migrational period for the coho in the Susitna River segment above Talkeetna. Field investigations conducted in fall 1981 indicated, however, that coho salmon were still spawning in early October (Barrett, pers. comm. 1981).

A total of 33,470 coho salmon were enumerated across the SSS counters at Susitna Station. The migration began, reached a midpoint, and ended on 20 July, 28 July, and 25 August, respectively. Approximately 75% of the fish passed in the time period between 23 July and 16 August. Fishwheel catches indicated a migration peak occurring between 25 July and 30 July.

At the Yentna Station, 17,017 coho were enumerated by the sonar counters. The migration essentially began on 22 July, reaching a midpointon 31 July and ending on 20 August. The major portion of the run passed this location between 23 July and 16 August. The peak of migration, shown from fishwheel catches, occurred between 23 July and 6 August.

SSS counters at Sunshsine counted 22,793 coho salmon. The beginning of the migrational period was 29 July, reaching a midpoint on 18 August and ending on 5 September. Seventy-five percent of the migration run was counted between 4 August and 24 August. Fishwheel catches indicated a peak migration period between 18 August and 25 August.

At Talkeetna, 3,522 coho were enumerated by sonar counters. July 30 was the beginning of the migration run, 24 August the midpoint, and 11 September the termination. The majority of coho were counted between 11 August and 1 September. Fishwheel catches indicated a migrational peak period occurring between 19 August and 30 August.

Curry Station fishwheel catches indicated that the coho migration began in this location on 5 August, was at its midpoint on 22 August, and ended on 4 September.

Population estimates derived from tagging and recapture operations indicated that approximately 19,841 salmon were present at Sunshine Station; 3,306 at Talkeetna Station; and 1,041 at Curry Station. The majority of individuals sampled for age analyses were age 4_3, from the 1977 brood year, followed by age 3_2, from the 1978 brood year. Less than 10% of the coho escapement consisted of other age classes.

The average migrational travel time for coho salmon between Susitna Station and Yentna Station was two days, which was a travel rate of approximately 5 km/day. An average of fourteen days were required to reach Sunshine from Susitna Station. Total travel time from Susitna Station beyond Sunshine Station to Talkeetna Station was approximately 24 days and represented a migration rate of 6.2 km/day to Sunshine Station from Susitna Station and 5 km/day between Susitna Station and Talkeetna Station.

Tag recapture of marked coho indicated that between Talkeetna and Curry Stations, the migration took between two and 15 days with an average travel time of 4.5 days. This was a migrational rate of approximately 6 km/day.

Coho salmon were reported to spawn in the Susitna River mainstem at three of the 12 study sites. At one site, coho were found spawning in the same area as chum salmon. Two of the three mainstem sites were located in the vicinity of Curry Station.

Coho were also seen in Slough 9; however, the vast majority of spawning fish were located in various tributaries. These included Whiskers Creek, Chase Creek, Lane Creek, Gash Creek, Lower McKenzie Creek, Fourth of July Creek, Indian River, and Portage Creek (Figures 3.25-3.30). The highest densities of coho, based on peak index counts, were in Whiskers Creek, Chase Creek, Gash Creek, and Indian River, where 70, 80, 141, and 85 coho salmon, respectively, were recorded spawning in a single survey. The survey data indicate that the spawning peak probably occurred in the second and third week of September.

Ten coho salmon were radio tagged from 31 August through 4 September, four at Curry Station and six at Talkeetna Station. Coho displayed one or all three types of directional movement: downstream, upstream, or multi-directional. Coho movement did not appear to be influenced by flow conditions within the Susitna River.

In any case, about 8% to 10% of these fish reach the area above Talkeetna. Using the harvest versus escapement ratios of 2.2 to 1, the 1981 sonar counts at Talkeetna indicate that from 7,000 to 8,000 Cook Inlet coho salmon harvested for 1981 can be attributed to this reach of the river. A significant sport fishery exists for coho in the river above Talkeetna, but this harvest is probably a small fraction of the total harvest and has not been included in these figures.

- Juvenile

It should be noted that a significant portion of the discussion on juvenile salmon is presented as the percent occurrence at respective sampling locations. The actual number of individuals collected at some of the sampling sites was quite small and translates into low catch per unit effort values. These percent occurrences are indicative of the overall general distribution of the species under discussion and are not intended to present definitive findings as to the relative abundance of juvenile salmon in the specific habitats of the Susitna River system. This is particularly true in regard to winter sampling data which was minimal.

o Chinook

During the winter, the majority of juvenile chinook salmon were captured at slough and mainstem Susitna River sites. In summer, most of the chinook juveniles were collected at tributary mouth sites. Two age classes, (0+ and 1+) were identified. Age 1+, however, were not captured after July in the Talkeetna to Devil Canyon stretch and not after August in the Cook Inlet to Talkeetna reach.

Sites associated with tributary mouths appear to provide important milling areas for juvenile chinook salmon in the Cook Inlet to Talkeetna reach. The change to clear water conditions which occurs during the winter makes the Susitna River and its sloughs primary overwintering sites as icing and lowered flow conditions develop in the tributary streams. A more detailed narrative is included below.

The vast majority of juvenile chinook salmon in the Susitna River basin spend one winter in fresh water before migrating to the sea. A comparison of the freshwater ages of chinook sampled at Susitna and Yentna stations indicated that nearly all of these fish had migrated to sea after spending one winter in fresh water. Similarly, at Talkeetna and Curry stations, nearly 95% had migrated to the ocean after spending one winter in fresh water. The remaining population had smolted before their first winter at Sunshine. Only 5% of the Sunshine Station fish sample had smolted prior to their first winter, while 95% did so after spending one winter in the system.

Juvenile chinook salmon were captured beginning with the first winter sampling conducted in November 1980. Surveys continued through May and pointed up the presence of rearing chinooks from Alexander Creek upstream to Portage Creek.

Eleven of 18 (61%) habitat location sites sampled in the Cook Inlet to Talkeetna reach from November through May contained juvenile chinook salmon. Some were collected at four of six (67%) mainstem and slough habitat locations and at seven of 12 (58%) tributary mouth habitat location sites in this reach. Consistent catches were observed at Sunshine Creek and Rustic Wilderness (Figure 3.32). The highest catch rate for juvenile chinooks in this reach occurred during March at Rustic Wilderness, where 2.7 fish per trap were captured.

Juvenile chinooks were captured at eight of the 12 habitat locations sampled between Talkeetna and Devil Canyon from January through April 1981. More specifically, they were collected at seven of eight (88%) mainstem and slough habitat locations and at one of four (25%) tributary mouth habitat locations in this reach. Although rearing chinooks were consistently noted at Slough 8A, Slough 10, and Slough 20, the highest individual catch of juveniles during winter sampling was observed in March in an open lead at Slough 6A (Figures 3.26, 3.28, and 3.29). Twenty fish were captured in a single trap set at this location.

Sampling took place on Indian River and on Portage Creek from February through April 1981. Indian River was surveyed from its mouth to approximately 13 km upstream, while Portage Creek was surveyed from its mouth to approximately 10 km upstream.

During March, small numbers of juvenile chinooks, all from the 1979 brood class, were observed in Indian River, while April surveys showed the presence of both 1979 and 1980 brood classes. The highest catch rate of 0.3 fish per trap was recorded during March at a spot 4.3 km upstream in the Indian River. Juvenile fish, also all from the 1979 brood class, were likewise observed in March at Portage Creek. The highest catch rate of 0.8 fish per trap was recorded in an area of Portage Creek 15.2 km upstream from its mouth.

During sampling conducted in the period from 1 June to 30 September 1981 of the summer field season, juvenile chinook salmon were captured at habitat location sites from Alexander Creek upstream to Portage Creek. Moreover, selected fish habitat sites located on Indian River and Portage Creek produced catches of juvenile chinooks when sampled in June, August, and October. During the 1981 studies, chinook juveniles were not observed, however, above Susitna River kilometer 238.

Juvenile chinooks were captured at 43 of 44 (97.8%) of the habitat location sites surveyed between Cook Inlet and Devil Canyon during the summer months. In fact, Kroto Slough mouth was the only habitat location site where juveniles were not observed. Beginning in April, with the first captures of juvenile chinooks from the 1980 brood year, two age classes, age 0+ and age 1+, were present.

Chinook juveniles were observed at over 50% of the habitat location sites surveyed in the Cook Inlet to Talkeetna reach from June through September 1981. The highest incidence of juveniles was recorded during early July and late September, when over 75% of the sites surveyed produced fish. Ten (37.0%) of the habitat sites in this reach showed a 100% incidence of juvenile chinooks for the surveys, while 19 (70.4%) of the sites had at least at 50% incidence of occurrence.

In this reach, catches during the June through September surveys were generally higher at tributary location sites than those observed at mainstem river or slough sites. Catches at tributary mouth habitat location sites illustrated a high incidence of occurrence throughout the summer, ranging from 60.0% of the sites sampled in early June to 93.3% in early July.

On the other hand, throughout most of the summer in this reach, a lower percentage of incidence was recorded at mainstem and slough sites than at tributary mouth sites. The percentage of incidence of juvenile chinooks in mainstem slough habitat site catches ranged from 27.3% in early August to 87.5% in late September.

Two age classes of juvenile chinook salmon, 0+ and 1+, were collected at habitat location sites in the lower Susitna River from June to September 1981; these age classes represented brood years 1979 and 1980. The catch per unit effort of chinook salmon age 0+ for the Talkeetna to Devil Canyon reach ranged from 0.0 fish per trap at Mainstem-Curry throughout the season to a catch rate of 12.0 fish per trap recorded at Fourth of July Creek. As the season progressed, however, an increase in catch per unit effort of age 0+ fish was apparent at most habitat locations in this reach. This increase was most obvious in the late September survey at Whiskers Creek Slough, Slough 6A, Slough 10, and Slough 20 (Figures 3.25, 3.26, and 3.29). As none of these sites are known spawning areas for chinook salmon, this seasonal change indicates a redistribution of chinooks age 0+ from areas of high post-emergent density to more favorable conditions as fish size increased and the season progressed.

The percentage of incidence of age 0+ chinook salmon in habitat location catches in the Talkeetna to Devil Canyon reach increased from 15% of the locations sampled in late June to 92% of the locations in early September.

The chinook salmon age 1+ catch rates recorded during the summer in the Talkeetna to Devil Canyon reach were low compared to those catch rates observed in this reach during the winter surveys. Winter catch rates reached a high of 10.0 fish per trap compared to a high of 0.4 fish per trap for summer surveys. This reduction in catch rate indicated that a majority of age 1+ chinook salmon had moved out of the Talkeetna to Devil Canyon reach prior to the initiation of sampling in early June.

Age 0+ chinook catches were recorded at 80-100% of the tributary mouth habitat locations surveyed from early July through late September. As the season progressed, mainstem slough habitat location catches indicated a net increase in percentage of incidence from a low of 20.0% in late June to a high of 87.5% in early September. Age 0+ chinooks appeared to extend their distribution from tributary streams and stream mouth sites into mainstem and slough sites as the summer advanced. Indian River mouth was the only habitat location in this reach producing chinooks age 0+ for 100% of the surveys.

Chinook salmon age 1+ were observed at 45% of the sites surveyed during the first two weeks of June. This figure decreased through late July, however, and these chinooks completely disappeared from this reach prior to the early August survey. It is presumed these age 1+ chinooks were smolts undertaking a seaward migration, with the peak movement occurring prior to the early June sampling. No chinook salmon age 1+ were captured between Talkeetna and Devil Canyon after the last two weeks of July.

At Indian River selected fish habitat sites, juvenile chinook salmon were captured during all three sampling periods. All sites sampled in August and October recorded the presence of juvenile chinooks, with the highest catches occurring in August at site 2, 11.5 km up the Indian River, where 7.0 fish per trap were observed. Indian River selected fish habitat site 3A, 19.2 km up the Indian River, produced the highest catch in October - 1.9 fish per trap.

No juvenile chinooks were captured in Portage Creek during the June survey. The highest catch for Portage Creek was observed at site 1 (7.2 km up Portage Creek) in August where 10.4 chinook salmon age 0+ per trap were recorded. In October, the fish per trap at this site had decreased to 4.4.

Two age classes of juvenile chinook salmon were present in habitat site catches made during early June between Cook Inlet and Talkeetna. Analysis of length frequency composition for 3,646 juvenile chinook salmon measured by two-week periods from June through September indicates that age 1+ chinooks were no longer present in this reach after August 31. On the other hand, age 0+ chinook salmon remained throughout the summer. The range of lengths for age 0+ and age 1+ can be approximated from the length frequency data; however, it is impossible to determine the extent of overlap or to establish accurately a point of division between these two ages of chinook salmon in the Cook Inlet to Talkeetna reach of the Susitna River.

o Sockeye

Winter sampling in March and April produced 25 sockeye fry at Slough 11, one individual each at Slough 9, and an individual downstream of Talkeetna. Sockeye fry were collected at Alexander Creek, Birch Creek, and Cache Creek in September. The outmigration period for sockeye is thought to occur during May and June.

o Pink

In both Slough 11 and Indian River, sac fry of pink salmon appeared on 23 March. Pink salmon fry were collected at Mainstem Slough, Slough 8A, Fourth of July Creek, and Slough 10 during June and July. The outmigration period for pink salmon occurs primarily during the month of May.

o Chum

Approximately 1,700 juvenile chum salmon were captured during the sampling effort conducted in the summer field season of 1981. Beach seining at Slough 11 (Gold Creek area) on 19 June accounted for 1,650 chum fry, while 13 chum fry were captured by beach seine in Slough 19. Chum fry were also captured in Alexander Creek during July. The outmigration period for chum salmon is believed to occur during May and June.

o Coho

Juvenile coho salmon were collected throughout the study area with the majority of individuals captured at tributary mouth sites during both winter and summer. Between Talkeetna and Devil Canyon, the occurrence of individuals was greater at slough sites in the winter and at tributary mouth sites in summer. Three age classes (0+, 1+, 2+) were identified. Age 2+ individuals were not captured after May in the Talkeetna to Devil Canyon reach and not after mid-June in the Cook Inlet to Talkeetna reach. A detailed narrative of these findings is given below.

Age class determinations were made by correlating complementary length/frequency and scale analysis data. Discussion of distribution and relative abundance is provided by age class for juvenile coho salmon in the Talkeetna to Devil Canyon reach only. Because of the extensive overlap in lengths for age classes of juvenile coho captured downstream of Talkeetna, distribution and relative abundance of all age classes will be discussed collectively for this reach.

Juvenile coho were captured at a total of 11 of the 18 (61%) habitat location sites sampled in the Cook Inlet to Talkeetna reach from November to May. During this time, juvenile coho were collected at two of six (33%) mainstem habitat location sites and at nine of 12 (75%) tributary mouth habitat location sites. Juvenile coho salmon occurred in greater than 40% of the habitat location site catches each month from November to May, except during December and April, when no catch was recorded.

The highest individual catch per unit effort for the Cook Inlet to Talkeetna reach was 1.2 fish per trap day, observed at the mouth of Sunshine Creek. Relatively high catch rates were also recorded in January and again in March at a side channel habitat location site located near Rustic Wilderness and in November, at the mouth of Montana Creek.

From December 1980 to April 1981, juvenile coho were captured at six of the 12 (50%) habitat location sites sampled between Talkeetna and Devil Canyon. During this time, juveniles were collected at five of eight (62%) mainstem habitat location sites and at one of four (25%) tributary mouth habitat location sites. Of these latter four sites, only Whiskers Creek, sampled during March contained any juvenile coho. In addition, no juveniles were encountered at the mouths of Lane Creek, Indian River, or Portage Creek in 1980-81 winter sampling.

Juvenile coho salmon were present, however, at 50% or more of the mainstem and slough habitat location sites sampled in the Talkeetna to Devil Canyon reach each month from February 1981 to April 1981. No juvenile coho salmon were collected during January at any habitat location sites upstream from Talkeetna.

Five selected fish habitat sites on Indian River, with the farthest upstream being 12.8 km, and six selected fish habitat sites on Portage Creek between 4.8 km and 18.9 km upstream were sampled in February, March, and April 1981. Although a single juvenile coho was collected at Indian River (1.8 km upstream) during April, no juveniles were encountered in Portage Creek in any of these months.

The highest individual catch per unit effort was 8.0 fish per trap, observed at Slough 6A in March 1981. Relatively high catch rates were also recorded at Whiskers Creek mouth in March and, also in March, at Slough 8A.

From June to September 1981, juvenile coho salmon were collected at 86.7% of the habitat location sites in the lower Susitna River. These sites extended from the mouth of Alexander Creek to the mouth of Portage Creek. Catches of juvenile coho were also recorded at selected fish habitat sites at Indian River and Portage Creek during August and October.

In the Cook Inlet to Talkeetna reach, from June to September, juvenile coho salmon were collected at 25 of the 27 (92.6%) habitat location sites. The incidence of juveniles in catches at habitat location sites ranged from 42.9% in late June to 83.3% in early September. Juvenile coho catches were recorded at all (100%) of the tributary mouth habitat location sites in the Cook Inlet to Talkeetna River reach one or more times during the summer of 1981. The incidence of juvenile coho salmon in catches at tributary mouth habitat location sites ranged from 66.7% in late June to 100% in late August and early September.

Catches of juvenile coho were recorded at 82% of the mainstem and slough habitat location sites in the Cook Inlet to Talkeetna River reach from June to September. The incidence of juvenile coho salmon at mainstem and slough habitat location sites ranged from 11.1% in late June to 62.5% in late September.

Below Talkeetna, the highest catch per unit effort, 41.0 juvenile fish per trap, was recorded at the mouth of Caswell Creek in late August. Relatively high catch rates were also observed from late July to early September at the mouths of Birch Creek, Sheep Creek Slough, Sunshine Creek, and Montana Creek. In the Talkeetna to Devil Canyon reach from June to September, juvenile coho were collected at 13 of the 17 (76.5%) habitat locations.

Two age classes of juvenile coho salmon, 1+ and 2+, from brood years 1978 and 1979 were captured at habitat location sites in the lower Susitna River from November 1980 to May 1981. Age 0+ coho salmon, offspring of brood year 1980, were collected at 12 of the 17 (70.6%) Talkeetna to Devil Canyon habitat locations, while age 1+ were observed at seven of the 17 (41.2%) sites. No juveniles from brood year 1978 (age 2+) were observed in Talkeetna to Devil Canyon habitat location catches during the summer 1981. Age 0+ coho distribution progressively increased from early June through the summer and was most extensive in early September, when the fish were collected at 53.9% of the habitat locations upstream from Talkeetna to Devil Canyon. The incidence of age 1+ coho salmon in catches at habitat locations ranged from 11.8% in late July and late September to 30.8% in early September. Throughout the summer, occurrence of age 0+ fish was more consistent at tributary mouth locations than at mainstem or slough locations. During this same period, age 1+ coho appeared in a lower percentage of both tributary mouth and mainstem-slough habitat locations.

Age 0+ coho were also observed in Indian River and Portage Creek at selected fish habitat sites. Distribution was more extensive, however, in Indian River, where age 0+ coho were collected from Indian River at 4.3, 11.4, and 19.2 km upstream. Age 0+ fish were observed in Portage Creek (7.2 km upstream) only once during the season in October.

The highest age 0+ coho catch per unit effort, 7.0 fish per trap, was recorded at Whiskers Creek in late August. Comparatively high age 0+ catch rates were also recorded at Whiskers Creek mouth during each two-week interval throughout the summer. Relatively high catch rates for age 0+ coho salmon were likewise recorded at Slough 6A and Fourth of July Creek during August and September and at Indian River, 19.2 km upstream, in August.

The highest age 1+ coho catch per unit effort, 0.6 juveniles per trap, was recorded at both Whiskers Creek during early July and at Slough 6A during late August. Consistent catches were recorded throughout the summer at both these sites.

(ii) Other Anadromous Species

- Bering Cisco

Prior to this study, Bering cisco were not known to inhabit the Susitna River. Bering cisco were first captured at river kilometer (rkm) 126 by the lower east bank fishwheel at Sunshine Station on August 25. The fishwheel catch rate on cisco gradually increased until it peaked between 17 and 21 September. At Mainstem Slough and the mouth of Kroto Slough, Bering cisco were taken by gill net on 10 September and again at Mainstem Slough on 14 and 28 September.

Electrofishing conducted 25 September through 15 October demonstrated that Bering cisco were dispersed in the Susitna River from rkm 112 to rkm 161 (measured from the mouth of the

Susitna). Relatively large numbers were located near Sunshine Station, Montana Creek, and the mainstem west bank at rkm 119. One hundred ninety Susitna River Bering cisco were aged. The majority of fish were age 4 (88%), with the remaining age 3 (9%) and age 5 (3%).

Sexually mature Bering cisco were captured from habitat locations over a 112 km reach of the Susitna River. Although spawning sites may generally occur throughout this reach, electrofishing surveys were only able to identify three areas of spawning concentrations. These sites were opposite Sunshine Station, opposite the mouth of Montana Creek, and at rkm 119 to rkm 120 of the mainstem along the west bank.

Susitna River Bering cisco appear to be the anadromous form. The fish captured and identified were evidently undertaking their spawning migration, as no substantiated occurrence of the species was noted prior to 25 August 1981. The fish evidently began their spawning migration up the Susitna River from Cook Inlet in August and arrived at the Sunshine Station fishwheel site over a five-week period from August 25 to September 30. Fish captured by the fishwheel during this time were all bright silver and appeared to be sexually mature; although, with normal handling, they did not produce a discharge of eggs or milt.

From 4 through 7 October, relatively large numbers of Bering cisco, dispersed along gradually sloping gravel bars in the Montana Creek-Sunshine Station area, were located by electrofishing. Random necropsy showed all fish to contain mature sex products, but none had yet spawned.

Electrofishing was again conducted in the Montana-Sunshine area from 13 through 15 October. All fish handled on these dates freely expelled either eggs or milt or were already spent. From these observations, spawning appeared to peak during the second week of October.

- Eulachon

Eulachon are known to utilize the Susitna River system at least as far upstream as the Deshka River-Susitna River confluence. The eulachon is an anadromous member of the smelt family but spends most of its life in the marine environment. Adults are believed to live at moderate ocean depths in the vicinity of the echo-scattering layer and in proximity to shore. In the northern portion of its range, spawning does not occur until May. Upstream migration from the ocean begins when river water temperatures reach approximately 4.4°C and ceases as temperatures exceed 7.8°C. The migration runs usually take place in larger rivers (such as the Susitna mainstem), but spawning grounds may be located in tributary systems. The timing of the Susitna River migration run and the location of spawning grounds have not been determined. A compilation of life history and ecology information by Terrestrial Environmental Specialists, Inc. (APA 1981) contains additional details from available literature on the eulachon.

(b) Resident Species

(i) Impoundment Zones and Vicinity

The following section describes the fisheries resource of the upper Susitna River basin in the proposed impoundment regions. Of greatest significance was the presence of sizeable grayling populations throughout the tributaries. In general, though, information on the Susitna mainstem in this region remains limited.

The numbers of individuals of several species, including burbot, round whitefish, longnose suckers, and cottids, are rather small. It is not known whether this is because of the limited populations of these species, to sampling site locations, or to sampling efficency. As a result, conclusions drawn from the information presented are preliminary.

- Arctic Grayling

During the 1981 studies of the Upper Susitna River, 3,279 adult Arctic grayling over 135 mm fork length were captured. Table 3.53 lists grayling catches by tributary and month. Arctic grayling were collected at 100% of the habitat location sites in the upper Susitna River during the 1981 season.

The population estimate for Arctic grayling in the upper Susitna River study area calculated at the 95% confidence level (4df), is 10,279 with a range of 9,194 to 11,654. This population level would give an average of approximately 501 adult grayling per clearwater tributary mile or 121 per river mile including the main Susitna, to be inundated. Tagged grayling demonstrated interchange between tributaries using the main Susitna as a migratory corridor.

Kosina Creek has the highest estimate for an individual tributary at 2,787 (range 2,228-3,720) followed by the Oshetna River at 2,017 (range 1,525-2,976). Fog Creek had the lowest estimate at 176 (range 115-369). No estimate is listed for Watana Creek, although Watana is included in the study area total estimate, because the low number of tagged fish recovered would have resulted in an estimate with an unacceptably wide range of values.

Three hundred eighty-one upper Susitna River Arctic grayling from hook and line and gill net catches were aged by using scale analysis. These fish ranged from age 1 to age 8; age 5 and age 6 were dominant, comprising 33.9% and 31.5% of the sample, respectively.

Arctic grayling examined during May and early July exhibited spent gonads and frayed dorsal and caudal fins, indicating that they had already spawned. Fish in this condition were collected at the mouths of the tributaries.

In the course of the upper Susitna River study, a total of 2,652 Arctic grayling were tagged and released during 1981. As a result, there is some indication of Arctic grayling intrasystem migration in the upper Susitna River drainage. Preliminary analysis indicates not only a wide range of movement within the individual tributaries but also inter-tributary migration.

- Lake Trout

Lake trout were found only in Sally Lake and Deadman Lake (Figure 3.35, two selected fish habitat sites in the upper Susitna River basin, both of which support a limited sport fishery. Of these two sites, only Sally Lake will be inundated by the proposed Watana impoundment. All lake trout were captured by gill net and rod and reel and all within 39 m of the shoreline in less than 1.8 m of water. Gear was fished at various depths of up to 12 m in Sally Lake. A total of 35 lake trout were captured, 32 in Sally Lake and three in Deadman Lake. All Deadman Lake fish were captured by hook and line, while gill nets produced the greatest results in Sally Lake. Catch per rod and reel hour was highest in Deadman Lake, where it was 0.75/hour.

Scales were taken from 19 lake trout collected in Sally Lake. Only seven scales were readable, and all of these were age 5. During mid-August, both pre-spawning and post-spawning lake trout were captured in Sally Lake.

- Burbot

Burbot were collected at all eight upper Susitna River habitat locations between May and September 1981. The percentage of incidence of burbot in sampling catches ranged from 50% of the locations sampled in May to 100% of the locations sampled in July.

Catch rates for all streams combined varied from 0.53 burbot per trotline day in May to 0.95 in September. The second highest catch rate, 0.73 burbot per trotline day, was recorded in July. Although sampling was also conducted upstream in the tributary study areas, all burbot catches were made in the Susitna mainstem, immediately up- or downstream of the tributary confluences with the Susitna. Jay Creek, with a May to September average catch rate of 1.14 burbot per trotline day and total catch of 32 burbot, was the most consistently productive habitat location, followed closely by Watana and Goose creeks.

Otoliths were removed from 54 burbot and analyzed for age determination. Age classes 4, 5, and 6 made up the majority of burbot caught, comprising 25%, 20%, and 35% of the sample respectively.

- Round Whitefish

Round whitefish were captured at all habitat locations sampled in the upper Susitna River system, except Fog, Deadman, and Goose creeks. Jay and Kosina creeks were the most productive. The percentage of incidence of round whitefish at habitat locations ranged from 33% in July to 7% in September. The capture of 47 juvenile round whitefish (18-52 mm) at Jay Creek was achieved by using seines and electroshockers.

Twenty-two upper Susitna River round whitefish from gill net catches were aged by scale analysis. Ages ranged from 6 to 8, with age 7 encountered most frequently.

- Longnose Sucker

Longnose suckers were found in all habitat locations except Fog and Tsusena creeks. All adult suckers were captured in gill nets set immediately upstream or downstream of the confluence of the tributary streams. A total of 144 suckers were captured from May to September. The mouth of Watana Creek produced consistent catches of suckers for a total of 75. In July suckers were caught in all habitat locations fished. (Kosina and Fog creeks were not fished.) This species was caught in 25% of the habitat locations fished in May and in September.

Scales of 90 upper Susitna River longnose suckers were removed and analyzed. Age classes 7, 8, and 9 made up the majority of longnose suckers and comprised 25%, 36%, and 20% of the sample, respectively. Juvenile longnose suckers (24-105 mm) were captured in sloughs and backwater areas of the Susitna River at Jay, Kosina, and Watana creeks.

- Sculpins

Thirty-eight sculpins were taken during 352 minnow trap days from upper Susitna River reach habitat locations. Habitat locations associated with clear water and other tributaries were most productive. The catch rate from May to September 1982 was 0.11/trap day. The largest numbers of sculpins were recorded for Fog Creek, Tsusena Creek, and the Oshetna River, with total catches of 8, 9, and 10, respectively. Tsusena Creek had the highest catch rate at 0.23/trap day, while no sculpins were captured at Jay Creek during this study. Sally Lake, a selected fish habitat site, was minnow trapped only during May and resulted in the collection of four sculpins.

- Miscellaneous Species

During the course of the 1981 field studies, a single specimen each of humpback whitefish and Dolly Varden was captured. The humpback whitefish was a male, 347 mm fork length taken at the mouth of Kosina Creek on September 24. The single Dolly Varden was taken at the mouth of Fog Creek on 25 August. This fish was also a male, 235 mm fork length. Possible occurrences of the Alaska whitefish and lake whitefish have been reported in the Susitna River drainage (McPhail and Lindsey 1970, Williams 1968). As discussed below, these two species are not readily distinguished from the humpback whitefish. The presently known range of the humpback whitefish in Alaska is restricted to rivers which empty into the Bering, Chukchi, and Beaufort seas (Morrow 1980). Dolly Varden are known to be present in this portion of Alaska (Morrow 1980).

(ii) Downstream (below Devil Canyon)

- Arctic Grayling

Arctic grayling were first captured at rkm 150, 1.6 km southwest of the head of Birch Creek Slough on 19 February 1981. Throughout the winter months, gill netting under the ice infrequently produced grayling. Gill net catches of adult grayling increased sharply from 1 to 15 May at the mouths of the Deshka River and Cache Creek Slough. After 15 May, catches declined at all habitat locations on the Susitna River between Cook Inlet and Devil Canyon. Incidence of Arctic grayling, however, principally juvenile and immature, ranged from 10% to 20% of the 44 habitat location sites sampled during each two-week period throughout the summer months. In September, catches of adult grayling at tributary mouths increased. At that time, relatively large numbers of these fish were located on the Susitna River at Kashwitna River, Montana Creek, Birch Creek Slough, Lane Creek, Indian River, and Portage Creek.

Age determinations were made on 174 Arctic grayling caught on the Susitna River between Alexander Creek and Portage Creek. These fish ranged in age from age 0+ to age 10. The most prevalent age classes captured were age 5 (17.9%) and age 6 (23.4%).

Arctic grayling began their spawning migration in the Susitna River in late April and a substantial increase in grayling catches by gill net was noted at the mouths of the Deshka River and Cache Creek between 1 May and 15 May. Necropsies showed most of the fish were sexually mature, but since manipulation of the fishes' abdominal cavities produced no milt or eggs, the fish were not fully ripe.

No evidence of Arctic grayling spawning was found at any sampling locations between Cook Inlet and Devil Canyon during the 1981 season. It can only be speculated that the adult Arctic grayling from the Susitna River migrate into non-glacial tributaries to spawn some time in late April or May.

- Rainbow Trout

Rainbow trout were collected at seven tributary and four mainstem habitat location sites along the Susitna River from Alexander Creek to Slough 10 (rkm 214) from November 1980 to May 1981. This species did not appear consistently in catches from any of the locations sampled, but low densities of rainbow trout appeared throughout the winter months.

Rainbow trout were captured at a total of 89% of the habitat locations in the Cook Inlet to Devil Canyon reach. The percentage of incidence of catches in the Cook Inlet to Talkeetna and the Talkeetna to Devil Canyon reaches was 81% and 94%, respectively.

In the Cook Inlet to Talkeetna reach, the percentage of incidence of catches at habitat location sites ranged from a low of 7% during the first two weeks of August, to a high of 50% during the first two weeks of September.

The incidence of rainbow trout in habitat locations sampled remained in the 20% to 30% range from the first of June through 30 July and again from 15 August to 30 August. The low percentage of incidence occurring from 1 August to 14 August was probably due to coinciding high water levels and the resulting ineffectiveness of the sampling gear.

Habitat locations associated with tributary streams produced higher catches per unit effort than did the mainstem locations. Consistent catches of rainbow trout were recorded at Anderson Creek, Alexander Creek, and Deshka River habitat location sites.

Catch per gill net at Anderson Creek rose to 9.0 in late September, while during the last two weeks of August, highs of 1.0 and 0.8 fish per trotline were reached at Alexander Creek and the Deshka River, respectively.

In the Talkeetna to Devil Canyon reach, the percentage of incidence of rainbow trout catches at habitat locations ranged from 77% during late June and again in early September, to a low of 18% in early August. The June peak is probably due to the presence and movements of spawning fish, while the high in September reflects movement downstream to winter habitat.

The low percentage of incidence in early August, as in the Cook Inlet to Talkeetna reach, was probably caused by high flood stage waters and associated factors. Rainbow trout were captured at all habitat locations, with the exception of the mainstem site below Portage Creek. The most consistent catches occurred at tributary mouth and slough habitat locations. Catches per gill net ranged from 0.0 to 6.0 per day at tributary and slough locations, with the high of 6.0 rainbows per day recorded at Whiskers Creek Slough during late June. Hook and line catches produced highs of 2.0

and 7.0 rainbows per hour at Portage Creek and Whiskers Slough, respectively. High catches per unit effort at Whiskers Creek and Whiskers Slough in June are attributed to the presence of spawning rainbows.

One hundred eighty-four Susitna River rainbow trout collected from Cook Inlet to Devil Canyon by fishwheel, trotline, electrofishing, and hook and line were aged using scale analysis. Age classes 3, 4, and 5 made up the majority of the fish at 30.8%, 32.0%, and 19.9% of the total sample, respectively. The age class composition was similar for each reporting reach of the lower Susitna River. Rainbow trout in the age sample ranged from age 1 to age 7.

- Burbot

From November 1980 through May 1981, burbot were captured by various sampling gear placed in the Susitna River at a total of 42 habitat locations and selected fish habitat sites beginning at the mouth of Alexander Creek and extending to a mainstem site at rkm 118.

Habitat locations and selected fish habitat sites downstream of Talkeetna, particularly the mouth of the Deshka River, the mouth of Alexander Creek, and four mainstem sites located at rkm 16, 69, 97, and 134, yielded the highest catch rates.

Burbot were occasionally encountered in habitat locations or selected sites located upstream of Talkeetna during the winter and those catches were made exclusively at mainstem sites. The mainstem site opposite Curry recorded the highest catch rate of all sites above Talkeetna.

The distribution of burbot in the Cook Inlet to Talkeetna reach, as indicated by the percentage of habitat location sites recording catches of burbot by any gear type, appeared to increase as the summer progressed. Burbot catch rates generally remained low and varied through June and July at most habitat locations. One location, a large, stable eddy located just upstream of the Parks Highway bridge, recorded the most consistent catches of burbot throughout the year. During August and September, catch rates generally increased, and the percentage of habitat locations recording catches of burbot rose to a maximum of 88% for the first two weeks of September. In addition, burbot were also abundant at the mouths of the Deshka River, Alexander Creek, and the Birch Creek Slough.

The incidence of burbot catches in the Talkeetna to Devil Canyon reach decreased steadily from early June to mid-July when only mainstem sites at rkm 193, 198, and 235 were producing catches. After July 16, the percentage of habitat location sites recording catches sharply increased, while sloughs, creek mouths, and mainstem sites all recorded catches of burbot.

The catch per unit effort from June to September varied from 0.0 to 3.0 burbot per trotline day. Throughout the reach upstream of Talkeetna, the mainstem site 3.2 km below Portage Creek and a mainstem site at rkm 183 were the most productive, while Slough 11 and the mouth of Whiskers Creek recorded the lowest catches.

At no time during this period of sampling did a stream mouth site show any consistent catch per unit effort except for Lane Creek in late August and September. Lane Creek is a clear, cold tributary that, until the last two weeks of August 1981, flowed straight into the Susitna River. At that time, the creek changed course and began flowing into a slough channel of the Susitna River. After this change, the catch per unit effort increased and stayed fairly consistent until the end of September.

Small but consistent catches of juvenile burbot were recorded during late August and September at both the mouth of the Deshka River and the mouth of Alexander Creek. Juvenile burbot were occasionally found at only six other locations from Cook Inlet to Devil Canyon during this study.

Electrofishing surveys conducted during August, September, and October 1981 succeeded in locating burbot in mainstem and slough channels of the Susitna River from rkm 70 to rkm 160. Catch rates varied from 0.0 to 12.8 burbot per hour, but as these surveys were not designed to reflect relative abundance of burbot, the results could only be used to further document the distribution.

Age classes 4, 5, and 8 made up the majority of burbot, and comprised 14%, 11%, and 12.5% of the sample, respectively. Of Of the burbot used for age determination, age 4 averaged 407 mm (range 303-520 mm), age 5 averaged 439 mm (range 365-620 mm), and age 8 averaged 559 mm (range 465-647 mm).

Burbot are known to spawn from mid-December to early April. Female burbot collected in the Susitna River beginning in early Septmber were observed with well-developed eggs. Throughout June and through September, both sexually mature and immature burbot were observed.

- Round Whitefish

Round whitefish were captured at only four habitat locations during winter studies from November 1980 to May 1981; all of these sites were located downstream of Talkeetna. Small numbers of round whitefish were taken in gill nets set at the mouth of Sunshine Creek in March and again in gill nets set during May at the mouths of the Deshka and Kashwitna Rivers as well as in Cache Creek Slough. As indicated by the direction from which they hit the nets, the fish were all captured while moving upstream.

The presence of round whitefish near the mouths of tributary streams in March and May, after no catches were made in these same locations during November through February, indicated a general pattern of movement into these areas and on into these tributaries.

Round whitefish were collected at 30% of the habitat location sites sampled from Cook Inlet to Talkeetna during the first two weeks of June. The mouth of Sunshine Creek recorded the highest catch rate of all gear types, 5.5 fish per gill net night. After June 15, the incidence of round whitefish in habitat location catches downstream of Talkeetna dropped to between 0.0% and 11.1% of location sites sampled until the last two weeks of September, when catch incidence rose to 45% of all sites sampled. During these weeks, round whitefish were collected at three mainstem sites and six tributary mouth sites downstream of Talkeetna.

Round whitefish were more consistent in sampling gear catches above Talkeetna from June through September. The incidence of round whitefish catches ranged from 17.6% to 44.4% during June and July, then dropped to 0.0% in the first two weeks of August. The incidence of round whitefish in catches remained below 10.0% of sites sampled until the last two weeks of September when 35.3% of sites sampled recorded catches of round whitefish. The highest and most consistent catch rates were recorded at sloughs 6A and 10 and at the mouths of both Indian River and Portage Creek.

Forty-five Susitna River round whitefish, from fishwheel, gill net, and electrofishing catches made from Cook Inlet to Devil Canyon, were aged using scale analysis. Round whitefish analyzed for age composition ranged from age 0+ to age 8, with age 4 being encountered most often.

- Humpback Whitefish

(In the discussions pertaining to the resident fish species of the Susitna River Study area, ADF&G has listed three species of whitefish as humpback whitefish. The three species are the humpback whitefish, Alaska whitefish, and lake whitefish. The difficulty in readily distinguishing among these three species necessitated this action.)

The first capture and observation of a humpback whitefish occurred on 12 February, 4.2 km below the mouth of Montana Creek. This fish, caught in an under-ice gill net, was the only one of its kind captured that winter. During June, relatively large numbers of humpback whitefish were also collected at the mouth of Anderson Creek, Sunshine Creek, Slough 6A, and Portage Creek.

From mid-July until September, humpback whitefish were collected at habitat locations on the Susitna River between Cook Inlet and Devil Canyon. Adults were more frequently collected in the

1 to 15 September time period and were more common in the habitats sampled below Talkeetna than in the river reach above Talkeetna.

The ages of 67 Susitna River humpback whitefish were confirmed via scale analysis. The fish ranged in age from age 2 to age 7. Age 4 fish, which made up 31.3% of the aged catch, was the predominant age class encountered. Age 3, age 5, and age 6 fish each composed 19.4% of those fish aged.

Between 1 and 30 June, large gill net catches were made on the Susitna at Anderson Creek, Sunshine Creek, Slough 6A, and Portage Creek. Necropsies indicated that the fish in these catches were sexually mature but not ready to spawn. Between 26 August and 14 September, 170 humpback whitefish were caught at the Sunshine fishwheel. Inspections of fish caught from mid-September to early October showed well-developed gonads, but again, the fish were not yet ripe. No humpback whitefish were caught or observed after 7 October.

During the 1981 season, between Cook Inlet and Devil Canyon, no evidence of spawning among humpback whitefish was collected at any sampling location. Consequently, one could only speculate that humpback whitefish spawn in the Susitna River some time after 7 October.

- Longnose Sucker

Longnose suckers were first captured and observed at the mouths of the Deshka River and Cache Creek Slough on 9 May. By early June, longnose suckers were dispersed on the Susitna River between Kroto Slough and Portage Creek. The percentage of habitat locations at which longnose suckers were captured by gill net was relatively high during the early part of the summer and then decreased during mid-summer. The percentage increased again during September in the lower river, but not above Talkeetna. The highest fall gill net catches were reported at the Deshka River and Sheep Creek Slough. An increased presence of longnose suckers was also found in September in the mainstem Susitna below Talkeetna.

Juvenile longnose suckers were continually present, primarily in the Susitna River below Curry. As the season progressed, however, they shifted farther downriver.

One hundred ninety-seven longnose suckers taken from the Susitna River by fishwheel, gill net, and electrofishing gear were aged by scale analysis. The majority of these fish were age 6 and 7, comprising 33% and 22% percent of the catch, respectively. The oldest fish caught, representing 3% of the catch, were age 9.

- Dolly Varden

November through May sampling within the Susitna River from Cook Inlet to Devil Canyon produced a catch of two Dolly Varden. One was taken by gill net from Little Willow Creek; the other, by trotline at rkm 134.

From June to September 1981, Dolly Varden were collected at a total of 52% of the habitat locations in the Cook Inlet to Talkeetna reach. The occurrence of Dolly Varden in habitat location catches by two-week periods varied from a low of 8% in the last two weeks of August to a high of 29% in the last two weeks of September. Tributary stream mouth habitat locations produced the most consistent catches of Dolly Varden, with the highest catches occurring in late June at the mouth of the Kashwitna River.

In the Talkeetna to Devil Canyon reach, Dolly Varden were collected at a total of 59% of the habitat locations. From June to September, the occurrence of Dolly Varden in habitat location catches varied from a high of 21% in June to a zero catch in July. Catches of Dolly Varden occurred in this reach again, however, in August and September. A total of 17 Dolly Varden were captured in habitat locations at the mouths of Indian River and Portage Creek; a selected fish habitat site at the mouth of Billion Slough produced seven of the 17 fish captured. Other sites in this reach produced only one Dolly Varden.

The higher incidence of Dolly Varden catches during July may be directly related to the migration and spawning at this time of pink, chum, and sockeye salmon, upon whose eggs Dolly Varden feed. The higher catch incidence in September can be attributed to two factors: Dolly Varden had moved into their own spawning areas within the clearwater tributaries, and they had begun outmigration into their wintering habitat.

During helicopter surveys of upper Indian River and upper Portage Creek, a stunted population of Dolly Varden was observed. In the lower Susitna River study, these fish were found only within upper Portage Creek and upper Indian River. Minnow traps produced good catches of these fish: Indian River, 50 fish; Portage Creek, 127 fish.

- Threespine Stickleback

Threespine stickleback were collected at 37 (84%) of the 44 habitat locations in the Cook Inlet to Devil Canyon reach of the Susitna River from Alexander Creek to the mainstem Susitna Island site. Catch per unit effort rates in the Cook Inlet to Talkeetna reach were higher, overall, than those in the Talkeetna to Devil Canyon reach.

The number of habitat locations that produced threespine stickleback was highest in June (84%) and declined steadily to 16% in September. The higher percentage in early summer indicated that fish observed then had been involved in spring spawning movement, activity that had disappeared by September. Except Goose Creek 1, all habitat locations in the Cook Inlet to Talkeetna reach produced stickleback. Twelve of the 17 habitat locations in the Talkeetna to Devil Canyon reach produced catches of this species.

- Cottids

Between November 1980 and October 1981, cottids were captured at 40 (91%) of the 44 habitat locations in the Cook Inlet to Devil Canyon reach of the Susitna River. The percentage of habitat locations producing catches in the Cook Inlet to Talkeetna portion of the reach ranged from a high of 70% in late August to a low of 42% in late July. For the Talkeetna to Devil Canyon reach, there was a high of 76% in early July and a low of 35% in late September.

- Lamprey

Arctic lamprey were captured at 14 habitat location sites between rkm 16 and rkm 162, which were surveyed from November 1980 through September 1981. During the winter surveys, the only habitat location site to produce Arctic lamprey was Rustic Wilderness, where only one lamprey was captured. All other lamprey were collected during the summer surveys.

The highest catch was recorded in early July at Whiskers Creek. These lampreys had an estimated length of 70 mm and were captured in a single trap which had become buried in the silt. The highest catch frequency was recorded during the 1 to 15 September sampling period when 27.8% of all sites surveyed produced lamprey. All productive habitat location site surveys during this period occurred at tributary sites downstream of rkm 81. The lowest incidence of capture for this species, 3.7%, was observed in the 16-31 July sampling period.

- Northern Pike

During the 1950's, northern pike were illegally transplanted by private individuals into the Susitna River drainage. As a result, northerns have been reported in the Yentna River drainage in Bulchitna, Hewitt, and Whiskey Lakes (Kubik, pers. comm.).

A northern pike, measuring 715 mm fork length and aged at nine years, was captured on 11 September 1981 in a gill net set overnight, 150 m upstream of the mouth of Kroto Slough. This fish is the first northern pike recorded in the mainstem Susitna River and is believed to have migrated out of Bulchitna Lake. This migration became possible where a hydraulic barrier washed out, thereby allowing northern pike into the Yentna River.

(c) Aquatic Habitat

(i) Impoundment Zones and Vicinity

In the proposed Devil Canyon impoundment zone, habitat evaluation sites were established at Fog Creek, at the Susitna mainstem near Tsusena Creek, and at Tsusena Creek. Both the mainstem of the Susitna as well as Fog and Tsusena creeks contained highly oxygenated water with pH values near seven or slightly higher. Conductivity values for all sites were moderate in range; turbidity levels were low in the two tributaries, with a moderate increase in the mainstem. Temperatures in both the tributaries and the mainstem were similar, with maximum recorded temperatures usually above 10°C.

Within the proposed Watana impoundment, habitat evaluation sites were located at: Susitna mainstem near Deadman Creek, Deadman Creek, Susitna mainstem near Watana Creek, Watana Creek, Susitna mainstem near Kosina Creek, Kosina Creek, Susitna mainstem near Jay Creek, Jay Creek, Susitna mainstem near Goose Creek, Goose Creek, Susitna mainstem near Oshetna River, and Oshetna River. The same trends in measured parameters discussed for the Devil Canyon impoundment are also present in these locations: well-oxygenated water, usually slightly basic pH, moderate conductivity levels, low turbidity levels in the tributaries compared to those in the mainstem, and similar water temperature ranges.

Watana Creek is located at river kilometer 305 on the north side of the Susitna River and is approximately 13 km upstream from the proposed Watana dam. Watana Creek is a shallow meandering stream. It has a gradual gradient, resulting in a moderate flow with few pools interspersed between the predominant riffle areas. The substrate consists mostly of gravel and rubble. The water is often turbid during the summer because of heavy rains and unstable soils present upstream.

Kosina Creek, located at river kilometer 324 on the south side of the Susitna River, lies approximately 32 km upstream from the proposed Watana dam. Kosina Creek is a deep and turbulent stream, predominantly whitewater interspersed with deep pools and shallower riffle areas. Substrates consist mostly of sand, large cobble, and boulders. The stream channel is stable and is situated in a narrow valley with a moderate gradient. It is often braided, with total widths frequently around 30 m.

Jay Creek is located at river kilometer 328 on the north side of the Susitna River and lies approximately 35 km upstream of the proposed Watana dam. Jay Creek is a relatively narrow, shallow stream, predominantly riffle with a moderate flow. Substrate consists of gravel, cobble, and rubble, often embedded in sand. Although the water is generally clear, unstable soils in upstream areas often result in landslides which can change the water to a turbid condition within minutes.

Located at river kilometer 360 on the south side of the Susitna River approximately 69 km upstream from the proposed Watana dam, Goose Creek is a narrow, shallow stream. The habitat is predominantly riffle with a moderate flow and few pools. Substrate consists of rubble, cobble, and boulders, often embedded in sand. The stream channels and banks are stable; the water usually remains clear even during period of moderate rain.

The Oshetna River, located at river kilometer 363 on the south side of the Susitna River, lies approximately 72 km upstream from the proposed Watana dam. The Oshetna River is a large, meandering stream approximately 30-40 m wide with an average depth of one meter. Streamflow is slow to moderate, with alternating pool and riffle areas. Substrate consists mostly of rubble and cobble, with some large boulders. The stream channel is stable throughout the study area and contains many large gravel bars. This stream is partially under glacial influence, and the water is often turbid even during periods of dry weather.

(ii) Downstream (below Devil Canyon)

Sampling was conducted in various reaches of the Susitna River from Cook Inlet to Devil Canyon. These included the Yentna reach, Sunshine reach, Talkeetna reach, and Gold Creek reach (Figures 3.31, 3.32, 3.33, and 3.34. In addition, five selected habitat evaluation sites in the vicinity of Gold Creek were studied in greater detail (Figure 3.34).

Water quality measurements in the Yentna reach were made at the following locations: Alexander Creek, Anderson Creek, Kroto Slough, Mainstem Slough, Deshka River, Lower Delta Islands, and Little Willow Creek. The tributaries, sloughs, and mainstem sampling localities all exhibited high dissolved oxygen readings. The pH values were generally in the high-six to middle-seven range, except for the Deshka River and Little Willow Creek readings, which were at the lower limits of this range. The most notable difference between tributary and other areas was the much lower turbidity levels recorded in the former. Anderson Creek, the only exception to this pattern, registered high levels.

Areas sampled in the Sunshine reach of the Susitna included: Rustic Wilderness, Kashwitna River, Caswell Creek, Slough West Bank, Sheep Creek Slough, Goose Creek, Mainstem West Bank, Montana Creek, and Rabideux Creek. All waters were well oxygenated, and pH values, typically around 7.0 or less in the tributary areas sampled, were slightly higher at slough and mainstem sites. Conductivity was generally low in the tributaries and moderately high in the mainstem and slough sites. Rabideux Creek showed the highest conductivity readings for any of the tributaries sampled in this region. Turbidity readings were extremely low in most of the tributaries, especially in Caswell and Montana creeks.

Sampling sites in the Talkeetna reach included: Mainstem 1, Sunshine Creek, Birch Creek Slough, Birch Creek, Cache Creek Slough, Cache Creek below Talkeetna and Whiskers Creek Slough, Whiskers Creek, Slough 6A, Lane Creek, and Mainstem 2 above Talkeetna. In general, high dissolved oxygen levels were present in all of the study areas sampled. The exception was Cache Creek, where a low dissolved oxygen reading during the latter part of the salmon run was attributed to low flows during this particular sampling period. The lower ranges of pH readings in this region, for example at Whiskers Creek and Whiskers Creek Slough, may have been due to more acidic flow than was present in the more downstream areas sampled. Conductivity readings were generally moderate, and, when the influence of the mainstem Susitna was negligible, turbidity levels were generally lower in the tributaries and in the sloughs than in the mainstem.

In the Gold Creek reach, the general habitat evaluation sites included: Mainstem Susitna at Curry, Susitna Side Channel, Mainstem Susitna Gravel Bar, Slough 8A, 4th of July Creek, Slough 10, Slough 11, Mainstem Susitna - Inside Bend, Indian River, Mainstem Susitna Island, and Portage Creek. In general, the trends seen in the previously discussed stretch of river were also seen in this stretch.

The ranges for the recorded parameters are shown in Table 3.54. In this table, unless listed differently, the ranges given for the tributary sites include all of the sampling sites from that particular tributary. The only really significant trend seen in the upstream tributary sampling was that turbidity levels were generally higher at the tributary mouths. This characteristic was undoubtedly caused by mainstem Susitna influence.

The five selected habitat evaluation sites studied were sloughs located along the Susitna River from approximately 8 km downstream of Sherman to approximately 6.4 km upstream of Indian River. The sloughs studied were: Sloughs 8A, 9, 16B, 19, and 21.

Slough 8A is approximately 2.9 km in length. The initial .4 km from the mouth upstream is influenced by the mainstem Susitna River and, except during periods of extremely low river flow, a backwater area is created in the slough. Above this area, during the study, the flow was free, obstructed only by beaver dams located within the middle section of the slough. Slough 8A can be characterized as having sloping, 1.8-meter cutbanks and six "heads" which, except during periods of low mainstem discharge, contributed flow from the mainstem. During those periods, flow was generated through groundwater percolation and water release from beaver dams. Sockeye and chum salmon were observed spawning in the lower stretches of the slough, which was the longest of the five sloughs sampled and exhibited the greatest diversity. Because they were so long, sloughs 8 and 9 had transects only at their "heads" and mouths.

Slough 9 is an open water channel approximately 1.9 km long, with sloping, 1.8-meter cutbanks and substrate composed of gravel, rubble, and cobble. The main source of water for the slough consisted of flow from the mainstem Susitna River except during periods of low discharge. Two small tributaries, which were located on the northeast and southeast banks, maintained flow in the slough during low discharge periods. They provided the entire low-flow discharge. The northeast tributary was a known site for coho spawning.

Slough 16B is a free-flowing channel approximately .6 km in length and consisting of steep cutbanks ranging from .3 m to 1.5 m in height along both sides of the entire length of the slough. The substrate observed during the study was fairly homogeneous throughout and consisted primarily of gravel and rubble. The main source of flow was from the mainstem Susitna River, which entered the head of the slough. During periods of low mainstem discharge, as the head of the slough was dewatered, the slough itself became isolated from mainstem influence, and groundwater percolation alone contributed most of the water. Although spawning was not observed during the present surveys, a few chum salmon carcasses were found in dewatered areas within the slough.

Slough 19, which is largely spring-fed, is backed up at its mouth by the Susitna River, forming a pool approximately half the slough's length. At the time of the study, the slough itself was approximately .3 km in length, with sloping, 1.5-meter cutbanks in the upper portion and generally sloping banks throughout the lower portion. The substrate was composed of 100% silt and scant aquatic vegetation from the slough's mouth approximately 60-90 m upstream. Above this distance, the substrate was primarily gravel, with a layer of silt ending with cobble and rubble near the head of the slough. Sockeye were observed spawning in this slough. Redds were located by noting areas where the fish had fanned the silt to gain access to the underlying gravel.

Slough 21 is a forked, open channel stream approximately .8 km long with sloping, 1.5-meter cutbanks. Except during periods of low discharge, the main source of water is the mainstem Susitna River. At low discharge of the mainstem, however, the slough is fed by a small, clearwater tributary entering the northeast channel of the slough. During the study period, this tributary along with ground water percolation, maintained water in the main channel and northeast channel, while the northwest channel was dewatered. From the mouth to approximately 225 m upstream, the substrate was composed primarily of silt sparsely interspersed with gravel and cobble. Above this portion of the main channel and in the northeast channel, the substrate was composed of silt, gravel, and rubble. It was in these channels that all spawning activity was observed.

The northeast channel substrate consisted primarily of rubble and cobble interspersed with gravel. During the sampling period, no fish were observed spawning in this site. This channel was also the first to dewater. The northeast channel, as a result of the contribution of a small tributary, was never found dewatered, nor was the main channel of the slough. The sites along Slough 21 were selected because varied types of habitat, water quality, and fish activities, such as spawning and rearing, were represented.

In general, average water temperature in the sloughs during the June, July, and early September sampling periods was 9.0°C or higher, decreasing significantly in late September, when average water temperature ranged between 1.8°C and 5.6°C. Although data were limited, a comparison between surface and intergravel temperatures indicated that intergravel temperatures remained constant at 3.0°C, and surface water temperatures varied diurnally between 4.5°C and 8.5°C. The intergravel temperatures were consistently 2°C below the lowest recorded surface temperatures.

Dissolved oxygen readings were usually near 100% saturation until a slight decrease occurred in September. Generally, the slough samples showed moderately high conductivity readings; moderate alkalinity levels; pH readings in the middle-six to middle-seven range; and, for the most part, fairly typical cation, anion, heavy and trace metals, and nutrient levels. The most notable metal concentrations were those reported for iron. Turbidity levels in the sloughs were high when sloughs were apparently influenced by mainstem water.

3.4 - Threatened or Endangered Species

(a) Plants

At present, no plant species are officially listed for Alaska by federal or state authorities as endangered or threatened; however, 37 species are currently under review by the U.S. Fish and Wildlife Service (USDI 1980b) for possible protection under the Endangered Species Act of 1973. A recent publication by Murray (1980) discusses the habitat, distribution, and key traits of most of these species. None of these species are known to occur, however, in the upper Susitna River basin.

A list of species (Table 3.55) extracted from Murray (1980) was believed to contain the most likely plants of this category that could potentially occur in the Susitna River drainage and in the landscape to be modified by the construction of the proposed dams and associated facilities. Since the upper reaches of the drainage were expected to be the least affected, however, the major portion of the present survey was devoted to the study of potential habitats in and around the impoundments. The general habitat requirements and occurrence of these plant species were known from previous taxonomic and ecological study in Alaska and from information given by Hulten (1968). For instance, several of the endangered species and the only threatened species, (Smelowskia pyriformis), favor well-drained rocky or scree slopes.

Field searches were made in potential habitats in August 1980 and early July 1981. On each field trip, aerial and ground reconnaissance was made by three to four botanists and agronomists with the purpose, thereby, of increasing the probability of finding the pertinent plant species.

Following an assessment of potential habitat, specific field surveys were conducted in the following areas: 1) the upper drainage basin, specifically alpine areas near the Susitna and West Fork Glaciers; 2) the lowlands of the upper drainage basin, Maclaren and Tyone Rivers, ridges, terraces, and periglacial features; 3) the lower drainage, outcrops, and promontories along the Susitna River near Watana Creek, Kosina Creek, and gravel bars in the river bed; 4) alternative access routes; and 5) Borrow Pit A (Figure 9.7).

Calcareous outcrop areas found in 1980 were surveyed again in 1981, but earlier in the season. A prominent light-colored outcrop on the northwest flank of Mt. Watana supported a mat and cushion vegetation type in which many calciphilic species were present. The exposed bench was both well-drained and calcareous, requirements for several of the species being sought.

The Kosina Creek calcareous outcrop area was re-surveyed in 1981 to make observations at an earlier phenological time and to obtain flowering specimens of the Taraxacum species collected there in 1980. Several flowering plants of Taraxacum were collected in 1981, and the preliminary determination indicated that the species was T. alaskanum, a common species in some areas. The aspect of the Kosina Creek outcrops is north-facing, and the dark soil around the calcareous rocks is rather fine-grained. The Kosina Creek outcrops are almost accordant both with the calcareous outcrops on the northwest side of Mt. Watana and with the calcareous lag gravel domes west of Watana Creek. The Taraxacum collections were made in proximity to the calcareous rocks of the outcrop, and none were found in the surrounding vegetation types; one may thus assume that the species has calciphilic tendencies. Saxifraga oppositifolia and Rhododendron lapponicum, two recognized calciphiles, were notably abundant in the Kosina Creek outcrop area.

The northern alternative access route to the proposed dam sites (from the Denali Highway, not the recommended route) was surveyed in July 1981 by the plant ecology team. Two sites were studied on the ground; the rest of the route was observed from low-level helicopter flights.

A sandy, blowout area on the northwest side of Deadman Mountain on this northern access route was chosen for ground study. The well-drained habitat was believed to be a favorable site for several of the endangered and threatened species. Vegetation was a shrubby heath-birch-willow type. A second site on the south side of Deadman Mountain was also studied in connection with the survey of the alternative access route to Watana from the Denali Highway. A series of dry ridges, probably glacial moraines or terraces, was present, and the vegetation on two of these ridges was surveyed. The vegetation was typically a mat and cushion type. A later survey was made of this northern alternative access route and a ground study site was chosen on the east side of Deadman Mountain near the 1200 m elevation. The area was characterized by dry, rocky, windblown ridges vegetated by mat and cushion species, and in the lower and moister sites, by low shrub willow-birch-heath vegetation.

In none of the three survey areas on the alternative access route from the Denali Highway were any of the species in question found. The other access routes were similarly surveyed, but the plants in question were apparently absent there as well.

The vegetation in the vicinity of Borrow Pit A was surveyed in July 1981. The low ridge area was characterized by rocky outcrops intermixed with low areas containing knee-high, shrubby vegetation. In shallow depressions or ravines, the vegetation included both more herbs and grasses and taller shrubs such as alder. No threatened or endangered species were found.

(b) Wildlife

The only endangered wildlife species, listed by either the U.S. Fish and Wildlife Service or the State of Alaska, that could possibly occur in the upper basin study area is the peregrine falcon. No evidence of this species' nesting or even migrating through the study area was discovered during the course of this study. Suitable cliff-nesting habitat was surveyed in both 1980 and 1981 with no peregrine nests found. In addition, despite the following ornithological effort expended during the course of this study no peregrines were seen: 385 party-hours of breeding bird censusing; 53 party-hours of ground censusing of waterbirds; 44 party-hours of ground observations of raptor/raven nest sites; and more than 630 party-hours of general bird surveys. Furthermore, qualified observers performing the other field studies were requested to report any incidental observations of noteworthy species; no confirmed sightings of peregrines were reported.

The only confirmed historical records of peregrines in the upper basin study area are presented by White (1974), who saw two individual peregrines during his June 1974 survey, but found no sign of nesting. One bird was a "single adult male. . . roosting on a cliff about 4 miles upriver from the Devil Canyon dam axis," and the other was a "sub-adult . . about 15 miles upriver from the Devil Canyon dam axis." White (ibid) stated that the Yentna-Chulitna-Susitna-Matanuska drainage basin "seemingly represents an hiatus in the breeding range of breeding peregrines . . .", and Roseneau et al.(1981) stated that "the Susitna and Copper rivers both provide . . . [very few] . . . potential nesting areas for peregrines."

Peregrine falcons are a concern along the transmission line north- ern study area. A nest site is located east of the proposed transmission route crossing of the Tanana River. The nest was not active during 1981 but was used prior to this time. Whether or not it will be used again is unknown.

(c) Fish

The U.S. Department of Interior, Fish and Wildlife Service, does not list any fish species in Alaska as being threatened or endangered (Richard Wilmot, pers. comm. 1981). The State of Alaska Endangered Species Act includes no fish species on its list of endangered species.

3.5 - Anticipated Impacts on Botanical Resources

Potential impacts on vegetation were identified by review of pertinent literature and by discussion with various specialists knowledgeable regarding the problems associated with hydroelectric development. Anticipated impact areas in the upper basin and transmission corridors were identified by overlaying expected activities on vegetation/habitat maps. Calculations of area size were made based on vertical projection. Because of slope, the actual area to be impacted will be somewhat higher than that presented. The general location of proposed facilities is presented in Figure 9.7. Impact analysis for the downstream floodplain consisted of relating the general changes in flow during reservoir filling and operation to plant succession trends.

(a) Watana Dam and Impoundment

(i) Construction

The obvious impact of constructing the dam and of filling the Watana reservoir will be the elimination of portions of different vegetation/habitat types. The hectares of each vegetation/habitat type to be affected are presented in comparison with the total hectares of those types in the entire upper Susitna River basin and in an area within 16 km of the upper river (Table 3.56).

At a maximum pool elevation of 666 m (2185 ft) the Watana impoundment will inundate approximately 14,691 ha. Of those, 12,587 ha are vegetated and represent 0.9% of all the vegetated area of the upper basin. Much of the impoundment area could be classified as wetland (Table 3.7). Primary losses will occur in the woodland and open spruce stands and in the open mixed forests. Birch forests will be substantially affected by the impoundment, relatively more so than any other vegetation/habitat type (Table 3.56). The other types which would experience a relatively major impact are conifer-deciduous forests and balsam poplar forests.

Additional impact on vegetation may occur beyond the impoundment areas, if roads or other activities associated with clearing the woody vegetation from the impoundment zone are not restricted to the impoundment area. As discussed under mitigation (Section 3.9), restriction of disturbance to the impoundment area will limit the extent of this impact.

Construction activities at the dam site, borrow sites, airstrip, construction camp and village sites will result in a loss of additional hectares of vegetation (Table 3.56). Proposed camp and village sites, airstrip site, and borrow areas will be located primarily in woodland black spruce and low shrub stands. Borrow areas D and H also cover large mixed forest stands. Borrow areas may eventually be revegetated and are discussed in more detail in Section 3.5 (c)--Borrow Areas.

All of the aforementioned construction activities will be almost entirely contained within an area designated as a construction zone. This zone (Figure 9.7) represents the maximum area of potential construction disturbance. It is unlikely that this entire zone will be directly affected; however, if all the vegetation is removed from this zone, 13,725 ha will be lost in addition to that in the reservoir area lost by inundation (Table 3.56). This loss represents 0.8% of the entire upper basin. Reclamation of areas that will only be temporarily affected will reduce this loss and is discussed under Section 3.9 (b).

The significance of these losses, aside from the vegetation loss itself, will be the associated loss of habitat for wildlife. The principal losses for big game will be a reduced food supply for black bears and moose. Browse supplies in the impoundment area are marginal and do not represent a late winter reserve for moose. Birch and mixed forest stands, however, provide bears with substantial supplies, which are particularly important in early spring. A more detailed discussion of the impacts on big game is presented in Section 3.6 (a) (i).

(ii) Operation and Maintenance

The pool elevation of the Watana reservoir will vary an average of 27 m (90 ft), with a low of 639 m (2095 ft) in May, and a gradual increase to a full pool elevation of 666 m (2185 ft) during September. The drawdown zone (from full pool to low pool) will be essentially unvegetated. During dry years, however, the full pool target elevation may not be attained and exposed areas that are not flooded may become naturally revegetated for a short period until they are flooded again. The greatest potential for this type of revegetation exists in areas of gentle slope, such as the Watana Creek area.

The Watana reservoir is located in a region of discontinuous permafrost. Consequently, there is potential for large earthflows and slumps, especially on north-facing slopes, as the relatively warm reservoir thaws adjacent permafrost. This type of disturbance will most likely occur on black spruce sites and may lead in places, to their replacement, by alder stands and, possibly, by open paper birch stands. Bank erosion from above the full pool elevation may also result from wave action and altered subsurface drainage.

An impact noted by Baxter and Glaude (1980) for northern reservoirs is the potential for peat masses to float to the surface of the reservoir. This type of impact should not be extensive at the Watana reservoir, since only a small amount of the peat-forming wet sedge-grass vegetation will be inundated. Some potential for such an occurrence does, however, exist in the Watana Creek area.

There are two other minor impacts that may occur during the operation of the Watana facility: the potential modification of local climate and the icing of vegetation around the dam outflow. In general, large bodies of water influence the local climate by acting as cold sinks in winter, thereby delaying the initiation of spring, and as heat sinks in summer, thus extending localized warm weather. It has been estimated that such influence will be restricted to within about 1.6 km of the reservoir shoreline.

Local climatic changes may, in turn, result in minor changes in vegetation phenology. The severity and extent of this potential change in vegetation is difficult to predict. They may, however, include a localized delay in snowmelt and in greening of vegetation in spring and, possibly, a delay in leaf-fall in autumn. Any impact on vegetation in the spring may be moderated somewhat, however, since the pool elevation will be at its lowest point and thus, the distance from the water edge to the vegetation edge will be at its greatest.

At the dam outflow, ice fog will probably occur during winter months when the temperature is in the approximate range of -12°C to -23°C (+10°F to -10°F). This ice fog will freeze on contact with vegetation and may accumulate to create loads sufficient to break twigs. Although this impact will be very localized, birch trees, because of their many small branches, will be the most susceptible to damage.

(b) Devil Canyon Dam and Impoundment

(i) Construction

Construction and filling of the Devil Canyon dam and impoundment will eliminate an estimated 3,214 ha of vegetation/habitat types (Table 3.57). Primary vegetation losses will be of open and closed mixed forests and open spruce forest. Construction activities at the dam, camp, and village sites will further eliminate or modify at least another 223 ha of vegetation, primarily closed mixed forest. An estimated 1,706 ha of wetlands are within these direct impact areas (Table 3.7).

If the entire construction zone (Figure 9.7) is affected, 5,688 ha will be lost in addition to the reservoir area (Table 3.57). It should be noted that the area of the construction zone represents a maximum potential loss; a certain portion of this area will probably not be disturbed and reclamation activities may restore areas temporarily affected. The maximum potential loss, including the construction zone and reservoir area, represents 8,884 ha and 0.5% of the entire upper basin.

Vegetation losses at Devil Canyon will not be significant in terms of moose or caribou, since most of the affected area is situated on steep slopes which are generally inaccessible to these ungulates. These areas do, however, provide a relatively large forage supply for black bears. Big game impacts are detailed in Section 3.6 (b) (i).

(ii) Operation and Maintenance

The pool elevation of the Devil Canyon reservoir will fluctuate an average of 17 m (55 ft) during the year. The drawdown zone created by this fluctuation will essentially be devoid of vegetation. As discussed for the Watana reservoir, vegetation may invade some portions of this zone when the full pool target elevation is not attained. On the other hand, since much of the Devil Canyon reservoir is very steep-sided, this invasion may only occur at the very upper reaches of the reservoir in the Tsusena Creek vicinity.

As discussed for the Watana reservoir, erosion of material from above the pool elevation may occur after filling. The extent of this impact will vary, depending on many factors, but the amount of slumping will probably be less than that at Watana.

Localized climatic changes may also occur around the Devil Canyon reservoir. Because of the long, narrow configuration of the reservoir, however, which leaves relatively smaller surface area exposed to create climatic change, the potential for such change will be less than that expected for the Watana reservoir. Any such changes are, therefore, expected to have a negligible effect on surrounding vegetation.

Finally, the operation of the Devil Canyon reservoir will result in changes in downstream flows, downstream water temperatures, and ice conditions. The impacts of these changes on vegetation are discussed in Section 3.5 (d) - Downstream Floodplain.

(c) Borrow Areas

The complete development of all borrow areas at both Devil Canyon and Watana will destroy an estimated 1,751 ha of vegetation/habitat types (Tables 3.56 and 3.57). Those portions of the borrow areas within the impoundment and those associated with access road construction are not included in this estimate. This estimate does include, however, those borrow areas within the construction zones previously discussed. Woodland and open spruce, low mixed shrub, and birch shrub will be the principal types affected. Borrow Area K, which is a quarry associated with the Devil Canyon dam, is covered primarily by mixed forests.

The total impact from borrow areas will probably be less than the 1,751 ha estimated, since certain areas (possibly A and H) may not be used and others may be only partially developed. Also, reclamation of all these areas is possible [(see Section 3.9 (b)]. Areas that are developed should not, therefore, be permanently destroyed as a terrestrial habitat but may remain changed in terms of the type of habitat for a long period of time.

The development of borrow areas may also influence vegetation in adjacent areas by lowering the water table. This type of impact will probably only occur to any noticeable extent around Borrow Area D, where adjacent land to the north and west may be influenced. This impact will be localized, however, and will probably result in only minor species composition changes in the areas affected.

(d) Downstream Floodplain

(i) Construction

Decreased flows during the period of filling will enable vegetation to move into the upper portions of what is now submerged river bottom. Between the Devil Canyon dam site and 0.5 km above the confluence of the Susitna and Chulitna rivers, the development of vegetation, however, will be relatively negligible, since most of the area to be exposed consists of rocky substrate, rather than smaller particles suitable for the rooting of vegetation. Thus, vegetation will probably be limited to fireweed, horsetails, dryas, sweetvetch, and possibly some other pioneering species. Another hindrance to vegetation development is that plants will be restricted to interstices of the rock-armored river bottom. Moreover, the filling period will not be long enough for sufficient wind-blown soil to accumulate to allow for further vegetation development.

Because of decreased flows, areas that are presently horsetail communities will quickly develop into balsam poplar sapling and willow communities. The rate of this change depends on the synchronization of seed crops with adequate precipitation and suitable temperatures. The areas supporting horsetail are relatively limited, however, most occurring within 11 km upstream of the confluence of the Susitna and Chulitna rivers. During the period of reservoir filling the impact on vegetation below the Susitna-Chulitna confluence is expected to be negligible.

(ii) Operation and Maintenance

At Gold Creek, river flows during the growing season (May to September) will be reduced from an average of about 20,000 cfs to an average of about 10,000 cfs. Seasonal floods will essentially be eliminated. As a result, some of the presently unvegetated bank areas in the reach from Devil Canyon to the Susitna-Chulitna confluence will begin to develop horsetail, dryas, willow, and balsam poplar communities. Barring disturbances by ice jams, willow and balsam poplar saplings will develop within five years of the last disturbing influence on sites presently having sandy or silty substrates.

Establishment of significant cover on rocky sites may require several decades while adequate wind-blown sands and silts accumulate; even then, vegetation will be dwarfed and slow-growing for several more decades. In the downstream Susitna above Talkeetna, the area above the level of the river during 40,000 cfs flows is already vegetated. Below that level, most of this area has a rocky substrate, not conducive to lush growth. Consequently, the overall increase in vegetation cover for this reach of the river will be minimal.

Since the Devil Canyon to Talkeetna reach of the river is expected to remain largely ice-free, a principal environmental force maintaining early successional vegetation will be absent during operation. This gap will allow present early successional vegetation to advance to later forest types. During some winters, however, accumulations of ice fog on vegetation adjacent to the wider sections of the river may break down trees and tall shrubs, creating brush fields of young balsam poplar, willow, and alder. This effect is not expected to proceed beyond bank-side vegetation.

Below Talkeetna, the effects of either reduced or increased flows will be moderated by the contributions of the Chulitna and Talkeetna rivers. While the degree of moderation is uncertain, certain trends in impacts can be expected. For example, the primary impact of decreased summer flow below Talkeetna will be to allow early successional vegetation to move down onto sites that are presently eroded by high summer flows. Thus, until a new equilibrium with the river is reached, new early successional stands will migrate toward the new level of peak flows, while older early successional stands (then less affected by high flows) will advance to alder and immature balsam poplar types.

The time required for transition from early successional stands of willow and balsam poplar to mid-successional stages is roughly equal to that required for establishment of new early successional stands (that is, six to eight years). The total area covered by the new stands is expected to be nearly equal to that lost to mid-successional vegetation.

The above sequence of events may be negated by floods from the Chulitna or Talkeetna rivers or, in rare instances, by flood water passing the Susitna project. Such events may maintain the distribution of vegetation types on the floodplain below Talkeetna similar to the way it is at present.

(e) Access Route

(i) Construction

Construction of the Parks Highway-to-Devil Canyon/Watana access road (including railroad yard and all potential borrow areas) will disturb approximately 900 hectares of vegetation, providing that machinery stays within 30 m (100 feet) of the center line (Table 3.58). Primary losses will be to open and closed conifer-deciduous forests and low shrub types.

The total direct impact of the permanent access road may be somewhat less extensive than the aforementioned estimate, since the roadbed will only be about 14 m (45 feet) wide and all the identified borrow areas may not be used. Between Gold Creek and Devil Canyon, however, the pioneer road will probably cover separate ground from the route of the permanent access road and, therefore, will result in additional temporary impact. Eventual revegetation will restore these areas.

(ii) Operation and Maintenance

During operation of the road, impacts may extend beyond the road base itself. Where the road restricts drainage, woody vegetation types will shift toward sedge-grass tundra and wet sedge-grass conditions. Areas which are presently wet but which will become drier will experience a gradual invasion of shrubs and trees, depending on specific soil/site conditions.

Accumulations of dust on roadside vegetation may cause snow melt to occur two to three weeks earlier for a distance of 30-100 m either side of the road (CRREL 1980). This factor, associated with accumulations of some elements, (particularly calcium), in road dust and changes in photosynthesis, may substantially reduce the density of four-angled Cassiope, stiff clubmoss, sphagnum moss, Cladina, and other mosses and lichens; on the other hand, cottongrass may increase (CRREL 1980). Such shifts in vegetation composition would not be obvious to any but the trained observer and should not cause any soil erosion problems.

The most significant source of impact associated with the access road may be damage caused by unrestricted off-road vehicle traffic (Sparrow et al. 1978). The most extensive impact of such use would be on willow and shrub birch. Sedges would be most resistant to damage. The most significant damage, however, would occur on upland tundra communities, where soils are shallow and rocky. The potential restriction of off-road vehicle traffic is discussed under mitigation (See Section 3.9 (b)).

Considerable potential for fire also exists, especially during the spring. The remoteness of the region increases the time required to reach a site and to bring a fire under control. Thus, while such an event may be localized, it may also extend over vast areas. In any event, fires will cause changes in the vegetation similar to those which have occurred historically from naturally occurring wildfires (that is, vegetation would be set back to early successional stages). Neither the wet areas nor the sparsely vegetated upland tundra communities will support a significant fire. The birch and low mixed shrub, the black and white spruce, and the mixed conifer-deciduous forest habitat types, however, may ignite into substantial fires. Fire could revert these latter types to seral brush communities, highly productive of moose browse.

(f) Transmission Line

(i) Construction

Construction of the transmission line will result in long-term vegetation impacts where tower structures and permanent access roads are placed. In addition, movement of machinery over the ground will temporarily set back brush growth. The major impact of construction will be to reduce the overstory cover of trees. Where spruce trees are cut, spruce bark beetle problems may arise.

The estimated amounts of different vegetation types that will be within the right-of-way are presented in Table 3.59. Additional areas may be affected if access roads are placed outside of this right-of-way.

The transmission line between the dams and the intertie will primarily traverse closed conifer-deciduous forests and the birch shrub type. Utilization of the access road to the dams will help limit the impact in this area. From Healy to Fairbanks the transmission line traverses open spruce forests, open conifer-deciduous forests, and low mixed shrubs. Extensive clearing will be required along this route from the Tanana River to Fairbanks. Within the route segment between Willow to Cook Inlet, the primary vegetation types include open spruce, closed conifer-deciduous forests, and wet sedge-grass types. Clearing will also be required in the forested areas here.

At several places, the transmission lines will cross wetlands. They are especially common in the Tanana Flats region of the northern corridor (from the Nenana crossing to the Tanana River) and along the southern portion of the Willow-to-Cook Inlet corridor. Small wetland areas may be spanned without impact, providing precautions are taken during construction. Larger expanses of wetlands, though, will be adversely affected, but impacts could be minimized if construction time is restricted to winter. Potential impacts include direct disturbance of wetland vegetation (and resultant loss of wildlife habitat) as well as changes in drainage patterns and possible erosion problems.

(ii) Operation and Maintenance

Maintenance of the transmission right-of-way may require the topping or removal of the taller tree species, such as white spruce, birch, aspen, balsam poplar, and tamarack. If these trees are removed, shrubby undergrowth is expected to accelerate growth and to thicken, and the number of individuals of some shade-tolerant species are expected to decrease temporarily until shrubs thicken. Periodic clearing of trees along the transmission right-of-way is expected to benefit wildlife from the standpoint of increased forage production once the animals become accustomed to the sound of the lines [See Section 3.6 (f)].

Impact on vegetation may also occur in the vicinity of the transmission line as a result of increased ATV use. Such use may be especially common where the transmission lines cross roads or other existing access points.

3.6 - Anticipated Impacts on Wildlife Resources

(a) Watana Dam and Impoundment

(i) Big Game

For the purposes of this discussion, the proposed Watana facility includes the dam, spillway, camp, village, airstrip, and impoundment as well as the construction zone around the dam site. Borrow areas associated with the construction of this facility are addressed separately [see Section 3.6(c)(i)].

- Moose

The construction and operation of the Watana dam and impoundment will negatively impact moose in several ways. The most obvious and probably the most important impact of the proposed facility on moose will be the direct loss of habitat. It is anticipated that 26,813 ha of habitat will be either permanently lost or temporarily disturbed. Of this total, 14,691 ha will be inundated and permanently lost, and the remaining 12,122 ha will be lost as a result of other facility components. A portion of this 12,122 will be permanently lost, but at a minimum, 50% may be available for reclamation. Regardless of how much can be restored, the figure of 26,813 ha does represent the immediate loss of moose habitat which will occur.

The severity of the impact of this habitat loss will vary within the moose population. Those moose that have home ranges that fall primarily within the impact zone will be displaced and be forced into adjacent areas where they will suffer high mortality. This is most likely to affect relatively sedentary moose which typically utilize a small area as both summer and winter range. (Within the upper basin, most radio-collared moose which displayed such a sedentary pattern were found west of Watana Creek.) Impacts on moose that utilize the impoundment zone on a limited or seasonal basis will be different and more difficult to predict although it is likely that these moose too will be reduced in number.

The impoundment zone appears to serve two major functions for moose which shift home ranges from summer to winter: (1) as winter habitat and (2) as an area which provides green forage early in the spring. Moose that use the impoundment zone as winter habitat typically spend the summer months at high elevations and then move down to lower elevations, frequently to river bottoms, during winter when deep snow at higher elevations impedes movement and reduces the availability of food. During the course of these studies, however, radio-collared moose did not display this type of movement pattern, probably due to mild winter conditions. It is therefore likely that the movement data on moose do not reflect typical movement patterns of moose during more severe winters. Therefore, the lowlands along the river which will be flooded should still be considered of importance to the moose population as winter habitat.

The level at which this winter habitat could support moose during a severe winter, though, is questionable. In the absence of detailed browse surveys within the impact zone, it is impossible to determine how many moose could be supported there under harsh winter conditions. Cursory and subjective conclusions developed during the course of the Susitna studies suggested that the quantity of browse along the river is low and appears to be virtually completely utilized by December. Based on this preliminary conclusion, on the blood data (which suggested that the condition of Susitna moose had deteriorated over the past few years), and on the apparent lack of any significant fires in the past 30 to 35 years, it appears that the impoundment zone may not presently be of any significant value as a winter food reserve for moose. If a natural fire were to occur in the forested areas along the river sometime in the future, the value of the proposed impoundment zone as a wintering area for moose would be greatly improved. The construction of the Watana facility, of course, would preclude that possibility.

The other manner in which the impoundment zone serves the needs of both sedentary and migratory moose is by providing green forage early in the spring. Such forage is most prevalent on south-facing slopes, which are the first areas to become snow free and allow for the early emergence of herbaceous plants. The availability of these plants is very important to moose, in particular to pregnant and lactating cows which have a very high nutritional demand. A very large proportion of the south-facing slopes in the area will be flooded by the Watana impoundment. What this will mean for the moose population will depend to a large degree on the severity of winter conditions. Following a mild winter, moose may not be nutritionally stressed enough to be impacted by this reduction in early spring forage. Following a more severe winter, however, the early availability of green forage may help to reduce starvation mortality.

The relatively sedentary moose which are displaced from the impoundment zone will aggravate the situation described above, since they will compete for food with moose already inhabiting adjacent areas. This will likely hasten the process of range deterioration that appears to be currently underway. The severity of this situation and the damage which will be done to vegetation will depend on the ability of the surrounding area to support additional moose and on the predation rate of wolves on these moose. If sufficient wolf predation takes place before the habitat is over-utilized, the long term quality of the habitat may not be too severely affected. In this case, the key element will be the degree to which wolves are adversely affected by the project. Being more sensitive to disturbance than moose, it is possible that, at least at first, the wolf population will be reduced to a greater degree than the moose population thus allowing for greater moose survival and consequently greater potentential for habitat damage because of an overabundance of moose.

In addition to direct habitat loss, the moose in the area may be adversely affected by microclimatic changes caused by the impoundment. It is predicted that the Watana impoundment will alter the microclimate in the immediate downwind areas. Temperatures may be reduced sufficiently in some areas to retard the emergence of spring vegetation which, as previously explained, moose utilize for forage in early spring. Although this possibility of microclimatic effects impacting moose through an influence on vegetation does exist, it is not likely to be of major significance due to the distances that will exist in early spring between the permanent shoreline and open water. Because of the projected drawdown schedule, the impoundment should be at its lowest level at or following the breakup of ice. In areas where the impoundment is very wide, such as the Watana Creek drainage, the potential for microclimatic changes are greatest because moving air will pass over a greater distance of water. It is also in such areas, however, that the greatest distances will exist, due to topographic features, between open water at this time of the year and the shoreline: in many areas these distances will exceed the 1.6 km zone of influence predicted for microclimatic changes. In those sections where the impoundment is narrow, such as east of Jay Creek, the potential for microclimatic changes is less because of the reduced surface area of water. In these areas, however, the distance between water and shoreline will be minimal in early spring, again due to topography. In other words, where the potential for microclimatic changes is greatest, the vegetation is far from the water, and where the vegetation is near the water, the possibility for microclimatic changes is less.

The potential for microclimatic changes having an impact on moose is far greater during the winter months when the impoundment is ice-covered. The relatively smooth surface of the ice will reduce the frictional drag of winds, which are from the east and northeast during winter and this will cause the blowing and drifting of snow for several kilometers inland on the downwind (west and southwest) side of the reservoir. It is therefore likely that, in many areas downwind of the impoundment, snow accumulations will be far greater than those that presently occur in the area. This will greatly restrict the use of such areas by moose in the winter. First of all, deep drifts will improve the ability of wolves to kill moose in these areas. There will also be less browse available. Finally, moose weakened by passing through such drifts will be more vulnerable to wolf predation.

In summary, moose will be impacted through the loss of 26,813 ha of habitat and a reduction in usable winter habitat downwind of the impoundment due to snow depths. This loss will cause the direct displacement of those moose whose home ranges are located primarily within the project area. It will also reduce significantly the availability of early spring forage, which is of some importance and, following severe winter conditions, probably critical to many moose in the area. The project will also eliminate a possible wintering area which is presently of questionable value. Although other factors may also affect moose (such as increased difficulty in negotiating ice conditions during breakup and disturbance from human activity around construction and clearing operations), they are all relatively minor in comparison to the direct and indirect loss of habitat. How many moose will be adversely affected and the degree to which the carrying capacity of the area will be reduced are currently unknown. Based on the census data collected and the distribution of moose use, it is possible that 400 moose may be severely impacted as a result of direct displacement or loss of major portions of their home ranges. An additional 800 moose could be impacted to a lesser degree through an overall reduction in the carrying capacity of the region and overcrowding from displaced moose. This is a very rough estimate and the actual numbers could vary as much as 50% (200 to 600 severely impacted and 400 to 1200 moderately impacted). Possible mitigation measures to reduce these impacts are discussed in Section 3.9.

- Caribou

The amount of caribou habitat lost as a result of the inundation of terrain by the Watana impoundment will be insignificant. Less than one percent of caribou habitat in the upper Susitna River basin will be inundated by both the Devil Canyon and Watana impoundments combined. Furthermore, the habitat to be lost is of low quality.

The proposed reservoir, however, does intercept an historically important migration route of the Nelchina caribou herd across the Susitna River between Deadman and Jay creeks. Ice conditions on the shoreline of the impoundment may act as an obstacle to future crossings of the impoundment, and the ice conditions on the impoundment itself may constitute an additional obstacle to migrating caribou.

The annual drawdown of the reservoir in winter will result in the impoundment being at its lowest level at the time of the spring migration, in late April and early May. At this low point, the impoundment will average approximately 27 m (90 ft) lower than when it is full in September. The gradual winter drawdown will result in the formation of ice shelves grounded on the shore. These shelves will fracture into linear strips as the supporting water recedes and strands the ice on the shore. The width of the strips and the difference in height between adjacent shelves will depend upon the thickness of the ice. The thinnest shelves will be lodged highest on the banks in early winter. Where the slopes of the shoreline are gradual, such as along the Watana Creek drainage, the shelves will be wide and flat and more easily traversed. Where the banks are steeper, the shelves will be fractured into smaller blocks and pile up as ice moves up from below and slides down from above; these areas may be more difficult for caribou to cross.

These spring conditions in the impoundment will be significantly different from those occurring at present in spring along the Susitna River in the vicinity of the traditional caribou crossing. The ice shelf area will be wider than the present shelves formed on the river bank. The breakup also will be delayed for several weeks. The risks involved in crossing the impoundment will be different from those associated with the swiftly flowing river carrying river ice floes downstream. During this period, crossing the reservoir would be hazardous to caribou.

In addition, during the winter months, the prevailing winds are from the east and northeast. They will push snow across the smooth ice of the impoundment to pile up and form a deep snow bank along the downwind shore. During the spring breakup, this snow bank will be alternately soft during the warmer days and crusted during the chill nights. It may constitute another obstacle to caribou attempting to climb the south bank.

This migration route was used in the past by a considerable portion of the Nelchina herd when it frequented the northwest portion of its distribution, but has been used by only small numbers of caribou since 1971, with the possible exception of 1976. It is not possible to predict when the herd might return to its former migration patterns, but it is reasonable to expect that it will at some period in the future, especially if the herd population increases dramatically. When the route was utilized, it was used by three distinct migrating groups: (1) pregnant cows and yearlings migrating southward during late April and May across the river to the traditional calving grounds in the Kosina Creek and Oshetna River valleys; (2) cows and calves during the post-calving migration to northern summer ranges in late June and July; and (3) mixed bands of caribou during August and September. The conditions that caribou will face in the impoundment during the later migrations will be much different from those described for the spring migration. During the summer and early autumn, the impoundment will be reaching its full level and will constitute a long, narrow lake averaging approximately 1-2 km wide. It is not expected that the caribou will experience any special difficulties in crossing the reservoir during those periods; caribou are excellent swimmers, and they regularly cross lakes when migrating.

Migrating caribou could respond in a variety of ways to the changed environment which the impoundment will create. The severity of the obstacle caused by the shore ice shelves will vary depending on the stage of breakup and the point at which the caribou reach the impoundment; they may approach at a steep bank or a gradually sloping shoreline.

The possible reactions produce a variety of potential results in the future distribution of the Nelchina herd. In one scenario, the migrating caribou will travel along the shore until they find a safe crossing point, as they do at present. In another, the caribou will attempt to cross a hazardous section of the reservoir and suffer increased injury or mortality. In a third, the caribou will continue eastward along the north shore of the impoundment towards the big bend of the Susitna River and cross the river above the confluence of the river with Goose Creek or the Oshetna River, where the impoundment largely will be drained at this time of year and contain a flowing river. This last action would lead to a delay of a day or two in reaching the calving grounds with unpredictable consequences for the pregnant cows. In a final scenario, the obstacles associated with the impoundment might constitute such a formidable barrier that the caribou will be forced to turn back and to bear their calves on the alpine plateau, between the Susitna and Nenana Rivers. This area is already recognized as a secondary calving ground.

The last scenario described above might cause a temporary separation of the cow and bull groups. The worst possible case is that it would cause the isolation of a sizable portion of the herd in the northwest portion of the range which has been used in the past as both summer and winter habitat. At present, this area supports a small subherd that is estimated to total less than 1,000 animals.

Although it is difficult to predict how caribou will react, based on the present knowledge of caribou behavior the possible reactions of the Nelchina herd to the impoundment have been placed in the following order, starting with the most likely reaction and proceeding to the least likely reaction.

1. The caribou will manage to cross the impoundment safely in the Watana and Kosina creek area.
2. The caribou will travel eastward and cross the Susitna River in the vicinity of the Oshetna and Tyone rivers on ice-covered flats.
3. The caribou will make hazardous crossings with increased mortality.
4. The caribou will refuse to cross the impoundment and return northward.

The number of activities associated with the construction phase of the Watana dam constitute potential short-term impacts on caribou. The clearing of woody material from the impoundment area prior to flooding may disturb migrating caribou for a period of up to five years before filling is complete. Caribou migrating southward in spring or northward in summer may be disturbed by the unnatural cleared area in the impoundment zone. Air traffic in and out of the Watana construction camp, particularly low-level helicopter traffic, also constitutes a potential impact upon the caribou. If low-level flights occur over the nearby traditional calving grounds, a deleterious impact upon the whole Nelchina herd could result. Similarly, any ground travel by workers to the calving grounds could constitute a serious disturbance to the caribou at a particularly sensitive period during their annual cycle. The dam site is a considerable distance from the calving grounds, but work crews clearing the impoundment zone will be much closer. Mitigation measures proposed to deal with this problem are presented in Section 3.9.

- Wolf

The most severe impact of the proposed Watana impoundment on wolves will be a reduction in the abundance of prey, in particular moose and caribou. As previously discussed, the likelihood of a major impact on caribou is not great, and therefore the prime avenue of impact on the local wolf population will be a reduction in the number of moose. There will definitely be fewer moose present in the area; and due to overcrowding by displaced moose, there will likely be some reduction in the total carrying capacity of the area. Since moose are the prime and most dependable food source for wolves, there will also be a parallel reduction in the resident wolf population.

This predicted reduction in wolves represents the long-term impact. For a short time following the filling of the impoundment, there may be an increase in wolf numbers. This possibility is based on the assumption that wolf numbers will not be reduced as a result of some other aspect of the project such as disturbance from human activity. As discussed in the description of impacts on moose, displacement which results in increased population density and competition for food may reduce the vigor of individual moose and improve the ability of wolves to secure food for a few years. Increased ease of obtaining food may result in wolves requiring smaller territories, and thus provide opportunities for the establishment of more packs. Greater food availability may also result in improved reproductive success on the part of resident packs. In addition, as mentioned in the moose section, deep snow drifts downwind of the impoundment during winter may further increase the vulnerability of moose to wolf predation. The change in moose vulnerability will, however, be of short duration; following the overall reduction in the number of moose and the carrying capacity of the adjacent areas, the mechanisms that served to increase the wolf population will be reversed and the net result will be fewer wolves.

If the impact on moose is restricted to the area immediately within and adjacent to the impoundment, at least six or seven resident wolf packs will be affected as described above. The impact of wolves farther removed from the impoundment will depend on how far the impoundment will have an influence on moose.

An associated factor in the long-term impact on wolves concerns the future of the Nelchina caribou herd. Since the impoundment is not expected to have a severe impact on that herd, caribou will still be available to wolves as an alternative to moose. Because of their migratory nature, caribou are less important than moose to the long-term maintenance of wolf numbers. Yet, if the Nelchina herd continues to increase, it is possible that, to some degree, caribou will compensate for the predicted loss of moose. The increase in the size of the caribou herd is not necessarily related to the project but is dependent to some extent on the current management objectives of ADF&G. The number of wolves and, more importantly, the locations of wolf packs that may benefit from an increase in the size of the caribou herd will vary and are impossible to predict.

Another direct manner in which the Watana impoundment may impact wolves is through the loss of den sites. Since not all of the wolf packs that are resident near the impoundment were radio-collared during the course of these studies, it is not known how many den sites may be lost. At least one and perhaps two den sites are very close to the impoundment and may be abandoned because of flooding or project-related disturbance. Based upon the characteristics of den sites examined during these studies and the apparent abundance of such sites in the area, it is not believed that the availability of den sites is a limiting factor for local wolf populations. The loss of some den sites as a result of flooding is therefore considered insignificant in comparison to the reduction in prey. Although it is pure speculation at this point, it should be noted, however, that since most wolf dens are enlarged red fox dens, the long-term status of the fox population may be important to the availability of suitable wolf dens. The fox population is not presently very high, and there are many old fox dens still available; should the Susitna project result in a major reduction in the number of foxes, however, the long-term availability of denning sites for wolves may ultimately be lower.

Increased air traffic and disturbance resulting from the clearing of the Watana impoundment are also sources of potential impacts on wolves. Although observations suggest that denning wolves can adjust to air traffic, they appear to be very intolerant of ground disturbances. Therefore, since at least two known den sites are close to the edge of the Watana impoundment, the clearing activities required to remove woody vegetation, if they are conducted during the denning period (May through July), could result in den abandonment and pup loss. This would most likely be a short-term impact and, assuming that the den sites were used following the disturbance, the overall impact might not be of major consequence.

- <u>Wolverine</u>

The construction and operation of the Watana facility will impact wolverines in basically three ways. The first is the loss of habitat that will result from the impoundment and associated facilities. As mentioned, this loss will total 26,813 ha. This loss of habitat and associated foraging areas will reduce the ability of the area to support wolverines to some unknown degree.

The second impact is related to the expected reduction in the number of moose and the associated reduction in wolves. Although wolverines do directly prey on a variety of animals, they are well known as scavengers which feed on large animals such as moose and caribou that have been killed by wolves. The reduction in moose and wolf numbers will mean that fewer wolf-killed moose will be available for use by wolverines. As discussed in the wolf section, for a few years following inundation, there may be a short-term increase in wolf-killed moose. Therefore, this impact on wolverines may take several years to materialize and will actually occur after the moose and wolf populations become lower.

The third and probably the most critical impact on wolverines will be disturbance by human activity. This species requires expanses of remote, uninhabited area. The development of a highly concentrated center of human activity around the Watana dam site plus the human activity associated with the clearing of the impoundment will most likely render a large portion of the land adjacent to the Watana impoundment unacceptable to wolverines. The disturbance associated with the clearing activities will be of a short term nature and the area adjacent to the impoundment may be suitable for wolverines following inundation; the permanent facilities around the dam site, however, will preclude the presence of wolverines in that portion of the upper Susitna basin.

In summary, the Watana impoundment and associated facilities will result in a reduction in the wolverine population. The mechanisms of impact include habitat loss, reduction in wolf-killed ungulates, and human activity. The core portion of the wolverine study area, which includes the Watana impoundment, was estimated to contain 11 to 21 adult wolverines during the current studies. It is likely, because of the sensitivity of this species to disturbance, that the majority of these wolverines will be displaced during the construction and filling phases of the project. The extent to which wolverines will use the area following the activities associated with construction and filling is unknown, but it is likely that the upper portions of the impoundment area will prove suitable for some wolverine use.

- <u>Brown Bear</u>

As is the case for other big game species, brown bears will be impacted by the Watana facility through a loss of habitat. Because brown bears exhibit very large home ranges which are characterized by major seasonal shifts in usage, the 26,813 ha of habitat that will be lost is used to various degrees by brown bears. The use of the impoundment area represents only a portion of the total area covered by this species over the course of a year. Based on radio-telemetry data and knowledge of brown bear habits, it has been determined that it is unlikely that the Watana facility will cause the loss of any individual brown bear's home range. As can be seen from Table 3.60, the highest percentage of overlap of a radio-collared brown bear's home range and the Watana impoundment was 25.1% (for bear number 281). Bears number 280 and 340 had home ranges that overlapped the impoundment area by 11.3% and 10.1%, respectively. The remaining bears had home ranges that each overlapped the impoundment area by less than 10%.

Although brown bears appeared to use the impoundment zone throughout the non-denning season, the greatest use probably occurred in early spring following their emergence from winter dens. There is a pronounced tendency for brown bears to move from the high elevations where dens are located to the lower elevations along the river at this time of the year. The reason for this movement is felt to be the attractiveness of areas along the south-facing slopes near the Susitna River which are the first to become snow free and thus make available overwintering berries and early herbaceous growth. It is also possible that bears are attracted to these areas because of the increased likelihood of finding winter-killed moose there.

The importance of these early snow-free areas to brown bears is not known. Regardless, for the purpose of impact prediction, it is assumed that the south-facing slopes that will be flooded (which represent a large proportion of the south-facing slopes in the area) are of some importance to brown bears, and that their loss will reduce, to some unknown degree, the ability of the upper basin to support a brown bear population comparable in numbers to the current one.

The Watana impoundment may also function as a barrer to seasonal movements of brown bears. Several radio-collared bears moved long distances to utilize the salmon in Prairie Creek. Brown bears also concentrated in the calving area of the Nelchina caribou herd where they were suspected of preying on calves. The bears may or may not find the impoundment an insurmountable barrier. That bears are able to cross the Susitna River under high flow conditions suggests that a relatively placid reservoir, especially at constricted points, should not be a barrier. If portions of the impoundment were to prove a barrier to brown bears, the tendency for bears to travel long distances should enable them to locate acceptable crossing points or even circumnavigate the impoundment.

As in the case of the nutritional importance of early snow-free slopes, it is not known how important the salmon and caribou calves are to bears. Obviously, many bears in the upper Susitna and Nelchina basins exist without salmon as a food source. Yet, it is crucial to note that the greater the number of these seasonal foraging areas that are lost, the greater will be the reduction in carrying capacity for brown bears. The relatively large home ranges of brown bears in the project area could be the result of widely dispersed food sources. Thus, the loss of any food source, either directly through flooding or indirectly through blocked access, could be significant to the bear population. This is especially true if more than one type of food is eliminated. It is likely that the brown bear population will be lowered due to the direct loss of habitat. The loss of additional food sources (such as Prairie Creek salmon) could greatly increase that loss.

Another impact on brown bear will be disturbance caused by human activity. Brown bears are fairly intolerant of human presence and will either withdraw from the zone of disturbance, in effect causing a further loss of usable habitat, or possibly come into direct conflict with humans. Any direct confrontation between bears and humans, such as would be caused by improperly disposed food refuse, would likely result in the need to destroy or remove the bear.

The one aspect of brown bear biology that will not be influenced by the Watana impoundment is denning. Brown bears den at high elevations which will be far removed from both the impoundment and disturbing human activity at Watana. Air traffic, however, could be a source of disturbance. No known brown bear dens will be inundated by the Watana impoundment, and it is unlikely that any undiscovered dens will be flooded.

In summary, the Watana impoundment and associated facilities will negatively affect brown bears. The mechanisms of impact will include: (1) direct habitat loss (especially that of probably significant early spring habitat), (2) possible blockage of the movement of bears to seasonally important foraging areas, and (3) potential indirect habitat loss resulting from disturbance by and conflicts with humans. In the absence of accurate population estimates, it is impossible to predict how many bears will be impacted. Because of the far-ranging movement patterns displayed by Susitna brown bears, the loss of any seasonal foraging areas will be a major impact on this population, however, and could cause a significant reduction in the number of bears that inhabit the area.

- Black Bear

Of all the big game species which inhabit the area, the black bear will be the most severely impacted by the Watana impoundment. Because of the association between black bears and forested habitats, the loss of 26,813 ha, most of which is suitable black bear habitat, will result in a drastic reduction in the number of black bears upstream from the Watana dam. The vast majority of the suitable black bear habitat east of the Watana dam site is within the area of the proposed impoundment.

Black bears are more sedentary than brown bears and spend a greater proportion of their time in these habitat types. As indicated on Tables 3.60 and 3.61, a far greater percentage of black bear than brown bear home ranges will be lost. In three cases, more than 40% of an individual radio-collared black bear's home range will be lost. The types of areas that will be lost are very important for black bears during spring, summer, and winter. Early fall is the only time when black bears tend to leave the forested areas in order to feed on ripening berries in shrub habitats located at slightly higher elevations. The construction zone around the Watana dam site will also eliminate a large area of such shrub communities.

Unlike brown bears, which den at higher elevations, black bears den on the slopes along the Susitna River and nearby tributaries and will thus be severely impacted by flooding. Proceeding upstream through the study area, the band of acceptable denning habitat becomes progressively narrower and more confined to the immediate vicinity of the Susitna River. Therefore, the impact of den loss will also become more pronounced farther upstream from the Watana dam. Typically, black bears in the study area denned at elevations between 457 m (1,500 ft) and 762 m (2,500 ft). Of the 13 den sites found in the vicinity of the Watana impoundment, 9 would be flooded by a pool elevation of 666 m (2,185 ft).

Black bears in the Susitna basin also differ from brown bears in regard to their reuse of den sites. None of the radio-collared brown bears that were tracked for two years reused the same den. Of the located black bear dens, all of the natural cavity dens examined and one of the dug dens examined had been previously utilized. This suggests that the availability of suitable den sites is limited and therefore increases the significance of the predicted den loss.

Along the Susitna River, upstream from the Watana dam site, the best black bear habitat is found on the steep slopes (especially the south-facing slopes) and the habitat becomes less suitable farther from the edge of these slopes where the density of trees becomes lower. Therefore, not only will the impoundment eliminate a large amount of black bear habitat, it will eliminate virtually all of the prime habitat, leaving only marginal habitat unflooded. Thus, the simple quantification of hectares of habitat lost does not accurately reflect the magnitude of that loss. The habitat which will remain is of marginal value to black bears not only for foraging and denning but also as protective cover from brown bears.

In summary, although the Watana impoundment will impact black bears in a variety of ways, they are all insignificant and moot in comparison to the direct loss of critical, prime habitat: there will be a major reduction in the number of black bears inhabiting the project area. East of Jay Creek, because of the constricted nature of the forested habitat in that area, it is likely that virtually all resident black bears will be lost. The degree of loss will be gradually less as on proceeds west from Jay Creek to the Watana dam site. In the absence of accurate density estimates, in addition to the many unknowns concerning the response of both black bears and brown bears which influence the abundance of black bears, it is difficult to accurately predict the magnitude of the loss that will occur between Jay Creek and the Watana dam. Based on the data available, however, it would be reasonable to assume that between 70% and 90% of the bears resident in this area will be eliminated. The percentage of loss will probably be lower as one approaches the Watana dam from the east.

- Dall Sheep

Of the three sheep herds identified in the upper Susitna basin during these studies (Portage-Tsusena Creek, Watana-Grebe Mountain, and Watana Hills), only the Watana Hills herd will be impacted by the Watana impoundment. This herd occupies the mountainous region north of the Susitna River and east of Watana Creek. The 1980 count of the Watana Hills herd indicated that 209 sheep were present. The Watana impoundment will inundate a portion of the Jay Creek mineral lick and none of the rest of the area used by the herd.

As described in Section 3.2(a)(viii), this mineral lick is located on cliffs along Jay Creek very close to its confluence with the Susitna River. Preliminary observations indicate that sheep use much of the cliff area, from the river bottom up to and beyond the upper rim. Sheep use appears to be concentrated during the months of May and June. Observations of numerous sheep using the lick at the same time and experience with mineral licks in other parts of Alaska indicate that it is likely that a large proportion of the Watana Hills herd visits the lick during spring.

It is difficult to determine to what extent this herd will be negatively impacted, if at all, by the loss of a portion of the lick. There are several other known licks within the range of this herd, but there is insufficient data available to ascertain the relative importance of each lick to the herd. Also, it is not known if sheep will continue to use the Jay Creek lick following flooding. Although a portion of the lick will be flooded, as a result of the proposed drawdown schedule, the greatest proportion of the lick will be exposed during May and June when sheep use it. It is not known whether or not sheep will continue to use any part of the lick once the project is operating. It is even more difficult to predict if sheep will use that portion of the lick that will be exposed during May and June and under water during the rest of the year.

Because of the high degree of use that the sheep make of it and their willingness to expose themselves to possible wolf predation in order to reach the lick, it should be assumed that the Jay Creek mineral lick is of major significance to the Watana Hills herd. The impact on the herd if flooding renders the lick unacceptable is a matter for speculation. If inadequate alternative mineral sources are available at other licks within the range of these sheep, the possible loss of the Jay Creek lick may result in a reduced ability of the area to support sheep.

In summary, the Jay Creek mineral lick will be affected by the Watana impoundment. The degree to which sheep will use the remaining portions of the lick following inundation and the significance of the lick to the Watana Hills sheep herd are unknown. The total loss or abandonment of the lick, however, could have a possible negative impact on the Watana Hills sheep herd and lower the carrying capacity of that area for sheep.

(ii) Furbearers

The flooding of the Watana reservoir will eliminate 15,320 ha of furbearer habitat, the majority of which is terrestrial habitat. Because of the annual fluctuations of water levels, the draw-down zone and the aquatic habitat created will be of limited value to otters, mink, muskrats, and beavers.

As a result of their great dependence upon forested habitats along the Susitna River and its tributaries, the species most severely affected by the inundation of terrestrial habitat will be pine marten. During summer and autumn, foxes utilize riparian zones along the Susitna River and its tributaries. Flooding of these areas may, therefore, reduce the carrying capacity of the region for foxes. None of the fox dens found during these studies will be flooded. Due to the nature of fox den sites it is likely that only a few, if any, undiscovered dens will be flooded.

At the present time, lynx appear to be restricted to habitats along the lower reaches of some tributaries and adjacent to the Susitna River between Vee Canyon and the Tyone River. Flooding of these sites may, therefore, totally eliminate lynx from the immediate vicinity of the Watana impoundment. Because lynx are dependent on snowshoe hares for food and since hares appear to be restricted currently to areas within the upper reaches of the Watana impoundment, the future of lynx in the area will depend on the status of hares in areas adjacent to the impoundment. Some form of habitat alteration, either through natural or artificial means, will have to occur if hares, and thus lynx, are to become abundant in the project area.

Development and maintenance of the construction camps and village associated with the Watana impoundment will displace a limited number of furbearers. The presence of the camps will probably result in the abandonment of a fox den located west of Deadman Creek. Although this den was not used for rearing pups during the study, indications were noted of past natal use and winter resting use. Foxes may experience additional negative consequences if domestic dogs, with the potential for introducing rabies into the fox population, are housed at the village or camp.

Foxes will also be negatively affected if project personnel, by storing garbage or disposing it in a manner that leaves food available, deliberately or unwittingly provide food for them. Such a practice may leave the animals dependent upon this food source and may also result in artificially high fox populations.

Humans may also experience negative effects of their proximity to traditional wildlife habitats. Property could be damaged and workers exposed to bites and to wildlife-transmitted diseases if foxes, marten, or weasels are attracted to the camps by workers who feed them directly or who establish feeding stations.

In summary, the Watana impoundment and its associated facilities will result in a loss of furbearer habitat. Pine marten will be most severely impacted by these facilities with foxes being impacted to a lesser degree. The result will be the direct loss, through mortality, of those animals that will be displaced, and a subsequent reduction in the carrying capacity of the area for furbearers.

(iii) Birds and Non-game Mammals

- Dam and Impoundment

The general types of impact on raptors that can result from development activities have been well described by Roseneau et al. (1981), and Tables 3.62 and 3.63, which summarize disturbance factors, are taken from their report. Inundation is an additional potential impact from hydroelectric projects. The Watana impoundment will flood 15.1 km of the better quality raptor cliffs (type "A"), leaving only 0.9 km of Type "A" cliff not inundated (Table 3.64). Four active and four inactive golden eagle nest sites, two active and one inactive bald eagle sites, and two inactive raven sites will be destroyed by inundation (Table 3.65). Loss of this nesting habitat will force these birds to other sites, either along the remaining cliffs of the Susitna River and its tributaries, in the nearby cliff/tor habitat (cliffs and high, craggy hills) of the uplands, or in the case of bald eagles, to other nest trees. Unflooded cliff habitat in the surrounding area (for example, along Fog and Tsusena creeks) may increase in importance to these birds. If fish became available in the impoundment, large trees surrounding the impoundment might be used for nesting by bald eagles.

The impoundment will inundate 70 km^2 of forest habitat, which generally includes the most productive avian habitats of the study area (Table 3.36). A number of bird species are restricted to forest habitats for breeding (see Table 3.37). Most of these species are short-lived (except goshawks and great horned owls), and healthy populations occur in adjacent regions. Red squirrels and porcupines are also forest species and also occur commonly in adjacent regions.

Flooding of the fluviatile shorelines and alluvia, both in the main Susitna River and up the mouths of tributary creeks, will destroy breeding habitat of a few bird species (harlequin duck, common merganser, semipalmated plover, spotted sandpiper, wandering tattler, Arctic tern, dipper), some of which are considered uncommon, but none rare, in the region. Impact on wintering habitat of the dipper (open water along fast-running tributaries and in the Susitna River channel) may be the most serious impact in this category because local alternative sites of open water might not be available. Flooding will also deprive early migrant waterfowl of one of the first sources of open water in the region--the rapidly flowing waters of the Susitna River. It is expected, however, that the project will result in open water year round below Devil Canyon, at least as far as Talkeetna [see Section 3.6(d)(vi)].

The large impoundment that will be formed may provide habitat for waterbirds, but the degree of utilization will depend upon the rate and kind of development of food resources in the new lake. Because of the late spring thaw, the lake will be available only for the late-migrating diving ducks, loons, and grebes; in fall, however, it may remain open long enough to be used by late-migrating swans. As with the other large lakes of the region, a low level of use by breeding waterfowl can be anticipated (provided food resources are available). The anticipated draw-down zone will impede use of the reservoir edge by nesting loons and grebes, which usually nest at the edge of sedge shorelines or on small low-lying islands. Migrant shorebirds, who primarily move through central Alaska during the last three weeks of May, will probably use exposed areas of the drawdown zone for resting and feeding. This zone will be of little use to small mammals.

- Camp/Village Sites

The impacts of camp/village sites will be of two main types: 1) habitat destruction and alteration and 2) disturbance to animals themselves, by various types of human activities during and after construction. The latter impact applies more to birds than to small mammals. The amount and types of habitat that will be directly damaged appear inconsequential to the bird and small mammal populations of the area, primarily because these upland habitats are widespread in the region. Ground squirrels can be expected to increase and become tame, especially if fed by workers, and would probably become pests about the camp and village sites. Some birds, too, such as ravens, magpies, and mew gulls, will be attracted to any open refuse dumps. The present plan, however, is to cover the landfill with soil daily to prevent this and other problems associated with birds and mammals using dumps as food sources. If this plan is carried out, the problem will diminish.

Perhaps more important, there could be significant effects on sensitive bird species and habitats in nearby areas, primarily on raptors and waterbirds that use wetlands. Increased air traffic over the Fog Lakes wetlands as a result of activities about the dam site or over the Stephan Lake area as a result of trips between Watana and Devil Canyon camps/villages/dam sites could adversely affect the waterfowl populations. Although some species may, to a certain degree, acclimate to such disturbance, the net result will be a reduction in the suitability of these areas for raptors and waterfowl.

A few waterbirds use the small, scattered ponds between Deadman and Tsusena creeks, but because their numbers are small, potential losses through human influence will be minor compared to their overall population levels in the region.

The Watana camp site is in the general vicinity of raptor/raven cliff habitat along lower Deadman Creek. An active raven nest and territorial merlins were observed here in 1981. The habitat in this location will be flooded by the impoundment, however, so the major impact here will be the habitat's proximity to the reservoir and not to the camp. Depending on its exact location, the village site could be within 1.5 km of a bald eagle nest that was active in both 1980 and 1981, or within 2 km of two raven nest sites, one active and one inactive, along Tsusena Creek.

(b) Devil Canyon Dam and Impoundment

(i) Big Game

A total of 8,736 ha of habitat will be lost as a result of the construction of the Devil Canyon facility. This total includes the impoundment, dam, spillway, and camp and also the construction zone around the dam site. Impacts of borrow areas associated with the construction of the Devil Canyon dam are addressed in Section 3.6 (c). Of this total, 3,196 ha will be permanently lost through flooding, and the remaining 5,540 ha lost as a result of other facility components. Some of the 5,540 ha will be reclaimed following use, and will probably, to some degree, serve as habitat for big game in the future.

- Moose

The Devil Canyon impoundment and associated project facilities will impact moose in the same manner as described for the proposed Watana impoundment [see Section 3.6(a)(i)]. Because fewer moose were found in the vicinity of the Devil Canyon impoundment, the impacts of the facility should be less than those predicted for Watana.

The primary reason for the difference in moose abundance (depicted on Figure 3.12) is that moose in the Devil Canyon area are more sedentary than those in the Watana area, especially the easternmost portion of the Watana impoundment. Moose were tallied during March 1980 in areas that abutted the Watana and Devil Canyon impoundments. Of the total 636 moose counted, only 106 were in the vicinity of the Devil Canyon impoundment, and only two were actually in the impoundment zone. During an intensive survey of the impoundment zones during March 1981, 30 moose were estimated to be present in the proposed Devil Canyon impoundment zone. The difference between the two years is probably a result of the level of intensity employed in the survey effort. Thirty is probably a more typical number of moose than two. Yet, it is likely, because of the mild winter conditions that prevailed during these surveys, that this reported extent of use of the impoundment zone does not represent the situation as it would exist during more harsh winter conditions, when more moose would be expected near the river.

Another difference between the two impoundments is the difference in their expected impacts on microclimatic conditions. The same type of changes described for Watana will probably occur around the Devil Canyon impoundment, but, because of the smaller size and narrower configuration of the Devil Canyon impoundment, the degree to which microclimatic conditions will change and affect vegetation will probably be less than at Watana. Although there will be less of an exposed drawdown zone in Devil Canyon and thus the open water will be close to shoreline vegetation, the distances that air will move over open water will be less than in many portions of the Watana impoundment, and so the net impact will be less. The same principle holds true for blowing and drifting snow during winter. Blowing snow will be deposited over land areas on the downwind side of the impoundment, but because of the size and orientation of the impoundment, the impact of such snow drifts will probably be more localized and less severe than at Watana.

In summary, moose will be impacted through habitat loss, and the number of moose present in the Devil Canyon impoundment zone and adjacent areas will be reduced. The mechanisms described for impacting moose in the Watana impoundment area also will function to impact moose in the vicinity of the Devil Canyon impoundment. The total loss of moose will be less than at Watana as fewer moose are present, less habitat will be lost, and there will be reduced impacts from changes in microclimatic conditions. Based on the moose census and distribution data, approximately 100 moose may be severely impacted as a result of direct displacement or the loss of major portions of their home ranges. An additional 200 moose could be moderately impacted as the result of an overall reduction in the carrying capacity of the region. This is a very rough estimate, and the actual number of moose impacted could differ by as much as 50% (50 to 150 severely impacted and 100 to 300 moderately impacted).

- <u>Caribou</u>

The construction of the Devil Canyon dam and impoundment will have an insignificant impact on the Nelchina caribou herd. The terrain to be flooded contains low quality caribou habitat. The scarcity of caribou trails crossing the valley in this area indicates little caribou traffic. The Chunilna Hills subherd, which occupies the plateau south of the Susitna River, consists of fewer than 350 animals. This subherd is relatively sedentary.

- Wolf

The same mechanisms that will function to impact wolves in the vicinity of the Watana impoundment [see Section 3.6(a)(i)] will also serve to impact wolves residing near the Devil Canyon impoundment. In general, the predicted reduction in the number of moose inhabiting the area will result in the presence of fewer wolves. Three or four resident wolf packs are suspected to inhabit the area adjacent to or just west of the Devil Canyon dam and impoundment (see Figure 3.16) and could be impacted by a reduction in the number of moose available in that general area. As discussed for the Watana impoundment, impacts on moose will represent a short-term benefit, but a long-term detriment, to the wolves in the area.

Despite the similarity of impacts on wolves in the two impoundment zones, there is one major difference which could increase the relative magnitude of the predicted impacts on wolf packs in the Devil Canyon area. Wolves in the vicinity of the Watana impoundment frequently have access to caribou as alternative prey. Because of the migration patterns of the Nelchina herd, there is and has historically been comparatively little use of the area west of Devil Creek by Nelchina caribou. Therefore, the wolf packs that will be affected by the Devil Canyon facility are probably totally dependent on moose for their winter food supply, and a reduction in the number of moose available to these packs may represent a more severe impact than that suffered by wolves residing east of the Watana dam site.

- Wolverine

Because of the lack of accurate census data on wolverines, it is impossible to predict exactly how many wolverines will be negatively impacted by the Devil Canyon impoundment. As described in the discussion of the Watana impoundment [Section 3.6(a)(i)], wolverines will be impacted by habitat loss, a reduction in the availability of wolf-killed moose, and disturbance by human activity. Since wolverines are typically a low density species even under ideal habitat conditions, the number of wolverines that will be impacted by the Devil Canyon facility will be low.

Following the clearing of the Watana impoundment, it is expected that there will be relatively little human activity in the upper reaches of the impoundment; this situation might allow for wolverines to use the area again sometime in the future. The disturbance of wolverines around the proposed Devil Canyon impoundment will be more permanent. The presence of an access road and transmission lines between the two dam sites as well as a center of human activity at each dam site may preclude the existence of any resident wolverines on the north side of the Devil Canyon impoundment. If there is no additional development, the land area south of the Devil Canyon impoundment could be utilized by wolverines following the clearing and filling operations.

- Brown Bear

Because there is less open country adjacent to the Devil Canyon impoundment than to the Watana impoundment, there are fewer brown bears in the vicinity. As can be seen on Table 3.60, only five of the radio-collared brown bears had home ranges that overlapped the Devil Canyon impoundment zone, and in all cases the percentage of overlap was relatively small. Therefore, although the Devil Canyon impoundment will be detrimental to brown bears in the same fashion as will the Watana impoundment [see Section 3.6(a)(i)] there will be fewer brown bears impacted by the Devil Canyon facility.

The severity of the predicted impacts will be less because of differences in the proportion of spring foraging habitat lost. In the Watana impoundment, a large proportion of the south-facing slopes will be lost. Because of differences in pool level and associated topography, a far greater proportion of spring foraging areas will be left in the Devil Canyon impoundment area than at Watana.

The Devil Canyon impoundment also will be a potential barrier to the movement of brown bears to Prairie Creek to feed on salmon. Although the Devil Canyon impoundment will be narrower than that at Watana and, therefore, brown bears might find crossing the impoundment less of an obstacle, it will be more difficult for brown bears in this area to move around it because of other project components that will be present at each end. It is possible, however, that the placid reservoir will be more easily crossed than the flowing waters of the river.

- Black Bear

The proposed Devil Canyon impoundment will have less severe impacts on local black bear populations than will the Watana impoundment [see Section 3.6(a)(i)], but impacts will be marked regardless. Table 3.61 presents the percentage of overlap between the Devil Canyon impoundment and the home ranges of radio-collared black bears.

The average elevation of black bear dens in the vicinity of the Devil Canyon impoundment was 664 m (2,178 ft) with a range of 454 m (1,490 ft) to 1,323 m (4,340 ft). Of 16 black bear dens found in the vicinity of the Devil Canyon impoundment, only one would be flooded by a maximum pool elevation of 444 m (1,455 ft). There will also be a large area of suitable foraging habitat left adjacent to the impoundment. There will be a reduction in the number of black bears in the area, but, unlike the impact at the Watana impoundment (where the vast majority of the suitable black bear habitat in that portion of the upper basin will be lost), the relative magnitude of the impact of the loss of habitat at Devil Canyon will be reduced by the proximity of large areas of suitable habitat.

- Dall Sheep

None of the three sheep herds identified in the upper Susitna basin during these studies (Portage-Tsusena Creek, Watana-Grebe Mountain, and Watana Hills) will be affected by the proposed Devil Canyon impoundment. The herd closest to the impoundment is the Portage-Tsusena Creek herd; a total of 72 sheep were counted in this herd during July 1980. This herd occupies the mountainous area northwest of the Devil Canyon impoundment and should not be affected in any manner by the impoundment.

(ii) Furbearers

The proposed Devil Canyon impoundment will eliminate approximately 2,834 ha of furbearer habitat, the majority of which would be terrestrial habitat. The greatest impact of this flooding would be on pine marten and, to a lesser degree, red foxes. None of the fox dens found during this study would be flooded by the Devil Canyon impoundment. Due to the nature of fox den sites, it is likely that only a few, if any, undiscovered dens would be flooded. The elimination of some riverine aquatic habitat would also result in a reduction of the number of mink and river otters that the area can support. Since beavers and muskrats utilize the area within the Devil Canyon impoundment zone very little at this time, there will be relatively less impact on these species.

Because of the drawdown schedule, the aquatic habitat created by this reservoir will be of limited value to otters, mink, beavers, and muskrats. For example, Murray (1961) indicated that the annual rise and fall from the normal water level should be no more than 0.6 m for beavers to utilize an area. The unvegetated drawdown zone will also reduce the suitability of the newly created aquatic habitat for species such as mink and otters.

The construction camp and village associated with the Devil Canyon impoundment will displace a limited number of furbearers. At Devil Canyon, problems are expected to be similar to but not as serious as those in the Watana impoundment zone because furbearer numbers are generally lower near Devil Canyon.

(iii) Birds and Non-game Mammals

- Impoundment

The Devil Canyon impoundment will involve many of the same consequences to birds and non-game mammals as the Watana impoundment will create. Inundation, which will flood 27.4 km of type "A" raptor cliffs and leave 24.9 km not inundated (Table 3.64), will destroy one active and two inactive golden eagle nest sites and two raven sites, one active and one inactive (Table 3.65).

For some reason, in spite of the presence of cliffs with good structural characteristics, Devil Canyon itself is little used for raptor nesting. Possibly, the deep, narrow canyon with its often strong and buffeting winds makes this area undesirable for raptors. With the filling of the deeper, narrow portions of the canyon upstream of the Devil Canyon dam, the environmental conditions along the remaining type "A" cliffs may conceivably be altered enough to attract nesting raptors and ravens. That is, the remaining canyon will be wider and shallower and perhaps have less violent winds and, thus, be more hospitable to nesting birds.

Finally, cliffs along Portage and Devil creeks and others draining into the south side of the proposed Devil Canyon impoundment may become more important to birds displaced by inundation. Moreover, if the reservoir supports fish, then bald eagles may nest in large trees around the impoundment.

In addition to cliff habitat, the Devil Canyon impoundment will destroy 25 km^2 of forest habitat, which a number of bird species as well as red squirrels and porcupines rely on for breeding sites (see Tables 3.36 and 3.37).

Flooding associated with Devil Canyon will destroy the breeding habitats of the same few unusual bird species as those affected by the Watana inundation. Likewise, early migrant waterfowl may lose sections of the Susitna River that represent some of the region's first sources of open water. This loss of early open water may be compensated for by the availability of open water throughout the winter and spring below the proposed Devil Canyon dam at least as far downstream as Talkeetna.

Like Watana, the Devil Canyon reservoir may offer habitat in the spring to some late-migrating diving ducks, loons, and grebes and, in fall, to late-migrating swans. In addition, if food is available, it may also be used to a limited extent by breeding waterfowl. On the other hand, the changed shoreline at the Devil Canyon site probably will not create the level of impact that Watana will exert. The steep slope of the shoreline will limit waterbird nesting habitat around the impoundment. Moreover, the steeper and smaller drawdown area will be less attractive to migrant shorebirds than the Watana drawdown zone will be.

- Dam Site

Cheechako Creek, the tributary canyon 1.0 km southeast of Devil Canyon dam site and south-southeast of Borrow Area G, contains raptor cliff habitat. A gyrfalcon nested here in 1974 (White 1974), and in 1981 a goshawk nested in birch woods on the east bank. The dam project itself may avoid damage to this tributary above the impoundment level. Depending upon the proximity and degree of human activity associated with a proposed recreation facility, raptors that may be driven away by construction activities may return to nest on the cliffs after construction activities subside.

- Camp/Village Sites

The impact of the Devil Canyon camp/village sites will generally be the same as those at the Watana sites, that is, habitat destruction and alteration compounded by disruption from human activities during and after construction. Habitat loss will consist of 75 ha of closed conifer-deciduous forest.

An active golden eagle nest site along the north side of the Susitna River, below the dam site, is 1.5 km from the camp site and 1.6 km from the village site. In 1974, a gyrfalcon nested (White 1974) in the canyon (Cheechako Creek) 2.2 km east of the village site. This nest site was active in 1980 (species unknown) and was inactive in 1981.

No wetlands significant to waterfowl occur in this area, but air traffic between Devil Canyon and Watana camp/village/dam sites could adversely impact the relatively important Stephan Lake wetlands. Although some duck species may acclimate to the air traffic, it is unlikely that swans will successfully make the adjustment.

(c) Borrow Areas

(i) Big Game

The major impact that the borrow areas for dam construction will have on big game species is the loss of habitat: a total of 1,751 ha will be disturbed (excluding those borrow areas that will eventually be inundated) and thus lost as habitat. The specific plant community types and corresponding quantities affected can be found on Tables 3.56 and 3.57. The cover types that comprise most of the area to be disturbed are woodland spruce (black and white), mixed low shrub, birch shrub, and closed mixed forest. To some extent, the habitat loss will be temporary. With reclamation efforts, many of the borrow areas will be restored to a level that will permit some use by big game.

This loss of habitat will affect big game species to various degrees. Moose and black bears will incur the greatest impact. All of the land area encompassed by the proposed borrow sites is used by moose; the greatest use probably occurs in borrow areas D, E, F, and H (see Figures 3.11 and 3.12). Since most of the moose in the vicinity of the Watana dam site are relatively sedentary, the borrow areas there will probably result in the loss of such a large portion of the annual home range of these moose that they will be displaced. Displaced moose will incur high mortality and for a short time period could compete for food with moose in adjacent areas. The net impact will be fewer moose in the area of the borrow sites and, as a result of overcrowding, a possible long-term reduction in the carrying capacity of adjacent areas.

Black bears in the borrow areas will be impacted in several ways, all of which are similar to those described in Sections 3.6(a)(i) and 3.6(b)(i). With the exception of 70 ha of mat and cushion tundra in Borrow Area A, the area to be lost is all suitable black bear habitat. All of the forested portion is good habitat during winter (when bears den), spring, and summer. The shrub types (mixed low and birch) serve as early fall foraging areas for black bears when berries are available. The greatest loss of forest types will be in Borrow Areas A, E, H, I, and K. Fall habitat areas (shrub) that will be lost are found primarily in borrow areas D and F and, to a lesser extent, in Borrow Area A.

Most of the borrow sites will be located at elevations within the acceptable range of denning elevations for black bears in the area (457 m - 762 m). Due to relatively flat topography, Borrow Areas A and D are probably not good denning areas, and thus their loss will represent only a loss of foraging sites. Borrow Area F is probably too far north of the forested zone along the river to be used for denning by black bears. The greatest potential for the loss of denning sites as a result of borrow activities is in Borrow Areas E, H, I, and K. Borrow Area E, located along the lower reaches of Tsusena Creek, is probably good denning habitat; because of its proximity to the Watana construction area, however, it is likely that this area and any denning potential it offers, will be disturbed in many ways other than through borrow activities. Borrow Area I will be almost entirely within the Devil Canyon impoundment with the exception of 34 ha. This 34 ha, however is composed of closed mixed forest and open black spruce situated along the slopes adjacent to the Devil Canyon impoundment zone and is therefore probably good denning habitat. Borrow Areas H and K are also situated in suitable bear denning areas; both of these borrow areas are south of the Susitna River, however, and, since the data collected on black bears suggests that there is less black bear activity south of the river than north of the river, the loss of denning sites from Borrow Areas H and K many not be too extensive.

Brown bears, wolverines, and wolves will also be impacted by the borrow areas, but probably to a lesser degree than moose and black bears. The primary impact on these species will be a reduction in numbers of prey. This impact will primarily affect wolves, and to a lesser degree, brown bears and wolverines. Brown bears will also lose some spring foraging habitat. A more detailed discussion of these two types of impact was presented in Section 3.6(a)(i). In addition to habitat loss, wolves, wolverines, and brown bears will be impacted through disturbance by the human activity associated with the borrow activities. Blasting and the movement of large vehicles in these areas will most likely cause these species to totally avoid the areas while they are being used.

Caribou will also be impacted by the borrow areas but not to the degree described for other big game species. There is relatively little caribou use of the areas identified for borrow sites. Most of the use that does occur is attributable to summer use by bulls. It is unlikely that the cow/calf segment of the Nelchina herd will come close to the borrow areas during annual movements. As a result, the borrow areas will represent primarily a loss of summer bull habitat. Since bull caribou appear to be less sensitive than other portions of the herd to human activity and disturbance, they may continue to use adjacent areas. Considering the intensity and magnitude of disturbance that will be associated with the borrow areas, however, they will probably avoid the immediate vicinity of each borrow area (possibly by more than 2 kilometers). Borrow Areas A, D, and F are the areas most likely to result in this limited loss of caribou habitat.

Due to the location of the borrow areas, there should be no impact on Dall sheep. The closest known sheep usage is on Mt. Watana, which is approximately 10 to 16 km east of proposed Borrow Area A. The herd that used Mt. Watana (Watana-Grebe Mountain herd) was not noted in the vicinity of Mt. Watana during the 1980 survey. They were located in the southern extreme of the survey area, well away from the proposed Watana impoundment area.

Although the borrow areas may affect big game in other ways (such as through the creation of dust which could reduce the productivity of vegetation in adjacent downwind areas), the prime impacts will be habitat loss and disturbance by human activity. The habitat loss is likely to affect moose and black bears more than other big game species. Disturbance, on the other hand, will probably be more significant for wolves, brown bears, and wolverines.

(ii) Furbearers

Excavation of borrow sites would have negative effects upon furbearers using the area. Borrow Areas A,D,E,H, and K (Figure 9.7) would primarily impact pine marten, red fox, and short-tailed weasels. Because of the relatively large area of land involved, developing Borrow Areas E and F, along Tsusena Creek, would negatively affect red foxes, pine marten, mink, otters, and short-tailed weasels throughout a sizable portion of the drainage of that creek.

If left unvegetated following excavation, the borrow areas would have little long-term value to furbearers. The extent of vegetation restoration measures would determine the future suitability of restored habitats for various furbearer species. The creation of herbaceous and shrub vegetation may be attractive to small mammals and birds and could provide valuable foraging habitat for foxes, short-tailed weasels, least weasels, and coyotes, especially if vegetative heterogeneity is established. Because of the dependence of pine marten on conifer forests and, specifically, on red squirrel middens, it is highly unlikely that marten would use revegetated borrow areas in less than 100 years.

(iii) Birds and Non-game Mammals

Mining of borrow areas will cause two main types of impact: 1) habitat destruction and alteration and 2) direct disturbances resulting from human activities. The amount and types of habitat to be affected by possible borrow areas appear insignificant to the total bird and small mammal populations of the area, primarily because these habitats are widespread in the region. Some borrow areas will eventually be flooded, anyway, and the others will be recontoured and revegetated.

The specific effects of borrow mining will vary somewhat at each site, depending on the types of habitats destroyed and the types remaining after construction and reclamation activities. While birds and small mammals dependent on the destroyed or altered habitats will disappear, those species favoring the newly created habitats will increase their populations. Replacement shrub and forest habitats will be slow in forming because of the harsh environment.

Overall, the impact of borrow areas will be greater on forest habitats than on shrub habitats, partly because forest areas are considerably less abundant in the region. In addition, a high proportion of these already less extensive forest habitats will be inundated by the proposed reservoirs. Thus, the additional loss of forest habitats to borrow areas will have more impact on the avifauna than will the destruction of relatively prevalent shrub habitats.

The activity and noise surrounding the mining operations might disturb breeding raptors and ravens at nearby cliffs. Table 3.66 is a list of the nest sites within about 1.6 km of the proposed borrow areas and thus those potentially subject to disturbance. Any nest sites not in use by 1 June in any year may be considered inactive in that year (Roseaneau et al. 1981) and not subject to the impact of construction noises and the movement of equipment.

(d) Downstream Impacts

(i) Moose

Moose that use the Susitna River area downstream of Devil Canyon may be impacted by the project. The manner in which moose could be impacted relates to changes in the quantity of browse available for winter forage. As discussed in Section 3.2(a)(i), moose congregate along the Susitna River during severe winters and subsist on browse that is associated with the early successional vegetation in the riparian zone. As a result, the riparian zone of the Susitna River downstream of Devil Canyon is a critical factor in maintaining a healthy moose population over a very large area.

The browse species upon which moose rely are typically found growing abundantly on newly disturbed islands or sand bars: such islands are constantly being created and removed by the action of the river. The mechanism of creating new sites suitable for the invasion of browse species which serve the winter food needs of moose is complicated and includes a variety of factors such as flooding, ice scouring, and silt deposition. Since the creation of such sites is dependent to a large extent upon the flow regime of the river including the timing and duration of floods, the volume of ice moving in the river, and the silt load of the water, the flow regulation and changes in other aspects of the river that will result from the Susitna project may possibly alter these mechanisms. [Details of the plant succession process that is operative in this area are presented in Section 3.1(b), and information concerning the availability and utilization of browse along the lower river appears in Section 3.2(a)(i)].

The possible degree of alteration of the present flow regime varies substantially between that portion of the river upstream of Talkeetna and that portion downstream from Talkeetna. Since tributaries between Devil Canyon and Talkeetna contribute relatively little flow, the project will result in major changes in the hydrologic characteristics of this part of the river. The situation downstream from Talkeetna is considerably different. At Talkeetna, water is added to the Susitna from both the Chulitna and Talkeetna rivers. In addition, downstream from Talkeetna numerous tributaries and eventually the Yentna River continue to add water to the Susitna. In other words, at and below Talkeetna the changes in the hydrologic characteristics of the river as a result of the project will be considerably less. Since there is such a marked difference between these two reaches of the river, the discussion of impacts on moose is most appropriately presented in two sections.

- <u>Devil Canyon to Talkeetna</u>

  In this reach of the river, it is anticipated that the project will have very little negative impact on moose. The moose that use this area appear to be relatively sedentary, and, therefore, any impact will be confined to those moose that are resident in the area immediately adjacent to the river. In the absence of census data, it is impossible to present the number of moose that are associated with this area.

  A detailed description of the vegetation changes that may occur along this part of the Susitna River is presented in Section 3.5 (d). Between Devil Canyon and Talkeetna, the Susitna River is well channelized with comparatively few islands and sand bars. Therefore, the quantity of available browse is probably less than what can be found along the more braided reaches of the river south of Talkeetna.

  Since it is predicted that seasonal floods will be totally eliminated in this area some of the currently unvegetated areas along the river will begin to develop some early successional vegetation. Due to the very rocky substrate in the river bottom, however, it is unlikely that any significant increase in vegetative development will take place.

  In general, there will be a trend for the development of more mature vegetation on some of the islands. This process will occur because the project will result in less ice formation along this part of the river. Flowing ice is a very powerful force in the disturbance of streamside vegetation.

This trend towards more mature vegetation could be offset, however, by an increase in the frequency and duration of ice fog along the river. In the absence of ice cover during the winter, the difference in temperature between the water and the air will generate ice fog which will in turn accumulate on streamside vegetation. Although the ice fog is not expected to be very damaging, it will probably result in broken branches on tall shrubs and trees. An increase in young balsam poplar, willow, and alder would result. Two of these species, balsam poplar and willow, are important browse species, and, therefore, moose would probably benefit from this aspect of the project.

In summary, there should be little negative impact on moose residing along that portion of the Susitna River between Talkeetna and Devil Canyon. Although changes in the flow regime of the river will be greatest in this area, there should be little reduction in the amount of available moose browse along the river. An increase in the duration and frequency of ice fog may serve to increase the quantity of browse available along the river, thus either negating any minor loss or possibly even resulting in more available browse than currently exists.

- Talkeetna to Cook Inlet

That portion of the Susitna downstream from Talkeetna differs from the upstream portion (Talkeetna to Devil Canyon) in many respects, three of which are important for moose. First, as one proceeds downstream from Talkeetna, the river becomes progressively wider and more braided with a corresponding increase in the number of islands. These islands are less stable than those above Talkeetna; a considerable amount of land is washed away each year, and new bars and islands are created. Second, the extent of moose use is greater south of Talkeetna. The winter forage along the lower Susitna is utilized by moose from a large geographic range extending to the Talkeetna Mountains to the east and across the extensive flat marshy area lying to the west of the river. The third major difference is the fact that the changes brought about by the Susitna project will be considerably less south of than north of Talkeetna. This is because, as previously mentioned, water from several other major sources is added to the Susitna at and below Talkeetna and will reduce the project's effects there. Thus, any changes in available moose browse are not expected to be major.

If the Susitna project does cause some slowing of the rate at which islands are developed and removed, the moose population that uses the area will be subject to two successive changes. First, there will be a short-term increase in the amount of browse as a result of the increased stability of the substrate which will allow early succession vegetation to move down onto the sites that are presently eroded by high summer flows. This increase in early successional vegetation and associated moose browse is likely to prevail for 10 to 20 years. High rates of use would retard the rate of succession and prolong the situation. Ultimately, however plant succession will proceed to the point where plants no longer serve as suitable browse, and the ability of the area to support moose under severe winter conditions will be reduced. A general although unknown decrease in the moose population would therefore follow. The timing of such a reduction will probably be determined by the occurrence of harsh winter conditions.

A more indirect impact on the moose population in this area is related to the status of the beaver population. Beavers are a factor in determining the composition of vegetation in the areas they inhabit. Should the beaver population along the lower river be negatively impacted by the project there could be a corresponding negative impact on moose. It is possible, however, that increased winter flows may in fact allow for greater beaver abundance downstream of Talkeetna. Should this occur, the increase in beavers in the long run might assist in negating any negative impacts on the moose population. The impacts on beaver are discussed in Section 3.6(d)(iii).

In summary, the changes in hydrologic parameters brought about by the project downstream from Talkeetna may be sufficiently diluted to have little if any impact on moose. Should a change result, however, it is expected to be minor in magnitude and to result first in a short-term increase in the amount of browse available to moose and then in a long-term decrease in browse. Any impact on the beaver population could also have an impact on moose: a positive impact on beavers would have corresponding positive impact on moose; a negative impact on beavers would have negative consequences for moose.

(ii) Bears

Both black and brown bears have been reported to utilize the Susitna River downstream from Devil Canyon for fishing. The majority of the bears noted feeding on salmon in this reach of the river were black bears, and the feeding activity was concentrated during August and early September coinciding with salmon spawning. Since changes in the flow regime of the river are expected to drastically reduce salmon spawning in the side channels and sloughs of the river between Talkeetna and Devil Canyon, the opportunity for bears to feed on salmon in these areas will be correspondingly reduced, unless mitigative actions for the fish habitat are undertaken [see Section 3.9(d)]. The loss of this salmon resource will likely affect bears in two different areas.

The primary impact will be on bears that reside in relatively close proximity to the river. The food supply represented by salmon spawning in tributaries is not expected to be directly affected by project flows, so competition among bears for this resource will likely increase. The overall result will likely be a general reduction in the number of bears inhabiting the area, especially in the number of black bears, which are more likely to be permanent residents in the locally available forested habitats.

Bear populations in more distant regions will also be impacted. It appears that in addition to the resident bears which feed on salmon, some bears travel long distances to take advantage of this resource. During 1981, when a total failure of the berry crop in the upper basin was noted, two radio-collared black bears moved from the vicinity of the Devil Canyon impoundment downstream to Gold Creek. Based on the numerous bears noted along the river during 1981, it is thought that bears probably traveled to the river from many areas to take advantage of this alternative food source. Therefore, the loss of this food source would impact bear populations, both black and brown, over a very large area.

Salmon probably represent the most dependable source of pre-denning food. Therefore, during years when other pre-denning food items are not available, the lack of an abundant salmon resource could result in many bears entering dens later than normal and probably in less than optimal condition. Under such conditions, populations could decline as a result of starvation during the winter and higher cub losses due to lactation failure.

The overall impact of the loss of salmon habitat downstream from Devil Canyon will be a long-term reduction in the number of bears that inhabit the region, especially north, east, and west of that portion of the Susitna River between Talkeetna and Devil Canyon.

(iii) Aquatic Furbearers

Projected changes in the flow of the Susitna River downstream from the Devil Canyon dam could result in marked changes in aquatic furbearer habitat. The nature and the degree of change will vary for various portions of the river below Devil Canyon. The greatest change in flow regime will occur between Devil Canyon and Talkeetna. At present, this area is relatively poor habitat for beavers (Table 3.28), and, therefore, any negative impact on beavers will be relatively minor. Since the likelihood of a reduction in fish populations is greatest in this area, however, there could be a corresponding negative impact on river otters and mink. Changes in water turbidity are also likely in this portion of the river but should not affect either aquatic (beaver and muskrat) or semiaquatic (river otter and mink) furbearers since they are not known to select habitats on the basis of water turbidity.

The situation between Talkeetna and Cook Inlet is different in two respects from that in the stretch between Talkeetna and Devil Canyon. First, as one progresses farther downstream from Talkeetna, the suitability of the river for use by beavers increases (Table 3.28). On the other hand, the changes in flow regimes caused by the project become continually diluted and, thus, less likely to result in an impact on beavers. It is difficult to determine the extent or even the direction of any impact associated with these changes. If a change in subclimax, riparian vegetation results, it could mean a reduced food supply for beavers; however, since beavers are themselves a force in creating such subclimax vegetation, this situation may not negatively affect current beaver populations.

Reduced summer flows could also cause a decrease in the areas usable for beavers at that time of the year, either directly or by allowing for a long-term reduction in the number of available sloughs. The latter are highly useful areas for beavers. Increased winter flow, however, may provide greater opportunities for overwintering beavers. Since it is unknown whether summer or winter habitat components are prime factors in controlling the density of beavers in this area, it is difficult to predict exactly what changes will result. At the present time, however, some general speculations can be advanced. First, those portions of the river that contain the greatest numbers of beavers are also those areas that will be least affected by changes in flow regimes, that is, those areas farther downstream from the Devil Canyon dam. Second, any changes in riparian vegetation may be negated by the activity of beavers themselves. And third, increased winter flows may result in improved overwintering opportunities. In summary, that portion of the river that has the fewest beavers will be most affected, while that portion that has high numbers of beavers will experience the least impact.

(iv) Marine Mammals

Several hundred beluga whales concentrate in the upper Cook Inlet area to feed on anadromous fish. Whales have even been reported to enter the lower reaches of the Susitna River during times when salmon and other anadromous fish are present. Little is known concerning these whales and the extent to which they are dependent on any one of the many food sources available in the Cook Inlet region.

The potential for the Susitna Hydroelectric Project having an impact on beluga whales that inhabit Cook Inlet is dependent upon the net effect of the project on Cook Inlet salmon, and is tempered by the availability of alternative food sources. Based on the current predictions of the effect of the project on Cook Inlet salmon populations, and with the possible alternative food sources, it appears unlikely that the Susitna project will have any significant effect on the total food source available to these whales.

(v) Bald Eagles

The survey of nesting bald eagles conducted in 1981 resulted in an estimate of 15 to 20 active nests between Cook Inlet and Portage Creek. This estimate could be converted to an estimate of one nest per 15.8 km of river (based on 15 nests) or one nest per 11.9 km of river (based on 20 nests). The nesting eagle population along the Susitna River could be affected by the proposed project in two ways. First, the availability of suitable nesting trees could be altered. Along the lower river, eagles appear to prefer to erect nests in decadent balsam poplar trees. It is unlikely, because of the abundance of such nesting sites, that changes in river flow could appreciably reduce the number of such nesting sites. In fact, if reduced flows result in any changes in the plant succession trends, such changes would likely favor conditions that permit the development of older, more mature, and thus more suitable balsam poplars.

The second avenue of potential impact is related to changes in the food supply for eagles, in particular, salmon. The potential for a reduction in available salmon appears to be greatest between Talkeetna and Devil Canyon, and thus, any corresponding impact on eagles would most likely occur in this vicinity. Considering the density of nesting eagles along the river, however, and the likelihood of salmon's continuing to be generally abundant, especially south of Talkeetna, there should be little, if any, negative impact on the number of eagles nesting here. If any such impact on bald eagles occurs it would be in the area between Talkeetna and Devil Canyon, which had relatively few nests active during 1981. In fact, any stranding of fish as a result of lower water levels could temporarily increase the food supply for eagles in such locations.

(vi) Waterfowl

Based on the data collected during a survey of river use by migrating spring waterfowl (Table 3.42), it does not appear that the Susitna River is heavily used by these birds. The proposed action may possibly affect this limited use by reducing the area of calm water, such as sloughs, available to migrants. Although such a reduction is possible between Talkeetna and Devil Canyon, this area was found to be the least used portion of the river (Table 3.42) . The project is expected to result in open water year round below Devil Canyon, at least as far as Talkeetna. In the spring, early migrants may use this new source of open water.

In contrast to the mainstem Susitna River, waterfowl do make considerable use of the estuary portion of Cook Inlet near the mouth of the Susitna. The suitability of the tidal flats used by waterfowl in this area could be endangered by a reduction in water levels. Because of the extensive tidal influence, however, it is unlikely that a small change in the Susitna will sufficiently alter the coastal marshes of Cook Inlet as to make them unattractive to migrating and nesting waterfowl.

(e) Access Route

(i) Big Game

The proposed access road will impact big game in two ways: through loss of habitat and by enabling greater access by people into the area. The first source of impact, habitat loss, will be relatively minor in comparison to the increase in access that will take place. A total of 614 ha will be lost to the access road right-of-way [assuming a right-of-way 61 m (200 ft) wide] with an additional 267 ha lost for access road borrow areas and 22 ha lost for a railroad yard. All access road components combined total 903 ha. Closed mixed forest (313 ha) and birch shrub (140 ha) are the most common community types that will be impacted. The other community types involved with the access road are each represented by less than 75 ha. This loss of habitat will affect big game species in the same fashion as previously discussed [see Sections 3.6(a)(i), 3.6(b)(i), and 3.6(c)(i)].

The improved access that will be available as a result of the construction of a road from Gold Creek to Watana will have a definite impact on the big game resource. At the present time, there is very little human activity in the upper Susitna basin. With the exception of a few cabins and the seasonal presence of hunters, the big game animals in the upper basin are basically free of disturbance by humans. The construction and operation of the Susitna project will change this situation dramatically. Some species will tolerate additional human presence, while others will either totally avoid areas of human activity or temporarily come in conflict with humans. Improved access will also increase and change the distribution of hunting pressure in the upper basin, exposing to hunting some subpopulations which have been previously unaffected by that activity. Although regulated hunting is not considered to be generically detrimental to game species, there will be resulting change in the abundance, distribution, and sex and age composition of certain species and subpopulations.

The greatest changes will most likely occur along that portion of the access road between Devil Canyon and Watana. Presently, this area is one of the more remote portions of the upper Susitna basin. Between Devil Canyon and Gold Creek, some level of ground access already exists and the addition of a major construction road in that area will not result in as major a change as will the Devil Canyon to Watana segment. Although the access road will unquestionably have a negative impact on the big game resource, the magnitude and distribution of that impact will depend to a large extent on the manner, if any, in which access and hunting are regulated by appropriate state agencies following construction.

If unregulated access is permitted, the zone of impact essentially will be defined by the ability of people to travel distances off the road with ATVs. If, on the other hand, ATV use is prohibited or regulated, the zone of impact will be greatly reduced and probably limited to within a few kilometers of the road. The types of impacts that could result are many and vary among the species concerned. If hunting is permitted from the road, all big game species will gradually adjust to this situation and either avoid the road or become far more secretive in its vicinity. If hunting is not permitted from the road, it is likely that moose, bull caribou, and black bears will not react negatively to the presence of either the road or human activities along it. Wolves, wolverines, and brown bears are big game species that will most likely avoid the road, especially during the construction period when numerous large vehicles will be present.

Impact of the road on the Nelchina caribou herd will probably be minimal; any effects will be greatest during the construction phase. That portion of the road west of Devil Canyon dam traverses an area of low-quality caribou habitat that is seldom visited by caribou. The construction of this section will have negligible impacts on caribou. The proposed route between Devil Canyon and Watana, on the other hand, traverses an area of shrub land and tundra that consists of fairly good summer range. At present this area is marginally occupied by caribou; these are predominantly scattered groups of bulls. No major pathways of migration are located west of Deadman Creek. The road will not provide easy access to presently critical and remote caribou habitat such as the calving area. Caribou mortality resulting from collisions with vehicles will probably be minimal. It is expected that caribou generally will avoid the vicinity of the road, although bulls are known to be more tolerant of traffic than cows and calves (Cameron and Whitton 1978). It is possible that the road may influence the success of predator attacks on caribou, but since caribou use of the area traversed by the road is low, the significance of this possibility is not great.

Brown bears could be impacted as a reault of a change in the hunting pressure, a disruption of current movement patterns, or both. If hunting is permitted from the road, there will be an increase in the harvest of brown bears in this region. Available data suggest that this increased hunting effort is unlikely to significantly impact brown bear populations, although a combination of improved access and the liberalization of seasons and bag limits could result in local overharvests of brown bear subpopulations. Most likely any such overharvest would result in a reduction in bear density and a lowering of age structure rather than in an elimination of subpopulations.

The access road, in particular that portion between Devil Canyon and Watana, could also function as a deterrent to brown bears moving to Prairie Creek in late summer to feed on salmon. This type of impact and its ramifications have been discussed in Sections 3.6(a)(i) and 3.6(b)(i). The possibility of this happening is greatest during the construction period when large volumes of heavy vehicles will be using the road. The possibility would also be high following construction if the Devil Canyon impoundment acts as a further deterrent, but especially if hunting is permitted from the road. If bears are allowed to encounter the road without being harassed, there is a greater chance that they will find crossing the road acceptable. The major problem is thus during the construction period. Since it is likely that the movement to Prairie Creek is a learned behavior passed on from adult females to cubs and yearlings, the disruption of this behavior for 5 to 10 years could lead to the extinction of this behavior. This would result in a lower capacity for the area, in total, to support the brown bear numbers that presently exist, although it is possible that at some time in the future, following construction, bears would again locate the Prairie Creek salmon resource and reestablish this behavior pattern.

Due to their wilderness characteristics and intolerance of human presence, the access road will probably result in wolverines abandoning the area, especially during the construction period. Following construction, they may again inhabit areas nearby, but they will probably never regain complete use of the area traversed by the road.

There will be little, if any, impact of the road on Dall sheep. The only possibility of any influence would be on the Portage-Tsusena Creek herd if hunting from the road were permitted and sheep hunters using ATVs would be able to gain access to the southern portion of the area presently utilized by these sheep. But again, regulated hunting is not considered a negative source of impact any may simply allow for the utilization of a resource that has up to this point been unavailable.

(ii) Furbearers

If care is taken to avoid wetland areas, the physical disturbance and habitat loss from road construction will be relatively minor because of the small amount of land involved. The segment of the proposed access route between Parks Highway and Gold Creek poses the greatest potential for impact on aquatic furbearers. The long-term negative effects of borrow site development for fill for roads will depend upon the extent of restoration measures. Borrow sites or extended sections of roadways in or adjacent to wetland areas or stands of white spruce or near fox dens could be harmful.

The most serious impact from road construction will arise from improved human access. The effects of public use of roads will consist primarily of increased harvest and human disturbance of furbearers in the study area. Roads will provide convenient access to areas which are now and have historically been remote. The severity of this impact will depend upon regulatory measures imposed.

Red foxes and, to a lesser degree, marten will be most affected by road use. The greatest impact to foxes as a result of increased human activity will occur along the northern portion of the access road between Devil Canyon and Watana. Foxes presently use this area for denning. The impact on marten will not be great along this stretch of the road, but marten populations between Gold Creek and Devil Canyon will probably be reduced by additional trapping pressure that could be associated with the access road.

Vehicle-wildlife collisions will be another source of impact to furbearers. The severity of this impact is difficult to predict because of the paucity of relevant published information. Indications are, however, that losses of furbearers as a result of collisions with vehicles will be relatively low.

(iii) Birds and Non-game Mammals

Construction, maintenance, and use of the access route would have three main types of impacts: 1) destruction of habitat for the roadbed itself and alteration of habitat adjacent to the road and in borrow areas, 2) disturbances, such as noise and moving equipment, along the road, and 3) increased access to the region, and, therefore increased use by humans. The effect of this last impact on birds and small mammals is undetermined at this time, but would be greatest on the larger birds, including waterfowl and raptors.

Birds and small mammals dependent on the habitats destroyed or altered by construction would disappear from the immediate area of the road and borrow areas. On the other hand, after construction, populations of species that favor the newly created habitats will increase. Retarded plant successional development, such as that found adjacent to roads and railroads, will provide habitat for several species of shrubland sparrows and for small mammals generally restricted to open plant communities dominated by herbaceous species--Arctic ground squirrel, tundra vole, and meadow vole. Although borrow areas will be revegetated, recovery of shrub and forest habitats at borrow areas will be slow because of the harsh environment at the elevations of much of the access route.

Recovery rates of forested areas may be faster along Indian River because these areas are at lower elevations and are somewhat more protected than other forested sites. Known raptor and raven nest sites within 1.6 km (1 mile) of the access route or access route borrow areas are as follows:

- Bald eagle nest in balsam poplar near the junction of the Indian and Susitna rivers is only 500 m from the access road and 100 m from Borrow Area 1.

- Gyrfalcon nest (1974) and goshawk nest (1981) in a canyon just east of Devil Canyon dam site are about 1.6 km from the road.

- Two raven nest sites are within 0.5 km of the access road along Tsusena Creek.

Wetlands likely to be adversely affected by the access route are primarily those along Indian River and in the Chulitna Pass area. The degree to which these wetlands will be impacted will depend upon the exact alignment of the road. These wetlands have been viewed only cursorily from the air, so specific effects or levels thereof cannot be predicted. One lake, a productive alpine lake east of upper Devil Creek, appears close enough to be seriously influenced by the segment of the access route between the two dam sites. The route, however, could be "fine-tuned" to avoid serious impact to this waterbody.

(f) Transmission Line

(i) Big Game

- Central Study Area (Dams to Intertie)

In the central study area, the construction and operation of the transmission facility will impact big game species through disturbance and habitat alteration. Little habitat will actually be lost due to the transmission line; in most cases a change in habitat will occur rather than an actual loss. The right-of-way will encompass approximately 927 ha (see Table 3.59). The five most common vegetation types within this 927 ha area are closed mixed forest (347 ha), birch shrub (109 ha), open mixed forest (95 ha), mixed low shrub (82 ha), and woodland white spruce (82 ha). Because of the relatively low height of the dominant plant species, there should be little disturbance of the two shrub types. The three forested communities plus other less abundant forested communities, however, will require the removal of tall vegetation. This will result in a change from forested types to vegetation types dominated by low shrubs or young trees.

Moose and black bears are the two big game species most likely to be impacted by this type of habitat alteration. The impact on black bears will probably be insignificant and may actually be beneficial since it will result in an increased diversity of vegetation types within the affected area. In spite of disturbance during construction and maintenance operations, moose will probably be benefited by the clearing of forested areas. This will allow for the development of early successional community types which will provide an increase in the quantity of browse. Thus, it can be predicted that the carrying capacity of the area traversed by much of the transmission corridor will be increased for moose.

The disturbance of big game species as a result of the transmission line will be greatest during the construction period. The proximity of the transmission line to the access road will greatly reduce the significance of any disturbing activities, however, since disturbance from the access road will be far greater. As discussed in previous sections, the magnitude of this type of impact will vary among the big game species: moose and black bears are the most tolerant of disturbance; wolves, wolverines, and brown bears are the least tolerant. Caribou may also suffer some from construction activities, but, since there is presently very little caribou use of the area, it is anticipated that only a few summering bulls will be bothered by construction activities.

The same relationship of the transmission line with the access road applies to the possibly blocking of movement patterns. Although the transmission line construction activities do have the potential to interfere with the movement of some species (brown bears in particular), the access road is more likely to result in this impact prior to the construction of the transmission line. During operation, however, noise from the conductors (especially in bad weather) may repel animals even at times when there is little traffic on the road. The issue of possible improvement in human access that could result from a transmission line is moot, since the access road represents a far greater potential for this type of impact.

The likelihood of some level of synergistic effect occurring as a result of the proximity of the transmission line to the access road should not be ignored. This effect may be especially significant during the operation phase. Although the major disturbance from the construction phase of the access road will no longer be operative, it is possible that animals will find it more difficult to cross two corridors that will be in close proximity than it would be to cross two more widely separated, especially at times when both traffic is frequent and the conductors are particularly noisy.

In summary, the transmission line in the central study area will have little negative impact on big game species over most of its length. In forested areas, there will probably be an improvement in moose habitat. Disturbance and access impacts associated with the transmission line in most areas will be overshadowed by similar and more severe impacts emanating from the adjacent access road. During operation, however, more sensitive big game species, such as brown bears, could be disturbed to a greater extent due to the close proximity of the transmission line to the access road.

- <u>Northern Study area (Healy to Fairbanks)</u>

The primary type of impact that can be expected to occur in the northern study area is habitat alteration. The transmission line right-of-way in this area will utilize approximately 1,923 ha (see Table 3.59). The four most common vegetation types in the proposed right-of-way are open spruce (685 ha), mixed low shrub (294 ha), open mixed forest (251 ha), and open deciduous forest (150 ha). A variety of other community types are represented by lesser amounts, in all cases less than 100 ha each. The greatest change will be in the forested areas, which represent three of the four most common types.

The clearing of forested communities is expected to be of benefit to moose, since it will result in the creation of early successional vegetation stages which typically provide much more browse than the mature types that presently exist. In all cases, community types that will be so affected are very widespread and abundant in the area, so the change of these community types will not represent a significant negative impact on any big game species. In addition to moose, it is likely that black bears will also benefit from the increased plant community diversity that will occur. Predatory species, such as wolf, where they occur, will benefit indirectly from the increase in moose.

As described for the central study area, most of the disturbance will occur during the construction period and will be minimal following construction. Improved access will result from the establishment of a transmission corridor. The magnitude of the impacts of the increase in both disturbance and access will vary along portions of the proposed line and will be least detrimental in areas where the line will be in close proximity to already existing road or transmission corridors and greatest in areas where the line deviates from existing corridors. The two species most likely to be associated with the line (moose and black bears) are, however, relatively insensitive to disturbance resulting from human activity and should not be severely impacted.

- Southern Study Area (Willow to Cook Inlet)

A total of 866 ha will be affected by that portion of the proposed transmission line between Willow and Cook Inlet (see Table 3.59). The four most common vegetation types traversed by this segment of the line are closed mixed forest (307 ha), closed birch forest (115 ha), open mixed forest (112 ha), and wet sedge grass (101 ha). Other community types, the majority of which are forest types, are also present in lesser amounts. Based on these figures, it is obvious that the greatest impact on big game will result from habitat alteration. As explained previously, this will entail a change from forested communities to shrub-dominated communities. The two big game species that will be primarily associated with this segment of the transmission line are moose and black bear. These species, and moose in particular, should benefit from the habitat alteration that will result.

The disturbance and improved access that will result from this line will represent a potential for negative impacts on these species. Significant disturbance will be, however, of a temporary nature and confined primarily to the construction phase, although maintenance of the facilities and right-of-way will also cause occasional disturbance. In the case of both disturbance and improved access, the net impact will be relatively minor; the area between Willow and Cook Inlet is already heavily subject to human activity, and it is likely that these two species have already adjusted to existing in close proximity to humans.

(ii) Furbearers

The construction and operation of the transmission line will likely affect furbearer species in two ways. First, the creation of a cleared corridor will probably result in some level of additional access for trappers. Increased trapping attributable solely to the transmission line is most likely to occur along portions of the northern and southern study area, where access into certain areas will be improved by the right-of-way. Although some additional trapping pressure will result, it is unlikely that there will be long-term detrimental impact on furbearers. Within the central study area, on the other hand, the proximity of the access road will represent a far greater avenue of human access than the transmission line.

The second manner in which the transmission line will affect furbearers is in those portions where forested vegetation will be cleared. The clearing of vegetation and the operation and maintenance procedures will result in the creation of early successional plant communities, which will most likely be of value as habitat for a variety of small mammals, nesting birds, and snowshoe hares. These prey species will then be utilized by predators such as foxes, marten, short-tailed weasels, and coyotes. In those areas where vegetation clearing will not be required, especially between Devil Canyon and Watana dams, there should be negligible impact on furbearers.

(iii) Birds and Non-game Mammals

In the central and southern study areas, the major impact on avian and small mammal species resulting from the construction and operation of the transmission line will be the alteration of habitat. In areas where vegetation clearing will not be required, the impacts on these species will be negligible. Where clearing is necessitated, there will be some impact, but it will be in the form of a change in species composition and not necessarily a reduction in the number of birds and small mammals using the corridor. This change will entail a reduction in those species that inhabit forested communities and an increase in those species that require plant communities in an earlier stage of succession, such as shrub or grassland type communities.

In the northern study area, the same changes can be expected where clearing is required. In addition, there are several other issues of concern regarding birds along the proposed route. Of prime interest is the proximity of a peregrine falcon nesting site located along the Tanana River east of the proposed transmission route. The nest was inactive during 1981 but was used prior to this time. Whether or not it will be used again is unknown. If the nest is active during the construction of the line, the birds may abandon it as a result of the disturbance. If the nest remains inactive during the line construction, however, it will most likely be acceptable for later use during the operational phase of the line. If necessary, the transmission line in this area could be constructed during a time period that would reduce the liklihood of disturbing nesting peregrines. Furthermore, a Section 7 consultation, as required by the Endangered Species Act, will be conducted with the U.S. Fish and Wildlife Service to help insure that the peregrine nest is not impacted.

Another concern along the northern study area is the proximity of several trumpeter swan nesting areas. North of the Tanana River, the center line of the transmission route passes within 0.4 km of a swan nesting area. South of the Tanana, the center line is approximately 1.6 km from two other nesting areas. All other identified swan nesting sites are farther than 1.6 km from the center line. As in the case of the peregrine falcon, construction activities, especially blasting, might result in the temporary abandonment of that nest located 0.4 km from the line. No long-term impacts on swans are anticipated, however. The only other manner in which swans might be affected by the line is through collisions with wires, an event most likely to occur under poor visibility conditions.

3.7 - Anticipated Impacts on Fish Resources

(a) Watana Dam and Impoundment

The impacts associated with the development of the impoundments of the Susitna Hydroelectric Project are divided into construction impacts, including those connected with filling time, and operation impacts. Table 3.67 identifies potential impact issues associated with the various project stages of hydroelectric facilities.

(i) Construction

Construction impacts can be subdivided into impacts resulting from construction of the cofferdams and those arising from construction of the main dam. The impacts associated with cofferdam construction are relatively brief, however, and the major dam's construction will begin soon after the cofferdams are complete. The effects of the major dam will essentially be a continuation of those created by the cofferdam, so both types will be treated as one for this section of the report.

An obvious impact that has occurred on other hydroelectric projects and will also occur on this project concerns changes in water quality. These changes can be expected when a lentic environment replaces a lotic system. Physical changes, such as temperature and turbidity, as well as chemical changes associated with such factors as leaching of nutrients and minerals from the reservoir area soils will impact the aquatic organisms that currently inhabit the reservoir area. Inundation of the mainstem and tributaries will eliminate present habitat in those areas.

The construction of the Watana dam and the subsequent development of the impoundment will affect the mainstem resident fish species by eliminating approximately 85 km of mainstem riverine habitat. The mainstem has populations of burbot and round whitefish, which are often associated with the mouths of clear water tributaries. In addition, sculpins, longnose sucker, Dolly Varden and Arctic grayling have been found in this section of the drainage. The grayling, however, has been primarily associated with the clear water tributaries.

Inundation of the mainstem, although it will cause a loss of riverine habitat, is not expected to affect adversely the fish populations that are present. It is expected that the reservoir will provide the habitat necessary for the existing populations of burbot, longnose sucker, and whitefish to sustain themselves and possibly even to increase. In addition, studies show that 85-95% of the incoming sediment will be trapped and will settle out in the Watana reservoir. Thus clear or almost clear water may be present in the upper Watana reservoir waters during the winter. As a result, additional or improved overwintering sites may be available.

Moreover, overwintering areas that are associated with the clear water flows of the area's tributaries will probably also increase. While the drawdown during the winter months reduces this area, the remainder is still many times the pre-project stream area. The flooded tributary areas will be much deeper and should continue to have clear water entering them from the tributaries. These areas could provide additional overwintering areas for such tributary fish as grayling. It is not known, however, whether overwintering habitat availability is a population-limiting factor in this region. These areas may possibly become productive habitat for other life stages of the fish populations.

Many tributaries enter the mainstem Susitna in the area that will be affected by both construction of the dam and inundation by impounded waters. The impacts associated with construction of both the cofferdam and the Watana dam will be concentrated in the tributaries closest to the actual dam site, namely, Tsusena and Deadman creeks. These both contain grayling. Deadman Creek will also be affected by inundation, but Tsusena Creek is downstream of the Watana dam and, thus, will not be flooded by the Watana impoundment. It will, however, be affected by other project facilities [Section 3.7 (c)]. It is expected that Tsusena and Deadman creeks will be further affected during construction, primarily by additional sport fishing pressure exerted by construction personnel.

During dam construction, Tsusena Creek will be additionally affected by the planned removal of gravel. This process will affect the stream habitat of Tsusena Creek (see Section 3.7 (c), Borrow Areas). In addition, a water supply dam to be constructed on Tsusena Creek will eliminate migratory movement of resident species through this area. The impoundment behind the water supply dam may, however, provide additional over- wintering habitat.

Deadman Creek lies approximately 1.6 km upstream from the proposed Watana dam. A large waterfall, which is presently a barrier to fish migration, is located about 1.6 km upstream from the creek's mouth. Approximately 3.7 stream kilometers would be inundated by the proposed impoundment, which would also inundate the waterfall and allow fish migration between Deadman Lake, about 10 km upstream, and the Susitna River.

In addition to Tsusena and Deadman creeks, which are in the immediate vicinity of the proposed Watana dam, other Susitna tributaries will be affected by the creation of the Watana impoundment. These include Watana, Kosina, Jay, and Goose creeks, and the Oshetna River, all of which are upstream of the dam site. At Watana Creek, about 14 stream kilometers will be inundated by the proposed impoundment; at Kosina, approximately 6.4 stream kilometers; at Jay Creek, about 5.0; at Goose, approximately 2.4; and at the Oshetna River, about 3.2 stream kilometers.

A primary concern in regard to fisheries is the impact of the Watana impoundment upon the Arctic grayling populations in the region. ADF&G (1981) has estimated that 10,000 ± grayling inhabit the areas of the streams and mainstem that will be inundated, and most of the impact will be felt in those streams in the vicinity of the Watana impoundment. Grayling in all the streams mentioned are not presently subject to heavy sport fishing pressure. Thus, although a moderate amount of increased sport fishing pressure may occur on the streams distant from the dam site, it is not expected to be a significant consequence.

Grayling populations in the tributaries are probably near their maximum, with some natural limiting factor controlling any increases. The limiting factors could be the number of spawning sites or overwintering areas, the amount of available food, or a combination of several factors. If overwintering areas are the limiting factor, then grayling could be moving downstream during the winter to find suitable sites. If they move through Devil Canyon, they would not be able to ascend the canyon in the spring. It is evident, however, that a large portion of the suitable stream habitat currently used by the grayling in the clearwater tributary areas within the Watana impoundment zone will be lost to the inundating waters. There is also a possible loss of some spawning areas associated with the mainstem that are fed by clear water. Overwintering habitat presently available in the Susitna mainstem will be lost, but replaced by impoundment lake waters. Clearwater rearing habitat that support this population in the tributaries will be lost by inundation. Sally Lake (Figure 3.35), an 18-hectare clearwater lake with a population of both grayling and lake trout, would be eliminated.

(ii) Operation and Maintenance

Operation of the Watana power development will necessitate an annual fluctuation in the reservoir surface water elevation. At full capacity, the reservoir maximum surface elevation will be 666 m (2185 ft. m.s.l.). During an average year, the reservoir will be drawn down 27 m (90 feet). During a succession of dry years, however, the reservoir may be drawn down 43 m (140 feet) from the maximum surface elevation. Drawdowns of this magnitude will eliminate shallow shoreline environments which are necessary for the reproduction, shelter, and food requirements of many fish species.

The annual fluctuation, a characteristic of all hydroelectric power developments except run-of-river, will create a broad, barren shoreline that, at the end of the winter season, will be exposed. During the summer, water being stored in the Watana impoundment will cover this shoreline. During filling and in the early years of operation, mud slides will occur as the soils in the reservoir become saturated and the water levels fluctuate.

During winter months, as the reservoir waters are drawn down to provide power, ice shelving is also expected. Ice formation in the impoundment will be different from the formation of ice that currently takes place in the same reach of the Susitna River. A fairly uniform thickness of approximately 80 cm can be expected throughout the reservoir. The timing of ice formation, however, is expected to be consistent with present patterns. The reservoir ice is expected to begin forming along the shore about the middle of October, the same time as it presently begins.

Ice jamming may occur in Watana Creek and in the Susitna River near the Oshetna River and Goose Creek. Another ice-related impact has to do with ice jamming. Winding channels with steep banks and the possible supply of large quantities of ice from upstream are indicators for jamming. Ice will only affect the fish populations, though, if it limits access either to tributaries in the spring for spawning or access to the reservoir for overwintering. Such restriction is not expected to happen, however. Any ice formations that block the stream will be quickly eroded by the high flows from the tributaries in the spring.

The Watana reservoir with a storage volume of 9,625,000 acre-feet has a ratio of capacity to inflow of approximately 1.82. Preliminary estimates indicate that from 85-95% of incoming sediment will be trapped in the reservoir, with particles smaller than two microns possibly passing through. The sediment-laden streamflow from the Susitna mainstem will initially spread through the reservoir as either surface flow, interflow, or underflow, depending on the relative densities of the reservoir waters and the Susitna waters. Increased winter turbidity levels are expected to be the impact associated with the reservoir sedimentation process. The fish that currently inhabit the mainstem are presently subjected to glacial stream conditions much more severe than they will be during the operation of the project. Reservoir turbidity should not be a negative impact on longnose suckers, round whitefish, or burbot -- the species most likely to inhabit the reservoir.

Temperature conditions in the Watana reservoir will be different from those that now occur in the mainstem and tributaries, although the reservoir will not actually stratify. A gradual temperature decrease with depth will occur in summer until water temperature is 4°C. In winter the temperature will increase with depth from 0°C to 4°C, with the top 5+ meters predicted to be colder than 4°C. This temperature structure is not expected to cause an adverse impact on reservoir fish.

(b) Devil Canyon Dam and Impoundment

(i) Construction

Construction impacts for the Devil Canyon development are expected to be similar to the Watana impacts. Construction of the cofferdam is expected to increase temporarily the downstream load of suspended solids. The two micron and smaller fraction of the sediments may remain in suspension and pass through the Watana reservoir to Devil Canyon. If this happens, construction of the cofferdam during low water periods of the year, when water is normally clear, will result in slightly more turbid conditions downstream. Turbidity from construction during high water flows would be far less noticeable. In addition, during the period when the Watana development comes on line and the Devil Canyon project begins, increased flows for power generation will be discharged downstream. The increased flow of water will have the effect of diluting any additional sediments caused by cofferdam construction. No other direct impact of actual construction of the Devil Canyon dam is expected.

An indirect impact of construction that can be expected, however, is increased fishing pressure on the sport fish in the tributaries near the construction site. With the possible exception of salmon fishing on Portage Creek, these tributary areas are not currently subject to high fishing pressure. In fact, the grayling populations in the impoundment tributaries are probably at their maximum density levels. Increased fishing pressure will alter these population levels as well as fish populations in Portage Creek and Indian River.

Impoundment of the Susitna waters will provide the major impact in the Devil Canyon development. Inundation of the mainstem and tributaries will alter the present habitat of resident fish in this reach. These streams will be flooded to the 443.5 m (1455 ft) msl elevation.

The tributaries in the Devil Canyon impoundment area, however, are characterized as having steep slopes with occasional barriers, such as waterfalls. Cheechako, Devil and Tsusena creeks, three creeks entering the Devil Canyon impoundment, all contain waterfalls. These falls will not be inundated by the creation of the impoundment and will still function as effective barriers to fish passage.

Because of the glacial input, the mainstem is very turbid during the summer months and is not, therefore, considered to be prime fishery habitat. Resident species have, however, been collected in the mainstem. Longnose suckers, round whitefish, and burbot are the major contributors to the mainstem fishery. Impoundment of waters is not expected to adversely affect these fish populations.

On the other hand, grayling populations, which inhabit portions of the tributaries, will be affected by the habitat change. Loss of spawning areas near the stream mouths could be a negative impact. In addition, the impoundment will surely increase overwintering area. In conjunction with the loss of the riverine environment will be the creation of a lake environment. The change from a lotic to lentic environment will probably be accompanied by a shift in species composition. For example, burbot, longnose suckers, and possibly whitefish would be present as opposed to grayling.

Finally, in addition to the other tributaries mentioned above, Fog Creek, located at river kilometer 278 on the south side of the Susitna River, and approximately 37 km upstream from the proposed Devil Canyon dam, would be inundated by the proposed impoundment to a point approximately 1 km upstream of its mouth.

(ii) Operation and Maintenance

The Devil Canyon development will be operated in conjunction with the Watana dam, located just upstream of the Devil Canyon impoundment. Annual drawdown at Devil Canyon will be about 17 m (55 ft). As in the Watana impoundment, drawdowns of such magnitude will eliminate shallow shoreline environments in the reservoir, which are necessary for the reproduction, shelter, and food requirements of many fish species.

The Devil Canyon impoundment will have a capacity to inflow ratio of .16, making it much more reactive to upstream influences than the Watana project will be. The outflow from the Watana project, however, will provide water with chemical characteristics different from those currently prevailing in the Susitna River.. In addition, leaching of minerals and nutrients from the reservoir soils will further change the chemistry of the water. Until the banks stabilize, mud slides from the steep slopes into the reservoir will increase the rate of input of minerals from the soils. The extent of this impact on both the Devil Canyon and Watana development cannot be fully assessed, however, on the basis of current information; at present, little is known about the zone of mineralization or about the soil nutrients. A decrease in the suspended sediment load entering the Devil Canyon reservoir, which results from the Watana operation, should permit an increase in light penetration and a corresponding increase in primary productivity.

(c) Borrow Areas

Impacts associated with the construction phase of the project in regard to borrow and quarry areas would result from direct excavation of stream bed material and sedimentation problems caused by runoff or meltoff entering nearby aquatic habitats. Heavy metals which could degrade the existing water quality of these aquatic habitats, could also be an impact associated with runoff and meltoff from excavated areas. It should be noted that borrow or quarry areas not located near any streams or lakes would not have any impact on fish resources.

The most significant and long-term impacts could result from Areas E and F (Figure 9.7). Area E is situated near the mouth of Tsusena Creek, an area which would be inundated; area F would be along sections of the creek that would not be inundated by the impoundment. Persistent siltation problems could occur and affect the remaining resident fish populations, especially grayling. A similar situation could exist at Area H in regard to Fog Creek and Area D with respect to Deadman Creek.

Those areas which would eventually be inundated by the impoundments could cause a temporary impact which could be either fairly significant or rather minimal, depending upon the size and/or location of the borrow area in question.

For example, Area L would be inundated by the Watana impoundment, and any impact directly associated with this area would be temporary and insignificant in comparison to inundation of the region. The same also can be said of Area J, although the Susitna stream bed excavation would certainly hasten the destruction of resident fish habitat in the Susitna mainstem.

Most of Area I, located in the mainstem Susitna River, will be inundated by the Devil Canyon impoundment. Its impact upon the fish habitat in this section of the Susitna would, therefore, normally be termed insignificant. The extent of this area, however, and the fact that siltation could occur well downstream and possibly affect resident and perhaps anadromous species' reproductive habitat in the Susitna River make the potential impact from Area I of some significance. As this situation points out, areas that will only be partially inundated by the Devil Canyon reservoir could be a persistent source of siltation as water levels in the impoundment rise and fall. On the other hand, while this increase in siltation could reduce primary productivity in the reservoir, it would probably not create any significant impact on the fishery.

Excavation at Area G could have a similar impact if siltation is permitted downstream of the Devil Canyon dam site. Even though this area is closer to portions of the river utilized by salmon, the much smaller size of Area G in comparison to Area I could limit its impact. Area G would not be of any impact following inundation.

(d) Downstream Impacts

(i) Construction

- River Mouth to Talkeetna

Construction-related impacts on downstream resident fisheries are related to changes in discharge, water quality, water temperature, ice formation, and geomorphological changes in the river. These changes are caused by the re-routing of the Susitna flow through diversion structures during the construction of the dams, disturbances of the river or its tributaries during construction, and reduction in flows during the filling of the reservoirs.

During the immediate construction period, water will be diverted around the dam construction site by means of a bypass tunnel. This structure should pass the run-of-river discharge until the dams are to be filled. Discharge changes from the pre-project conditions during this initial diversion period will probably be minor and not significantly affect downstream fisheries.

During the filling period, a net loss of downstream water to the fisheries will occur over several years. The monthly mean and annual frequency duration curves for the Sunshine Station project decreases in the monthly discharges for June, July, and August. Increases in discharge occur in October through May. There is no significant change in discharge during the month of September.

An analysis of the natural variability of flows has been prepared for data collected at gaging stations located at Gold Creek and Susitna Station on the Susitna River and from the Chulitna and Talkeetna rivers. A comparison of the pre- and post-project discharges at the Sunshine Station indicate the post-project monthly average discharge would be approximately 69% of the pre-project discharge during June, 77% during July, 85% during August, and 94% during September. The flow variability data were not available for the Sunshine site, but patterns were very similar for the four sites evaluated, with Talkeetna the most variable and Susitna Station the least. Gold Creek and the Chulitna Station data were similar and intermediate between the other two sites.

For purposes of comparison of natural variability with the post-project changes, the Gold Creek data were used as representative of the lower river conditions. The data analysis indicated that post-project average monthly flows resemble the annual average low flows that occur over one day during June and July and are slightly below the three-day occurrence. The post-project August flows are similar to those that normally occur over a 14-day period, while the September flows are not significantly different from the natural flow. October post-project flows are higher than those which occur normally but are within the natural variability that occurs over a 14-day period at Sunshine Station. Winter flows during this filling period should not deviate from the natural conditions.

Post-project water quality changes have been presented only for sediment with regard to the trap efficiency of the reservoirs. Trap efficiency was estimated to be between 85% and 97%, with particle sizes of less than two microns remaining in suspension. A general statement that the turbidity of the river water below Devil Canyon will decrease during the summer and increase in the winter appears to be appropriate. The winter increase in turbidity may even be noticeable below Talkeetna. Turbidity values in the winter are currently less than 5 NTU's.

Examination of other water quality parameters measured throughout the year does not indicate any abnormally high concentrations that may be limiting to aquatic life. Increases in nutrient concentrations should result from the flooding of vegetation within the impoundments. Phosphorous concentrations are often associated with increases in productivity. Increases in nutrients in glacial systems that are light-limiting, however, do not necessarily cause increases in production. Downstream nutrient increases are a likely consequence of the construction of the project, although predictions of these concentrations have not been made.

Below the confluence of the Susitna and Chulitna rivers, summer changes in water quality should not be perceptible because of the influence of the Chulitna on the mainstem river and the natural variability of water quality within the system.

Temperature changes have only been projected for the portion of the Susitna above Talkeetna. During dam construction, no effect on river temperature should occur. During the filling period, warmer winter temperatures are projected. The temperature changes in the river below Talkeetna have not been analyzed, but they would appear to be minor. During the filling of the reservoirs, the small winter flows are projected to have only minor influence at the three-river confluence area near Talkeetna. The filling flow will be similar to normal winter flows, allowing the river to cool between Devil Canyon and Talkeetna at a rate more rapid than that which will occur during operation.

The few effects on temperature during the summer period should not be discernible below Talkeetna because of the reduced flow contribution of the upper Susitna on the main channel during this period.

Ice conditions will change somewhat in post-project conditions during operation. During filling and construction, however, the normal winter flows should not create any significant changes in ice formation below the Chulitna river confluence.

During the filling period, flood peaks from the Susitna will be eliminated while the flood waters contributed by the other tributaries will continue. This change should provide more channel stability than that which now occurs, but the differences will probably not have perceptible changes on any of the fish habitat in the lower river.

o Anadromous Species

The Susitna hydroelectric project's effect on the runs of anadromous fish in the lower Susitna River from the mouth to the confluence of the Talkeetna River - a distance of about 157 km has not been fully established at this time. This portion of the river flows through a broad floodplain with some shifting (or instability) of the channels, and in places, the channel is divided into numerous channels. Only about 20% of the total flow in the lower Susitna originates from the river and its tributaries above the confluence of the Talkeetna River. Thus, any effect of the hydroelectric dams would, in general, be masked by the discharge of water from the tributaries flowing into the lower Susitna.

At the same time, however, the lower Susitna River provides the sole migratory route for the very large runs of salmon that enter the various tributaries below the Talkeetna to spawn and for the young returning to the sea. The effect on migration of salmon of any change in the flow regime of the Susitna, though small and whether beneficial or detrimental, would be magnified in importance accordingly.

The extent to which various species of salmon spawn in the main channels of the lower Susitna River and its adjacent sloughs is not known at this time, nor is the extent to which the main channel may serve as a nursery area for the juvenile coho, chinook, and possibly sockeye salmon.

In addition to these general effects upon the salmon population that are attributable to the Susitna project, other impacts will occur and will vary with the project activity in question. That is, the impact associated with dam construction, for example, will differ from the effects of filling the reservoir, and these will vary from the impact of operating and maintaining the facility.

During the construction and filling period, minimal flows ranging from 900 cfs in the winter to 6,000 cfs in the summer will be discharged from the dam. As the reservoirs gradually fill, there will be no provision for adjustment of water temperature to satisfy the needs of early development of salmon eggs. It should be noted that during filling, the temperature of the water is expected to reach the near ambient level by the time it reaches Gold Creek in both summer and winter and should have little effect on the spawning or migrating salmon in the lower Susitna River.

Also, during the filling of the reservoir, a gradual decrease in turbidity in the summer and an increase in level of chemical constituents of the water as a result of leaching from the soils can be expected. Turbidity will be slightly less in the summer months of glacial melt but will be overshadowed by the turbidity load of the Chulitna River.

Any addition of nutrients will tend to increase the biological productivity of the stream; exceptions would be concentrations of toxic chemicals (for example, copper and iron), but whether such concentrations will exist is not presently known.

It is not expected that the reduced flows that will occur in late spring and summer will be sufficient to cause any physical block to salmon migration. On the contrary, those flows should improve the migratory conditions for salmon ascending the lower Susitna River by reducing the water velocities and thus requiring the salmon to expend less energy during their migration upstream. Conditions for access to the small sloughs and tributaries used by salmon for spawning could be affected with an expected lowering of the water level by from .3-.6 m in the vicinity of Susitna Station. The reduced flows would have minimal effect on the mainstem spawning if it occurs.

o Resident Species

The resident fish probably spawn primarily in clearwater tributaries of the Susitna, with possible spawning in the mainstem by burbot, longnose sucker, and whitefish. During the winter months, many of the tributary residents outmigrate from the tributaries and overwinter in the mainstem. This movement has been inferred from capture data gathered during the fall and spring near tributary mouths. Information on the distribution of juvenile residents by season is minimal. Based on existing data, no major impacts are projected for the resident species below the Susitna and Chulitna confluences during construction and filling.

- Talkeetna to Devil Canyon

There are two periods to be considered when describing potential impact issues in the Susitna River downstream of Devil Canyon during the construction phase. The first period is the construction time. The river area affected during this period will be minor and will be contained within the cofferdams. At most, there may be some minor modification of turbidity levels from time to time during the construction of the cofferdams and diversion tunnel and during the road-building activities. This modification is not expected to be significant, however. During the cofferdam stage of construction, the cofferdams must not be overtopped. The river flows will be passed as the river runs through the discharge ports. Discharge will not change appreciably during the dams' construction period; except at the start of diversion, there will be no modification of flow.

One concern during the construction period is the accidental spill of chemicals and petroleum products in the impoundment area. Such accidents would primarily affect local fisheries in the impoundment area and, depending of course on the magnitude of the spill, should have minor consequences on downstream areas.

The second period of the construction phase that is expected to affect fish populations in the Susitna River downstream of Devil Canyon is the filling time, when water in the reservoirs will be brought to a usable level. This filling is expected to begin before the main dams are completed. There will be a subtraction of flow and minimal, if any, change in river bed morphology. The filling period will also mark the beginning of any changes that may occur in the deltas of incoming streams.

The main interference to flow will occur during the short period of time needed to bring the pool levels behind the cofferdam to an operating head in order for the diversion works to function.

Since Watana dam will be fully developed before Devil Canyon dam is started, there will be two short interruptions of flow as the two reservoirs are filled.

As the dams get higher, the water levels of the lakes forming behind them will also rise. The incoming flows will be modified to the extent that storage will permit, and a safety freeboard level will be provided to prevent overtopping of the works during an unusual flood. Particularly during summer, there will probably be some modification of flow, which will equal the volume of stored water behind the uncompleted structure.

As the reservoirs approach their lower operating levels, conditions closely approaching operating conditions will exist. This situation will provide some benefits from lowered flood flows but will not contribute additional flows for the summer period unless these are allowed for in the filling schedule. Thus, substantial changes in the summer flows will occur, which will, in turn, considerably reduce the flow in the side channels and sloughs in this reach to only local run-off and spring-fed flow. With normal flood peaks that occur during summer eliminated during the filling period, a more stable channel will be created and the bedload movement that occurs during this time will be reduced.

With the summer flows well below the natural variability of the river under pre-project conditions, it is expected that the sloughs from below Devil Canyon to Talkeetna will be affected in that adequate water will not be made available to them. The sloughs in question will be those that fish have been found to use either for spawning or for spawning and rearing. Approximately 40 such slough areas have been identified in this stretch of the Susitna River.

At some time during the filling period, density water layers will form in the impoundment. Firm control of temperature will probably not be possible until the reservoirs have reached their lower operating levels. Temperature modification caused by the Watana reservoir will probably equilibrate by the time the water reaches Portage Creek.

Present monthly average temperature changes have been recorded, and post-project temperature changes expected to occur during the filling of the reservoir have been projected for this reach at the Gold Creek site and near the mouth of the river at the Chulitna confluence. Depending upon the summer flow level provided, there will be modifications of natural temperatures in the spilled water after the stratification resulting from the formation of density water layers occurs. In general, temperatures will decrease slightly in the summer and increase more markedly in the spring and fall. This temperature pattern is likely to delay formation of winter ice cover over the Susitna River above Talkeetna and, with substantial increases in temperatures during April and May, to accelerate breakup in the spring.

Apart from temperatures, there may be some other modifications of water quality. These alterations would primarily be at the beginning of the storage of silt in the reservoir areas or at the beginning of discharge of less silt-ladened water below the projects. In addition, if the diversion tunnels are installed in the winter, the sediment level may be significant unless proper mitigative actions are taken to prevent any sediment additions to the river. If, on the other hand, the by-pass tunnels are installed in the summer, the increase in sediment levels will be only minor.

Nutrient levels (phosphorous and nitrogen compounds) will probably also increase in the impoundments during the filling period as vegetation within the impoundment becomes inundated. The consequences of these increases on downstream water quality have not been determined, however. Besides the phosphorous and nitrogen compounds, no other chemical parameters have exhibited abnormal levels that might be detrimental to aquatic life under pre-project conditions. It should be noted that there are presently no data to suggest any adverse effects on water quality related to these other chemical parameters during reservoir construction and filling. Furthermore, there are only limited data on mineralization levels with the reservoir areas, and as a result, no forecast can be made as to the effect on downstream fishery of alterations in mineralization levels.

During the winter months, very little change in usable habitat is likely, either during construction or filling of the reservoirs. Unlike summer flows, winter flows should be very similar to those occurring before construction begins. The only major difference between winter and summer impacts is that, as noted above, if diversion tunnels are installed in winter, they could result in significant additions of sediment to the river.

o <u>Anadromous Species</u>

Estimates of the number of each salmon species to be affected in this reach of the river are discussed in section (iii) below. One change in the habitat that will result from the Susitna project is that the low summer flows will dewater the side sloughs along the river.

The low summer flows will be due, in part, to the planned diversion tunnels. Although the water drop may be rather sudden, the river should quickly recover as the narrow segment is filled upstream from the cofferdam. Thus, the effect on salmon populations is expected to be minor.

o Resident Species

During the summer, resident fish in this reach of the mainstem are primarily burbot and longnose suckers. During the filling period, most other residents are associated with the mouths of clear water tributaries. During the early spring and late fall sampling periods, adults were more often associated with the mainstem than they were during the summer. This difference probably reflects migratory movements between the clear water tributaries.

During the late summer months, whitefish, grayling, and rainbow trout fry have been found to use the slough habitats, pointing up the relative importance of these areas to the rearing of juveniles. Very little information on winter distribution is available.

Geomorphological changes, in general, should not adversely affect the resident fish in that, with a decreased variability in discharge, a more stable channel should result. More specifically, however, as described above, dewatering of the side slough habitats will occur during the summer months, with water from springs being the only contribution to these areas. Even though the effects of reduced Susitna flows on the recharge of these springs is not known, the portion of the resident fisheries using these areas should be reduced. On the other hand, most of the resident fish are dependent on clear water tributaries, and these are not likely to be affected by the project. The significance to the overall population size of the rearing fish using these areas is not known.

The decrease in scouring floods during the summer should make the mainstem more hospitable to resident fish than under pre-project conditions. Sufficient information is lacking, however, as to whether the post-project conditions will be a sufficient enough improvement in habitat to enhance the current, almost non-existent use of this type of habitat. The decreased flows during the spring and fall should not significantly affect the inter-system migration that occurs at this time. One reason is that no fish passage problems are anticipated; moreover, no other changes in water quality are expected which may cause any adverse impacts.

The temperature changes described above are well within the range of tolerance of the resident species, so no direct effect is anticipated. If temperature changes trigger migratory movements of overwintering fish, however, premature migration may occur. The delay in ice formation and the earlier spring breakup that is likely to occur during reservoir filling also as a result of temperature modifications will probably have a minor impact on the resident fisheries. The full effect of either of these change on the resident species is not known, however.

Geomorphological changes, in general, should not adversely affect the resident fish, in that with a decreased variability in discharge, a more stable channel should result.

(ii) Operation and Maintenance

- Estuary

The proposed Susitna hydroelectric project will alter the monthly and seasonal discharge patterns of the Susitna River. Based on a simulated 30-year average, flow increases over existing conditions will occur during the October through April period, with monthly average flows increasing from approximately 50% to 120% in the Susitna Station region. The greatest increases will occur during the December through March period. Summer discharge levels will be decreased slightly, with the maximum monthly average decrease in discharge being approximately 15% at Susitna Station. This maximum decrease will occur during June.

The effect on the upper Cook Inlet estuary of altered discharge patterns will be of much smaller magnitude than those which may possibly occur in the Susitna River between Talkeetna and Devil Canyon. The difference in importance is mainly because the upper Susitna River contributes roughly only 20% of the total Susitna River discharge entering Cook Inlet.

The Susitna does contribute a significant portion of the total volume of fresh water entering Cook Inlet annually. It has been estimated that the Susitna and the other rivers entering the Knik Arm contribute nearly 80% of this volume. The Susitna River alone is responsible for approximately 60% of the annual freshwater contribution to the inlet. During the operation, first, of Watana and, then, of Watana and Devil Canyon as well as during the filling of the Watana impoundment, however, changes in the annual freshwater contribution entering Cook Inlet from the Susitna will be negligible.

Increased winter discharges will increase the volume of fresh water entering the estuary during the winter and may lower salinity levels in the vicinity of the river mouth. Strong tidal action in this region is likely to result in water's being mixed fairly rapidly through the water column. Such mixing will further reduce the possibility of the formation of a well-defined surface layer characterized by significantly lower salinities. Air temperatures are low enough during November and December, however, to cause the rapid onset of freezing, despite minor variations near the Susitna River mouth in either the salinity or water temperature. The ice breakup pattern in the spring could be altered slightly by the decrease in the volume of the annual freshet.

In general, substantial decreases in turbidity levels in an estuary could influence productivity and result in an increase in predation upon larval and juvenile fishes, particularly pink salmon. Studies have shown that predation on juvenile pink salmon in estuarine environments can be exceedingly high. Since much of this predation is based upon visibility, lower turbidity levels can increase predation considerably. Decreased turbidity levels in the estuarine plume, however, could increase primary productivity levels. This decreased turbidity could result in a corresponding drop in the extinction coefficient which indicates a greater amount of light penetration into the water column.

Increased winter flows could shift the region of maximum productivity in the upper estuary farther from the river mouth region. Effects upon estuarine ecological conditions will probably be minor.

As mentioned previously, however, the maximum decreases during the May through August period in the lower Susitna near Cook Inlet will be, on the average, approximately 15% and will occur during June. Decreases of around 10% are anticipated during May, July, and August. These changes are not thought to be of significance, especially when compared to the mean monthly fluctuations on a year-to-year basis. These have been estimated to be over 50% in July and over 100% during June and August. It would appear that predicted post-project changes in summer discharge levels will not affect smolt outmigration or adult spawning migration patterns in the vicinity of the upper Cook Inlet estuary.

As discussed in Section 3.6 (d), the impacts to the various marine mammals and birds utilizing the upper Cook Inlet estuary should be minimal. Among these are the belugas, or white whales, which frequent the area between Anchorage and the mouth of the Beluga River. Some changes in the sedimentation processes within the estuary, may occur, however, especially in the delta regions.

- River Mouth to Talkeetna

The operation period for the dams is assumed to begin at the time when power generation starts. At that time, there will be a gradual shift from the previous 900 cfs winter flow discharge during the filling period to an average 9,000 cfs flow during full operation. The projected summer flow will range from 5,000 to 17,000 cfs, with some periods of spill resulting from heavy summer rain and glacial melt.

The operation and maintenance of the proposed Susitna Hydro Project will alter the physical and chemical parameters at the lower river in the same way that these characteristics will change during the filling period in the summer. During the winter, however, additional water will be discharged from the reservoir pool, increasing downstream flows and providing conditions that do not normally occur under the natural flow regime.

During the operation and maintenance of this project, discharge in the lower river will decrease somewhat during the summer months and increase substantially during the winter. For the Sunshine Station, the monthly mean and annual frequency duration curves project decreases in the average monthly discharge for June, July, and August. Increases in discharge will occur in October through May. No significant change in discharge is projected for September.

Data analysis indicates that post-project operation average monthly flows will resemble the historic average low flows that occur over one day during said month and are slightly below the average low flow three-day occurrence of June and July. The post-project August flows will be similar to those that normally occur over a 14-day period, while the September flows will not differ significantly from the natural flow. October post-project flows will be higher than those which occur normally but will be within the natural variability that occurs over a 14-day period. Post-project flows at Sunshine Station during November, December, January, February, March, and April will be well above the normal variability. The largest departure from the normal conditions will occur in December when normal winter flows of 4,200 cfs at Sunshine will be increased three-fold to 12,000 cfs. This change will increase the stage at the Sunshine station about one meter. The channel at this station is much narrower than at other portions of the lower river, so this stage change should project a maximum that could be expected to occur. During this winter period the total wetted surface area of the Susitna River below Talkeetna will increase above the normally wetted area of pre-project conditions.

As in the construction phase, an increase in turbidity levels during the winter should be noticeable below Talkeetna in that the Susitna under post-project water conditions will be the dominant flow contributor during these months. On the other hand, during the summer months, the turbidity below Talkeetna should not change appreciably because of the minor contribution of the Susitna in this reach to the suspended sediment load.

Examination of other water quality parameters measured throughout the year does not indicate any abnormal concentrations that may be limiting to aquatic life. Increases in nutrient concentrations should result from the flooding of vegetation within the impoundments. Phosphorous concentrations are often associated with increases in productivity. Increases in nutrients in glacial systems, however, which are already light limiting, do not necessarily cause increases in production. Downstream nutrient increases are a likely consequence of the construction of the project, although predictions of these concentrations have not been made.

Below the confluence of the Susitna and Chulitna rivers, summer changes in water quality should not be perceptible, both because of the influence of the Chulitna on the mainstem river and because of the natural variability of water quality within the system.

Temperature changes have been projected for the portion of the Susitna above Talkeetna only. By the time the water in the lower Susitna reaches the confluence of the Talkeetna, there is likely to be no difference in the water temperatures of the two rivers. During operation of the reservoirs, the larger winter flows, which will also be warmer than present winter flows, are projected to have only minor influences at the three-river confluence area near Talkeetna.

In the confluence area near Talkeetna, ice conditions will be substantially altered during the operation of the project. Under normal year temperature conditions, the increased winter water temperatures are not expected to allow an ice cover to form above the confluence. Consequently, a delay in ice formation will probably occur in the river as far down as the Parks Highway bridge. If ice is formed in November, the discharge is projected to increase by approximately one-third during the month of December. Ice jams and aufeis formation should occur at increased rates in this reach, creating high backwaters in the vicinity of Talkeetna. This ice should not have adverse effects on resident fisheries habitat but may cause flooding under normal conditions.

During the operation of the dam, flood peaks from the Susitna will be reduced, but the flood contributed by the other tributaries will continue. The flood events that currently occur every two years at Sunshine bridge will occur every 10 years during operation. The five-year peak flood that will occur under post-project conditions is predicted to be the same as the present 25-year flood. These changes are likely to provide more channel stability than that which now occurs.

o Anadromous Species

The decreased summer flows that are projected may inhibit or prevent salmon from entering some of the spawning sloughs.

Bering cisco enter the river in mid-September and spawn in the mainstem in the area between Montana Creek and Talkeetna during the first week of October. They apparently outmigrate to the ocean immediately after spawning. The times of emergence of the young and outmigration of the juveniles to the estuary have not been established. Based on the available data, however, no impacts are currently foreseen for any of the project phases.

Little is presently known about the use of the Susitna River by the eulachon. It would be expected that this species would spawn in some tributaries or in the Susitna mainstem. Eulachon upstream migration runs are temperature triggered. Since temperature in the river mouth region will not be altered, migrational runs will not be affected. On the basis of available information, it thus appears that there will probably be no impacts during any of the project phases.

o Resident Species

The species investigated by ADF&G during the summer of 1981 (with reconnaissance investigations during the winter of 1980-81) included rainbow trout, Arctic grayling, burbot, round whitefish, humpback whitefish, longnose sucker, Dolly Varden, threespine stickleback, cottids, Arctic lamprey, and northern pike.

These resident species probably spawn primarily in clear water tributaries to the Susitna with possible spawning in the mainstem by burbot, longnose suckers, and whitefish. During the winter months, many of the tributary residents outmigrate from the tributaries and overwinter in the mainstem. This movement has been inferred from capture data during the fall and spring near tributary mouths. Information on the seasonal distribution of juvenile residents is minimal.

Although very small changes in temperature regime are projected below Talkeetna, those that do take place will occur primarily during the winter months. These changes will all be well within the tolerance ranges of the resident species.

In post-project conditions, geomorphological changes in the system should be very minor in terms of their effects upon resident fisheries habitat. Because of reduced flows during the summer, there is a potential for aggradation near the confluence of the Susitna and Chulitna rivers but these changes should not affect fisheries habitat of the resident species. Ice processes will change in the confluence area but are not anticipated to create problems for resident fishery habitat.

- Talkeetna to Devil Canyon

o Anadromous Species

The third period of concern when assessing the impact of the Susitna project on local fisheries is the start of the operation, when varying flows either will be discharged through the power units or will be spilled. The following impact discussion is based on the current proposed operation of the facilities for maximum power production. The desired flows will be supplied, in part, through Cone valves. With the jets dispersing the outflow, there should be no penetration to carry air below a .6 m depth in the plunge pool. The only exception would be a major flood occurring at 50-year or longer intervals. There is now supersaturation of dissolved gas (oxygen and nitrogen) at high flows in the Devil Canyon area, but these levels are below critical levels [Figure 3.36 (APA 1981)].

It is evident that this stream becomes more turbulent and entrains more air at higher flows. It is possible that with the reduction of flow in the canyons even a small increase of saturated gas in the plunge pool will not increase present natural levels below Devil Canyon.

As mentioned above, the period of filling is the time when possible changes will begin in the deltas of the incoming streams because at that time there will be a loss of support level. This change will continue until stability is reached. The period of existing minimum flow in the river will be altered to become the period of the maximum discharge through the power units. This flow, however, is below that which would be needed to wet the sloughs, between Devil Canyon and Talkeetna which are presently used by salmon for spawning or rearing. Thus, approximately 40 sloughs, and, in particular, important chum salmon spawning habitat will be lost by the proposed project flows.

Various studies have been undertaken to indicate the temperatures that may be expected below Watana dam and below both Watana and Devil Canyon dams, when both are in operation. It is expected that as a result of river modifications caused by the project, the entire winter flow pattern will be changed at least to Talkeetna. With this change in winter flow and temperature pattern, ice production would be altered. While this alteration poses no problem above Talkeetna, it represents a potential problem to both fish and fish habitat below Talkeetna.

The clear water sources, or the aquifers, that supply the sloughs in the winter are presently unknown. In some cases, this water is apparently supplied from bank storage, and it is speculated that, in some cases the flow has an origin in the main river channel, with the water being clarified by passing through the gravels of an island. In the absence of this information, it cannot be predicted whether or not these areas will remain as salmon producers.

Recent studies have indicated that there will be significant storage of river-borne particles in the Watana reservoir. Below the two dams there will be clarification of flow during summer. This clarity, in turn, can alter the food production and the usefulness of the river for improved salmon production. Increased predation on young salmon, however, is also a possibility.

Under the maximum power production scheduled, there still will be periodic spills from Watana reservoir, which must be passed through Devil Canyon into the natural river bed. The level of these flows will be important with respect to their effect upon the morphology of the river downstream to Talkeetna, particularly their effect upon the morphology of the side sloughs or side channels where fish may now be produced.

o <u>Resident Species</u>

During the operation of the Susitna hydro project, physical habitat in the reach of river between Talkeetna and Devil Canyon will be changed the most. For example, during the operation phase of the program, substantial changes in the summer flows will occur. These flows will considerably alter the flow in the side channels and sloughs in this reach, reducing it to local run-off and spring flow.

During operation, sediment will probably decrease in the lower river during the summer months and increase during the winter.

Like the increases expected during filling, nutrient levels (phosphorous and nitrogen compounds) are also likely to increase during the operational period as vegetation within the impoundment becomes inundated. The consequences of these increases on downstream water quality, however, have not been determined. The limited data base does not indicate that, under pre-project conditions, any other chemicals are present at enough levels to be detrimental to aquatic life. Similarly, current available data suggest no adverse effects of reservoir operation on water quality in relation to these other chemical parameters.

The normal flood peaks that occur during the summer will be substantially reduced during the operation of the project, creating a more stable channel and reducing the bedload movement that occurs. The fall spills, whenever, they occur, however, may disrupt the newly stabilized stream bed.

The resident fish found throughout the year in this reach of the river are primarily burbot and longnose suckers. Other residents are chiefly associated with the mouths of clear water tributaries. During the early spring and late fall sampling periods, adults were found associated more often with the mainstem than they were during the summer. This probably reflects migratory movements between the clear water tributaries and the mainstem. Very little information on winter distribution is available. Friese (1975) found whitefish, grayling, and rainbow trout fry using the slough habitats during the late summer months, a reflection of the relative importance of these areas to rearing juveniles.

During the winter months, a significant increase in the wetted area of the main channel should occur. Dewatering of the side slough habitats will occur during the summer months, when water from springs will be the only contribution to these areas. The effects of reduced Susitna flows on the recharge of these springs is not known. While the portion of the resident fisheries using these areas will probably be reduced, most of the resident fish are dependent on clear water tributaries, and these areas will not be affected by the project. The significance of the rearing fish using these areas to the overall population is not known.

The decrease in scouring floods during the summer should make the mainstem more hospitable to resident fish during the summer than it is under pre-project conditions. However, insufficient information is available as to whether the post-project conditions will result in sufficient improvement in habitat to enhance the current, almost non-existent use of this type of habitat. The decreased flows during the spring, when inter-system migration of resident fish occurs, should not significantly affect this activity. No fish passage problems are anticipated, nor are there any changes in water quality anticipated which suggest adverse impacts.

Temperature effects on the river above Talkeetna will be most noticeable during the winter months. These temperatures will be well within the tolerance range of the resident species, so no direct effect will be expected.

(iii) Overview of Impacts on Salmon - Talkeetna to Devil Canyon

The following discussion is an estimate of the magnitude of the Susitna Hydroelectric Project's impact upon the five salmon species utilizing the Talkeetna to Devil Canyon reach of the Susitna River. As stated earlier, between 1% and 2% of the Susitna escapement use this reach of the river.

It is believed that the primary spawning sites for chinook salmon in this reach of the river are located in the tributaries, particularly Indian River and Portage Creek. Although the use of this stretch as a migrational route will not likely be hampered by project flow, potential loss of rearing habitat here may be an adverse impact on the chinook.

As a result of the impacts in the Talkeetna to Devil Canyon reach of the Susitna, approximately 14,000 of the annual sockeye salmon harvest in the Cook Inlet could be lost. All of the sockeye salmon in the Susitna River reach above Talkeetna were found only in the slough habitats. Yet to be defined for this reach of the river, however, is the location of rearing habitat for the sockeye. There are no lakes in this area to which they have access. If it is assumed that, at this time, the sockeye have contributed on an equal basis with sockeye from other portions of the Susitna with known rearing habitats, then the impact will be a loss of all or most of the slough spawning habitat in the Talkeetna to Devil Canyon reach. This loss will alter the Susitna escapement by approximately 1% and the Cook Inlet run by about .05%

It is expected that practically the entire adverse impact on pink salmon will occur in the reach of river above Talkeetna. Based on 1981 escapement data, if all spawning habitat were lost above Talkeetna, it would impact approximately 2% of the Cook Inlet harvest or approximately 9,000 to 10,000 odd-year run pink salmon. Since the odd-year pink salmon were found spawning primarily in the tributaries in this reach of the river and not in the side channels of the mainstem, what impact upon them that occurs is not expected to be extensive. Even-year pink salmon must, by virtue of their numbers, be less selective about the choice of spawning sites. It is, therefore, anticipated that even-year pink salmon will be found in all available habitat; however, 1982 information is needed to address this impact in detail.

Seventy percent of the Cook Inlet harvest run of coho salmon are estimated to originate from the Susitna River drainage. The Cook Inlet annual harvest for 20 years of record is 231,000 coho salmon. Preliminary sources have indicated that the 1981 Cook Inlet coho salmon harvest was a record catch of nearly 500,000 fish. An excessive harvest may have occurred and could be responsible for the low escapement of coho into the Susitna in 1981. Twenty-two percent of the Cook Inlet run returns to the Susitna River for reproduction. In 1981 this was estimated to be approximately 33,000 to 34,000 fish by the ADF&G. Coho escapement was thought to be rather weak during 1981 and the coho population is thought to be somewhat depressed. As a result, the 1981 figure is probably below the long-term average.

Most of the coho salmon that go above Talkeetna use tributaries for spawning, although some mainstem spawning has been observed. Thus, impact of power flows on the coho salmon in this reach is not expected to be severe.

It is anticipated that the flows associated with power production will all but eliminate access to essentially all of the sloughs in the Talkeetna to Devil Canyon reach of the Susitna River. The sloughs are used extensively by chum salmon for spawning. This lack of access will adversely affect the chum salmon causing a severe reduction in their population in this section of the Susitna River. On the other hand, at least 80% of the chum salmon in the Susitna River use other areas for spawning.

The percentage of all five Pacific salmon species that use the Susitna River above Talkeetna is low. In some cases, the impact associated with the power project will be minimal, as with the chinook. In other cases, such as with the chum salmon, consequences will be more severe. With regard to the useful habitats of the Pacific salmon, the remainder of the Susitna drainage, including the major tributaries and the Yentna, Chulitna, and Talkeetna rivers, will not be affected.

(e) Access Route

(i) Construction

Impacts on fish resources from access road construction could effect both anadromous and resident fish species. With proper mitigation procedures, however, these effects are not expected to be severe. Stream bank and stream bed disturbances during construction could disturb spawning, rearing, or shelter habitat in the immediate construction zone or could result in the siltation of these habitats downstream. Failure to remove fallen trees and other debris resulting from construction activities could prevent fish passage in both an upstream or downstream direction. Such obstructions would most likely be a problem in the smaller streams.

Oil residue and bacterial as well as nutrient contamination resulting from the presence of construction vehicles, facilities, and the construction work force and families could degrade the water quality of any nearby aquatic habitats. This contamination would be of greatest impact in smaller tributaries or lakes where the potential dilution of any contaminants would be limited.

The proposed access plan includes a road from the Parks Highway at Hurricane to Gold Creek, a road to Devil Canyon on the south side of the Susitna, and a north-side connection between the two dams. If this plan is implemented, the anadromous fish populations of Indian River, in particular, and the Susitna River generally could be affected during the construction phase. The construction of a bridge across the Indian River and the access road along the Indian River could both create siltation problems for spawning salmon species, in particular, king, chum, and coho salmon. Resident species could also be affected.

The construction of two bridges across the Susitna (near Gold Creek and at Devil Canyon) could also cause siltation problems downstream of both construction sites. This siltation could be detrimental to salmon utilizing the mainstem Susitna for spawning; both chum and coho salmon spawning sites have been identified in this general region of the mainstem.

The access road segment between Gold Creek and the Devil Canyon dam site would cross several small tributaries located south of the Susitna River. Most or all of these streams contain grayling populations, which may be affected during road construction.

More significant grayling populations could be affected along the Devil Canyon to Watana portion of the access road. Devil and Tsusena creeks, which would be crossed, have fairly sizable grayling populations. Since the areas of these creeks that will be crossed by the access road will not be inundated by the Devil Canyon impoundment, these crossings must be considered possible additional impacts.

Increases in angling pressure from the presence of a larger number of construction workers and their families could affect the salmon and resident fish populations throughout the regions where satellite and large construction camps and villages are located. Specifically, the presence of a construction camp at Hurricane could increase fishing pressure upon the Indian River salmon stocks. The Gold Creek camp could increase the pressure on both the Indian and the Susitna rivers. Salmon stocks in Portage Creek could be influenced by the camp location at Devil Canyon. The fish to be affected by the Watana camp population are most likely to be grayling in the Watana and possibly Tsusena creeks.

The same type of construction-related impacts noted above are possible during pioneer road construction. The same area between the Devil Canyon and the Watana dam sites that could be affected by access road building may also experience changes from pioneer road building. The segment between Gold Creek and Devil Canyon will affect areas additional to those to be affected by the permanent road. On the other hand, because of the smaller workforce, the contamination and pollution impacts would be fewer and the angling pressure far less during pioneer road construction.

Sedimentation problems may also be an impact associated with borrow pits used for access road construction. These problems would be minimal, however, compared to those created by the borrow and quarry areas used for dam construction.

(ii) Operation and Maintenance

The most significant potential impacts associated with the operation and maintenance of the access road will arise from two different sources. First, a lack of maintenance of the stream crossings could result in a degeneration of those areas, which could, in turn, affect the fish populations. The second major impact on fisheries could be triggered by the failure of the stream crossings themselves or the failure of any road design or construction methods that may have been implemented, in fact, to limit or to eliminate siltation or blockages to fish passage. General road maintenance and repair could have the same types of effects as those associated with construction, but the levels of these impacts would be lower than those of their construction period counterparts. With proper design and adequate maintenance of stream crossings these significant potential impacts can virtually be eliminated.

(iii) Public Access

The presence of the access road and any allowance of permanent access on the pioneer road could have a significant impact upon the fish resource within the vicinity of these routes. Increased public access could result in a corresponding increase in angling pressure. In contrast to a more temporary increase in angling pressure associated with the presence of the construction population, public access would create a long-term or permanent impact. An example of such a long-term consequence is the possible creation of a permanent village near the Watana dam site. The regions of greatest access would be the entire stretch of the Indian River, with its salmon fishery, and the grayling and lake trout populations in the upper basin.

Resident fish species may be particularly vulnerable to excessive fishing pressure because of their late maturity and slow growth rate. In the case of the grayling, the ease with which they may be caught by hook and line makes this species particularly vulnerable to angling pressure.

(f) Transmission Line

(i) Construction

Transmission line construction could affect fish habitat through direct streambed disturbance or by causing siltation problems downstream. This siltation would occur during the movement of construction equipment or materials through streams that need to be crossed. If stream crossings are constructed, the same impacts could occur, and problems with fish passage could arise if these structures should fail. In general, however, impacts associated with tranmission line construction should be minimal.

Impacts associated with construction camps used during transmission line construction would be similar to those associated with construction camps for access road building. The same camp sites will be used for both construction projects. Thus, the same possibility of contamination and angling pressure impacts discussed in relation to access road construction will exist for transmission line construction.

(ii) Operation and Maintenance

In terms of fisheries, impacts associated with the operation and maintenance of transmission lines should also be minimal. Streambed disturbances during routine maintenance and operation should be insignificant. Any stream crossings erected during the transmission line construction phase, if not properly maintained, could result in fish passage blockage. In the northern corridor, stream crossings over the Tanana and Nenana Rivers could be significant. Indian River and Susitna River crossings, in the central area, are also important crossing sites. In the southern corridor, critical stream crossings will be made over Willow Creek and the Little Susitna River.

3.8 - Anticipated Impacts on Threatened or Endangered Species

(a) Plants

None of the plant species under review for possible protection under the Endangered Species Act of 1973 are known to occur in the vicinity of any proposed project facilities, nor were any of these species found during searches of potential habitat [Section 3.4(a)]. Although some potential habitat does exist in the upper basin, it is distant from any proposed facilities. As a result, it is not anticipated that any of these species will be adversely affected by any project activity.

(b) Wildlife

No endangered wildlife species are presently known to occur in the project area in the upper basin [see Section 3.4(b)]. As previously noted, the peregrine falcon is the only species that could occur in the project area and no peregrines were documented during the present study. This does not, however, mean that peregrines will not, sometime in the future, attempt to use the cliff habitat along the Susitna River or adjacent tributaries for nesting purposes. Some of the cliff habitat will have been inundated, but some will remain [Section 3.6(a) and (b)]. One may speculate that if peregrines attempt to breed in the project area following construction of the hydroelectric facilities they would stand a good chance of being successful. Due to construction activity, the possibility of successful breeding during the construction phase might be considerably less, depending upon the proximity of the selected nest site to the construction sites.

There is a possibility that future use of the peregrine nest site located near the Tanana River may be affected by the transmission line. The nest was not active during 1981 but could conceivably be used at some time in the future. If the nest is active during the construction of the line, the birds may abandon it as a result of the disturbance. If the nest remains inactive during the line construction, however, it may be acceptable for later use during the operational phase of the line.

(c) Fish

Since there are no threatened or endangered fish species listed for the State of Alaska, there can be no impact in regard to this topic.

3.9 - Mitigation of Impacts on Fish, Wildlife, and Botanical Resources

(a) Mitigation Policy and Approach

The mitigation policy and approach was developed by TES in cooperation with Acres American and the Alaska Power Authority. The text was released by the Power Authority for agency review and comment. The following text is a revision of the original, incorporating agency comments.

1 - INTRODUCTION

The fish and wildlife mitigation aspects of the Susitna project have been addressed through a Fisheries Mitigation Core Group, a Wildlife Mitigation Core Group, and a Fish and Wildlife Mitigation Review Group. The two core groups consist of staff members of Terrestrial Environmental Specialists, Inc., consultants with expertise in special areas (caribou, furbearers, anadromous fish, etc.), and a representative of the Alaska Department of Fish and Game. The purpose of the two core groups is to develop the technical specifics of the mitigation policy and plans.

The purpose of the Review Group is to review and comment on the results of the core groups. Agencies represented on the Mitigation Review Group are:

Alaska Department of Natural Resources
Alaska Department of Fish and Game
U.S. Fish and Wildlife Service
U.S. Environmental Protection Agency
U.S. Bureau of Land Management
National Marine Fisheries Service

A mandate of the APA charter is to develop supplies of electrical energy to meet the present and future needs of the state of Alaska. APA also recognizes the value of our natural resources and accepts the responsibility of ensuring that the development of any new projects is as compatible as possible with the fish and wildlife resources of the state and that the overall effects of any such projects will be beneficial to the state as a whole. In this regard APA has prepared a Fisheries and Wildlife Mitigation Policy for the Susitna Hydroelectric Project as contained herein.

2 - LEGAL MANDATES

There are numerous state and federal laws and regulations that specifically require mitigation planning. The mitigation policy and plans contained within this document are designed to comply with the collective and specific intent of these legal mandates. Following are the major laws or regulations that require the consideration and eventual implementation of mitigation efforts.

Protection of Fish and Game (AS 16.05.870)

The Alaska state laws pertaining to the disturbance of streams important to anadromous fish address the need to mitigate impacts on fish and game that may result from such action. The pertinent portion of item (c) from Section 16.05.870 reads as follows:

"If the Commissioner determines to do so, he shall, in the letter of acknowledgement, require the person or governmental agency to submit to him full plans and specifications of the proposed construction or work, complete plans and specifications for the proper protection of fish and game in connection with the construction or work, or in connection with the use, and the approximate date the construction, work, or use will begin, and shall require the person or governmental agency to obtain written approval from him as to the sufficiency of the plans or specifications before the proposed construction or use is begun."

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 USC 4321-4347) was designed to encourage the consideration of environmental concerns in the planning of federally controlled projects. Regulations pertaining to the implementation of NEPA have been issued by the Council on Environmental Quality (40 CFR 1500-1508; 43 FR 55990; corrected by 44 FR 873 Title 40, Chapter V, Part 1500). Items (e) and (f) under Section 1500.2 (Policy) of these regulations describe the responsibilities of federal agencies in regard to mitigation.

Federal agencies shall to the fullest extent possible:

"(e) Use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment.

(f) Use all practicable means, consistent with the requirements of the Act and other essential considerations of national policy, to restore and enhance the quality of the human environment and avoid or minimize any possible adverse effects of their actions upon the quality of the human environment."

Federal Energy Regulatory Commission

Federal Energy Regulatory Commission (FERC) regulations also refer directly to the need for mitigation actions on the part of the developers of hydroelectric projects (18 CFR Part 4). The following reference is quoted from Section 4.41 of the Notice of Final Rule as it appeared in the November 13, 1981, issue of the Federal Register (46 FR 55926-55954) and was adopted. Exhibit E of a FERC license application should include, among other information,

". . . a description of any measures or facilities recommended by state or Federal agencies for the mitigation of impacts on fish, wildlife, and botanical resources, or for the protection or enhancement of these resources. . . ."

The regulations go on to require details concerning mitigation including a description of measures and facilities, schedule, costs, and funding sources.

Fish and Wildlife Coordination Act (915 USC 661-667)

Item (a) of Section 662 of the Fish and Wildlife Coordination Act describes the role of the federal agencies in reviewing federally licensed water projects.

". . . such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State wherein the impoundment, diversion, or other control facility is to be constructed, with view to conservation of wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource development."

FERC will comply with the consultation provisions of the Fish and Wildlife Coordination Act.

3 - GENERAL POLICIES TO BE CARRIED OUT BY THE APPLICANT

3.1 - Basic Intent of the Applicant

In fulfilling its mandate, an objective of the Alaska Power Authority (APA) is to mitigate the negative impacts of the Susitna Project on the fish and wildlife resources. This goal will be achieved through comprehensive planning during the early stages of project development and through a program of ongoing consultation with the appropriate resource agencies. Since the APA realizes that highly coordinated planning will be necessary to achieve this goal, a decision-making methodology has been developed to provide a framework for addressing each impact and the mitigation options available. This methodology outline also identifies the process for resolving conflicts that may develop between APA and the resource agencies. The FERC will resolve any disputes which the agencies and APA cannot resolve.

The mitigation plan will be submitted by the APA to the FERC as a component of the license application. Prior to this, any draft mitigation plans will be submitted to resource agencies for formal review and comment. The final mitigation plan to be implemented will be stipulated by the FERC. The ultimate responsibility for insuring implementation of the plan will be that of the APA and will be carried out by the APA or any other organization charged with managing the project as stipulated by the FERC.

3.2 - Consultation with Natural Resources Agencies and the Public

In order to achieve the above-mentioned goals, it will be necessary to provide opportunities for the review and evaluation of concerns and recommendations from the public as well as federal and state agencies. During the early stages of planning, representatives of state and federal agencies will be encouraged to consult with the applicant and the applicant's representatives, as members of the Fish and Wildlife Mitigation Review Group. Additional review and evaluation of the mitigation plan will be provided through formal agency comments in response to state and/or federally administered licensing and permitting programs.

APA will consider all concerns expressed by members of the general public and regulatory agencies regarding the mitigation plan. Input from the public will be given appropriate consideration in the decision-making process as it pertains to the direction of the mitigation effort and the selection of mitigation options.

3.3 - Implementation of the Mitigation Plan

The ultimate responsiblity for insuring implementation of the mitigation plan rests with APA. Prior to implementing the plan, an agreement will be reached as to the most efficient manner in which to execute the plan. The agreement will determine which organization will serve to carry out various portions of the plan and will include stipulations to insure adherence to the accepted plan.

Realizing that a mitigation monitoring team will be necessary to insure the proper and successful execution of the mitigation plan, part of the plan will detail the structure and responsibilities of such a monitoring body. The successful organization and operation of a monitoring team will require both funding and commitments. These matters will be resolved through negotiation leading to mutual agreement among the various involved parties after the mitigation plan is complete and the necessary level of resources can be more accurately defined.

3.4 - Modification of the Mitigation Plan

As part of the mitigation plan, a monitoring plan will be established, the purpose of which will be to monitor fish and wildlife populations during the construction and operation of the project to determine the effectiveness of the plan as well as to identify problems that were not anticipated during the initial preparation of the plan.

The mitigation plan will be sufficiently flexible so that if data secured during the monitoring of fish and wildlife populations indicate that the mitigation effort should be modified, the mitigation plan can be adjusted accordingly. This may involve an increased effort in some areas where the original plan has proven ineffective, as well as a reduction of effort where impacts failed to materialize as predicted. Any modifications to the mitigation plan proposed by the monitoring team will not be implemented without consultation with appropriate state and federal agencies and approval of APA and FERC. The need for continuing this monitoring will be reviewed periodically. The monitoring program will be terminated when the need for further mitigation is considered unnecessary, subject to FERC approval.

4 - APPROACH TO DEVELOPING THE FISH AND WILDLIFE MITIGATION PLANS

The development of the Susitna Fish and Wildlife Mitigation Plans will follow a logical step-by-step process. Figure 1 [Figure 3.37] illustrates this process and identifies the major components of the process. Also identified in Figure 1 [Figure 3.37] are the organizations responsible for each step. The following discussion is based on Figure 1 [Figure 3.37] and uses the numbers in the lower right corner of each block of that figure for reference purposes.

The first step in the approach (Step 1) entails the identification of impacts that will occur as a result of the project. Each impacted resource and the nature and extent of the impact will be defined. The fish and wildlife resources will vary in definition and may include a population, subpopulation, habitat type, or geographic area. The nature and degree of impact on each respective resource will be predicted to the greatest extent possible. This step will be the responsibility of the Core Group of the Mitigation Task Force.

Following the identification of impact issues, the Core Group will agree upon a logical order of priority for addressing the impact issues. This will include ranking resources in order of their importance. The ranking will take into consideration a variety of factors such as ecological value, consumptive value, and nonconsumptive value. Other factors may be considered in the ranking if deemed necessary. The impact issues will also be considered in regard to the confidence associated with the impact prediction. In other words, those resources that will most certainly be impacted will be given priority over impact issues where there is less confidence in the impact's actually occurring. The result of this dual prioritization will be the application of mitigation planning efforts in a logical and effective manner. The results of the prioritization process will be reviewed by the Fish and Wildlife Mitigation Review Group.

Step 2 is the option analysis procedure to be performed by the Core Group. The intent of this procedure is to consider each impact issue, starting with high priority issues, and reviewing all practicable mitigation options.

Mitigation for each impact issue will be considered according to the types and sequence identified by the CEQ (Figure 2 [Figure 3.38]). If a proposed form of mitigation is technically infeasible, only partially effective, or in conflict with other project objectives, additional options will be evaluated. All options considered will be evaluated and documented. The result of this process will be an identification and evaluation of feasible mitigation options for each impact issue and a description of residual impacts.

Additional items that may be addressed by the Core Group include an identification of organizations qualified to execute the mitigation plan and recommendations concerning the staffing, funding and responsibilities of the mitigation monitoring team.

Step 3 concerns the development of an acceptable mitigation plan. The feasible mitigation options identified through Step 2 will be forwarded to the mitigation review group for informal agency review and comment. Any recommendations received from the review group will be considered by APA and the Core Group, prior to the preparation of draft fisheries and wildlife mitigation plans. These draft plans will be sent to the Fish and Wildlife Mitigation Review Group for comment and then, following revision, to the FERC as a component of the license application. The final fish and wildlife mitigation plans to be implemented will be stipulated by the FERC following discussions with APA and appropriate natural resource agencies.

Step 4 will be the implementation of the plan as agreed to during Step 3. This will commence, as appropriate, following the reaching of an agreement by all parties.

During the implementation of the plan, which will include both the construction and operation phases of the project until further mitigation is deemed unnecessary, the mitigation monitoring team will review the work and evaluate the effectiveness of the plan (Step 5). To accomplish this goal, the monitoring team will have the responsibility of assuring that the agreed upon plan is properly executed by the designated organizations. The team will be provided with the results of ongoing monitoring efforts. This will enable the team to determine in which cases the mitigation plan is effective, where it has proven to be less than effective, and also in which cases the predicted impact did not materialize and the proposed mitigation efforts are unnecessary. The monitoring team will submit regularly scheduled reports concerning the mitigation effort, and where appropriate, propose modifications to the plan. If stipulated in the FERC license, such reports would be distributed to FERC and State and Federal regulatory agencies.

In the event that plan modifications are recommended (Step 6), they will be reviewed by a Core Group and appropriate options considered (Step 2). The results of the option analysis will then be passed on to the APA and the resource agencies for negotiation of modifications to the plan (Step 3). Following the reaching of an agreement on the modifications, they will be implemented (Step 4) and monitored (Step 5).

Following satisfactory implementation of any plan modifications, the mitigation planning process and monitoring will terminate (Steps 7 and 8).

(b) Mitigation of Impacts on Botanical Resources

The discussion of mitigation of impacts on botanical resources centers around avoidance, minimization, compensation, and rectification. Avoidance and minimization are, in many instances, related. These types of mitigation involve refraining from unnecessary ground disturbance and regulating particularly disruptive activities, especially those involving heavy machinery and ATV use during summer and fall.

Some of these first mitigation considerations have been incorporated into the timing of construction, the layout and the location of certain proposed facilities. For example, placing of the transmission corridor close to the access road will minimize impact on vegetation by encouraging use of the road for access to tower structures. Winter construction would also limit ground disturbance.

Locating some temporary facilities or undertaking some construction activities within the future impoundment zone will also help minimize the impact on vegetation. If, for instance, access roads or other ground disturbing activities related to the selective clearing of the drawdown area are restricted to the impoundment zone, which will eventually be flooded, then associated impacts will be limited.

The location, too, within the reservoirs of several of the potential borrow areas is another example of how the total impact on vegetation will be minimized.

As mentioned above, regulation of ATV use is an important aspect of avoidance/minimization mitigation methods. During the construction period, if ATV use from the access road is restricted, then a potential impact on vegetation will be minimized. If this restriction is extended into the operation stage (especially from Devil Canyon to Watana), then impact will be further limited.

Another mitigation technique of this type concerns permafrost. In areas along the access road where drainage patterns may be changed, installing culverts or other drainage viaducts will control impacts associated with those changes. A sufficiently thick insulating layer of gravel, placed directly on the vegetation mat, will limit the potential for melting of permafrost. This standard construction technique will avoid those impacts on vegetation associated with permafrost disturbance.

Slash from spruce trees that are cut from the access road or transmission right-of-way will increase the potential for spruce bark beetle infestation. The burning of the spruce slash would limit or remove this potential.

In areas that will be directly affected, such as the impoundment zones, dams and spillways, airstrip and other permanent facilities, the elimination of vegetation/habitat area cannot be avoided. Compensation for losses of wildlife habitat could be provided, however, in adjacent open and woodland spruce stands and/or downstream balsam poplar stands. Downstream balsam poplar stands, in particular, provide the greatest opportunity for increased browse production and are located in prime moose range, where increased browse production can be more fully utilized by a consistently productive herd. Compensation techniques could include clearing (commercial or otherwise) and/or burning to enhance sprouting of poplar, birch, and willow species. Commercial clearing of downstream stands will be economically attractive, and will benefit moose, and will probably also increase the value of timber in the area, as decadent and diseased stands of balsam poplar and birch are cut and replaced by younger, healthier growth. Compensation, as a mitigation technique, for the benefit of wildlife is discussed in greater detail in the wildlife section [3.9 (c)].

Although permanent facilities will eliminate certain areas as vegetation/habitat types, impact from temporary facilities or activities can be somewhat rectified by reclamation. Standard construction practices of either recontouring or creating gentle slopes will help avoid erosion problems and will aid reclamation efforts. Borrow areas, access road cuts, areas of construction activity, and temporary facility sites will be revegetated upon completion of construction. This revegetation process will be greatly simplified and accelerated by stockpiling both topsoil and the organic layer during construction.

The stockpiling and redistribution of this material is the most important part of reclamation. Redistribution of these materials and subsequent fertilization will, in many instances, restore the vegetation cover. The first step in the process is to mix organic material into the upper 10 cm of mineral soils. Adequate fertilization can be accomplished by using fertilizer mixtures high in phosphorous [such as (N,P,K) 10-20-10, 8-32-16, etc.] and applying the fertilizer at a rate sufficient to supply 85 to 110 kg of nitrogen per hectare (75 to 100 lbs. of nitrogen per acre). During the second and third growing seasons, follow-up treatments at one-half to one-third the original rate will probably be warranted.

With topsoil in place, fertilization alone will often provide the necessary impetus for natural revegetation. Where erosion potential or aesthetic considerations are great, however, more intensive revegetation practices involving mulching and seeding, preferably with native species, will be employed. Experience in other regions of Alaska indicates that a relatively light seeding rate, which would establish a sparse stand of grass, is the best way to encourage rapid re-invasion of native plants. Ten to 20 well-established grass plants per square meter (one or two per square foot) would be adequate on sites not threatened by erosion.

(c) Mitigation of Impacts on Wildlife Resources

Following is a discussion of various means that could be employed to mitigate the impacts on wildlife resources that will be incurred as a result of the Susitna project. Mitigation options are identified for each impact issue. The options are then discussed and the most viable courses of action are identified.

Since the impacts are not of equal significance, they have been grouped into three categories. The results of this grouping are presented on Table 3.68. The impact issue numbers on Table 3.68 correspond to the numbers associated with the discussion below. The three categories are high priority, moderate priority, and low priority. Criteria applied in the determination of these categories included the importance of the resource (both biological and consumptive), the likelihood of the impact occurring, and the severity of the impact on the resource. The purpose of this approach was to insure that the emphasis of the mitigation effort is applied in the most appropriate manner.

- (W-1) Watana and Devil Canyon Impoundments - Mink and River Otter

Creation of both impoundments will result in the loss of riverine and terrestrial habitat and an associated decrease in the available food base [See Sections 3.6 (a)(ii) and 3.6(b)(ii)].

o Mitigation Options

Due to the nature of this impact, compensation is the only form of mitigation that is feasible. Since it would be impossible to create suitable terrestrial habitat, in-kind compensation would require taking appropriate steps to insure that the aquatic habitat created by the impoundments would supply an adequate food base for these two furbearer species. If that approach is not possible, some form of out-of-kind compensation would be required.

o Discussion

There would be a negative impact on mink and river otter as a result of the elimination of a considerable amount of both terrestrial and riverine habitat. Conversely, the creation of two large impoundments will result in a net increase in the amount of aquatic habitat available. The important question is how suitable the impoundments will be in providing available feeding opportunities for mink and river otter. The impoundments may, without any action on the part of the applicant, provide an adequate food base to compensate for the predicted loss. Until further details are available, it is difficult to quantify this potential. There are thus three scenarios associated with this situation: 1) the impoundments will be suitable for a healthy fisheries resource and that resource will develop naturally, 2) the reservoirs will be suitable for the establishment of a fisheries resource but the introduction of fish will be required to stimulate the growth of that resource, and 3) the impoundments will not be capable, from a limnological standpoint, of supporting an adequate fisheries resource.

o Conclusion

The predicted impacts on mink and river otter could be mitigated to some degree by a program of establishing a viable fisheries resource in the two impoundments. The first step in such a program would entail determining the suitability of the impoundments to support fish. If the impoundments were determined to be suitable for fish, and if natural processes were determined to be insufficient to develop such a fish resource, a stocking program could be implemented to stimulate the creation of a suitable fish population, which would also provide recreational fishing opportunities. If the development of a fisheries resource, either naturally or as a result of artificial means, were not to prove feasible, the impact could be compensated for through some other species.

- (W-2) Watana and Devil Canyon Impoundments - Pine Marten

Creation of both impoundments will result in the loss of pine marten habitat by flooding [see Sections 3.6(a)(ii) and 3.6(b)(ii)].

o Mitigation Options

It will be impossible to avoid this impact entirely, and unless a project with a lower pool elevation were to be built, no minimization opportunities exist. Therefore, the only feasible form of mitigation is through compensation in an out-of-kind manner.

o Discussion

Due to the nature of pine marten habitat, it will be impossible to manage or create compensatory habitat in the project area. In addition, this species will be severely affected in the project area because the bulk of suitable marten habitat lies within the project impoundment zones.

o Conclusion

Since the marten is an important resource to trappers, any out-of-kind compensatory action would most appropriately involve other furbearer species if at all possible. If the loss of marten habitat and the resultant impact on marten were to be compensated for by improving the habitat for some other furbearer species, either within the project area or outside of the project area, the result would be no net loss to the total furbearer resource. If full compensation were not accomplished, the net loss to the resource would be attributable to the Susitna hydroelectric project.

- (W-3) Watana and Devil Canyon Impoundments - Cliff-nesting Raptors

Due to inundation, a total of 42.5 km of good nesting cliffs will be lost. This reduction in the number of available nesting sites will result in an increase in the importance of the remaining good nesting cliffs in the vicinity of the proposed impoundments [see Sections 3.6(a)(iii) and 3.6(b)(iii)].

o Mitigation Options

Although it would be impossible to avoid this impact, it could be minimized by taking action to allow raptors to utilize the remaining sites. If the raptors do not find the remaining nest sites acceptable, or if attempts to protect these sites fail, it is unlikely that the impact could be compensated for in any in-kind manner, thus necessitating an out-of-kind act of compensation. The following options exist and would serve to minimize the impact by protecting remaining sites.

1. Planning by people such as recreation specialists could attempt to avoid schemes that would bring people in proximity to cliff-nesting sites, at least during the sensitive time period (gyrfalcon: 15 February-15 August and golden eagle: 1 April-31 August) or until June 1 when a nesting site could be determined to be inactive.

2. Activities associated with the clearing of woody material from the impoundments could be scheduled so as to avoid those areas where suitable nesting habitat is expected to remain following flooding.

3. During the construction and operation phases of the project, helicopter traffic could be restricted, unless absolutely necessary, from those areas that are suitable nesting sites. This restriction would need to apply only during the sensitive time period. See Impact Issue W-23 for details on air traffic restrictions.

o Discussion

It would be preferable that raptors currently nesting along the river not be unduly harassed during the construction phase. This protection would increase the likelihood of these birds utilizing alternative sites as presently used sites are inundated. It would be possible to identify potential alternative sites prior to the start of construction. If these sites could be protected, the impact associated with the loss of presently used sites might be minimized.

o Conclusion

If the options identified above were to be implemented, the impact on cliff-nesting raptors could be reduced. Of the three options, numbers 1 and 3 would have the greatest likelihood of achieving the desired reduction in impact. Option number 2 might or might not prove of importance depending on the proximity of areas to be cleared to nesting sites. It is anticipated, that due to topographic factors, the amount of clearing necessary near nesting sites would probably be minimal. If the remaining nest sites were to prove to be unacceptable to raptors, the possibility of erecting artificial nest platforms could also be investigated.

- (W-4) Watana and Devil Canyon Impoundment - Bald Eagle

The two impoundments will result in the loss of bald eagle feeding habitat and the flooding of two of the six active .nests and the one known inactive nest in the area, [see Sections 3.6 (a)(iii) and 3.6(b)(iii)].

o Mitigation Options

A variety of steps could be taken to minimize, and if necessary, compensate for the loss of nesting sites and feeding habitat.

1. During the clearing of the impoundments, clumps of tall spruce trees (where they are available) could be left uncut along the impoundment at 1 to 2 km intervals. The clumps selected should be located in the cleared zone as far from the normal high pool level as possible to avoid their being washed away during unusually high water periods. If other conditions permit the existence of a large eagle population, but suitable trees are not available, artificial perching sites could also be provided.

2. Following inundation, eagle nesting could be monitored to determine if eagles are successfully locating and using alternative sites. If it were determined that the eagle population had suffered due to a failure to use the remaining nesting opportunities, artificial nesting platforms could be erected in suitable locations.

3. If limnological conditions were suitable, and the impoundments did not naturally develop a suitable fisheries resource, efforts could be undertaken to stock fish species to generate a good food base for bald eagles. Species with recreational fishing potential could be selected.

o Discussion

Although some eagle nests and suitable nesting sites will be lost as a result of the project, the creation of two large impoundments may, if suitable conditions exist, result in a greater abundance of bald eagles using this area in the future than are currently found here. If the proper steps were taken, this potential increase in eagle abundance and some form of management could function as a form of out-of-kind compensation to offset losses suffered by other species.

o Conclusion

The three mitigation options identified above would all be feasible and if implemented could serve not only to minimize the magnitude of the predicted impact, but also possibly to increase the present bald eagle population as a form of compensation for impacts on other species. Of the three options, numbers 2 and 3 would be the most important in terms of achieving the desired goal.

- (W-5) Watana and Devil Canyon Impoundments - Forest-dwelling and Riverine Bird and Small Mammal Species

The two impoundments will inundate a large percentage of the forested habitats in the vicinity of the project with a resulting negative impact on those bird and small mammal species that utilize these habitat types [see Sections 3.6(a)(iii) and 3.6(b)(iii)].

o Mitigation Options

It will be impossible to avoid this impact entirely, and unless a project with a lower pool level is selected, no minimization opportunities exist. In-kind compensation is also not feasible since it would be impossible through habitat management techniques to create comparable habitat in the project area. Thus, the only form of mitigation that is feasible is out-of-kind compensation through a different species or group of species.

o Discussion

In the vicinity of the project the type of habitat associated with this group is found primarily within the impoundment zones. Thus, avian and small mammal species that utilize the vegetation cover types that will be inundated will be severely impacted within the project area.

o Conclusion

Since direct in-kind compensation is not practical, the only practical way to offset the losses incurred in this situation would be to increase compensatory efforts in regard to other species where practical mitigation options do exist. One possibility along these lines would be to compensate for this loss of terrestrial habitat by taking advantage of the newly created aquatic habitat (see Impact Issue W-17).

- (W-6) Watana and Devil Canyon Impoundments - Upper Basin Moose Population

The inundation resulting from the two impoundments will reduce the capacity of the area to support moose. Details of this impact are presented in Sections 3.6 (a)(i) and 3.6(b)(i).

o Mitigation Options

The only appropriate form of mitigation in regard to this impact issue would be compensation: it would be feasible through habitat management to compensate for the loss that will be incurred. Habitat management efforts could be carried out in any of the following areas: 1) the upper basin adjacent to the new impoundments, 2) selected portions of the lower basin, 3) a combination of upstream and downstream areas, or 4) some area totally removed from the influence of the project.

The only practical approach to improving moose habitat in the upstream area may be through prescribed burning. In the downstream area, it would be possible to improve moose habitat directly either on selected river islands and/or associated riparian areas, or in more upland situations east of the river. On the islands with more mature stands of timber, logging operations could provide the needed habitat alterations: in those areas that do not contain mature balsam poplar trees, prescribed burning could provide the needed alterations. In upland areas, either burning, crushing, logging, or a combination of all three are possible management options.

o Discussion

The first determination is whether the mitigation efforts should be implemented in the immediate vicinity of the impact (upstream) or if more distant areas are acceptable (downstream). The factors in this decision would be the consequences for the moose population itself, for related species, and for sportsmen. Along the lower river, there are proven techniques available that would, with a high degree of certainty, be effective in achieving the desired mitigation. On the other hand, in the upper basin the only practical option appears to be prescribed burning, and this technique may not be able to produce the desired results under the environmental conditions present. An upstream management effort might so alter the habitat as to enable the existence of a moose population at an artifically high level, and unless long-term management efforts were continued, there would ultimately be a reduction in carrying capacity. (Of course, management efforts in the downstream area might also result in a high moose population that would require long-term management.) By not managing the upstream area, the moose population would be allowed to reach a new, lower level that natural conditions could support.

The status of moose in the upper basin is important to a variety of other species, including: (1) wolves and bears, which prey on moose; (2) caribou, which would probably incur higher wolf predation if the moose population decreased; and (3) numerous scavengers, such as the wolverine and red fox that frequently utilize wolf-killed moose for food. Therefore, allowing the project to reduce the carrying capacity of the upper basin for moose would have indirect impacts on other species.

The impact on sportsmen, although not a biological consideration, should also be factored into the choice. Failing to support upstream moose would not be taken favorably by hunters who use that area, but likewise the improvement of moose habitat in the downstream area would be viewed positively by sportsmen there. In addition, improved access to the upper basin will probably result in greater hunting pressure and an associated demand for game.

An associated aspect is the impact that habitat management would have on other species: some species in addition to moose would also benefit from this type of habitat alteration, while other species would be negatively influenced.

As noted in the list of mitigation options, both the upstream and downstream areas might not be acceptable, and management efforts could be considered for other appropriate portions of the state. Areas of possible consideration could be portions of the upper Susitna basin far removed from the project areas, the Tanana Flats near Fairbanks, the Kenai Peninsula, etc.

o Conclusion

The impact on moose and other species that utilize moose could be mitigated by improving habitat in both the upper basin adjacent to the proposed impoundments and in the lower basin (see Impact Issue W-13). If habitat management in the upper basin were to be conducted, research efforts would first have to be undertaken to gain an understanding of how burning would affect vegetation and, if the results were to prove favorable, a program of prescribed burning could be undertaken. Since the effectiveness of burning is currently questionable, a program of moose habitat improvement along the lower river could also be developed. The ultimate decision as to the distribution of effort between these two areas would have to await the determination of the usefulness of burning in the upper basin.

- (W-7) Watana and Devil Canyon Impoundment - Black Bear

The two impoundments will severely impact local black bear populations [see Sections 3.6(a)(i) and 3.6(b)(i)] by eliminating a large portion of both foraging habitat and denning sites.

o Mitigation Options

The only options in regard to this impact issue are compensation by improving black bear habitat in some other area or compensation in an out-of-kind fashion through some other species.

o Discussion

The presence of a large and healthy brown bear population in adjacent areas and the restriction of forested habitats to the river area restricts the areas inhabited by black bears. Therefore, the black bear population in the project area will be severely impacted, since the impoundments will result in the elimination of most of this habitat in the area. Although the biological consequences to the total Alaskan black bear population will be minimal, black bears are of local value as a game animal. Since there is no possibility of managing the adjacent areas for black bears, the choices are to compensate through mitigation efforts directed at other species, to attempt to improve black bear habitat in areas outside of the upper basin, or to do both. Although the black bear is an abundant species in Alaska, as evidenced by the liberal game regulations, demands for this species as a game animal will probably increase in the future. Thus, this resource will probably be more important in the future than it is now.

o Conclusion

A thorough literature review of the habitat requirements of black bears could be conducted to identify any practical management techniques. These techniques could be implemented in conjunction with moose management along the lower river to improve the same areas for black bears. Encouraging greater black bear abundance, however, could reduce moose calf survival and thus be counterproductive to the goals of the moose management program. On the other hand, the loss of black bears could be compensated for by improving the status or abundance of other species, as, for instance, the above mentioned moose.

- (W-8) Watana and Devil Canyon Impoundments - Brown Bear

The impoundments created by the Watana and Devil Canyon dams will flood an area that is currently used as spring foraging habitat by brown bears [see Section 3.6(a)(i) and 3.6(b)(i)].

o Mitigation Options

Out-of-kind compensation is the only appropriate form of mitigation of this impact.

o Discussion

The distribution of the brown bear is not as restricted to the impoundment area in the upper basin, as is the distribution of the black bear, and thus the inundation of that area will result in the elimination of only a portion of the total area used by this species. As in the case of the black bear (see Impact Issue W-7), it would be impossible to create in another area habitat similar to that lost to inundation. At the present time, it is impossible to predict how much the loss of this area, which appears to be most important during spring, will mean to the brown bear population. This loss, however, will be only one of several project-related impacts on brown bears (see Impact Issues W-14, W-16, W-17, W-18, W-20, and W-23); it may not be in itself of a critical nature, but in conjunction with other impacts may severely influence the future of this species in the project area.

o Conclusion

Little could be done to compensate directly for this impact. Some level of mitigation could be achieved by: 1) increasing compensation efforts directed towards other species, and 2) implementing mitigation options for other impacts on this species to reduce the combined impact on brown bears.

- (W-9) Watana and Devil Canyon Impoundments - Wolf

The Watana and Devil Canyon impoundments will have a negative impact on several wolf packs. The two impoundments will flood moose habitat, and the predicted result is a reduction in the number of moose that will be able to inhabit the project area [see Sections 3.6(a)(i) and 3.6(b)(i)]. This reduction in the number of moose will affect wolves since moose serve as an important, if not the most important, food source for wolves.

o Mitigation Options

The only feasible form of mitigation would be to take steps to maintain the present abundance of moose in the upper basin. If this were to prove impossible, the impact on wolves would have to be compensated for in some out-of-kind manner.

o Discussion

The extent to which the reduction in moose will impact this species is difficult to predict, although it will certainly have some negative impact. Although wolves feed on moose, they also kill numerous caribou; the distribution of caribou, however, varies both from year to year and also among seasons. Thus, caribou do not represent as consistently available a source of food as do moose. Whether or not the upper basin could successfully be managed for moose is questionable and the extent to which the moose population could be maintained through management is unknown (see discussion on Impact Issue W-6). Yet, the location of moose management efforts and their success would be one factor that would influence greatly the future status of wolves in the upper basin.

o Conclusion

If the options for managing upper basin moose (as identified in Impact Issue W-6) were to be implemented successfully, the impact on wolves could be minimized. The project will impact wolves in other ways, and although each impact may not appear severe by itself, collectively they represent a major impact on this species; therefore, the total impact of the project on wolves will depend on the overall mitigation of impacts on wolves.

- (W-10) Watana Impoundment - Dall Sheep

The impoundment created by the Watana dam seasonally will flood a major portion of the Jay Creek mineral lick and thus may negatively impact the sheep population that currently uses it [see Section 3.6(a)(i)].

o Mitigation Options

Compensation for this loss would be the only possible form of mitigation. An artifical lick within the range of the sheep that currently use the Jay Creek lick could replace the inundated mineral lick.

o Discussion

It appears that at least a portion of the Jay Creek lick will be inundated during a part of the year. It is possible, however, that the lick will not be under water during May and June, when most use of the lick occurs. Whether or not the lick will still be usable or acceptable to sheep under project conditions is a matter for speculation. It is also not known how dependent the sheep population is on this lick. Considering the frequency of use and the willingness of sheep to expose themselves to predation in order to reach the lick, however, it must be of some significance to them.

o Conclusion

The following steps could be taken to mitigate this impact:

1. Efforts currently underway to determine the chemical composition of the lick and the number of sheep using the lick could continue.

2. Following inundation, monitoring efforts could be undertaken to actually document the reaction of sheep to the change and the extent to which they continue to use the lick.

3. If the lick is abandoned following flooding, or if the use of it is reduced substantially, an artifical lick could be established using mineral blocks specifically designed to match or improve upon the chemical composition of the current lick. The artificial lick would need to be placed within the natural range of these sheep and preferably in a location where sheep would be less vulnerable to predation.

- (W-11) Watana Impoundment - Caribou

It is possible that ice conditions and/or floating debris will act as a barrier to migrating caribou [see Section 3.6(a)(i)].

o Mitigation Options

The potential problems associated with floating debris acting as a barrier would be minimized by totally clearing all woody material from the reservoir site. If problems were to materialize with floating debris, a removal program could eliminate the barrier. Another option, which would also mitigate the potential impact of hazardous ice conditions, would be to erect temporary fences to direct migrating caribou to safer crossing points. If attempts to direct the Nelchina herd to safe crossing points were to fail, and the herd were to be blocked totally from reaching the present calving area, the only other mitigation option would be to insure that the area it selects for calving would be protected during the calving period.

o Discussion

The severity of this impact will depend on four factors: 1) whether or not conditions actually develop which create barriers, 2) whether or not the caribou are able to locate safe crossing points, 3) whether or not the herd has to cross the impoundment, and 4) if they are forced to calve in a new area, whether or not that area will prove suitable for successful calving. In the past, the Nelchina herd frequently has wintered north of the Susitna River and so has crossed the river as it moves to the calving area on the south side. During the past few years, however, it has wintered east of the calving area (particularly on the Lake Louise Flats) and so has moved in a westerly direction to reach the calving area. Likewise, the herd has not recently moved across the river from south to north after calving, although such a post-calving movement frequently has occurred in the past. It is impossible to predict whether or not the current movement patterns will persist after the impoundment is created. Considering the tendency of caribou herds to suddenly shift migratory patterns, however, it is likely that sometime following inundation they will again attempt to cross in a southerly direction en route to the calving area and/or in a northerly direction following the calving period.

If, as a result of the project rafts of debris, shelf ice, or both exist, and if and when such a crossing takes place, the movement of the herd could be blocked or altered. The conditions present during a crossing attempt will probably vary greatly from area to area and from year to year, and presently it is predicted that caribou will attempt to locate safe crossing points if faced with hazardous conditions. They may also attempt to circumvent the situation by moving around the entire impoundment on the eastern end. If they fail to select safe crossing points, it might be possible to erect temporary fences to alter the direction of their movement and guide them to safer points. If all this were to fail and the herd were to be blocked totally by the Watana impoundment and forced to calve elsewhere, some means could be found to insure the total protection of the herd from human disturbance as it attempts to adjust to a new calving situation.

o Conclusion

If the potential for severe impacts on caribou materializes, they could be avoided or minimized through a program of monitoring, fencing, protection, and debris removal. To eliminate some of the unknowns associated with mitigating these potential impacts, the movements of the herd could be monitored from late winter through the post-calving period. Any such monitoring effort would need to continue until it were to be demonstrated that the herd had either successfully negotiated the impoundment in crossing, or had established a new calving area that would reduce the need for future crossings. In other words, such a monitoring effort would have to continue for at least several years following the first attempt of the herd to cross the impoundment. It is impossible, of course, to predict at this point how long it might be until the Nelchina herd actually attempts a crossing under operating conditions. During the first several springs following the initiation of the project, a reconnaissance survey could be conducted to ascertain the condition of drawdown ice conditions and the existence of any floating debris sufficiently extensive to serve as a barrier.

This information would be needed if an attempt to alter the direction of migratory movements by fencing were to be made. Depending on this review of crossing conditions, a plan for establishing temporary fences could be prepared; if it appears that traditional crossing points will be difficult for caribou to negotiate, fencing material could be placed so that, if monitoring efforts indicated the likelihood of an attempted crossing, fences could be erected quickly.

The fencing would create a visual barrier, not necessarily a physical one. Thus, relatively inexpensive material such as snow fencing or even burlap sheeting could be used. In order to avoid undue interference with other species, such a fencing effort would be employed only when the herd is migrating towards the river and appears to be heading for hazardous crossing points.

If a new calving area is established, it may be feasible to protect the herd from human disturbance during the calving period. Such protection could include a total closure to all human activity during the calving and post-calving periods as well as air traffic restrictions specifying a minimum flight altitude of at least 300 m (1,000 ft) above ground during the calving period and over the post-calving aggregation.

- (W-12) Operation of Devil Canyon Dam - Downstream Beavers

Changes in the flow regime caused by the Devil Canyon dam will affect beavers living downstream from the dam [see Section 3.6 (d)(iii)]. Reduced summer flows may result in the availability of fewer sloughs for use by these aquatic furbearers. The daily fluctuations in flow may also cause unstable ice conditions and make it very difficult for beavers to maintain winter food caches.

o Mitigation Options

The predicted impact on aquatic furbearers in this area could be minimized by reducing the degree of daily flow fluctuations during the winter months and by operating the dam so that flow regimens are as close to natural conditions as possible.

o Discussion

The exact extent of this impact is difficult to predict at this time and will differ between the areas north and south of Talkeetna. Although there may be less summer habitat available, it is possible that higher winter flows may actually increase the amount of suitable overwintering habitat for beavers. If unstable ice conditions exist due to daily fluctuations, however, there could be a net decrease in beaver abundance because they will not be able to maintain food caches which are normally frozen in place by ice. It is anticipated that such ice problems would be most prevalent north of Talkeetna which has comparatively fewer beavers than the area south of Talkeetna.

In addition to serving as an important fur resource, beavers inhabiting the floodplain of the lower Susitna River also aid in the creation of moose browse by cutting trees and opening areas for the generation of early successional shrub species.

Thus, any negative impact on beavers in this area could indirectly reduce the winter carrying capacity for moose. At this time, it is impossible to state what proportion of the moose browse is the result of beaver activity in comparison to other factors that influence the generation of browse.

o Conclusion

If the Devil Canyon dam were to be operated so as to reduce the magnitude of daily fluctuations, then the possibility of negatively impacting downstream beavers would be reduced. Since the activities of beavers can influence the status of other species, such as moose, studies documenting the degree of this influence could also be undertaken. Such studies would be necessary if the total impact on downstream moose, and thus the level of compensatory efforts required, were to be determined (see Impact Issues W-6 and W-13).

- (W-13) Operation of Devil Canyon Dam - Downstream Moose

Downstream from Devil Canyon to Cook Inlet there may be an alteration of plant succession trends due to flow regulation. As a result, there may be a reduction over time in the amount of winter browse available to moose that rely on this area during winter, especially when deep snows prevail [see Section 3.6(d)(i)].

o Mitigation Options

There are several management techniques that could be employed to improve moose habitat in this area in order to compensate for possible reductions in the quantity of browse. These include: 1) commercial logging of mature balsam poplar trees on selected islands; 2) prescribed burning of islands that are not dominated by mature balsam poplar trees; 3) logging, burning, or crushing of vegetation in upland areas east of the river.

o Discussion

Based on the information currently available, it is difficult to accurately predict the extent of this impact. Trends in the quantity of browse will be predictable, as the nature of the river and the number of factors that influence the creation and movements of islands are understood. Still, it will probably be impossible to ever determine the actual quantity of browse that may be lost as a result of the project. If the regulation of the river does cause a reduction in the creation of new islands (and thus areas suitable for the invasion of browse species such as willow), it is expected that two changes will occur in sequence. First, many areas that would have been washed away under present flow conditions will remain secure enough for the development of moose browse; as a result, there will be a short-term (10 - 20 years) increase in the amount of browse available to moose. But, second, as plant succession proceeds and the vegetation matures there will be a gradual long-term reduction in the capacity of the riparian area to support moose during deep snow conditions; there will thus be a reduction in the abundance of moose.

o Conclusions

The possible loss of moose browse could be mitigated if a habitat management program were developed to improve the habitat in the area south of Devil Canyon to support wintering moose. As previously discussed (Impact Issue W-6), this area could also compensate for moose habitat losses in the upper basin.

Moose currently use the riparian area during severe winters. They move to the river both from the east and the west. Those who move into this area from the east move down from the foothills of the Talkeetna Mountains, and many are killed crossing the Parks Highway and the Alaska Railroad. If management efforts were to be directed at areas east of these two transportation corridors, these moose might no longer move into the riparian area to browse. On the other hand, management efforts directly on the river could be undertaken to provide browse for those moose that would continue to enter the riparian area from the west.

The first step would be to identify appropriate areas for management activities; considerations would include ownership and vegetation types, and a correlation of this information with census and movement data being collected by ADF&G. Where appropriate, blocks of mature trees could be removed by commercial logging operations. Prescribed burning could also be used; but due to the extent of human habitation in this area, there could be severe constraints on burning. The use of vegetation crushers also would be a possible management technique in areas where burning and logging might not be feasible.

- (W-14) Clearing of Woody Material From the Impoundments - All Upstream Big Game Species

Big game species will avoid the area being cleared during the period of clearing [see Sections 3.6(a)(i) and 3.6(b)(i)].

o Mitigation Options

In order to minimize the magnitude of this impact on animals existing adjacent to the proposed impoundment zones, the clearing of woody material in the drawdown zone could be conducted during the later portion of the filling period. This would also leave more habitat intact for a longer time. Therefore, the temporal magnitude of the habitat loss that will result from the impoundment will be reduced. In certain cases, the timing of clearing activities could be scheduled so as to minimize disturbance of important wildlife areas.

o Discussion

There is little justification for a large mitigative effort in this area since this impact will be relatively short and basically will impact animals that will be far more severely impacted by inundation and the associated permanent loss of habitat. In addition, there will be differences in the severity of the disturbance depending on the associated big game species.

o Conclusion

If the impoundment zone were to be cleared during the filling period, then the temporal magnitude of this impact could be minimized. The only other mitigation opportunities associated with this impact concern the Jay Creek mineral lick (see Impact Issue W-10). Since sheep may be able to use this lick following inundation, disturbance resulting from any necessary clearing activities in this vicinity could be avoided if no clearing were to be conducted within 2 km (1 mile) of the lick during the months of May and June. This would enable the uninterrupted use of the lick by sheep and possibly allow for continued use following filling.

- (W-15) Clearing of Woody Material from the Watana Impoundment - Caribou

The activities associated with the clearing of woody material from the Watana impoundment will disturb caribou migration to the calving area south of the river and/or post-calving movement to the area north of the river [see Section 3.6(a)(i)].

o Mitigation Options

Two options exist to avoid or minimize the magnitude of this impact: 1) clearing activities could be scheduled to avoid areas used as crossings during the migratory period, and 2) travel lanes could be left uncut to provide sheltered routes across the impoundment zone during the construction period.

o Discussion

Caribou movement patterns are unpredictable. During the clearing period a major movement of the Nelchina herd through the impoundment zone en route to or from the calving area may or may not occur. (Such movements have occurred in the past.)

In order to avoid undue disturbance of this critical activity, certain steps could be taken to minimize disturbance of migrating caribou. Late winter and early spring monitoring of the herd could be conducted to predict if any action were necessary. Clearing schedules could be kept flexible enough to accommodate a shift in the location of clearing efforts if necessary.

It can be argued that little attention should be devoted to this short-term impact since a reservoir will ultimately cover the area in question. Even though the disturbance of migration caused by clearing activities admittedly is a short-term impact, it is also one of many forms of impact to which the Nelchina herd will be subjected as a result of the project (see Impact Issues W-11, W,14, W-17, W-18, W-20, W-22, and W-23). Each impact may not by itself represent a severe impact on the herd, but collectively there could be a major disruption of the activities of this herd with associated negative consequences. Therefore, it is important that each caribou-related impact issue be mitigated to the fullest extent possible in order to minimize the collective effects of all forms of impact.

The major issue in this case is the disruption of the movement of the herd to and from its calving area. If the herd is permitted to cross the river during the clearing and filling phases of the project, its chances of making successful crossings during operation will be increased.

o Conclusion

This impact could be avoided or minimized if travel lanes were to be left uncut until absolutely necessary. Such travel lanes would have to be located between Deadman and Jay creeks and would have to be at least 0.8 km wide. Three or four such lanes would appear to be adequate and would have to be continuous from one side of the impoundment zone to the other.

During the clearing period, the Nelchina herd could be monitored by ADF&G (especially in late winter and early spring) so that the possibility of the herd attempting to cross the river from north to south could be determined. If such monitoring efforts indicate that a crossing is about to occur, clearing operations could be halted in the crossing area for the four to six week period during which crossing normally takes place. (This will likely occur from early April to mid-May.) Any monitoring effort could continue during the early post-calving period, and, if it appears that the post-calving aggregation of cows and calves will cross the river moving north, clearing activities could be temporarily halted in the area of crossing.

- (W-16) Construction Camps/Villages and All Access Roads - Red Fox, Black Bear, Brown Bear, Ground Squirrel, Gulls, and Raven

These species could be negatively impacted as a result of illegal feeding by personnel associated with the construction and operation of the Susitna project. Improper disposal of garbage would also result in an impact on these species.

o Mitigation Options

The following options exist to avoid and/or minimize impacts associated with the feeding of wild animals by humans and the acquired dependency of wild animals on available refuse. Current plans to cover the landfills with soil on a daily basis would help minimize this potential problem.

1. All camp facilities (especially landfills) could be securely fenced with the bottom edge of the fences buried 0.5 m (18 in) below ground.

2. Secure garbage containers could be available in all work areas, and all refuse could be collected and incinerated or disposed of in a properly operated landfill.

3. Work crews could be hired and charged with picking up all discarded refuse from work areas and along all access roads.

4. State laws prohibiting the feeding of wild animals could be strictly enforced by security personnel and repeated violators dismissed from their positions of employment and permanently prohibited from future work on any aspect of the project.

5. A mandatory education program for all project personnel could be prepared and implemented.

o Discussion

Through proper planning and a concerted effort, this is one impact that could be minimized, if not totally avoided. The key element in the successful execution of these options would be the personnel responsible for the actions of all workers associated with the construction effort. It therefore would be critical that all supervisory personnel be impressed with the need to prevent illegal feeding of wildlife and be committed to maintaining a preventative program to that end. All construction contracts and union agreements entered into for this project could clearly identify the agreed-upon rules and regulations that pertain to this issue and the consequences to workers who fail to comply.

o Conclusion

If the mitigation options identified above were to be implemented and if the Watana landfill were to be covered daily as planned, the probability of avoiding or minimizing this impact would be very high.

- (W-17) Main Access Road, Borrow Areas, Access Roads to Borrow Areas, and Construction Camps - All Furbearer Species, Many Avian and Small Mammal Species, and All Big Game Species Except Dall Sheep

These project components will result in a loss of habitat for the indicated wildlife resources. Details of these impacts are presented in Sections 3.6(a), 3.6(b), 3.6(c) and 3.6(e).

o Mitigation Options

The magnitude of this impact could be reduced by arranging camp facilities compactly and keeping them as close to work areas as feasible. Permanent facilities (main access road and town site) will represent a permanent loss of habitat, and compensatory actions through habitat management could be implemented. Areas containing temporary facilities (borrow areas, roads to borrow areas, and temporary camp facilities) could be restored to a condition that would provide usable wildlife habitat.

o Discussion

There are basically three levels of consideration involved with this issue. First, through careful planning the magnitude of the habitat loss associated with these project components could be minimized to some degree. Second, temporary use areas, such as borrow areas and portions of camp facilities, could be restored to allow for some future use by wildlife. And third, unavoidable losses that will result from the permanent portion of the project could be mitigated through compensatory action.

o Conclusion

If the following steps are taken, the anticipated habitat losses associated with the project components mentioned above could be mitigated.

1. As presently proposed, camp facilities will be arranged compactly and located close to work areas in order to avoid undue habitat disturbance.

2. Presently there are plans to restore temporary use areas (borrow areas, roads to borrow areas, and temporary portions of the camp). All topsoil removed from these areas will be stockpiled and saved. In addition, any topsoil removed from areas that will be permanently disturbed could be saved and added to the stockpiles. Following the use of each area, the topsoil will be reapplied and the area regraded, if necessary, to avoid erosion. Restored areas will then be seeded lightly with grasses and fertilized to stimulate the initial growth of native vegetation. During the first year of such an effort,

the recommended fertilizer is a mix high in phosphorous (such as N,P,K 10-20-10 or 8-32-16) applied at a rate sufficient to supply 85-110 kg of nitrogen per hectare (75-100 lbs per acre). During the second growing season, these areas should be fertilized at a rate one-half that of the initial treatment. During the third growing season, they should be fertilized at a rate one-third that of the initial treatment.

3. To compensate for permanent losses to big game species, habitat management efforts could be directed toward moose.

   In the case of avian species, efforts could be expended to improve habitat for certain waterfowl in the newly created aquatic habitat of the impoundments in order to compensate for the loss of terrestrial habitat and associated terrestrial species. Once the limnological suitability of the impoundments to support a good fisheries resource can be determined, an adequate fisheries food base in the impoundments could be insured by stocking appropriate fish species. This aspect of such a compensation program would also benefit aquatic fur-bearers, and such stocking would additionally have recreational potential. Following the establishment of a food base, nest boxes could be erected in adjacent forest areas to provide nesting opportunities for cavity-nesting waterfowl such as goldeneye and bufflehead.

- <u>(W-18) Borrow Areas and Access Roads to Borrow Areas - All Upstream Big Game Species Except Dall Sheep</u>

  The activities associated with borrow excavation and transportation will cause an avoidance reaction by and resultant habitat loss to big game species during the construction period [see Section 3.6(c)(i)].

  o <u>Mitigation Options</u>

  The only option to minimize the magnitude of this impact would be to schedule activity and equipment movement so as to allow animals to utilize the area adjacent to the borrow areas for a portion of each 24-hour period.

  o <u>Discussion</u>

  Limiting human activity in these areas to certain portions of the day may prove effective only for some species. It is likely that moose would benefit from such an arrangement, while species with a greater aversion to man, such as wolf and wolverine, would not respond positively to such an approach.

  o <u>Conclusion</u>

  Duration of this impact will be only the construction period, and it is likely that any scheduling program would be only partially effective. Thus, restoration of these areas so as to secure the long-term availability of the habitat could be more effective than a scheduling program.

- (W-19) All Access Roads - Moose and Caribou

Moose and caribou may be killed as a result of collisions with vehicles using both the main access road and the access roads to borrow areas [see Section 3.6 (e)].

o Mitigation Options

Although it is unlikely that this impact could be totally avoided, steps could be taken to minimize the magnitude of this impact. Construction workers, and especially truck drivers, could be educated concerning the value of wildlife in the area and the need to minimize negative impacts through careful and thoughtful driving. Warning signs could be erected in areas of high collision potential. Speed limits that would reduce the frequency of collisions could be posted and enforced. During winter months when moose and caribou may frequent roads to take advantage of superior traveling conditions, numerous pull-off areas could be plowed clear to give animals opportunities to escape vehicles.

o Discussion

The severity of this impact will depend on several factors, the volume and speed of project-associated traffic, the attitude of the drivers, and the depth and duration of winter snow. Collisions will be a continuing hazard, to both wildlife and motorists, during operation of the project, especially if public access is allowed.

o Conclusion

In conjunction with the educational program to reduce the illegal feeding of animals (see Impact Issue W-16), an attempt could be made to impress upon workers (especially those workers who will be driving trucks and other large equipment) the value of wildlife and the need to avoid killing animals through collisions with vehicles. Speed limits could also be established on the access road and strictly enforced. The appropriate rate of speed would depend on the design of the road, the types of vehicles using the road, etc. To mitigate this potential impact, the speed limit could be kept as low as possible while still allowing for the timely movement of equipment and personnel. Due to the increased frequency of collisions after dark, it would also be advantageous to have two speed limits: one for daylight hours and a lower limit for night. The placement of warning signs at known crossing points could alert motorists to the increased likelihood of encountering moose or caribou on the road.

When extremely deep snow conditions prevail, pull-off areas could be provided along the road to provide opportunities particularly for moose to get out of the way of vehicles. The number of such pull-off areas and the spacing between them would probably vary depending on the associated vegetation cover type and the distribution of the impacted species. Therefore, prior to road construction, areas could be identified where pull-off points will be needed.

- (W-20) Access Roads and Construction Camps - All Upstream Furbearer and Big Game Species, Except Dall Sheep

These project components will result in increased human activity and resulting disturbance and harassment of wildlife, and in increased hunting and trapping pressure on the wildlife resource [see Sections 3.6(a)(i), 3.6(b)(i) and 3.6(e)(i)].

o Mitigation Options

During both the construction and post-construction period there are three options associated with human access and activity in the project areas. First, no effort could be undertaken to restrict or control human access or activity; second, efforts could be undertaken to restrict totally additional activity; and third, is a compromise option in which human access would be permitted during certain times of the year and/or in certain areas.

o Discussion

The improved access associated with the Susitna project and the impact of that improved access on both furbearer and big game species may represent the most severe single avenue of impact on wildlife as a result of this project. It may exceed those impacts associated with habitat loss due to inundation and other aspects of the project that disturb habitats. It is therefore very important that the negative aspects of this source of impact be minimized to the greatest extent possible. Because of the differences in the available control options and also differences in the magnitude of the impact potential, this issue will be considered separately for the construction period and the post-construction period.

Construction Period

During this period there will be a great number of people in the area throughout the year, and the potential for disturbing wildlife is very high. It is assumed, however, that no public use of the access road will be allowed during the construction period. Thus, during this period the opportunity for controlling human activity is greatest since the majority of personnel in the area will be under the direct control of the camp managers and will be in the area primarily for work purposes.

Therefore, although the potential for negative impact is great during the construction period, the opportunity to minimize that impact also would be available and could be used.

Post-construction Period

It is assumed that following construction the access road to Devil Canyon will be open to the general public for whatever use they wish to make of it. It is also assumed that imposing some restrictions on public use beyond Devil Canyon is a potential mitigation option. The magnitude and nature of human activity during this period is expected to differ from that of the construction period, and thus different considerations apply to mitigation planning for the post-construction period.

o Conclusion

The specific steps that could be taken to mitigate these impacts differ in the construction and the post-construction periods and are thus discussed separately.

Construction Period

The best policy that could be adopted for the construction period would be that project personnel would have no greater access to the upper basin than that available to the general public except, of course, access to the actual construction sites. All project personnel could be required to travel directly from the start of the access road to the camp or work area without stopping except in emergencies. Personnel could be restricted from leaving the access road for any reason including to hunt or trap. From mid-April to mid-September, all traffic could be restricted to a time period extending from two hours after sunrise to two hours before sunset in order to provide opportunities for big game species, especially brown bears, to cross the highway without being disturbed by traffic. The need for continuing such a restriction could be determined by means of a monitoring program during the first year of access road use under this restriction.

Post-construction Period

Following the construction period, when the road (at least to Devil Canyon) is open to the general public, ADF&G could monitor the status of big game populations in the area and take whatever regulatory steps would be practical to prevent a game harvest in excess of that which would allow for a sustained yield. The value of continuing some restrictions in access beyond Devil Canyon could be evaluated during the initial years of the post-construction period. In order to minimize undue disturbance of big game, in particular, caribou during the calving and post-calving period, ATV activity from the access road could be prohibited entirely or at least from 1 May to 15 August of each year.

There would be considerable merit to prohibiting ATV use entirely. Such a prohibition would help reduce long-term destruction of vegetation. Restriction of ATV use would be particularly important between Devil Canyon and Watana, where the road traverses open terrain.

- (W-21) Construction Camps and Village - Red Fox and Wolf

The housing of domestic dogs at the camps and villages represents the potential for the introduction of rabies into native canid species. Improper control of dogs could also result in the creation of a population of feral dogs [see Sections 3.6(a)(ii) and 3.6(b)(ii)].

o Mitigation Options

There are two options available to avoid or minimize the possibility of this impact taking place: 1) total prohibition of all dogs in the camp facilities, or 2) regulations concerning the housing and control of domestic dogs.

o Discussion

It is believed that at the present time rabies and feral dogs are not a problem in the upper Susitna basin. The housing of domestic dogs at the camp facilities represents the potential for both of these situations to change. The introduction of rabies would have a potentially severe impact on native carnivores, especially foxes and wolves, which are highly susceptible to the disease. The establishment of a feral dog population would also be a negative impact, although the potential severity of that impact is less than the scenario of a rabies epidemic.

o Conclusion

This impact could be avoided or minimized while still permitting the housing of domestic dogs by camp residents if certain precautions were exercised. Such precautions would include registering all dogs housed in the camp with the camp manager. To prevent the introduction of rabies, certification of immunization could accompany any such registration rule. The potential problem of dogs becoming feral could be avoided by requiring dogs to be under control at all times. If any dog were found outside of the camp area, and not under direct control of the owner, the dog could be destroyed by camp security personnel if reasonable attempts to capture it were to prove futile.

- (W-22) Construction Camps and Access Roads - All Upper Basin Wildlife Species

If unauthorized fires occur, the result could be the destruction or alteration of habitat for many wildlife species. The impacts on the wildlife resource that could result from unplanned fires are great.

o <u>Mitigation Options</u>

In order to avoid this impact, preventative measures could be taken to minimize the potential for the occurrence of uncontrolled fires. Adequate fire fighting equipment could be made available to extinguish any fires that occur at those times and places where the impact would be undesirable (see following discussion).

o <u>Discussion</u>

It has been recognized that fire can be a positive ecological force, rejuvenating vegetation, improving certain wildlife habitats, and releasing soil nutrients. According to field evidences of old burns and restricted tree ages, fire has long been a natural part of the ecosystem in this area. Burns in other northern areas seem to be related to weather patterns and climatic changes. The same may be said for the upper Susitna basin. Hence, the effects of fires of human origin would not be incongruent with the overall scheme of nature. If human safety and property were not threatened, there might be instances when fires could be left to burn their natural course.

On the other hand, since the consequences of fire can be extensive, proper precautions would have to be taken. In addition, in attempting to maintain control over the vegetation/habitat types in specific areas, uncontrolled fire is generally undesirable.

o <u>Conclusion</u>

Part of an education/orientation program for workers (Impact Issues W-16 and W-19), could deal with fire prevention, fire fighting plans and the potential harm to wildlife that fire represents. A program of fire prevention and fire fighting plans could be prepared by the camp manager and strictly enforced. Adequate fire fighting equipment and knowledgeable operators could also be available in the event that a fire occurs. To identify the potential for fires occurring, and thus the level of preventative measures needed during periods of high fire potential, camp personnel could periodically contact the BLM for an evaluation of fire potential. This would be especially important during periods of hot, dry weather. If these precautions were to be taken, the potential for a fire that would negatively impact wildlife would be greatly reduced. Fires that would ultimately benefit wildlife and do not threaten human safety or property could be allowed to burn. A plan could be prepared which would outline various levels of fire suppression to be employed in various portions of the project area.

- (W-23) Air Traffic - All Big Game Species, Raptors, and Trumpeter Swans

These species will be negatively impacted as a result of disturbance caused by air traffic, especially low-flying, large helicopters.

o Mitigation Options

Although there is no way to totally avoid disturbing wildlife as a result of air traffic, there are several options for minimizing this impact. In general, restrictions in both the altitude and location of flying activity could be employed to keep the disturbance to a minimum. Seasonal restrictions also could prove helpful in some cases. Since wildlife species vary in their sensitivity to aircraft disturbance, restrictions could be developed to avoid the most sensitive species (such as brown bears, nesting raptors and trumpeter swans).

o Discussion

It is anticipated that over time some species will acclimate to air traffic, and the negative aspects of disturbance will be reduced. Other species (trumpeter swans, brown bears, and nesting raptors, for example) may be negatively impacted before any such adjustment level is achieved, if one ever is. Therefore, it is very important that air traffic restrictions be designed to minimize impact on such sensitive species.

o Conclusion

If the impact of air traffic disturbance on wildlife is to be minimized, the following restrictions would be required:

1. All air traffic would fly directly to and from the camps or work sites with no unnecessary diversions.

2. Flight distances and weather permitting, all air traffic would maintain an altitude of at least 150 m (500 ft) above ground throughout the upper basin during all seasons.

3. A minimum altitude of 300 m (1000 ft) above ground should be maintained in the following areas:
   - caribou calving area (May and June) and over any post-calving aggregations (June and July)
   - wolf dens (April through July)
   - bald eagle nests (15 March - 31 August) including a horizontal restriction zone of a 0.4-km (0.25 mi) radius
   - gyrfalcon nests (15 February - 15 August) including a horizontal restriction zone of a 0.4-km (0.25 mi) radius
   - golden eagle nests (1 April - 31 August) including a horizontal restriction zone of 0.8-km (0.50 mi) radius
   - the Jay Creek sheep lick (May and June)
   - nesting trumpeter swans near the Oshetna River and other adjacent areas in the upper reaches of the Watana impoundment (May through July).

Some of these areas would have to be identified on a yearly basis in order to keep the location of such critical areas up to date and available for review by personnel responsible for controlling air traffic.

4. Minimize the number of private planes using the Watana airstrip, perhaps by limiting the availability of tie-down spaces.

(d) Mitigation of Impacts on Fish Resources

Under pre-project conditions, fish in the Susitna River are subject to highly variable stream conditions. These conditions are controlled by the extremes in weather and climate of the region. During the summer months, high flows are caused by melting glacial ice, and even higher peak flows occur when a storm coincides with the already high summer flows. In the winter, neither of these events take place, and the flow is reduced to less than 5% of its summer volume. These circumstances, in conjunction with with the streambed and sediment conditions that accompany them, make the Susitna mainstem a less than ideal fishery habitat. In fact, most salmon spawning activity is confined to tributaries and slough environments.

The primary impact areas of the hydroelectric development are the reservoir areas and the Susitna River from Talkeetna to Devil Canyon. The dams themselves will not curtail the migration of any anadromous species because Devil Canyon is, even now, a natural barrier to such migration. The project will, however, alter in many ways the conditions to which fish are subject. Post-project conditions, for example, will alter the timing and volume of downstream flows. Summer peaks will be reduced, and winter flows will increase. Both of these changes could be beneficial to the fish using the Susitna River, but adverse effects are also possible.

The degree to which the project will change conditions and the impacts accompanying those changes will also vary by project stage and location. The stages considered are construction, including filling, and operation and maintenance. The project locations are the Devil Canyon and Watana impoundments, the Susitna River reach downstream to Talkeetna, the reach between Talkeetna and Cook Inlet, and the access road and transmission line routes.

For both the project stages and the locations, various mitigation options are available. These approaches have been preliminarily examined with close attention to the following order: avoiding the impact, minimizing the impact, rectifying the impact, reducing or eliminating the impact over time, and compensating for the impact. Reducing or eliminating impacts includes basic monitoring both of the resource as impacts develop and of the planned mitigation measures.

Mitigation options for dealing with the project's impacts can be categorized in several ways. Operational procedure is one such category. Operational procedures can be designed that will avoid or minimize impacts on the fish or allow for the rectification, reduction over time, or compensation of impacts. Some of these procedures may be project limiting, however, because they may offset project economics or power output.

Regulation of downstream flow to meet fishery needs would be the primary operational procedure for mitigative purposes. An additional flow that could be provided through operational procedures would provide a sufficient amount of water at the proper time to permit or to stimulate outmigration. The power operational flow could probably be adjusted to meet this need. Although daily peaking at the Devil Canyon facility is, in general, viewed as potentially detrimental, under certain circumstances daily peaking for a short time during this period of outmigration could be beneficial to the fishery. Operational procedures that are primarily for power production, with some possible minor modifications, will stabilize the river channel, change the formation of tributary deltas, and reduce summer floods.

Construction or design procedures can also avoid adverse impacts or, at least, minimize them. These include the use of special valves for spilling excess water to avoid or minimize dissolved gas supersaturation and the use of multilevel intakes to regulate water temperatures. Both of these techniques will be described below.

Modification of the existing stream by excavating or by adding gravel to build spawning areas is another type of mitigation opportunity. The placement of the dams on the Susitna River will act to control the extreme conditions that occur naturally and, as will be discussed, may make the conditions in the mainstem more favorable for fish.

Such modifications of the stream, side channels, or sloughs could replace or even increase the amount of usable habitat. The construction of artificial spawning channels or hatcheries can also be used as a mitigative measure to compensate for loss of fish production, but maintaining existing habitat or creating new habitats by way of the modifications just mentioned are more promising options.

A final category of possible mitigation is the management of existing fishery resources to increase their productivity, including the possible stocking of unproductive but viable areas.

- Impoundments

  The impacts associated with construction will be of relatively short duration and masked by the inundation of the area. Intensive management of the recreational fishing in the tributaries above the impoundment water level during the construction stage, however, could protect the grayling populations not directly affected by the construction activities. In addition, insuring that effluent discharges are compatible with the stream's water quality, or discharging waste effluents from the sewage treatment facility somewhere other than into Deadman Creek above the Watana impoundment's upper water level, would protect the grayling fishery that will remain after inundation.

For the resident fish, the inundation of the mainstem will probably result in the formation of new habitats that are as hospitable to the fish as former habitats. Furthermore, since no anadromous fish occur above Devil Canyon, no impacts on anadromous fish are associated with the actual impoundments.

Avoiding or minimizing impacts associated with operation and maintenance of the Watana impoundment is restricted by engineering and economic aspects of the project. For example, fluctuation of the water level and storage of water is necessary to provide needed power during the cold months, which are also the periods of low flow. On the other hand, however, the annual fluctuations of approximately 27 m (90 ft) in Watana will inhibit the formation of a littoral zone, which is a general requirement for cover and food for rearing fish in lakes; for some species, it is also a necessity for spawning habitat.

Adverse impacts may be rectified by managing the stream areas not inundated or by developing a resident sport fishery in the reservoirs, the latter of which could provide a replacement for lost stream fishery habitat. Development of a resident reservoir fishery may be limited by post-project water quality of the reservoirs.

The ability to establish a fishery in the reservoir will depend on the water quality characteristics that develop. Although fisheries in other glacially fed lakes in this region have not been very productive, indications are that conditions could be present that would allow at least a limited fishery to be established in the impoundments. A clear, productive upper layer of water in the reservoir will aid in the development of such a fishery. Initial investigations on the settling rate of incoming sediment, combined with the length and depth of the Watana reservoir, indicate that the necessary clear layer could develop. The fraction of incoming sediment measuring two microns or less, however, may cause the reservoir to remain cloudy in summer and, thus, limit the prospects for establishing a good reservoir fishery.

Gas balance of nitrogen and oxygen in the Devil Canyon reservoir is another impact that can be solved. Installing cone-type valves for spilling instead of using conventional spillways will solve the problem of entraining nitrogen and oxygen and thus eliminate a problem for fish in the Devil Canyon reservoir and downstream. A further control is to prevent the valve discharges from plunging more than .6 m, on the average, below the surface. This precaution would keep the levels at or above those naturally occurring. These measures are part of the proposed design.

As previously mentioned, the placement of the Devil Canyon facility at the upper limit of the salmon migration is a positive factor in the design of the project. No part of the present range or habitat of the five species of Pacific salmon is excluded by the project. Although it is not within the scope of this study to evaluate the enhancement potential of the upper Susitna River basin above Devil Canyon, whether or not the project precludes this possible enhancement can be evaluated on a preliminary basis. For example, to permit salmon access farther into the upper basin, the natural barrier of Devil Canyon (without the project) or the barrier represented by the dams (with the project) would need to be circumvented in some manner.

More significant, however, is the consideration that any enhancement plans for the basin above Devil Canyon requiring the use of the Susitna for outmigration would be made more difficult by the downstream passage problems presented by the dams. A suggestion has been offered in the past for enhancing the salmon resources of the upper basin by connecting Lake Louise to the Copper River drainage. Such enhancement, while never entertained by the present study, would not be precluded by the Susitna project. Of course, if any suitable habitat for salmon presently exists in the areas of the planned impoundment zones, it would be eliminated by inundation. Obviously, any proposed action to permit salmon access to the reaches of the upper basin where they do not occur naturally would have other environmental implications that would need to be evaluated.

- Downstream

Mitigation activities associated with downstream impacts during the construction stage would be minimal. Avoiding or minimizing impacts could be accomplished principally by close inspection of the work to see that all prudent measures are undertaken to reduce turbidity or to prevent any toxic materials from entering the river.

Impacts associated with downstream temperature regimes could be avoided during some periods of the year and minimized during other periods by the use of multilevel intakes which would provide a mixed flow with water temperatures equal or near to naturally occurring conditions. The appropriate multilevel intakes, if included in the design, will allow for temperature regulation of discharged waters. Downstream water temperatures can then be regulated to follow the naturally occurring temperature regime as closely as possible and thus to reduce or minimize the impact on fish resources. Table 3.70 gives the predicted temperature values with intake structures that will draw from the surface and the depths of the reservoirs. Stream reaches that will have the correct temperature conditions for egg development and emergence at the proper time could be considered for management of salmon fisheries and for modifications to provide additional habitat.

If the primary water supply for developing salmon eggs during the winter comes from aquifers that are charged by high water levels in the Susitna River, then presently projected flows during the summer will not be sufficient to recharge these aquifers. In addition, during the post-project period, the projected summer flows will not allow salmon access to many slough and side channel areas. Avoidance of this impact may require increasing the river flows either during the summer or sometime before the winter season begins for whatever length of time is necessary to recharge the aquifers. It is believed that a downstream flow of approximately 19,000 cfs for about 50 to 60 days, keyed specifically to spawning salmon needs, would avoid most or all of the impacts on the salmon fishery in the Talkeetna to Devil Canyon reach by allowing slough and side channel access. Some flow less than 17,000 cfs for the same period of time could minimize the impacts, but what that flow rate is is unknown.

For success in reconstructing habitat areas, modifying existing habitats, and altering the streambed in any way, a stipulated flow would have to be maintained that would provide the necessary water of the required quality. The alteration of the sloughs or mainstem to provide for spawning type habitat would be similar to creating an artificial spawning channel but with the benefit of maintaining the wild stock of fish. Flows adequate for outmigration would need to be maintained for any management or other mitigation option to work. Flow regulation fitted to the needs of outmigrating salmon could probably be accommodated within the constraints of project operations. The need for and success of this flow manipulation for outmigration would be dependent, however, upon having previously maintained or established conditions necessary for spawning, incubation, and rearing of some of the salmon species.

Rearing habitat for species that currently use the slough and side channel areas may still be available in the mainstem during the post-project period. It is not known whether the conditions that may be present would meet the habitat needs for rearing.

Artificial spawning channels and hatcheries could also be considered. The use of artificial spawning channels and hatcheries can be used to replace the fish that would be lost during the post-project period. The placement of these type of facilities, however, depends on finding a source of water that is suitable. In addition, for the fish produced from artificial spawning channels and/or hatcheries to be useful to the commercial fishery the location is critical. Such facilities must be placed in a location that will allow maximum harvest of hatchery or spawning channel fish without affecting the management of the natural runs.

The use of the mainstem Susitna as a transportation route should not be affected by the project flows. Likewise, tributary access should not be blocked, as it is anticipated that high flows from the tributaries will lower the mouths to the post-project stream levels. Once the flows can be regulated from the partially filled reservoirs, certain levels could be provided to coincide with the timing of the salmon runs. At these times, stipulated flow levels would be implemented that are suited to the needs of the salmon with consideration either to improvements of the stream channel or side sloughs or to other mitigative measures which may be undertaken.

Stable summer flows and increased winter flows, accompanied by a reduction in turbidity during the summer, should increase the habitat available for resident fish. In addition, another positive impact of increased winter flows will be the possible addition of overwintering areas for both salmon and resident fish. On the basis of available information or post-project mainstem habitat conditions for the rearing of fish, however, it is difficult to assess accurately the actual suitability of this habitat for overwintering.

A more stable channel and reduced or eliminated floods would make it possible to insure that any river area used by fish for spawning would not be destroyed by a major flood. In addition, except during an unusual flood period, any gravel deposited for spawning purposes would not be carried away.

Controlling floods and eliminating flood peaks could be made possible by operational procedures that reduce or eliminate spills. Many operational modes have been examined in an effort to accomplish this objective. Presently, spills from the hydroelectric development are not expected to occur more frequently than four or five times in 30 years, with only one of the spills being of significant volume. Additionally, consistent, stable summer flows may be necessary to mitigate post-project impacts in the Devil Canyon to Talkeetna reach.

Prior to completion of the Devil Canyon dam, the downstream reach of the Susitna may be affected by daily peaking at the Watana reservoir. During this period, currently projected to be nine to ten years long, the daily fluctuations in flow are expected to be about 4,000 cfs, with flows ranging from approximately 8,000 cfs to 12,000 cfs. The Devil Canyon cofferdam will be in place during this time, however, and its presence is expected to attenuate, to some extent, the daily flow variation downstream. Should additional regulations of these flows be necessary for fishery mitigation, a re-regulation device could be installed on the cofferdam. Once the Devil Canyon dam is in place, the peaking at Watana will not affect the downstream reach because Devil Canyon will have the effect of re-regulating the flows. Some daily peaking is currently planned for the Devil Canyon facility, but it will be of relatively small magnitude. Significant power peaking flows, however, would cause downstream impacts of a much greater magnitude.

A construction activity that could potentially provide a positive impact is associated with the construction of the tailrace tunnel at Devil Canyon. It has been suggested that the rock excavated during construction of the tailrace tunnel be crushed to the size of spawning gravel and returned to the Susitna River. If this action were taken, the gravel would be a positive addition to the Susitna's substrate, since in the reach from Devil Canyon to Talkeetna, the river is presently thought to contain very limited suitable spawning gravel. The reduction in flow and the limiting of flood peaks, both described above, will make it possible for spawning-size gravel to possibly provide a substrate for improving fishery habitat in the mainstem.

Another aspect of flow that has been examined is the mechanism for spilling from the two dams. The present plan provides for all floods up to the one-in-50-year flood to be passed through cone-type valves. As described above under Impoundments, this procedure for spilling will reduce the plunging of spilled waters to an average of about 0.6 m or less. This control of plunging flows will provide benefits downstream similar to those afforded the reservoir, that is, it should keep the supersatura- tion of gases, particularly nitrogen and oxygen, at or below the level that occurs naturally below Devil Canyon.

Below the confluence of the Chulitna, Susitna, and Talkeetna rivers, the contribution of waters from the Chulitna and Talkeetna rivers is expected to reduce greatly or to eliminate the potential for impacts resulting from flow alteration in the upper river. In addition, the load contribution from the Chulitna River will probably mask any reduction in suspended material caused by settling behind the dams. As one progresses downstream, the differences between pre- and post-project conditions will be less and less apparent until, eventually, any change will be well within the range of natural fluctuations. No adverse water quality changes are expected in the lower Susitna River. Possibly the change in flows below Talkeetna could lower the stage in certain areas and thus limit access to some of the sloughs and side channels used for spawning. Should this happen, then a possible mitigation measure that would avoid impacts or minimize them would consist of some alteration at the mouths of the sloughs or tributaries.

Reducing or eliminating impacts through stream stocking and lake fertilization may also be used. Several lakes in the Susitna River drainage that may have management potential have already been identified by the Fisheries Rehabilitation Enhancement & Development (FRED) Division of ADF&G. These, plus other possible locations, could be considered for future management activities.

The number of fish that will be adversely affected by the project represents a relatively small portion of the total fish population using the Susitna River system. Mitigation of these adverse impacts could most likely be accomplished by a program combining various approaches; such techniques may even improve the fisheries. Although improvement of fish stocks is not a re- quirement, considering the present size of the stocks versus its potential size with active management, improvement of the fish resource is a definite possibility.

- Access Road - Borrow Areas - Transmission Lines

A majority of potential impacts associated with the construction, operation, and maintenance of access roads, borrow areas, and transmission lines can either be reduced significantly or eliminated completely. A major portion of the impacts associated with public access and stream sedimentation will be avoided if the mitigation measures already described by Acres are implemented (Acres American Access Route Selection Report 1981). For example, it is assumed that the access road will be controlled as a private road during construction of both dams and that, subsequent to construction, management policies will be established for future use of the road. Furthermore, many potential impacts can be avoided if restrictions on off-road vehicle use are imposed and if some restrictions are placed on public access beyond Devil Canyon. Additionally, it has been assumed that, whenever feasible, borrow sites for the access road (as well as those for dam construction) will have a buffer strip of undisturbed land between them and any nearby aquatic habitat. Such a buffer strip, however, is not currently planned for Borrow Area F, along Tsusena Creek, although the streambed itself will not be excavated. Finally, it has been assumed that borrow sites will be revegetated [Section 3.9 (b) (ii)].

o Road Design and Construction

Road design and construction can incorporate measures to minimize mass-movement erosion of sediment into streams represented by soil creep, slump earth flows, debris avalanches, and debris torrents. Control of these phenomena can be accomplished by avoiding placing roads on the midslope of steep, unstable slopes; by reducing excavation to a minimum; in conjunction with a balanced earthwork design, by designing cut and fill slopes at proper slope angles; by providing vegetative or artificial stabilization of cut and fill slopes; and by constructing retaining walls to contain unstable slopes. Except at stream crossings, roads can be situated so as to provide a buffer strip of undisturbed land between the road and any streams. In addition, if bridges and arch culverts are used for stream crossings where anadromous or migratory resident fishes are present, the potential for impact on these species will be minimized. It is assumed that culverts will be of appropriate size and design and will be installed properly to permit fish passage. Any low water crossings may cause impacts if downstream fish resources are present. Where any such crossings are used, impacts can be reduced if the crossings are properly maintained and utilized only by light vehicular traffic and not by large construction vehicles.

It is assumed that permafrost areas will be avoided whenever possible. Any permafrost regions that cannot be avoided could perhaps be crossed on slopes where bedrock is near the mantle surface. If high ice waste piles are compact and covered with some form of insulation, rapid melting and subsequent siltation in streams can be prevented.

Erosion resulting from drainage from road surfaces can be minimized. Designs such as open-top culverts, rolled grades, cross drains, or shallow ditches are usually suitable drainage devices.

Some potential impacts can be avoided if construction work within or adjacent to streams and water channels is not attempted during periods of high streamflow, intensive rainfall, when migratory fish are spawning, or during crucial rearing times. This mitigation approach applies to transmission line construction as well as to access road construction.

Stream disturbance and resultant impact on fish can occur if logs are skidded or yarded across any stream; such impacts are avoidable. Similar potential impacts can be avoided if log landings are not located on the banks of any stream containing a viable fishery. Logging operations could leave a buffer strip of undisturbed ground and brush along the stream bank. In addition, if heavy equipment is not operated on the stream banks or in the stream channels, it will help minimize siltation. Finally, logging debris can be chipped for use in stabilizing cut banks.

Oil residue from construction equipment and the possible bacterial and nutrient contamination of aquatic habitats resulting from the presence of construction personnel can be minimized by following the standard precautions of the construction industry. It is assumed that oil from machinery will be disposed of properly and not buried at the site. Portable chemical toilets will eliminate possible bacterial and/or nutrient contamination.

o Public Access/Angling Pressure

To control public access further and to protect the fisheries resource from unwarranted angling pressure, additional mitigation measures can be implemented. These would include recommendations made to the proper Alaska management and regulatory agencies to control fishing pressure in the region. Such recommendations will apply especially to the salmon fishery in Indian River and to the grayling and lake trout fishery of the upper basin. Some potential impacts will be avoided if the pioneer road is made inaccessible to public use following its original use.

TABLE 3.1: COMMON AND SCIENTIFIC NAMES OF PLANT SPECIES APPEARING IN THE TEXT

Common Name	Scientific Name
alpine sweetvetch	Hedysarum alpinum
American green alder	Alnus crispa or A. c. subsp. crispa
American red raspberry	Rubus idaeus
balsam poplar (cottonwood)	Populus balsamifera
bearberry	Arctostaphylos spp.
Beauverd spiraea	Spiraea beauverdiana
bigelow sedge	Carex bigelowii
birch	Betula spp.
black spruce	Picea mariana
bladderwort	Utricularia vulgaris
bluejoint	Calamagrostis canadensis
bog blueberry	Vaccinium uliginosum
bunchberry	Cornus canadensis
bur reed	Sparganium angustifolium
cotton grass	Eriophorum spp.
crowberry	Empetrum nigrum
currant	Ribes spp.
diamond willow	Salix planifolia
dryas	Dryas spp.
dwarf arctic birch	Betula nana
feltleaf willow	Salix alaxensis
feather moss	Hylocomnium sp.
highbush cranberry	Viburnum edule
horsetail	Equisetum spp.

TABLE 3.1 (continued)

Common Name	Botanical Name
Labrador tea	*Ledum groenlandicum*
larch (tamarack)	*Larix laricina*
lupine	*Lupinus* spp.
mare's tail	*Hippuris vulgaris*
meadow horsetail	*Equisetum arvense* or *E. pratense*
mountain cranberry	*Vaccinium vitis-idaea*
nagoonberry	*Rubus arcticus*
northern Labrador tea	*Ledum decumbens*
oak fern	*Gymnocarpium dryopteris*
paper birch	*Betula papyrifera*
prickly rose	*Rosa acicularis*
resin birch	*Betula glandulosa*
sedge	*Carex* spp.
Sitka alder	*Alnus sinuata* or *A. crispa* subsp. *Sinuata*
sphagnum moss	*Sphagnum* spp.
tall blueberry willow	*Salix novae-angliae*
thinleaf alder	*Alnus tenuifolia*
trembling aspen	*Populus tremuloides*
twinflower	*Linnaea borealis*
water sedge	*Carex aquatilis*
white spruce	*Picea glauca*
willow	*Salix* spp.
woodland horsetail	*Equisetum silvaticum*
wormwood	*Artemisia telisii*
yellow pond lily	*Nuphar polysepalum*

TABLE 3.2: HECTARES AND PERCENTAGE OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES IN THE UPPER SUSITNA RIVER BASIN (ABOVE GOLD CREEK)[a]

VEGETATION/HABITAT TYPE	Hectares[b]	Percent of Total Area
Total Vegetation	1,387,607	85.08
Forest	348,232	21.35
Conifer	307,586	18.86
Woodland spruce	188,391	11.55
Open spruce	118,873	7.29
Closed spruce	323	0.02
Deciduous	1,290	0.08
Open birch	968	0.06
Closed birch	323	0.02
Mixed	39,355	2.41
Open	23,387	1.43
Closed	15,968	0.98
Tundra	394,685	24.20
Wet sedge grass	4,839	0.30
(Mesic) sedge grass	184,358	11.30
Herbaceous alpine	807	0.05
Mat and cushion	65,001	3.99
Mat and cushion/sedge grass	139,680	8.56
Shrubland	644,690	39.53
Tall shrub	129,035	7.91
Low shrub	515,655	31.62
Birch	33,549	2.06
Willow	10,645	0.65
Mixed	471,461	28.91
Unvegetated	243,392	14.92
Water	39,840	2.44
Lakes	25,162	1.54
Rivers	14,678	0.90
Rock	113,712	6.97
Snow and ice	89,841	5.51
Total Area	1,630,999	100.00

a. Based on maps produced at a scale of 1:250,000.

b. Differences in resolution as a result of differences in scale may result in some discrepancies for common areas between these figures and those presented in Table 3.3.

TABLE 3.3: HECTARES AND PERCENTAGE OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES FOR THE AREA 16 KM ON EITHER SIDE OF THE SUSITNA RIVER FROM GOLD CREEK TO THE MACLAREN RIVER[a]

VEGETATION/HABITAT TYPE	Hectares[b]	Percent of Total Area
Forest	142,306	30.75
Conifer	115,048	24.87
Woodland spruce-black	62,993	13.62
Woodland spruce-white	13,291	2.87
Open spruce-black	28,304	6.12
Open spruce-white	10,460	2.26
Deciduous	4,393	.94
Open birch	1,498	0.32
Closed birch	2,324	0.50
Closed balsam poplar	571	0.12
Mixed	22,865	4.94
Open conifer deciduous	9,639	2.08
Closed conifer deciduous	13,226	2.86
Tundra	114,728	24.81
Wet sedge grass	3,517	0.76
Sedge grass	27,505	5.95
Sedge shrub	20,073	4.34
Mat and cushion	63,633	13.76
Shrubland	177,264	38.34
Open tall shrub	15,524	3.36
Closed tall shrub	15,767	3.41
Birch shrub	42,880	9.27
Willow shrub	8,230	1.78
Mixed low shrub	94,863	20.52
Herbaceous	18	0.01
Grassland	1,079	0.23
Disturbed	24	0.01
Unvegetated	26,979	5.83
Rock	16,603	3.59
Snow and ice	249	0.05
Water		
River	4,236	0.92
Lake	5,891	1.27
Total Area	462,398	99.98

a. Based on maps produced at a scale of 1:63,360.

b. Differences in resolution as a result of differences in map scale may result in some discrepancies for common areas between these figures and those presented in Table 3.2.

TABLE 3.4: HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES WITHIN THE HEALY TO FAIRBANKS TRANSMISSION CORRIDOR

VEGETATION/HABITAT TYPE (a)	Hectares	Percent of Total Area
Forest	86,830	77.9
Woodland spruce	1,812	1.6
Open spruce	31,739	28.5
Closed spruce	1,347	1.2
Woodland deciduous	993	.9
Open deciduous	12,553	11.3
Closed deciduous	10,384	9.3
Woodland conifer-deciduous	961	0.9
Open conifer-deciduous	12,502	11.2
Closed conifer-deciduous	4,125	3.7
Open spruce/open deciduous	948	0.9
Open spruce/wet sedge-grass/ open deciduous	1,993	1.8
Open spruce/low shrub/wet sedge-grass/open deciduous	7,008	6.3
Open spruce/low shrub	465	0.4
Tundra	4,407	3.9
Wet sedge-grass	2,268	2.0
Sedge grass	277	0.2
Sedge shrub	566	.5
Sedge-grass/mat and cushion	1,296	1.2
Shrubland	17,199	15.4
low mixed shrub	15,405	13.8
willow shrub	58	.05
low shrub/wet sedge-grass	1,736	1.6
Agricultural land	175	.2
Disturbed	431	.4
Unvegetated	2,467	2.2
Lakes	196	.2
River	2,143	1.9
Gravel	128	.1
TOTAL AREA	111,509	100.0

a. The Tanana Flats portion of the transmission corridor is an area of extremely complex mosaics of various vegetation types. As a result, various complexes were recognized.

TABLE 3.5: HECTARES AND PERCENT OF TOTAL AREA COVERED BY VEGETATION/HABITAT TYPES WITHIN THE WILLOW TO COOK INLET TRANSMISSION CORRIDOR

VEGETATION/HABITAT TYPE	Hectares	Percent of Total Area
Forest	25,851	67.0
Woodland spruce	2,457	6.3
Open spruce	3,402	8.8
Closed spruce	3,226	8.4
Open birch	16	.04
Closed birch	3,638	9.4
Open balsam poplar	100	.3
Closed balsam poplar	172	.5
Open conifer-deciduous	1,697	4.4
Closed conifer-deciduous	11,143	28.9
Wet sedge-grass	9,123	23.7
Shrubland	2,213	5.7
Closed tall shrub	92	.2
Low mixed shrub	2,121	5.5
Lakes	1,011	2.6
Disturbed	381	1.0
TOTAL AREA	38,579	100.0

TABLE 3.6: VASCULAR PLANT SPECIES RECORDED IN THE UPPER SUSITNA RIVER BASIN WHICH ARE OUTSIDE OF THEIR RANGE AS REPORTED BY HULTEN (1968)

	Equisetum fluviatile
	Lycopodium selago spp. selago
	Lycopodium complanatum
(a)	Picea mariana
	Carex filifolia
	Danthonia intermedia
	Luzula wahlenbergii
	Veratrum viride
	Platanthera convallariaefolia
	Platanthera dilatata
	Platanthera hyperborea
	Listera cordata
	Echinopanax horridum
	Senecio sheldonensis
(a)	Myrica gale
	Ranunculus occidentalis
	Potentilla biflora
(a)	Rubus idaeus
	Rubus pedatus
	Galium triflorum
	Pedicularis kanei kanei
	Pedicularis parviflorus
	Potamogeton robbinsii

a. Viereck and Little (1972) include the upper Susitna River basin in the range of this species.

TABLE 3.7: HECTARES OF DIFFERENT WETLAND TYPES[a] BY PROJECT COMPONENT

Wetland Type	Watana Facility: Impoundment, Dam and Spillways	Watana Facility: Camp, Village and Airstrip	Borrow Areas: A	Borrow Areas: D	Borrow Areas: E	Borrow Areas: F	Borrow Areas: H	Borrow Areas: I
Palustrine forested	7,408		252	16	133	80	345	15
Palustrine scrub-shrub	1,126	142	62	212		199	38	
Palustrine emergent	139		8	8				
Lacustrine emergent	4							
Lacustrine	54	8						
Riverine	2,182							
TOTAL	10,913	150	322	236	133	279	383	15

Wetland Type	Devil Canyon Facility: Impoundment, Dam and Spillways	Devil Canyon Facility: Camp and Village	Devil Canyon Facility: Borrow Area K
Palustrine forested	800		11
Palustrine scrub-shrub	43		29
Palustrine emergent	12		
Lacustrine emergent			
Lacustrine	1		
Riverine	810		
TOTAL	1,666	-0-	40

a. Wetland types according to Cowardin, et al. (1979).

TABLE 3.8: COMMON AND SCIENTIFIC NAMES OF FURBEARER AND BIG GAME SPECIES MENTIONED IN THE TEXT

Common name	Scientific name
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethicus*
Coyote	*Canis latrans*
Gray wolf	*Canis lupus*
Red fox	*Vulpes fulva*
Black bear	*Ursus americanus*
Brown bear	*Ursus arctos*
Pine marten	*Martes americana*
Least weasel	*Mustela nivalis*
Short-tailed weasel	*Mustela erminea*
Mink	*Mustela vison*
Wolverine	*Gulo gulo*
River otter	*Lutra canadensis*
Lynx	*Felis lynx*
Moose	*Alces alces*
Barren ground caribou	*Rangifer tarandus*
Dall sheep	*Ovis dalli*

TABLE 3.9: SUMMARY OF ELEVATIONAL USE (IN METERS) BY APPROXIMATELY 200 RADIO-COLLARED MOOSE (BOTH SEXES AND ALL AGE CLASSES) FROM OCTOBER 1976 THROUGH MID-AUGUST 1981 IN THE UPPER SUSITNA AND NELCHINA RIVER BASINS OF SOUTHCENTRAL ALASKA

Month -	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mean elevation	853	834	788	785	805	820	840	850	837	913	900	900	838
Standard deviation	140.8	142.6	134.8	140.8	136.9	130.0	161.9	155.3	137.7	148.9	146.4	145.0	
Range of elevation													
Min.	549	427	518	457	427	396	---	549	549	427	442	457	
Max.	1,189	1,189	1,402	1,250	1,158	1,341	1,280	1,463	1,219	1,280	1,341	1,402	
Sample size	66	98	285	204	341	424	218	174	130	193	168	116	2,417

TABLE 3.10: NELCHINA CARIBOU HERD POPULATION ESTIMATES, IN FALL UNLESS OTHERWISE NOTED

Year	Total Estimate	Female Estimate	Male Estimate	Calf Estimate
1955	40,000[a]	-	-	-
1962	71,000[b]	-	-	-
1967	61,000[c]	-	-	-
1972	7,842	4,800	1,622	1,420
1973	7,693	4,646	1,268	1,779
1976	8,081	4,979	1,663	1,439
1977	13,936	7,509	2,868	3,559
1978	18,981	9,866	4,429	4,686
1980	18,713	9,164	5,673	3,876
1981	20,730[d]	10,172	6,195	4,364

a. Watson and Scott (1956), February census.
b. Siniff and Skoog (1964), February census, perhaps should be adjusted downward by as many as 5,000 caribou due to presence of Mentasta herd.
c. Felt by some to be an unreasonably high estimate.
d. Preliminary estimate, awaiting final female harvest data.

TABLE 3.11: REPORTED HUNTER HARVEST OF THE NELCHINA CARIBOU HERD, 1972-1981

Year	Total Harvest	Females		Males	
		No.	(%)	No.	(%)
1972	555	153	(28)	338	(72)
1973	629	203	(33)	411	(67)
1974	1,036	343	(34)	656	(66)
1975	669	201	(31)	441	(69)
1976	776	201	(26)	560	(74)
1977	360	77	(22)	275	(78)
1978	539	111	(21)	416	(79)
1979	630	90	(14)	509	(81)
1980	621	117	(21)	453	(79)
1981 (a)	856	144	(18)	675	(82)

a. Preliminary data

TABLE 3.12: SUMMARY OF TERRITORY SIZES FOR WOLF PACKS STUDIED AS PART OF THE SUSITNA HYDROELECTRIC PROJECT STUDIES DURING 1980 and 1981 IN SOUTHCENTRAL ALASKA

Pack		Territory Size (km^2)
Fish Lake		943
Susitna		1,453
Susitna-Sinona		1,208
Tolsona		2,541
Tyone Creek		943
Watana		1,383
	$\bar{x}$	1,412
	S.D.	541

TABLE 3.13: ESTIMATE OF NUMBERS OF WOLVES BY INDIVIDUAL PACK INHABITING THE SUSITNA HYDROELECTRIC STUDY AREA IN SPRING AND FALL 1980 AND 1981

Pack Area	Spring 1980 (Post-Hunt)	Fall 1980 (Prehunt)	Spring 1981	Fall 1981
Butte Lake	3-4?	3-4+	3	5
Fish Lake	?	2	9	12+
Jay Creek	6	7-8?	?	10
Keg Creek	?	?	2-3	2-3
Maclaren River	2	4-5	?	2-3
Portage Creek	?	?	?	6
Stephan Lake	2+	11	?	?
Susitna	4	10	5	4
Susitna-Sinona	4	4-5	2	?
Tolsona	9	16	13	15
Tyone Creek	4	2	0	?
Upper Talkeetna River	?	?	?	2
Watana	5	14	8	14
Total	40	77	42-43	72-74

TABLE 3.14: SUMMARY OF WOLF DEN AND RENDEZVOUS SITES DISCOVERED FROM 1975 THROUGH 1981 OCCURRING WITHIN AN 80 KILOMETER RADIUS OF THE PROPOSED SUSITNA HYDROELECTRIC PROJECT IN SOUTHCENTRAL ALASKA

Kilometers from upper water-level	Site		
	Pack Name	Type Site	Year of Documented Use
8	Watana	Rendezvous	80& 81
	Watana	Den	80, 81
	Deadman	Den	75
	Jay Creek	Den	78
	Stephan Lake	Den	76
24	Tyone Creek	Den	79
32	Susitna	Rendezvous	80
	Susitna	Rendezvous	80
	Brushkana	Den	75
40	Mendeltna	Rendezvous	76
	Susitna	Den	79 & 80
	Keg Creek	Den	75, 76, & 78
	Clearwater	Den	76
48	Tolsona	Den 80 & Mendeltna Rendezvous 77	
	Tolsona	Rendezvous 80 & Mendeltna Den 77	
48	Mendeltna	Rendezvous	77
	Mendeltna	Den	77
56	Mendeltna	Rendezvous	77
	Mendeltna	Rendezvous	77
	Mendeltna	Den	76, 77
64	Hogan Hill	Den	78
80+	Hogan Hill	Den	75
	Sinona	Den	78
	Sinona	Den	77

TABLE 3.15: COMPARISONS OF FOOD REMAINS IN WOLF SCATS COLLECTED AT DEN AND RENDEZVOUS SITES IN 1980 AND 1981 FROM GMU-13 OF SOUTHCENTRAL ALASKA

Food Items	1980 727 Scats		1981 290 Scats	
	# Items	% Occurrences	# Items	% Occurrences
Adult Moose	105	12.00	24	6.15
Calf Moose	369	42.17	87	22.31
Moose, Age Unknown	22	2.51	21	5.38
Adult Caribou	30	3.43	31	7.95
Calf Caribou	13	1.49	19	4.87
Caribou, Age Unknown	8	0.91	5	1.28
Moose or Caribou	31	3.54	9	2.31
Beaver	48	5.49	37	9.49
Muskrat	26	2.97	24	6.15
Snowshoe Hare	55	6.29	21	5.38
Microtine	40	4.57	37	9.49
Unidentified Small Mammal	15	1.71	20	5.13
Bird	16	1.83	8	2.05
Fish	1	0.11	2	0.51
Vegetation	22	2.51	5	1.28
Wolf	4	0.46	1	0.26
Unknown	70	8.00	39	10.00
Total	875	100.00	390	100.00

(a)

TABLE 3.16: AVERAGE SPRING AGES OF SUSITNA AREA BROWN BEAR SUBPOPULATIONS

Subpopulations	Males: Average Spring Age (Years)	Males: (Range)	Males: n	Females: Average Spring Age (Years)	Females: (Range)	Females: n	Avg. Both Sexes (Years)	% Males
GMU 13 fall harvests, 1970-1980	8.0	(3.5-23.5)	208	7.7	(3.5-28.5)	191	7.9	52
1979 Upper Susitna studies (Miller & Ballard 1980)	7.4	(3.5-21.5)	17	7.4	(3.5-16.5)	15	7.4	53
1980-81 Susitna Hydro studies[b]	7.7	(3.5-14.5)	14	7.9	(3.5-13.5)	15	7.8	48
Su-Hydro studies radio-collared bears w/ $\geq$ 5 locations[b]	6.0	(3.5-10.5)	4	8.6	(3.5-13.5)	13	8.0	24

a. Includes only bears of known sex and age that are 3.0 or older, spring age calculated as age + .5 years.

b. Average of age at first capture

TABLE 3.17: REPORTED BROWN BEAR DENSITIES IN NORTH AMERICA

mi^2/bear	km^2/bear	Location	Source
0.6	1.6	Kodiak Island, AK	Troyer and Hensel 1964[a]
6.0	15.5	Alaska Peninsula, AK	Unpublished data (Glenn pers. comm.)[b]
8.2	21.2	Glacier Nat. Park, Montana	Martinka 1974[a]
11.0	28.5	Glacier Nat. Park, B. C.	Mundy and Flook 1973[a]
9-11	23-27	SW Yukon Territory	Pearson 1975[a]
16-24	41-62	Upper Susitna R., AK	Miller and Ballard 1980
88 (16-300)[c]	288 (42-780)[c]	Western Brooks Range (NPR-A), AK	Reynolds 1980
100	260	Eastern Brooks Range, AK	Reynolds 1976

a. Taken from Pearson 1975.
b. Data refer to a 1,800 mi^2 intensively studied area of the central Alaska Peninsula.
c. Mean is for the whole of the Nat. Pet. Reserve, AK, the range represents values for different habitat types in this reserve where the highest density occurred in an intensively studied experimental area.

TABLE 3.18: COMPARISONS OF MEAN HOME RANGE SIZE OF BROWN BEARS RADIO-COLLARED IN 1978,[a] 1980[b] AND 1981 STUDIES IN GMU-13

	MALES		(c)	FEMALES		(c)	BOTH SEXES		(c)
	1978	1980	1981	1978	1980	1981	1978	1980	1981
Mean home range size (km^2)	769	845	1061	408	160	343	572	409	487
S.D	396	439	1390	222	48	302	356	422	660
Range =	282-1381	495-1409	100-2655	193-734	82-233	50-1136	193-1381	82-1409	50-2655
n	10	4	3	12	7	12	22	11	15
Mean age of sample	6.9	5.5	7.0	8.8	8.9	8.4	7.9	7.6	8.1
Range	3-11	3-10	4-11	4-13	3-13	3-14	3-13	3-13	3-14
Mean No. relocations/ bear =	16.2	10.8	12.7	24.9	11.7	20.8	21.0	11.4	19.1
Range =	8-29	8-14	8-21	12-33	6-15	13-35	8-33	6-15	8-35
% Males							45	36	20
% of females w/newborn cubs				8	0	33			

a. Includes all bears 3 years of age or older
b. Source: Ballard et al. (in press)
c. Includes data through 1 September 1981 only, actual 1981 home range sizes will be larger when all 1981 points are included in analysis

TABLE 3.19: COMPARISON OF REPORTED HOME RANGE SIZES OF BROWN/GRIZZLY BEARS IN NORTH AMERICA[a]

Area	Sex	Sample size	Mean home range (km^2)	Source
Kodiak Island, Ak.	M	7	24	Berns et al. 1977
	F	23	12	
Yellowstone National Park	M	6	161	Craighead 1976
	F	14	73	
Southwestern Yukon	M	5	287	Pearson 1975
	F	8	86	
Northern Yukon	M	9	414	Pearson 1975
	F	12	73	
Western Montana	M	3	513	Rockwell et al. 1978
	F	1	104	
Nelchina Basin	M	14	790	Susitna studies (1978 & 1980 results only)
	F	19	316	
Northwestern Alaska	M	8	1350	Reynolds 1980
	F	18	344	

a. Adapted from Reynolds 1980

TABLE 3.20: EARLY SPRING USE OF DEVIL CANYON AND WATANA IMPOUNDMENT AREAS BY RADIO-COLLARED BROWN BEARS[a]

BEAR ID (age)	Bear visited impoundment area?[a] (No. observations in/total observations) Spring 1980	Spring 1981	Mean elevation of observations in impoundment area (S.D.) 1980	1981
MALES				
G342 (2)	---	no (0/4)	---	---
G293 (3)	no (0/4)	no (0/1)	---	---
G214 (4)	yes (2/4)(to Watana)	---	2038(-)	---
G280 (5)	no (0/3)	yes (10/16)(to Watana)	---	2030(331)
G308a (6)	no (0/2)	---	---	---
G294 (10)	yes (4/4)(to Devil)	no (0/3)	1721(344)	---
sub totals	(6/17)	(10/24)		
FEMALES				
G335 (2)	---	no (0/20)	---	---
G281 (3)	yes (3/5)(to Watana)	yes (9/26)(to Watana)	2025(-)	2119(254)
G340 (3)	---	yes (9/26)(to Watana)	---	2083(301)
G308b (5)	yes (1/5)(to Devil)	yes (6/7)(to Devil)	1350(-)	1863(309)
G344 (5)[b]	---	no (0/6) (w/2 cubs	---	---
G331 (6)	---	yes (1/8)(to Watana)	---	1850(-)
G341 (6)	---	yes (12/17)(to Watana)	---	2160(474)
G313 (6)	no (0/5)	no (0/10)	---	---
G277 (10)	no (0/4)	---	---	---
G312 (10)[b]	yes (1/4 to Watana	no (0/10) w/2 cubs	1750(-)	---
G334 (10)	---	yes (1/22)(to Watana)	---	2525(-)
G283 (12)[b]	yes (3/5)(to Devil	no (0/9) w/2 cubs	2500(-)	---
G299 (13)	no (0/2)	yes (4/10)(to Watana)	---	2063(103)
G337 (13)[b]	---	no 0/7 w/3 cubs	---	---
subtotals	(8/30)	(42/178)		
total	(13/37)	(52/202)		

a. Defined as within 1 mile of impoundment prior to 19 June.

b. Females with newborn cubs tend to remain at high elevations throughout the summer.

TABLE 3.21: NUMBER OF AERIAL BROWN BEAR OBSERVATIONS BY MONTH IN EACH OF FIVE HABITAT CATEGORIES

Habitat	May	June	July	August	September	Oct.-April	Row Total (%)
SPRUCE	44	50	17	16	9	5	141
Row %	31.2	35.5	12.1	11.3	6.4	3.5	(25.0)
Column %	31.0	29.6	19.3	17.6	25.0	13.2	
RIPARIAN	16	26	22	20	4	1	89
Row %	18.0	29.2	24.7	22.5	4.5	1.1	(15.8)
Column %	11.3	15.4	25.0	22.0	11.1	2.6	
SHRUBLAND	39	75	46	52	21	5	238
Row %	16.4	31.5	19.3	21.8	8.8	2.1	(42.2)
Column %	27.5	44.4	52.3	57.1	58.3	13.2	
TUNDRA	12	14	1	1	0	0	28
Row %	42.9	50.0	3.6	3.6	0	0	(5.0)
Column %	8.5	8.3	1.1	1.1	0	0	
OTHER	31	4	2	2	2	27	68
Row %	45.6	5.9	2.9	2.9	2.9	39.7	(12.1)
Column %	21.8	2.4	2.3	2.2	5.6	71.1	
Column Total	142	169	88	91	36	38	564
(%)	(25.2)	(30.0)	(15.6)	(16.1)	(6.4)	(6.7)	(100.0)

TABLE 3.22: AVERAGE SPRING AGES OF BLACK BEAR SUBPOPULATIONS IN THE SUSITNA AREA AND KENAI PENINSULA (a)

	Males			Females				
Subpopulations	Average Spring Age (Years)	(Range)	n	Average Spring Age (Years)	(Range)	n	Avg. Both Sexes (Years)	% Males
GMU 13 harvests* 1973-1980	5.6	(2.5-18.5)	115	5.9	(2.5-11.5)	60	5.7	66
1980-1981 Su-Hydro studies**	6.6	(2.5-10.5)	19	8.1	(4.5-12.5)	13	7.2	59
Su-Hydro studies radio-collared bears w/ $\geq$ 5 relocations**	6.9	(2.5-10.5)	14	8.0	(4.5-11.5)	11	7.4	56
Kenai Peninsula studies 1978-1980***	6.2	(-)	45	5.0	(-)	42	5.6	52

a. Includes only bears of known sex and that are 2.0 years or older, spring age calculated as + .5 years.

* Includes all bear ($\geq$ 2 years) aged and sexed, in recent years not all teeth have been sectioned and read

** Represents age at first capture

*** Based on total bears known to be alive in each of the years of the study (same bear counted more than once). This procedure should yield a relatively older mean age than the procedure used in calculating mean age in Susitna studies. Data from the Kenai Peninsula from C. Schwartz, ADF&G, pers. comm.

TABLE 3.23: DENSITIES OF BLACK BEARS AS ESTIMATED IN STUDIES CONDUCTED IN DIFFERENT LOCALITIES

Source	Location	mi^2 Per Bear	km^2 Per Bear
McIlroy (1972)[(a)]	Alaska (coastal population)	0.1	0.3
Lindzey and Meslow (1977)	Washington (an island population)	0.3	0.8
Poelker and Hartwell (1973)	Washington (mainland population)	0.7-1.0	1.8-2.6
Piekielek and Burton (1975)	California	0.8-1.0	2.1-2.6
Beecham (1980)	Idaho (Council area)	0.8	2.1
	Idaho (Lowell area)	0.9	2.3
Jonkel and Cowan (1971)	Montana (Bear Creek)	0.8-1.7	2.1-4.4
LeCount (1980)	Arizona	0.8	2.1
Pelton and Burghardt (1976)	Tennessee	0.5-1.0	1.3-2.6
Kemp (1972)	Alberta	1.0	2.6
Modafferi (1978)	Prince William Sound, Alaska	1.2	3.1
Schwartz and Franzmann (1981)	Kenai Peninsula, Alaska	1.5	3.9
Erickson and Petrides (1964)	Michigan	3.4	8.8
Spencer (1955)	Maine	5.6	14.5
Clarke (1977)	New York (Adirondacks)	2.6	6.7
	New York (Catskills)	3.7	9.6
	New York (Allegany State Park)	10.0	25.9

a. Probably estimated during season concentration.
Source: Modified from Modafferi 1978

TABLE 3.24: COMPARISONS OF MEAN HOME RANGE SIZE OF BLACK BEARS RADIO-TRACKED IN 1980 and 1981 STUDIES IN GMU 13 (a)

	MALES			FEMALES			BOTH SEXES		
	1980	1981	1980 & 1981	1980	1981	1980 & 1981	1980	1981	1980 & 1981
Mean home range size (km^2)	46	250	153	16	219	117	31	235	136
S.D	42	180	167	16	368	274	35	278	223
Range	4-136	37-611	4-611	3-45	12-1036	3-1036	3-136	12-1036	3-1036
n	10	11	21	10	10	20	20	21	41
Mean age of sample	6.3	7.4	6.9	7.8	8.1	8.0	7.1	7.7	7.4
Range	2-10	3-11	2-11	5-11	4-12	5-12	2-11	3-12	2-12
Mean No. relocations/ bear =	9.2	19.4	14.5	10.4	16.5	13.5	9.8	18.0	14.0
Range	5-17	7-40	5-40	6-20	6-34	6-34	5-20	6-40	5-40
% Males							50	52	51
% of Females w/newborn cubs				30	40	35			

a. Includes all bears 2 years of age or older

TABLE 3.25: NUMBER OF AERIAL BLACK BEAR OBSERVATIONS BY MONTH IN EACH OF FIVE HABITAT CATEGORIES

Habitat	May	June	July	August	September	Oct.-April	Row Total (%)
SPRUCE	82	95	54	68	44	15	358
Row %	22.9	26.5	15.1	19.0	12.3	4.2	(39.4)
Column %	50.3	46.3	35.8	31.8	30.8	46.9	
RIPARIAN	23	33	23	18	23	1	121
Row %	19.0	27.3	19.0	14.9	19.0	.8	(13.3)
Column %	14.1	16.1	15.2	8.4	16.1	3.1	
SHRUBLAND	50	70	69	119	71	9	388
Row %	12.9	18.0	17.8	30.7	18.3	2.3	(42.7)
Column %	30.7	34.1	45.7	55.6	49.7	28.1	
TUNDRA	3	3	3	6	2	0	17
Row %	17.6	17.6	17.6	35.3	11.8	0	(1.9)
Column %	1.8	1.5	2.0	2.8	1.4	0	
OTHER	5	4	2	3	3	7	24
Row %	20.8	16.7	8.3	12.5	12.5	29.2	(2.6)
Column %	3.1	2.0	1.3	1.4	2.1	21.9	
Column Total	163	205	151	214	143	32	908
(%)	(18.0)	(22.6)	(16.6)	(23.6)	(15.7)	(3.5)	(100.0)

TABLE 3.26: TABULATION OF NOVEMBER, 1980 AERIAL SNOW TRANSECT DATA, INDICATING THE NUMBER OF FURBEARER TRACKS, BY SPECIES NOTED ON TRANSECT [a]

	Species					
Transect Number	Pine Marten	Red Fox	Short-tailed Weasel	Mink	River Otter	Transect Totals
01	41	1	3	5	2	52
02	80	0	7	1	6	94
03	91	9	5	3	0	108
04	198	0	20	0	3	221
05	84	0	11	1	0	96
06	163	0	6	0	1	170
07	202	23	39	0	2	266
08	86	11	0	2	5	104
09	85	11	1	2	0	99
10	125	20	95	2	3	245
11	39	30	58	2	1	130
12	40	38	96	5	1	180
13	7	60	77	5	3	152
14	112	10	328	6	3	459
Species TOTALS	1353	213	746	34	30	2376

a. See Figure 3.20 for location of transects

TABLE 3.27: BACKGROUND INFORMATION FOR RADIO-COLLARED MARTEN, TSUSENA CREEK AREA, 1980

Collar Number	Sex	Age Class	Weight (g)	Capture Date	Remarks
519	male	adult	1440	22 Aug 80	Testes scrotal
				23 Aug 80	Released from trap
				25 Sep 80	Released from trap
520	male	adult	1370	27 Aug 80	Testes scrotal
518	male	adult	1380	9 Sep 80	Testes receding
			1120	25 Nov 80	Transmitter dead, last heard 12 Nov, transmitter re-placed
516	male	?	1260	2 Nov 80	This animal caught by a trapper on 28 Nov.

TABLE 3.28: OCCURRENCE OF BEAVER SIGNS ALONG THREE SECTIONS OF THE LOWER SUSITNA RIVER[a]

River Section	Kilometers Surveyed	Beaver Sign Number Cuttings	Cuttings per Km	Number Houses	Houses per Km
Section I	62	12	.19	2	.03
Section II	30	7	.23 (.46)[b]	2	.06 (.12)
Section III	26	16	.62 (1.86)	4	.15 (.45)
Entire Survey	118	35	.30	8	.07

a. Section I=Devil Canyon to Confluence with Talkeetna and Chulitna Rivers, Section II=Confluence with Talkeetna and Chulitna Rivers to Confluence with Montana Creek, Section III=Confluence with Montana Creek to Delta Islands

b. Numbers in parenthesis are adjustments to realistically reflect signs present in Sections II and III. Signs were multiplied by a correction factor of 2 in Section II and a factor of 3 in Section III. The increasing width and braiding of the river permitted the team to see approximately half the signs in Section II and only a fourth to a third in Section III.

TABLE 3.29: RESULTS OF OTTER AND MINK SURVEYS, SUSITNA RIVER, 10 THROUGH 12 NOVEMBER 1980. NUMBERS OF TRACKS OF EACH SPECIES OBSERVED AT NORTH AND SOUTH SIDES OF 37 RIVER CHECK POINTS[a]

Checkpoint	North		South	
Numbers	Otters	Mink	Otters	Mink
01	3	0	0	0
02	0	2	0	0
03	0	0	0	0
04	0	0	3	1
05	0	0	2	0
06	0	0	0	0
07	0	1	0	1
08	0	0	0	2
09	0	0	1	0
10	0	0	0	2
11	4	1	0	1
12	3	1	0	0
13	0	0	0	1
14	2	0	3	1
15	0	0	4	0
16	3	1	0	2
17	0	3	0	4
18	0	0	0	2
19	0	0	1	2
20	2	0	1	0
21	1	1	0	0
22	0	0	0	0
23	2	1	0	2
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	4	0
28	0	0	4	0
29	0	0	0	2
30	0	0	0	0
31	0	0	0	0
32	0	0	0	3
33	0	2	0	3
34	0	1	0	2
35	0	1	2	3
36	0	0	2	2
37	0	1	0	2

a. See Figure 3.20 for location of checkpoints

TABLE 3.30: TABULATIONS OF NOVEMBER, 1980 AERIAL SNOW TRANSECT DATA, INDICATING THE DISTRIBUTION OF FURBEARER TRACKS, BY SPECIES NOTED IN VARIOUS VEGETATION TYPES

	Species					
Vegetation[(a)] Type	Pine Marten	Red Fox	Short-Tailed Weasel	Mink	River Otter	Vegetation Type Totals
White Spruce Forest	35	1	4	0	0	40
Birch Forest	3	0	2	0	0	5
Poplar Forest	0	0	1	0	0	1
Black Spruce Forest	0	2	0	0	0	2
Mixed Forest	54	0	1	0	0	55
Mat & Cushion Tundra	3	5	29	0	0	37
Sedge-grass Tundra	7	3	0	0	0	10
White Spruce Woodland	525	5	88	1	0	619
Black Spruce Woodland	605	61	401	3	1	1071
Mixed Woodland	29	0	5	0	0	34
Low Shrub	12	9	8	0	0	29
Medium Shrub	35	108	190	0	0	333
Alder Shrub	25	2	11	0	0	38
River Ice (Including Shelf Ice)	2	1	2	20	20	45
Lake Ice	0	4	0	0	0	4
Creek Ice	6	0	2	4	2	14
Marsh	3	4	0	3	0	10
River Bar	9	8	1	3	7	28
Rock	0	0	1	0	0	1
Species Totals	1353	213	746	34	30	2376

a. 0-10% Forest Canopy Cover = Shrub
11-60% Forest Canopy Cover = Woodland
60+% Forest Canopy Cover = Forest
25+% Secondary Tree Species = Mixed

TABLE 3.31: COMMON AND SCIENTIFIC NAMES OF BIRDS MENTIONED IN TEXT

Common loon
Gavia immer

Arctic loon
Gavia arctica

Red-throated loon
Gavia stellata

Red-necked grebe
Podiceps grisegena

Horned grebe
Podiceps auritus

Whistling swan
Olor columbianus

Trumpeter swan
Olor buccinator

Brant
Branta bernicla

Canada goose
Branta canadensis

White-fronted goose
Anser albifrons

Snow goose
Chen caerulescens

Mallard
Anas platyrhynchos

Gadwall
Anas strepera

Pintail
Anas acuta

American green-winged teal
Anas crecca carolinensis

Blue-winged teal
Anas discors

American wigeon
Anas americana

Northern shoveler
Anas clypeata

Redhead
Aythya americana

Ring-necked duck
Aythya collaris

Canvasback
Aythya valisineria

Greater scaup
Aythya marila

Lesser scaup
Aythya affinis

Common goldeneye
Bucephala clangula

Barrow's goldeneye
Bucephala islandica

Bufflehead
Bucephala albeola

Oldsquaw
Clangula hyemalis

Harlequin duck
Histrionicus histrionicus

White-winged scoter
Melanitta deglandi

Surf scoter
Melanitta perspicillata

Black scoter
Melanitta nigra

Common merganser
Mergus merganser

Red-breasted merganser
Mergus serrator

Goshawk
Accipiter gentilis

Sharp-shinned hawk
Accipiter striatus

Red-tailed hawk
Buteo jamaicensis

Golden eagle
Aquila chrysaetos

Bald eagle
Haliaeetus leucocephalus

Marsh hawk
Circus cyaneus

Osprey
Pandion haliaetus

Gyrfalcon
Falco rusticolus

Peregrine falcon
Falco peregrinus

Merlin
Falco columbarius

American kestrel
Falco sparverius

Spruce grouse
Canachites canadensis

Ruffed grouse
Bonasa umbellus

Willow ptarmigan
Lagopus lagopus

Rock ptarmigan
Lagopus mutus

White-tailed ptarmigan
Lagopus leucurus

Sandhill crane
Grus canadensis

American golden plover
Pluvialis dominica

Surfbird
Aphriza virgata

Semipalmated plover
Charadrius semipalmatus

Common snipe
Capella gallinago

Whimbrel
Numenius phaeopus

Upland sandpiper
Bartramia longicauda

Spotted sandpiper
Actitis macularia

Solitary sandpiper
Tringa solitaria

Greater yellowlegs
Tringa malanoleuca

Lesser yellowlegs
Tringa flavipes

Wandering tattler
Heteroscelus incanus

Pectoral sandpiper
Calidris melanotos

Baird's sandpiper
Calidris bairdii

Least sandpiper
Calidris minutilla

Semipalmated sandpiper
Calidris pusilla

Sanderling
Calidris alba

Northern phalarope
Lobipes lobatus

Long-billed dowitcher
Limnodromus scolopaceus

Long-tailed jaeger
Stercorarius longicaudus

Herring gull
Larus argentatus

Mew gull
Larus canus

Bonaparte's gull
Larus philadelphia

Arctic tern
Sterna paradisea

Great horned owl
Bubo virginianus

Hawk owl
Surnia ulula

Short-eared owl
Asio flammeus

Boreal owl
Aegolius funereus

Belted kingfisher
Megaceryle alcyon

Common flicker
Colaptes auratus

Hairy woodpecker
Picoides villosus

Downy woodpecker
Picoides pubescens

Black-backed three-toed woodpecker
Picoides arcticus

Northern three-toed woodpecker
Picoides tridactylus

Eastern kingbird
Tyrannus tyrannus

Say's phoebe
Sayornis saya

Alder flycatcher
Empidonax alnorum

Olive-sided flycatcher
Nuttallornis borealis

Western wood pewee
Contopus sordidulus

Horned lark
Eremophila alpestris

Violet-green swallow
Tachycineta thalassina

Bank swallow
Riparia riparia

Tree swallow
Iridoprocne bicolor

Cliff swallow
Petrochelidon pyrrhonota

Gray jay
Perisoreus canadensis

Black-billed magpie
Pica pica

Common raven
Corvus corax

Black-capped chickadee
Parus atricapillus

Boreal chickadee
Parus hudsonicus

Brown creeper
Certhia familiaris

Dipper
Cinclus mexicanus

American robin
Turdus migratorius

Varied thrush
Ixoreus naevius

Hermit thrush
Catharus guttata

Swainson's thrush
Catharus ustulatus

Gray-cheeked thrush
Catharus minimus

Wheatear
Oenanthe oenanthe

Townsend's solitaire
Myadestes townsendi

Arctic warbler
Phylloscopus borealis

Golden-crowned kinglet
Regulus satrapa

Ruby-crowned kinglet
Regulus calendula

Water pipit
Anthus spinoletta

Bohemian waxwing
Bombycilla garrulus

Northern shrike
Lanius excubitor

Orange-crowned warbler
Vermivora celata

Yellow warbler
Dendroica petechia

Yellow-rumped warbler
Dendroica coronata

Blackpoll warbler
Dendroica striata

Northern waterthrush
Seiurus noveboracensis

Wilson's warbler
Wilsonia pusilla

Rusty blackbird
Euphagus carolinus

Pine grosbeak
Pinicola enucleator

Gray-crowned rosy finch
Leucosticte tephrocotis

Common redpoll
Carduelis flammea

Pine siskin
Carduelis pinus

White-winged crossbill
Loxia leucoptera

Savannah sparrow
Passerculus sandwichensis

Dark-eyed junco
Junco hyemalis

Tree sparrow
Spizella arborea

White-crowned sparrow
Zonotrichia leucophrys

Golden-crowned sparrow
Zonotrichia atricapilla

Fox sparrow
Passerella iliaca

Lincoln's sparrow
Melospiza lincolnii

Lapland longspur
Calcarius lapponicus

Smith's longspur
Calcarius pictus

Snow bunting
Plectrophenax nivalis

TABLE 3.32: RELATIVE ABUNDANCE OF LOONS, GREBES, AND WATERFOWL, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED ON 1980 and 1981 AERIAL SURVEYS AND 1981 GROUND SURVEYS

Spring Migration (Aerial & Ground, 1981)

No.	Species	
802	Scaup spp.	COMMON
394	Mallard	
366	Pintail	
262	American wigeon	FAIRLY COMMON
215	Green-winged teal	
210	Scoter spp.	
140	Goldeneye spp.	
102	Oldsquaw	
52	Merganser spp.	UNCOMMON
51	Snow goose (=1 flock)	
46	Canada goose	
43	Northern shoveler	
43	Swan spp.	
31	Redhead	
23	Bufflehead	
11	Common loon	
8	Arctic loon	
6	White-fronted goose	
5	Red-necked grebe	
4	Canvasback	
3	Red-throated loon	
3	Horned grebe	
3	Blue-winged teal	RARE
3	Gadwall	
2	Ring-necked duck	

Fall Migration (Aerial: 7 Sept-3 Oct 80, 15 Sept-23 Oct 81)

No.	Species	
2658	Scaup spp.	--COMMON
905	Mallard	FAIRLY COMMON
874	American wigeon	
718	Goldeneye spp.	
551	Scoter spp.	
514	Bufflehead	
299	Merganser spp.	UNCOMMON
277	Swan spp.	
233	Pintail	
142	Green-winged teal	
111	Oldsquaw	
71	Canada goose	
35	Horned grebe (1980)	
33	Red-necked grebe	
28	Northern shoveler	
17	Common loon	
14	Ring-necked duck (1980)	RARE
1	Blue-winged teal (1980)	

Summer (Ground, 1981)

No.	Species	
94	Scaup (incl. 41 Lesser, 27 Greater)	FAIRLY COMMON
81	White-winged scoter (incl. flock of 65)	
60	Pintail	
59	Trumpeter swan[a]	
55	Oldsquaw	
47	Mallard	
33	Surf scoter	
32	American wigeon	
28	Green-winged teal	
26	Black scoter	
25	Common loon	
24	Harlequin duck	
16	Northern shoveler	UNCOMMON
11	Red-breasted merganser	
8	Red-throated loon	
8	Barrow's goldeneye	
7	Red-necked grebe	
7	Common goldeneye	
5	Horned grebe	
5	Common merganser	
4	Arctic loon	

a. 40 from aerial survey

TABLE 3.33: RELATIVE ABUNDANCE OF LARGE LANDBIRDS AND CRANES, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, EXCLUDING OBSERVATIONS FROM AIRCRAFT

No.	Species	
182	Rock Ptarmigan	COMMON
139	Common Raven	COMMON
137	Willow Ptarmigan	COMMON
71	Golden eagle	FAIRLY COMMON
52	Spruce grouse	FAIRLY COMMON
40	Marsh hawk	FAIRLY COMMON
27	Bald eagle	UNCOMMON
21	White-tailed ptarmigan	UNCOMMON
16	Goshawk	UNCOMMON
15	Sandhill Crane	UNCOMMON
07	Gyrfalcon	UNCOMMON
07	Great horned owl	UNCOMMON
07	Short-eared owl	UNCOMMON
06	Red-tailed hawk	UNCOMMON
03	Merlin	UNCOMMON
02	Sharp-shinned hawk	UNCOMMON
02	Hawk owl	UNCOMMON
01	Osprey	RARE
01	American kestrel (1980)	RARE
01	Ruffed grouse	RARE
01	Boreal owl	RARE

TABLE 3.34: RELATIVE ABUNDANCE OF SHOREBIRDS AND GULLS, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, BUT SUPPLEMENTED BY DATA FROM LATE SUMMER AND FALL 1981 FOR RARE SPECIES

No.	Species	
163	Mew gull	COMMON
146	American golden plover	COMMON
114	Common snipe	COMMON
103	Spotted sandpiper	COMMON
78	Northern phalarope	FAIRLY COMMON
69	Arctic tern	FAIRLY COMMON
58	Lesser yellowlegs	FAIRLY COMMON
55	Long-tailed jaeger	FAIRLY COMMON
51	Least sandpiper	FAIRLY COMMON
44	Bonaparte's gull	UNCOMMON
34	Baird's sandpiper	UNCOMMON
22	Semipalmated plover	UNCOMMON
20	Herring gull	UNCOMMON
19	Greater yellowlegs	UNCOMMON
17	Whimbrel	UNCOMMON
12	Semipalmated sandpiper	UNCOMMON
09	Wandering tattler	UNCOMMON
09	Pectoral sandpiper	UNCOMMON
06	Solitary sandpiper	UNCOMMON
03	Long-billed dowitcher	UNCOMMON
06	Upland sandpiper (1980)	RARE
01	Surfbird (1980)	RARE
01	Sanderling (1980)	RARE

TABLE 3.35: RELATIVE ABUNDANCE OF SMALL LANDBIRDS, UPPER SUSITNA RIVER BASIN, ALASKA, BASED PRIMARILY ON TOTAL NUMBER OBSERVED 17 APRIL-23 OCTOBER 1981, SUPPLEMENTED BY DATA FROM LATE SUMMER AND FALL 1980 FOR THE LESS NUMEROUS SPECIES

No.	Species	
1161	Common redpoll	
669	Savannah sparrow	
631	White-crowned sparrow	ABUNDANT
588	Lapland longspur	
583	Tree sparrow	
420	Horned lark	
398	Dark-eyed junco	
343	Ruby-crowned kinglet	
316	Yellow-rumped warbler	
288	Water pipit	
258	Varied thrush	COMMON
257	Gray jay	
249	Wilson's warbler	
225	Bohemian waxwing	
211	American robin	
195	Hermit thrush	
179	White-winged crossbill	
163	Fox sparrow	
146	Swainson's thrush	
145	Blackpoll warbler	
129	Boreal chickadee	FAIRLY
98	Snow bunting	
71	Arctic warbler	COMMON
64	Tree swallow	
62	Violet-green swallow	
55	Northern waterthrush	
54	Gray-cheeked thrush	
53	Bank swallow	
46	Cliff swallow	
45	Gray-crowned rosy finch	
42	Black-capped chickadee	
41	Golden-crowned sparrow	
35	Lincoln's sparrow	
33	Rusty blackbird	
29	Dipper	
26	Pine siskin	
23	Northern three-toed woodpecker	
23	Wheatear	
22	Black-billed magpie	
16	Belted kingfisher	
16	Olive-sided flycatcher	
14	Alder flycatcher	UNCOMMON
13	Common flicker	
11	Brown creeper	
10	Hairy woodpecker	
10	Orange-crowned warbler	
09	Pine grosbeak	
05	Say's phoebe	
03	Northern shrike (+27 in 1980)	
02	Townsend's solitaire (+4 in 1980)	
02	Smith's longspur (+5 in 1980)	
01	Downy woodpecker (+8 in 1980)	
01	Golden-crowned kinglet (+11 in 1980)	
1	Black-backed three-toed woodpecker (1980)	RARE
4	Western wood pewee (1980	
2	Yellow warbler (+3 in 1980)	
1	Eastern kingbird (1980)	--ACCIDENTAL

TABLE 3.36: AVIAN HABITAT OCCUPANCY LEVELS, UPPER SUSITNA RIVER BASIN, BREEDING SEASON, 1981

Avian Census Plot	No. species (No. breeding species)	Density (No. territories/ 10 ha)	Biomass (Grams/ 10 ha)	Species diversity (H')
Cottonwood Forest	21(16)	60.9	3653	2.55
Mixed Deciduous-Coniferous Forest II	22(13)	34.6	1836	2.07
Mixed Deciduous-Coniferous Forest I	18(14)	41.8	1709	2.47
Paper Birch Forest	18(10)	38.1	1814	2.05
White Spruce Scattered Woodland	23(16)	43.8	1775	2.29
Black Spruce Dwarf Forest	23(13)	24.8	1166	2.43
Low-Medium Willow Shrub	14(6)	45.4	1413	1.56
White Spruce Forest	18(8)	15.7	1059	1.83
Medium Birch Shrub	10(5)	32.5	952	1.48
Tall Alder Shrub	15(10)	12.5	888	2.05
Dwarf-Low Birch Shrub	11(6)	10.6	355	1.29
Alpine Tundra	8(7)	3.9	211	1.73

TABLE 3.37: NUMBER OF TERRITORIES OF EACH BIRD SPECIES ON EACH 10-HECTARE CENSUS PLOT, UPPER SUSITNA RIVER BASIN, ALASKA, 1981

Species	Alpine Tundra	Dwarf-Low Birch Shrub Thicket	Medium Birch Shrub Thicket	Low-Medium Willow Shrub Thicket	Tall Alder Shrub Thicket	Cotton-Wood Forest	Paper Birch Forest	White Spruce-Paper Birch Forest I	White Spruce Paper Birch Forest II	White Spruce Forest	White Spruce Scattered Woodland	Black Spruce Dwarf Forest
Pintail				v[b]								
Goshawk					v					v		
Marsh hawk												v
Spruce grouse					v	v	v	1.0	1.0	v	v	
Ruffed grouse										+[a]		
Willow ptarmigan		0.5		v								v
Rock ptarmigan		0.7										
White-tailed ptarmigan	+											
American golden plover	v											
Greater yellowlegs											+	
Common snipe			v	v							0.5	1.0
Baird's sandpiper	0.8	v										
Long-tailed jaeger		v										
Short-eared owl		v		v								
Common flicker									v			
Hairy woodpecker						1.0			1.0			
Downy woodpecker						0.5						
N. three-toed woodpecker								v	0.3	1.0	v	v
Alder flycatcher												
Olive-sided flycatcher						1.0			v	v		
Horned lark	0.3	v										
Tree swallow			v	v		v						
Gray jay					1.0		v	0.5	0.5	1.0	+	v
Black-billed magpie					v							
Common raven												v
Black-capped chickadee						1.8	v	v	v			
Boreal chickadee							v	1.7	1.0	v	v	1.0
Brown creeper						2.0			1.0			
American robin					0.5		v			v	0.5	0.5
Varied thrush					1.5	10.0	3.5	2.5	3.3	2.9	v	v
Hermit thrush					2.2	v	6.1	3.8	v			
Swainson's thrush						6.9	5.5	5.4	8.0	3.0	v	v
Gray-cheeked thrush						3.8	v	v			3.9	2.5
Arctic warbler			4.8	3.6							2.8	
Ruby-crowned kinglet						v	v	3.3	1.0	4.2	0.8	4.0
Water pipit	0.5											
Bohemian waxwing												v
Orange-crowned warbler											v	
Yellow-rumped warbler					+	7.0	9.8	7.5	9.5	1.0	0.8	2.5
Blackpoll warbler			v			4.4	3.9	1.8	0.5		2.0	1.5
Northern waterthrush						6.1	+	2.5	v			
Wilson's warbler			8.8	9.2	1.2	4.0	3.8	4.0			9.4	
Rusty blackbird												v
Common redpoll		v	v	1.5	v	2.5	2.0	2.0	3.0	v	0.5	1.0
Pine siskin							v			v		
White-winged crossbill					v	v		v	v	v	v	v
Savannah sparrow	1.0	5.8	3.0	12.3						v	2.5	0.8
Dark-eyed junco					2.8	1.8	2.5	3.9	4.5	2.5	2.0	2.0
Tree sparrow		2.5	11.8	15.0	1.5						7.9	2.6
White-crowned sparrow		0.3	4.1	3.8	+	3.5					6.5	2.5
Fox sparrow				v	1.6	4.6	1.0	1.9	v		3.5	2.9
Lincoln's sparrow				v								
Lapland longspur	1.0	0.8										
Snow bunting	0.2											

a. Small portion of a breeding territory on census plot, counted as 0.1 in density and diversity calculations
b. Visitor to plot

TABLE 3.38: NUMBER OF ADULT WATERBIRDS (OR INDEPENDENT YOUNG) AND BROODS FOUND ON 28 WATERBODIES (TOTAL = 20.5 KM^2 OF WETLANDS), UPPER SUSITNA RIVER BASIN, ALASKA, JULY 1981

Species [(a)]	No. Adults	No. Broods
White-winged scoter	81 (incl. flock 65)	0
Arctic tern	48	0
Oldsquaw	47	11
Mew gull	43	7
Lesser scaup	36	4
Scaup sp.	9	1
Surf scoter	33	2
Black scoter	26	11
Scoter sp.	6	1
Greater scaup	25	0
Northern phalarope	23	0
Common loon	22	3
Trumpeter swan	16	1
Mallard	10	1
Red-throated loon*	8	0
American wigeon	8	6
Red-necked grebe	7	1
Pintail	7	2
Northern shoveler	7	1
Goldeneye sp.	6	1(Common goldeneye)
Horned grebe	5	5
Bonaparte's gull	5	0
Bald eagle	3	0
Arctic loon	2	0
Green-winged teal	2	1
Red-breasted merganser	1	1
Merganser sp.	1	0
TOTAL	487	60
No./km^2	23.8	2.9

a. Arranged in decreasing order of adult numbers.

TABLE 3.39: SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, FALL 1980

	DATE OF SURVEY						
Species	7 Sept	11 Sept	16 Sept	20 Sept	26 Sept	3 Oct	TOTAL
Loon spp.				4	1		5
Common loon		3	2	3			8
Red-necked grebe	2	3	4		5	3	17
Horned grebe	1	4	17	9	2	2	35
Swan spp.		34	29	9	12	20	104
Canada goose				1	20		21
American wigeon		155	325	97	88	56	721
Green-winged teal		30	83	9	1	2	125
Mallard	10	64	14	116	110	124	438
Pintail	60	60	53	21	3	4	201
Blue-winged teal		1					1
Northern shoveler		8	20				28
Ring-necked duck			2	12			14
Scaup spp.	165	347	499	370	293	180	1854
Oldsquaw	7	4	13	13	16	4	57
Black scoter		8	38	25	24	10	105
Scoter spp.[a]				6	56	72	134
Surf scoter		5	4	2			11
White-winged scoter	10			1	6	1	18
Bufflehead		33	40	95	127	101	396
Goldeneye spp.	15	36	68	124	95	133	471
Merganser spp.		8	30	36	68	19	161
TOTAL BIRDS	270	803	1241	953	927	731	4925
Total wetland area surveyed (km^2)	13.11	22.08	25.76	27.53	29.00	24.25	
Density (birds/km^2 of wetlands)	20.6	36.4	48.2	34.6	32.0	30.1	

a. Surf or White-winged scoter

TABLE 3.40: SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, FALL 1981

	DATE OF SURVEY					
Species	15-16 Sept	26 Sept	26 Sept-9 Oct	12-19 Oct	20-23 Oct	TOTAL
Common loon	2	3	3	1		9
Arctic loon						
Red-throated loon						
Loon spp.						
Red-necked grebe	12	3	1			16
Horned grebe						
Whistling swan		18	24			42
Trumpeter swan	6		10	14		30
Swan spp.		41	25	22	13	101
Canada goose				50		50
Mallard	41	153	131	142		467
Pintail	32					32
Green-winged teal	13	3				16
Northern shoveler						
American wigeon	133		14	5		152
Canvasback						
Redhead						
Scaup, greater and lesser	479	166	51	90		786
Goldeneye, common & Barrow's	18	125	68	36		247
Bufflehead	17	20	29	52		118
Oldsquaw	15	31	7	1		54
White-winged scoter			69	13		82
Surf scoter				29		29
Black scoter	1	6	2	1		10
Scoter spp.	69		1	92		162
Common merganser			1	2		3
Red-breasted merganser						
Merganser spp.	77	38		18		133
TOTAL BIRDS	915	607	436	568	13	2539
Total wetland area surveyed (km^2)	25.68	25.68	21.31	11.57	6.62	
Km^2 of 100% frozen waterbodies surveyed[a]	0	1.41	3.91	3.76[b]	2.00	
Density (birds km^2 of wetlands	35.6	23.6	20.5	49.1	1.96	

a. Other waterbodies had at least some open water.

b. An additional 9.22 km^2 of 100% frozen waterbodies were not surveyed in mid-October because they were known to be frozen. By late October only Stephan Lake and one adjacent lake still had some open water.

TABLE 3.41: SUMMARY OF TOTAL NUMBERS AND SPECIES COMPOSITION OF WATERBIRDS SEEN ON SURVEYED WATERBODIES DURING AERIAL SURVEYS OF THE UPPER SUSITNA RIVER BASIN, SPRING, 1981

	DATE OF SURVEY			
Species	3 May	10 May	26 May	TOTAL
Common loon			4	4
Arctic loon			5	5
Red-throated			2	2
Loon spp.		3	4	7
Red-necked grebe			4	4
Horned grebe		1	1	2
Whistling swan				
Trumpeter swan	2		6	8
Swan spp.		11	10	21
Canada goose				
Mallard	97	78	121	296
Pintail	71	70	116	257
Green-winged teal	67	47	38	152
Northern shoveler		12	28	40
American wigeon	5	94	99	198
Canvasback		1		1
Redhead			28	28
Scaup, greater and lesser		103	513	616
Goldeneye, common and Barrow's		51	38	89
Bufflehead		2	10	12
Oldsquaw		2	84	86
White-winged scoter			16	16
Surf scoter		4	35	39
Black scoter		1	42	43
Scoter spp.		12	74	86
Common merganser			7	7
Red-breasted merganser			2	2
Merganser spp.			25	25
TOTAL BIRDS	242	492	1312	2046
Total wetland area surveyed (km^2)	25.68	25.68	25.68	
Km^2 of 100% frozen waterbodies surveyed [(a)]	14.31	1.97	0	
Density (birds/km^2 of wetlands)	9.4	19.2	51.1	

a. Other waterbodies had at least some open water.

TABLE 3.42: WATERFOWL NOTED ALONG THE SUSITNA RIVER BETWEEN DEVIL CANYON AND COOK INLET, 7 MAY 1981

Devil Canyon to Talkeetna

Mallard - 18	Canvasback - 2
Pintail - 13	Goldeneye spp. - 11
American green-winged teal - 34	Merganser spp. - 7
American wigeon - 2	

Talkeetna to Montana Creek

Mallard - 23	Goldeneye spp. - 6
American green-winged teal - 5	Bufflehead - 2
Scaup spp. - 2	Merganser spp. - 6

Montana Creek to Kashwitna Lake (a)

Mallard - 23	Goldeneye spp. - 2
Pintail - 3	Bufflehead - 14
American green-winged teal - 3	Scoter spp. - 2
American wigeon - 14	Merganser spp. - 61

Kashwitna Lake (a) to Yentna River

Mallard - 7	Goldeneye spp. - 3
American wigeon - 4	Merganser spp. - 8

Yentna River to Cook Inlet

Loon spp. - 8	Mallard - 2
Grebe spp. - 4	American wigeon - 9
Swan spp. - 60	Canvasback - 4
Canada goose - 1	Scaup spp. - 100
Brant - 2	Goldeneye spp. - 10
White-fronted goose - 80	Merganser spp. - 172
Geese spp. - 9	

a. Approximately halfway between Kashwitna River and Willow Creek.

TABLE 3.43: LOCATION OF ACTIVE RAPTOR AND RAVEN NEST SITES, UPPER SUSITNA RIVER BASIN, ALASKA, 1980 AND 1981

Nest	Species	Substrate elevation m (feet)	Active (a) 1980	Active (a) 1981	Nest Location
A	Bald eagle	490 (1600)	X	0	8.0 km up Susitna River from the mouth of Watana Creek. On wooded island in live, 15 m white spruce.
B	Bald eagle	690 (2260)	X	X	4.5 km up Oshetna River from its confluence with the Susitna River. Nest 4 m from edge of west river bank in a 22 m white spruce.
C	Golden eagle	750 (2450)	X	0	3.5 km upriver from Vee Canyon and 0.7 km up a narrow canyon on the north side of the Susitna River. Nest 26 m up a 33 m cliff, 100 m back from and 6.7 m above unnamed creek.
D	Golden eagle	700 (2300)	X	0	4.0 km up the Susitna River from the mouth of Jay Creek and in canyon on north side of the Susitna. Nest 5 m up 13 m cliff, 10 m back from and 18 m above unnamed creek.
E	Golden eagle	640 (2100)	X	X	2.5 km up Jay Creek from its junction with Susitna River. Nest 5 m up 30 m cliff, 150 m from west bank and 115 m above Jay Creek.
F	Golden eagle	550 (1800)	X	0	1.0 km down Susitna River from the mouth of Kosina Creek. Nest 32 km up 38 m cliff on north riverbank.
G	Golden eagle	490 (1600)	X	0	4.0 km down Susitna River from the mouth of Watana Creek. Nest 13 m up 23 m cliff, 40 m back from and 34 m above the north bank of the river.
H	Unknown	490 (1600)	X	0	6.8 km down Susitna River from mouth of Devil Creek and 4.0 km up a gorge on south side of the Susitna. Nest 100 m up 105 m cliff of creek canyon. Occupied by a gyrfalcon in 1974 (White 1974).

a. X = active
0 = inactive
- = site not located in 1980

Nest	Species	Substrate elevation m (feet)	Active (a) 1980	Active (a) 1981	Nest Location
I	Golden eagle	365 (1200)	X	X	0.5 km up Devil Creek from its mouth. Nest 30 m up 45 m vegetated cliff, 100 m back from and 120 m above Devil Creek, on west bank.
J	Raven	520 (1700)	X	?	1.0 km up Devil Creek from its mouth. Nest near top of cliff of west bank. Could not relocate nest in 1981.
K	Bald eagle	760 (2500)	X	X	9.0 km up Deadman Creek from its mouth. Nest on top of 15 m broken-topped cottonwood, 25 m from north side of Deadman Creek.
L	Bald eagle	275 (900)	X	X	1.0 km up Susitna River from confluence with Indian River. Nest on top of 23 m broken-topped cottonwood, 4 m from north river bank.
M	Golden eagle	305 (1000)	-	X	2.0 km up Susitna River from the mouth of Portage Creek. Nest on moderate-sized cliff on north bank, but not relocated on ground check.
N	Bald eagle	580 (1900)	-	X	On south shore of small lake, 1.0 km east of NE end of Stephan Lake. Nest on top of 13 m broken-topped cottonwood.
O	Raven	470 (1550)	-	X	2.0 km up Fog Creek from mouth. Nest 9 m up 23 m cliff on west bank, 17 m back from and 23 m above creek.
P	Raven	550 (1800)	-	X	5.0 km up Tsusena Creek from mouth. Nest on cliff on east bank of creek.
Q	Raven	625 (2050)	-	X	1.0 km up Deadman Creek from mouth. Nest 13 m up 32 m cliff on east bank of creek.
R	Golden eagle	975 (3200)	-	X	8.0 km down Susitna River from the mouth of Kosina Creek. Nest 7 m up 12 m cliff on tor above south bank of river.

Nest	Species	Substrate elevation m (feet)	Active(a) 1980	Active(a) 1981	Nest Location
S	Bald eagle	540 (1775)	0	X	2.0 km up Susitna River from the mouth of Kosina Creek. Nest 25 m up 33 m cliff on north bank of river.
T	Golden eagle	685 (2250)	0	X	4.0 km up Susitna River from the mouth of Jay Creek, in canyon on north side of river. Nest 1 m up 5 m vegetated cliff, 14 m back from and 33 m above unnamed creek.
U	Gyrfalcon	715 (2350)	-	X	At Vee Canyon. Nest 100 m up 113 m cliff at south bank of Susitna River.
V	Golden eagle	750 (2450)	0	X	3.5 km up Susitna River from Vee Canyon and 0.7 km up narrow canyon on north side of Susitna River. Nest 8 m up 12 m cliff, 81 m back from and 67 m above unnamed creek.
00	Goshawk	550 (1800)	-	X	2.0 km southwest of Devil Canyon dam site.

TABLE 3.44: BALD EAGLE OBSERVATIONS NOTED DURING THE 26 JUNE 1981 FLIGHT ALONG THE SUSITNA RIVER FROM COOK INLET TO PORTAGE CREEK

	Seward Meridian		
Observation	Range	Township	Comments
Active nest	7W	16N	
Active nest	7W	16N	1 adult bird on nest
1 adult bird	6W	18N	
1 immature bird	6W	18N	
Active nest	6W	19N	
1 adult bird	5W	20N	
1 adult bird	5W	22N	
Active nest	5W	22N	
Active nest	5W	22N	
1 adult bird	5W	24N	
Active nest	5W	25N	
1 adult bird	5W	25N	
Active nest	5W	26N	1 adult bird on nest
Active nest	3W	30N	1 adult bird on nest
1 immature bird	2W	31N	
1 immature bird	2W	31N	
Active nest	2W	31N	2 adult birds on nest

TABLE 3.45: BREEDING CHRONOLOGIES OF EAGLES, GYRFALCON, AND COMMON RAVEN IN INTERIOR ALASKA

Species	Status[a]	DATES OF PHASES OF BREEDING CYCLE				
		Arrival/courtship	Egg-Laying	Incubation	Nestlings	Fledging/dispersal
Golden eagle[b]	M	5 Mar-30 Apr	1 Apr-10 May	15 Apr-20 June	1 June-1 Sept	1 Aug-25 Sept
Bald eagle[b]	M/R	10 Mar-1 May	20 Mar-10 May	30 Apr-30 June	20 May-15 Sept	1 Aug-30 Sept
Gyrfalcon[b]	R	1 Mar-10 Apr	1 Apr-20 May	5 Apr-25 June	15 May-15 Aug	10 July-30 Sept
Raven[c]	R	1 Mar-15 Apr	1 Apr-5 May	5 Apr-25 May	25 Apr-25 June	25 May-15 July

a. M = migrant, R = resident
b. Data summarized from Roseneau et al. (1981)
c. Based on calculations from Kessel (unpubl. data) and Brown (1974)

TABLE 3.46: SPECIES OF SMALL MAMMALS FOUND IN THE UPPER SUSITNA RIVER BASIN, ALASKA, 1980 AND 1981

Order INSECTIVORA

Family Soricidae

Sorex cinereus, masked shrew

Sorex monticolus, dusky shrew

Sorex arcticus, arctic shrew

Sorex hoyi, pygmy shrew

Order LAGOMORPHA

Family Ochotonidae

Ochotona collaris, collared pika

Family Leporidae

Lepus americanus, snowshoe hare

Order RODENTIA

Family Sciuridae

Marmota caligata, hoary marmot

Spermophilus parryii, arctic ground squirrel

Tamiasciurus hudsonicus, red squirrel

Family Cricetidae

Clethrionomys rutilus, northern red-backed vole

Microtus pennsylvanicus, meadow vole

Microtus oeconomus, tundra vole

Microtus miurus, singing vole

Lemmus sibiricus, brown lemming

Synaptomys borealis, northern bog lemming

Family Erethizontidae

Erethizon dorsatum, porcupine

TABLE 3.47: HABITAT LOCATIONS BETWEEN COOK INLET AND DEVIL CANYON SAMPLED DURING THE JUVENILE ANADROMOUS AND RESIDENT FISH STUDY

Estuary to Talkeetna	Site [(a)]
Alexander Creek	A, B, C
Anderson Creek	
Kroto Slough Mouth	
Mainstem Susitna Slough	
Mid Kroto Slough	
Deshka River	A, B, C
Delta Islands	
Little Willow Creek	
Rustic Wilderness	
Kashwitna River	
Caswell Creek	
Slough West Bank	
Sheep Creek Slough	
Goose Creek	1, 2 [(b)]
Mainstem Susitna West Bank	
Montana Creek	
Mainstem 1	
Sunshine Creek	
Birch Creek Slough	
Birch Creek	
Cache Creek Slough	
Cache Creek	
Talkeetna to Devil Canyon	
Whiskers Creek Slough	
Whiskers Creek	
Slough 6A	
Lane Creek	
Mainstem 2	
Mainstem Susitna - Curry	
Susitna Side Channel	
Mainstem Susitna - Gravel Bar	
Slough 8A	
Fourth of July Creek	
Slough 10	
Slough 11	
Mainstem Susitna Gold Creek	
Indian River	
Slough 20	
Mainstem Susitna - Island	
Portage Creek	

a. Letter designation indicates multiple sampling sites in that particular region.

b. Number designation indicates two different sample locations near mouth of Goose Creek.

TABLE 3.48: COMMON AND SCIENTIFIC NAMES OF FISH SPECIES APPEARING IN THE TEXT

COMMON NAME	SCIENTIFIC NAME
Arctic Lamprey	*Lampeta japonica*
Bering Cisco	*Coregonus laurettae*
Lake Whitefish (Humpback whitefish)	*Coregonus clupeaformis*
Humpback Whitefish	*Coregonus pidschian*
Alaska Whitefish (Humpback whitefish)	*Coregonus nelsoni*
Pink Salmon	*Oncorhynchus gorbuscha*
Chum Salmon	*Oncorhynchus keta*
Coho Salmon	*Oncorhynchus kisutch*
Sockeye Salmon	*Oncorhynchus nerka*
Chinook Salmon	*Oncorhynchus tsawytscha*
Round Whitefish	*Prosopium cylindraceum*
Rainbow Trout	*Salmo gairdneri*
Dolly Varden	*Salvelinus malma*
Lake Trout	*Salvelinus namaycush*
Sheefish	*Stenodus leucichthys*
Arctic Grayling	*Thymallus arcticus*
Eulachon	*Thaleichthys pacificus*
Northern Pike	*Esox lucius*
Longnose Sucker	*Catostomus catostomus*
Burbot	*Lota lota*
Threespine Stickleback	*Gasterosteus aculeatus*
Sculpin	*Cottus* sp.

TABLE 3.49: APPORTIONED SONAR COUNTS OF CHINOOK SALMON BY SAMPLING STATION, ANADROMOUS ADULT INVESTIGATIONS, 1981

SAMPLING LOCATION	SONAR OPERATING PERIOD	CHINOOK SALMON COUNTED
Susitna Station	27 June-2 September	1,752
Yentna Station	29 June-2 September	427
Sunshine Station	23 June-15 August	2,415
Talkeetna Station	22 June-15 August	1,154

TABLE 3.50: APPORTIONED SONAR COUNTS AND PETERSEN POPULATION (TAG/RECAPTURE) ESTIMATES BY SPECIES AND SAMPLING LOCATION, ADULT ANADROMOUS INVESTIGATIONS, 1981

SAMPLING LOCATION	ESCAPEMENT ESTIMATES							
	SOCKEYE		PINK		CHUM		COHO	
	Sonar	Petersen	Sonar	Petersen	Sonar	Petersen	Sonar	Petersen
Susitna Station	340,232	-	113,349	-	46,461	-	33.470	-
Yentna Station	139,401	-	36,053	-	19,765	-	17,017	
Sunshine Station	89,906	130,489	72,945	49,501	59,630	262,851	22,793	19,841
Talkeetna Station	3,464	4,809	2,529	2,335	10,036	20,835	3,522	3,306
Curry Station	-	2,804	-	1,041	-	13,068	-	1,146

TABLE 3.51: SUMMARY OF FISHWHEEL CATCHES BY SPECIES AND SAMPLING LOCATION, ADULT ANADROMOUS INVESTIGATIONS, 1981

SAMPLING LOCATION	CATCH			
	SOCKEYE	PINK	CHUM	COHO
Susitna Station	4,087	691	250	329
Yentna Station	7,000	2,729	1,415	1,122
Sunshine Station	9,528	7,099	9,168	2,928
Talkeetna Station	398	379	1,285	533
Curry Station	470	229	1,276	182

TABLE 3.52: PETERSEN POPULATION ESTIMATES AND CORRESPONDING 95% CONFIDENCE INTERVALS OF SOCKEYE, PINK, CHUM, AND COHO SALMON MIGRATING TO SUNSHINE, TALKEETNA AND CURRY STATIONS, ADULT ANADROMOUS INVESTIGATIONS, 1981

LOCATION OF POPULATION ESTIMATE	PARAMETER (a)	SPECIES			
		SOCKEYE	PINK	CHUM	COHO
	m	8,179	5,900	7,600	2,240
	c	4,831	6,175	9,265	2,845
Sunshine Station	r	296	736	270	347
	$\hat{N}$	133,489	49,501	262,851	19,841
	95% C.I.	120,219-150,051	46,357-53,101	235,207-297,859	18,061-22,011
	m	322	258	1,142	454
	c	4,167	724	5,944	852
Talkeetna Station	r	279	80	333	117
	$\hat{N}$	4,809	2,335	20,835	3,306
	95% C.I.	4,320-5,424	1,935-2,943	18,413-22,829	2,830-3,975
	m	356	181	1,079	131
	c	3,040	69	4,033	105
Curry Station	r	386	12	333	12
	$\hat{N}$	2,804	1,041	13,068	1,146
	95% C.I.	2,565-3,092	687-2,143	11,849-14,566	748-2,452

a. m = Number of fish marked (adjusted for tag loss)
c = Total fish examined for marks during sampling census
r = Total number of marked fish observed during sampling census

$\hat{N}$ = Population estimate
C.I. = Confidence interval around N

TABLE 3.53: ARCTIC GRAYLING TOTAL CATCH BY MONTH IN THE UPPER SUSITNA RIVER DRAINAGE, 1981.

TRIBUTARY	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
Fog Creek[a]	30	17	38	5	5	95
Tsusena Creek[a]	23	75	133	53	9	293
Deadman Creek	53	86	110	23	3	275
Watana Creek	4	52	18	184	55	313
Kosina Creek	139	263	238	73	177	890
Jay Creek	84	181	74	21	68	428
Goose Creek	128	163	82	41	13	427
Oshetna River	24	93	157	73	167	514
Sally Lake	13	4	-	26	-	43
Deadman Lake	-	-	-	-	1	1
TOTAL	498	934	850	499	498	3,279

a. Tributaries in the proposed Devil Canyon impoundment.

TABLE 3.54: RANGES OR VALUES RECORDED FOR PARAMETERS MEASURED AT STUDY SITES IN THE SUSITNA RIVER AND ITS TRIBUTARIES DURING THE SUMMER FIELD SEASON, 1981

RIVER REACH	TEMPERATURE (C°)	DO (mg/l)	Ph	SPECIFIC CONDUCTIVITY (micromhos/cm)	TURBIDITY (NTU)
River Mouth to Talkeetna					
Alexander Creek	11.6-17.8	8.8-10.2	6.4-7.2	78-99	.99-36
Anderson Creek	6.0-14.3	8.4-11.3	6.5-7.9	70-123	4-190
Kroto Slough mouth	5.9-16.8	8.3-9.9	6.8-7.4	89-199	18-150
Mid-Kroto Slough	8.9-15.2	9.8-10.9	7.3-7.4	94-132	21-200
Mainstem Slough	3.6-14.3	9.7-12.0	7.0-7.4	81-137	24-225
Deshka River	3.9-19.4	8.2-12.0	5.95-7.4	28-80	1.60-90
Lower Delta Islands	10.9-13.2	9.7-10.6	7.6	103-118	110-150
Little Willow Creek	2.0-15.5	9.9-12.4	5.45-6.90	34-39	1.5-18
Rustic Wilderness	8.5-14.2	8.9-12.1	6.9-7.5	67-72	61-150
Kashwitna River	6.4-7.1	9.8-12.9	6.4-7.1	24-36	4.5-42
Caswell Creek	9.0-16.0	7.6-11.3	6.1-7.0	17-461	1.0-1.9
Slough West Bank	6.4-10.8	8.0-12.1	6.8-7.6	68-216	21-210
Sheep Creek Slough	7.8-18.0	9.3-11.0	6.2-7.2	29-47	2.2-4.0
Goose Creek	6.3-10.7	9.2-12.1	6.0-7.1	18-37	.4-4.5
Goose Creek Slough	7.7-11.0	10.6-12.1	6.8-7.7	56-82	9.1-12.0
Mainstem West Bank	3.2-10.0	10.5-12.6	6.7-8.0	76-142	6.3-255
Montana Creek	10.9-12.6	10.0-11.9	6.0-6.7	21-37	.3-1.7
Rabideux Creek	15.8-18.9	7.4	6.9-7.0	88-108	22.5-68
Mainstem 1	7.7-12.8	10.3-11.3	6.4-7.5	78-145	25-170
Sunshine Creek	8.9-15.5	9.8-10.9	5.6-7.3	40-65	1.6-23
Birch Creek Slough	8.4-16.0	9.4-10.3	6.2-7.4	67-132	2.4-95
Birch Creek	8.8-15.4	9.4-11.1	5.7-7.2	43-100	.5-7.5
Cache Creek Slough	4.9-14.1	11.2-12.3	6.2-7.7	57-135	80-270
Cache Creek	5.5-11.9	5.0-12.2	5.7-7.3	31-304	.6-22

Table 3.54 (Page 2 of 3)

RIVER REACH	TEMPERATURE (C°)	DO (mg/l)	Ph	CONDUCTIVITY (micromhos/cm)	TURBIDITY (NTU)
Talkeetna to Devil Canyon					
Whiskers Creek Slough	7.6-18.0	10.5-11.6	5.3-6.6	18-43	.5-23
Whiskers Creek	4.8-16.5	10.7-12.8	5.1-6.6	15-31	.6-3.7
Slough 6A	4.8-16.5	11.8	5.6-7.1	42-113	1.0-22
Lane Creek	5.2-9.8	10.9	6.4-7.2	45-65	.6-5.4
Mainstem 2	5.3-15.2	11.6	6.6-7.4	99-158	13-135
Mainstem at Curry	6.9-15.0	9.1-10.9	7.2-7.5	98-152	23-110
Susitna Side Channel	8.1-16.3	9.5-10.3	6.7-7.6	77-129	22-93
Mainstem Susitna Gravel Bar	.6-14.5	9.6-11.0	7.3-7.8	104-167	7.5-230
Slough 8A	4.5-16.4	8.8-10.5	6.8-7.6	118-160	.7-205
4th of July Creek	2.0-15.0	9.5-10.1	6.3-6.7	15-27	.4-3.0
Slough 10	2.7-12.8	9.0-10.7	7.0-7.8	101-171	1.5-130
Slough 11	4.0-9.7	9.3-10.7	6.8-7.1	144-210	1.5-98
Mainstem Susitna-Inside Bend	1.8-11.8	10.5-11.8	7.0-7.6	92-168	9-150
Indian River (mouth)	.5-12.2	8.6-10.6	5.75-7.4	31-52	2-15
Indian River	2.7-8.4	6.8-12.3	5.7-6.8	38-52	.5-3.4
Slough 20	1.5-14.8	10.3-11.0	6.9-7.4	39-104	3.8-11.5
Mainstem Susitna-Island	2.7-11.7	10.3-11.9	7.2-7.5	66-150	13-140
Portage Creek (mouth)	2.9-8.9	10.0-11.0	6.6-7.1	55-98	2.3-25
Portage Creek	1.5-9.4	10.2-12.3	6.05-7.2	48-158	.25-3.8
Devil Canyon Impoundment Zone and Vicinity					
Fog Creek	6.1-10.4	10.4-11.6	7.3-7.5	73-90	.34-1.50
Mainstem by Tsusena Creek	8.6-10.0	9.8-12.2	7.3-7.5	106-107	48-125
Tsusena Creek (mouth and upstream)	7.5-9.8	9.9-13.2	6.8-7.3	55-71	.6-1.8
Watana Impoundment Zone and Vicinity					
Mainstem by Deadman Creek	8.4-12.6	9.9-11.6	7.3-7.7	100-138	51-130
Deadman Creek	7.6-12.4	9.4-16.6	7.0-7.5	44-79	.68-2.3
Mainstem by Watana Creek	8.0-11.7	9.6-11.7	7.1-7.7	109-132	58

Table 3.54 (Page 3 of 3)

RIVER REACH	TEMPERATURE (C°)	DO (mg/l)	Ph	CONDUCTIVITY (micromhos/cm)	TURBIDITY (NTU)
Watana Impoundment Zone and Vicinity (cont'd)					
Mainstem by Deadman Creek	8.4-12.6	9.9-11.6	7.3-7.7	100-138	51-130
Deadman Creek	7.6-12.4	9.4-16.6	7.0-7.5	44-79	.68-2.3
Mainstem by Watana Creek	8.0-11.7	9.6-11.7	7.1-7.7	109-132	58
Watana Creek	1.5-11.4	9.5-14.3	7.1-7.7	101-248	1.3-9.8
Mainstem by Kosina Creek	3.3-12.4	9.0-12.1	7.1-7.6	106-146	10-145
Kosina	2.7-12.3	9.1-13.7	7.1-7.6	53-68	.5-4.4
Mainstem by Jay Creek	6.7-11.4	9.1-12.3	7.1-7.7	100-135	19-155
Jay Creek	3.6-9.7	9.9-13.2	7.4-7.9	124-175	.5-8.6
Mainstem by Goose Creek	5.0-13.7	8.5-12.0	7.3-7.7	100-152	23-155
Goose Creek	4.2-14.6	8.6-13.8	7.0-7.5	47-66	.32-2.2
Mainstem by Oshetna Creek	6.3-12.2	9.3-12.3	7.4-7.6	101-152	24-175
Oshetna River	5.2-12.6	8.9-12.1	7.2-7.6	65-135	1.2-19

TABLE 3.55: LIST OF ENDANGERED AND THREATENED PLANT SPECIES[a] SOUGHT IN THE UPPER SUSITNA BASIN SURVEYS

Species and Habitat	Unofficial Status [b]
Smelowskia pyriformis Drury & Rollins North American endemic calcareous scree, talus, in upper Kuskokwim R. drainage	Threatened species
Aster yukonensis Cronq. North American endemic river banks, dry streambeds, river delta sands and gravels Kluane Lake, Koyukuk River	Endangered species
Montia bostockii (A. E. Porsild) S. L. Welsh North American endemic wet, alpine meadows, St. Elias Mtns., Wrangell Mtns.	Endangered species
Papaver alboroseum Hult. Amphi-Beringian well-drained alpine tundra, Wrangell Mtns., St. Elias Mtns. Cook Inlet lowlands, Alaska Range	Endangered species
Podistera yukonensis Math & Const. North American endemic S.-facing rocky slopes, grasslands at low elevations, Eagle area, Yukon border	Endangered species
Smelowskia borealis (Greene) Drury & Rollins var. villosa North American endemic alpine calcareous scree, Mt. McKinley Park, Alaska Range	Endangered species
Taraxacum carneocoloratum Nels. North American endemic alpine rocky slopes, Alaska Range, Yukon Ogilvie Mtns.	Endangered species
Other Endangered Species Possibilities	
Cryptantha shackletteana	Upper Yukon River
Eriogonum flavum var. aquilinum	Eagle, Alaska
Erysimum asperum var. angustatum	Upper Yukon River

a. Species information and status from Murray (1980).

b. All species are under review by the U.S. Fish & Wildlife Service for inclusion in the Endangered Species Act of 1973.

TABLE 3.56: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE WATANA FACILITY COMPARED WITH TOTAL HECTARES OF THAT TYPE IN THE ENTIRE UPPER BASIN AND IN THE AREA WITHIN 16 KM OF THE SUSITNA RIVER

Vegetation/Habitat Type	Facility Components: Dam and Spillways	Impound-ment	Camp	Village	Airstrip	Borrow Areas: A	D	E	F	H	I	Construction Zone[a]	Total[b]	% of Upper Basin Total For That Type	% of 16 km Area[c] For That Type
Forest	34	10784				181	53	180	81	451	34	7825	18609	5.3	13.1
Woodland spruce-black	8	3870				179	16			224		2564	6434		10.2
Woodland spruce-white		397						71	69			1133	1530	4.2	11.5
Open spruce-black		2864								121	15	1499	4363	4.6	15.4
Open spruce-white		769				2		62	11			303	1072		10.2
Open birch	1	325										286	611	63.1	40.8
Closed birch	13	460					5					38	498[d]	154.2[d]	21.4
Closed balsam poplar		3											3	(e)	.5
Open conifer-deciduous	5	1337					32			106		453	1790	7.7	18.6
Closed conifer-deciduous	7	759						47	1		19	1549	2308	14.5	17.5
Tundra		84				70	8					502	586	.2	.5
Wet sedge-grass		84					8					91	175	3.6	5.0
Sedge-grass															
Sedge shrub												29	29	(b)	0.1
Mat and cushion						70						382	382	.7	0.7
Shrubland	46	1719	63	62	17	81	224		199	38		4942	6661	1.0	3.8
Open tall shrub	6	227				1							227	.4	1.5
Closed tall shrub	17	287				1	12						287		1.8
Birch shrub	1	443	34	35	13	4	88		195			2915	3358	10.0	7.8
Willow shrub		66							4	17		252	318	3.0	3.7
Mixed low shrub	22	651	29	27	4	75	124			21		1775	2426	0.5	2.6
Herbaceous		45											45		250.0
Grassland															
Disturbed															
Unvegetated	13	2104		8		1	2					456	2560	1.0	9.5
Rock	1	59					2						59	0.05	.36
Snow and ice															
River	12	2007										287	2294	15.6	54.2
Lake		38		8		1						169	207	0.8	3.5
TOTAL	93	14691	63	70	17	333	287	180	280	489	34	13725	28416	1.7	6.2

a. This area encompasses all facility components except the impoundment, with the exception of minor portions of Borrow Areas F and I.

b. Impoundment plus construction zone.

c. An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River (See Figures 3.2 through 3.4).

d. Hectares of closed birch are apparently greater in the impact areas than for the entire basin, because the basin was mapped at a much smaller scale, and many of the closed birch stands did not appear at that scale.

e. Areas of this type were too small to be mapped at the scale of which the upper Susitna River basin was mapped.

TABLE 3.57: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE DEVIL CANYON FACILITY COMPARED WITH TOTAL HECTARES OF THAT TYPE IN THE ENTIRE UPPER BASIN AND IN THE AREA WITHIN 16 KM OF THE SUSITNA RIVER

Vegetation/Habitat Type	Facility Component: Dam and Spillways	Impound-ment	Camp	Village	Borrow Area K	Construction Zone[a]	Total[b]	% of Upper Basin Total For That Type	% of 16 km Area[c] For That Type
Forest	16	2289	36	39	119	4504	6793	1.9	4.8
Woodland spruce-black		133				46	179	.36	.3
Woodland spruce-white		20				480	500		3.8
Open spruce-black	4	300			11	785	1085	1.6	3.8
Open spruce-white		329				474	803		7.7
Open birch		57				126	183	18.9	12.2
Closed birch	3	430				156	586[d]	181[d]	25.2
Open balsam poplar		6					6	(e)	
Closed balsam poplar		8				14	22	(e)	3.9
Open conifer-deciduous	7	279					279	1.2	2.9
Closed conifer-deciduous	2	727	36	39	108	2423	3150	19.7	23.8
Tundra		11				211	222	0.06	0.2
Wet sedge-grass		11				192	203	4.2	5.8
Sedge grass						18	18	.01	.07
Sedge shrub						1	1	0	.005
Mat and cushion									
Shrubland		70			18	802	872	0.2	0.5
Open tall shrub		2				125	127	.2	.8
Closed tall shrub		1				165	166		1.0
Birch shrub		49			18	266	315	.9	.7
Willow shrub		14				34	48	.5	.6
Mixed low-shrub		4				212	216	.05	.2
Herbaceous									
Grassland									
Disturbed									
Unvegetated	2	826			11	171	997	.4	3.7
Rock		15				2	17	.02	.1
Snow and ice									
River	1	810				137	947	6.5	22.4
Lake	1	1			11	32	33	0.13	0.6
TOTAL	18	3196	36	39	148	5688	8884	0.5	1.9

a. This area encompasses all facility components except the impoundment.
b. Impoundment plus construction zone.
c. An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River (see Figures 3.2 through 3.4).
d. Hectares of closed birch are apparently greater in the impact areas than for the entire basin, because the basin was mapped at a much smaller scale, and many of the closed birch stands did not appear at that scale.
e. Balsam poplar stands were too small to be mapped at the scale of which the upper Susitna River basin was mapped.

TABLE 3.58: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE ACCESS ROAD WITH TOTAL HECTARES OF THAT TYPE IN THE UPPER BASIN AND THE AREA WITHIN 16 KM OF THE SUSITNA RIVER

VEGETATION/HABITAT TYPE	Facility Component			Total	% of Upper Basin of That Type	% of 16 km Area (a) of That Type
	Right-of-Way (61 m wide)	Borrow Areas	Rail-road Yard			
Forest						
Woodland spruce	2.0	16.7		18.7	.001	0.02
Open spruce	38.3	35.5		73.8	.06	0.2
Open birch	10.8			10.8	1.0	0.7
Closed birch	4.4	1.8		6.2	2.0	0.3
Closed balsam poplar	14.7	11.0		25.7		4.0
Open conifer-deciduous	68.7	4.0		72.7		0.7
Closed conifer-deciduous	163.8	141.0	7.8	312.6		2.0
Tundra						
Wet sedge-grass	8.8	1.3		10.1	0.2	0.3
Sedge shrub	17.7			17.7		0.09
Mat and cushion	26.5			26.5	0.04	0.04
Shrubland						
Tall shrub	63.0	11.0		74.0	0.06	0.03
Low birch shrub	108.0	32.0		140.0	0.4	0.33
Low mixed shrub	69.0	3.5		72.5	0.01	0.08
Herbaceous-Grassland			14.6	14.6		1.0
Disturbed	2.0	7.5		9.5		39.0
Unvegetated						
Lakes	13.7			13.7	0.05	0.23
River	2.5			2.5	0.02	0.06
Rock		1.5		1.5	0.001	0.01
TOTAL AREA	613.9	266.8	22.4	903.1	0.06 (b)	0.20 (b)

a. An area 16 km on either side of the Susitna River from Gold Creek to the mouth of the Maclaren River.

b. This figure is not a summation of this column, but a percentage determined by dividing the total area to be impacted by the total available area.

TABLE 3.59: HECTARES OF DIFFERENT VEGETATION TYPES TO BE IMPACTED BY THE TRANSMISSION FACILITY COMPARED WITH TOTAL HECTARES OF THAT TYPE IN THE TRANSMISSION CORRIDORS

VEGETATION/HABITAT TYPE	Healy to Fairbanks		Dams to Intertie		Willow to Cook Inlet (a)		Total Rights-Of-Way
	Right-of-Way (b)	% of Corridor	Right-of-Way (b)	% of Corridor	Right-of-Way (b)	% of Corridor	
Forest	1533.7	1.8	587.1	1.7	713.5	2.8	2834.3
Woodland spruce-black	44.4	2.5	2.5	0.1	20.7	0.8	149.6
Woodland spruce - white			82.0	1.7			
Open spruce-black	685.2	2.2	4.9	0.2	98.0	2.9	812.6
Open spruce-white			24.5	0.6			
Closed spruce	74.6	5.5			61.7	1.9	136.3
Open deciduous	149.7	1.2					149.7
Closed deciduous	76.3	0.7					76.3
Open birch			20.4	2.5			20.4
Closed birch			10.8	0.6	114.8	3.2	125.6
Woodland conifer-deciduous	28.8	3.0					28.8
Open conifer-deciduous	251.0	2.0	95.4	1.9	111.8	6.6	458.2
Closed conifer-deciduous	60.2	1.5	346.6	3.0	306.5	2.8	713.3
Open spruce/open deciduous	30.8	3.2					30.8
Open spruce/wet sedge-grass/ open deciduous	43.0	2.2					43.0
Open spruce/low shrub/wet sedge-grass/open deciduous	70.1	1.0					70.1

TABLE 3.60: AREA OF OVERLAP OF BROWN BEAR HOME RANGES AND THE WATANA AND DEVIL CANYON IMPOUNDMENTS

Bear ID (age)	Home Range (km^2)	Area of intersection (km^2) with impoundment: Watana	Devil Canyon	%
MALES				
342a(2)	1774	0	16.3	0.9
293 (3)	4135	155.4	0.8	3.8
214 (4)	975	50.0	0	5.1
280 (5)	743	84.1	0	11.3
294(10)	611	0	13.7	2.2
FEMALES				
335 (2)	179	0	0	0
281 (3)(w/cubs in '81)	330	82.7	0	25.1
340 (3)	613	62.1	0	10.1
308b(5)	191	0	14.4	7.5
344 (5)	246	0	0	0
331 (6)	1136	50.4	0	4.4
341 (6)	536	43.6	0	8.1
313 (9)	218	0	0	0
277(10)	147	0	0	0
312(10)(w/cubs in '81)	280	1.2	0	0.004
334(10)(w/cubs in '81)	111	0	0	0
283(12)	323	0	12.9	4.0
299(13)	585	54.5	0	9.3
337(13)(w/cubs in '81)	270	0	0	0

TABLE 3.61: AREA OF OVERLAP OF BLACK BEAR HOME RANGES AND THE WATANA AND DEVIL CANYON IMPOUNDMENTS

Bear ID (age)	Home Range (km^2)	Area of intersection (km^2) with impoundment		
		Watana	Devil Canyon	%
MALES				
330 (1)	10	0	0	0
323 (2)	383	1.0	21.7	5.9
319 (3)	146	0	14.1	9.7
291 (4)	20	0	1.6	8.0
322 (4)	10	2.5	0	25.0
324 (5)	400	0.4	9.8	2.6
342B(5)	611	139.9	0	22.9
343B(5)	289	0	11.8	4.1
302 (8)	326	98.9	0	30.3
303 (8)	142	0	3.1	2.2
305 (9)	48	0	0	0
346 (9)	62	13.9	0	22.4
348 (9)	388	34.5	2.0	9.4
287(10)	292	6.3	2.5	3.0
304(10)	51	0	0	0
FEMALES				
329 (1)	15	6.8	0	45.3
349 (4)	36	11.4	0	31.7
318 (5)	1051	112.4	4.3	11.1
327 (5)	32	14.1	0	44.1
328 (6)	30	0	0.9	3.0
301 (7)	26	7.0	0	26.9
317 (7)	19	0	0	0
290 (8)	163	0	10.6	6.5
289 (9)	47	21.4	0	45.5
288(10)	7	0	0	0
321(10)	774	91.8	5.4	12.6
325(11)	146	9.7	3.3	8.9

TABLE 3.62: GENERAL TYPES OF IMPACTS TO RAPTORS

Disturbance

Construction and Operation Activities

- sudden loud noises (e.g., blasting, gas venting, etc.) can lead to panic flights and damage to nest contents
- noise, human presence, etc. can lead to disruption of daily activities

Aircraft Passage

- sudden appearance and noise can lead to panic flights and damage to nest contents

Human Presence Near Nests

- inadvertent - chance occurrence of people (and dogs) near nests; people may be unaware of nest, raptors, or raptor alarm behavior

- deliberate - curious passersby, naturalists, photographers, researchers can have impacts if safeguards are not taken

Direct Impacts

Intentionally Destructive Acts (as a result of increased public access)

- shooting
- legal or illegal removal of eggs, young, or adults
- rolling of rocks off cliff tops
- cutting of nest trees

Man-made Structures and Obstructions

- raptors may be struck on roads where they may perch or feed
- raptors may strike wires, fences, etc.
- raptors may be electrocuted on power poles
- raptors sometimes attack aircraft, or may accidentally strike aircraft

Environmental Contaminants

- deliberate application and accidental release of insecticides, herbicides, petro-chemicals, and toxic industrial materials can affect raptors and prey by affecting hormones, enzymes, shell thickness, bird behavior, egg fertility and viability, and survival rates of nestlings, fledglings, immatures and adults

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Source: Roseneau et al. 1981

TABLE 3.62 (continued)

Changes in Prey Availability

- decrease in prey abundance or loss of nearby hunting areas may affect territory size, efficiency of hunting, nest occupancy, nesting success, condition of adults and young
- changes may result from aircraft overflights, construction and maintenance activities, public access, etc.

Habitat Loss

Abandonment of area due to destruction of nest, perch or important hunting habitat

TABLE 3.63: DISTURBANCE OF RAPTORS -- INFLUENCE OF TIMING

Timing	Possible Effects of Disturbance
Winter	Raptor may abandon nest, roosting cliff, or hunting area (e.g., Gyrfalcon)
Arrival and courtship	Migrant raptor may be forced to use alternative nest site (if available), may remain but refuse to breed or may abandon nest site
Egg-laying	Partial clutch may be abandoned and remainder (or full clutch) laid at alternative nest; breeding effort may cease or site may be abandoned
Incubation	Eggs may be chilled, overheated, or preyed upon if parents are kept off nest too long; sudden flushing from nest may destroy eggs; male may cease incubating; clutch or site may be abandoned
Nestling phase	Chilling, overheating, or predation of young may occur if adults are kept off nest; sudden flushing of parent may injure or kill nestlings; malnutrition and death may result from missed feedings; premature flying of nestlings from nest may cause injury or death; adults may abandon nest or site
Fledgling	Missed feedings may result in malnutrition or death; fledglings may become lost if disturbed in high winds; increased chance of injury due to extra moving about; parents may abandon brood or site
Night	Panic flight may occur and birds may become lost or suffer injury or death
General	Undue expense of energy; increased risk of injury to alarmed or defending birds; missed hunting opportunities

Source: Roseneau et al. 1981

TABLE 3.64: LINEAR DISTANCES OF CLIFFS IN VICINITY OF PROPOSED IMPOUNDMENTS, AND DISTANCES THAT WOULD BE INUNDATED

	Type of cliff[(a)]	Length inundated (km)	Length above waterline (km)
Devil Canyon Reservoir			
	A	27.4	24.9
	B	8.3	7.9
	C	2.4	1.6
Watana Reservoir			
	A	15.1	0.9
	B	5.1	0
	C	1.6	0.3

a. "A" cliff habitat had cliffs large enough to support a nest, had ledges and nooks for nest placement, and had little loose material; "B" cliffs had these same attributes but were smaller and perhaps not large enough to support a nest; and "C" cliffs had loose substrates (dirt and rock banks or loose talus) and probably would not have been used by raptors.

TABLE 3.65: NUMBER OF KNOWN RAPTOR OR RAVEN NEST SITES IN UPPER SUSITNA RIVER BASIN, ALASKA, THAT WOULD BE INUNDATED BY DEVIL CANYON AND WATANA RESERVOIRS

Species	Total no. active nests	Total no. inactive nests	Active nests that would be flooded		Inactive nests that would be flooded		Total flooded nests
			Devil Canyon	Watana	Devil Canyon	Watana	
Golden Eagle	10	9	1	4	2	3	10
Bald Eagle	6	1	0	2	0	1	3
Gyrfalcon	1	0	0	0	0	0	0
Goshawk	1	0	0	0	0	0	0
Common Raven	4	7	1	0	1	2	4
Unknown	1	3	0	0	0	0	0
TOTALS	23	20	2	6	3	6	17

TABLE 3.66: RAPTOR/RAVEN NEST SITES WITHIN 1.6 km OF POTENTIAL BORROW AREAS

Borrow Area	Species	Distance from Borrow Area	Comments
E	golden eagle	0.2 km	
E	raven	0.5 km	two nest sites
H	raven	0.3 km	
H	unknown	0.4 km	
H	raven	0.8 km	three nest sites
H	gyrfalcon	0.0 km	1974 nest (White 1974)
K	goshawk	1.6 km	
K	gyrfalcon	1.6 km	1974 nest (White 1974)

TABLE 3.67: A GENERAL ASSESSMENT OF POTENTIAL FISH ECOLOGY IMPACT ISSUES BY PROJECT STAGE FOR THE ENTIRE SUSITNA RIVER STUDY AREA UNDER POST-PROJECT FLOWS

Project Stages (a)	Potential Impact Issues	General Assessment
CC, CD, RD, O	Changes in the water quality	Decreases in turbidity levels expected above Talkeetna in summer and minor increases above Talkeetna in winter.
CD, O	Alteration of the temperature structure of the stream.	Impact not yet determined. Greatest concern is for salmon egg development, especially during filling and in the Talkeetna to Devil Canyon reach.
CD	Possibility of excessive dissolved gas (nitrogen and oxygen) concentrations caused by plunging flows	No major impacts expected with appropriate dam design and construction procedures, as proposed.
O	Development of new ice-free areas.	Level of impact not known.
O	Change in ice conditions below Talkeetna affecting downstream movement of fish.	Level of impact on downstream fish movement not known.
CD, O	Summer and winter flow changes and the impact on fish reproduction, growth, and predation as well as critical flows for transportation (including access to tributaries and sloughs)	Level of information on impact on fish reproduction and growth not well-known. Access to main tributaries should not be impacted but access to sloughs above Talkeetna by adult salmon eliminated.
O	Effect on present type of fish collection devices in Cook Inlet	No impact expected.
CD	Extension of upstream anadromous fishery	Salmon passage through Devil Canyon possible during filling. After Devil Canyon dam is constructed, limit of migration will revert to present location.

a. Project stages:
CC - Construction of the cofferdam and river diversion
CD - Construction of the dam and reservoir filling time
RD - Development of limnological conditions and fishery management in the reservoir after filling
O - Operational stage including start-up

TABLE 3.67 (continued)

Project Stages (a)	Potential Impact Issues	General Assessment
O	Bank scour caused by piping effect of increased flows under the ice	No major impacts predicted above Talkeetna Impact below Talkeetna not known.
CD, O	Bed scour as affected by changing flows and ice	Decreases in scouring due to flood control. Open water year-round above Talkeetna may increase enhancement opportunities if proper flow control utilized.
O	Potential for increased production by the addition of new spawning areas and new rearing areas	Potential for mainstem spawning enhancment as a mitigative measure.
CD, RD, O	Formation (and management) of new lakes (impoundments)	Some tributary and mainstem Susitna habitat eliminated. Impoundment may increase amount of overwintering habitat for grayling and development of a resident fishery possible.
RD, O	Changes in personal use fishery	Major increases in impoundment areas and Indian River possible.
CD, O	Potential stranding of juveniles and exposure of redds due to diel variation	Under present project scheme, no significant impact predicted. Potential problem would occur, however, if there were to be significant power peaking at the Devil Canyon facility.
CD, RD, O	Changes in the habitats of downstream resident fish populations	If power peaking is minimal, overall impact on resident fish downstream is expected to be minimal.
CD, O	Effects on rearing, fish passage and egg incubation in the Susitna River from its mouth upstream to Talkeetna	Detailed predictions as to the level of impacts on fisheries in this reach have not been established with the information presently available.

TABLE 3.68: PRIORITY ORGANIZATION OF WILDLIFE MITIGATION IMPACT ISSUES

High Priority Impact Issues	Project Component	Wildlife Resource
W-6	Watana and Devil Canyon Impoundments	Upper Basin Moose
W-8	Watana and Devil Canyon Impoundments	Brown Bear
W-9	Watana and Devil Canyon Impoundments	Wolf
W-20	Access Roads and Construction Camps	All Upstream Furbearer and Big Game Species

Moderate Priority Impact Issues	Project Component	Wildlife Resource
W-2	Watana and Devil Canyon Impoundments	Pine Marten
W-3	Watana and Devil Canyon Impoundments	Cliff-nesting Raptors
W-4	Watana and Devil Canyon Impoundments	Bald Eagle
W-7	Watana and Devil Canyon Impoundments	Black Bear
W-11	Watana Impoundment	Caribou
W-12	Operation of Devil Canyon Dam	Downstream Beavers
W-13	Operation of Devil Canyon Dam	Downstream Moose
W-15	Clearing of Woody Material from the Watana Impoundment	Caribou
W-17	Main Access Road, Borrow Areas, Access Roads to Borrow Areas, and all Construction Camps/Villages	All Furbearer Species, Many Avian and Small Mammal Species, and all Big Game Species except Dall Sheep
W-22	Construction Camps and Access Roads	All Upper Basin Wildlife Species
W-23	Air Traffic	All Big Game Species, Raptors and Trumpeter Swans

TABLE 3.68 (Continued)

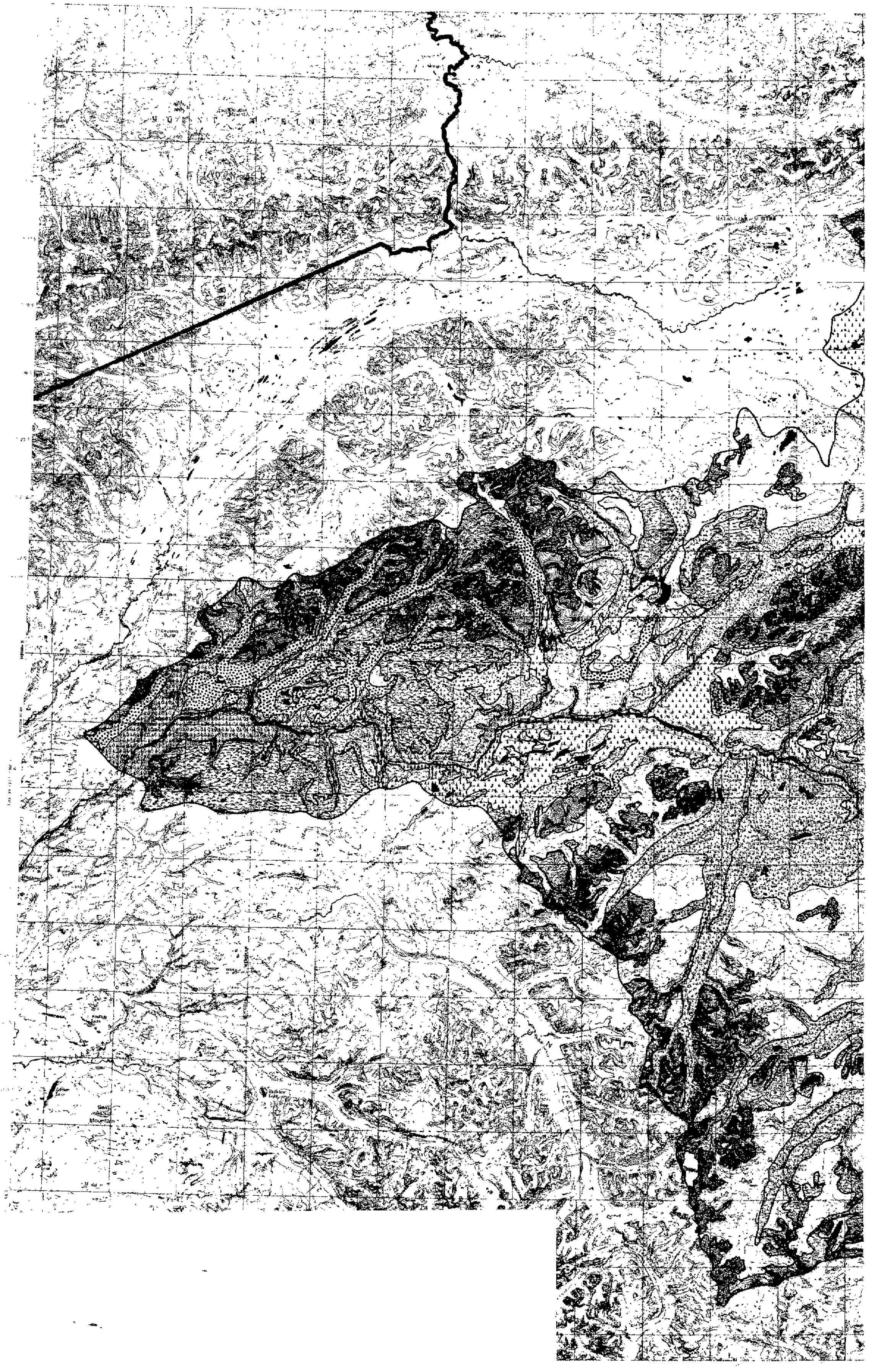
Low Priority Impact Issues	Project Component	Wildlife Resource
W-1	Watana and Devil Canyon Impoundments	Mink and River Otter
W-5	Watana and Devil Canyon Impoundments	Forest-dwelling and Riverine Bird and Small Mammal Species
W-10	Watana Impoundment	Dall Sheep
W-14	Clearing of Woody Material from Impoundments	All Upstream Big Game Species
W-16	Construction Camps/Villages and all Access Roads	Red fox, Wolf, Black and Brown Bear, Ground Squirrel, Gulls and Ravens
W-18	Borrow Areas and Access Roads to Borrow Areas	All Upstream Big Game Species except Dall Sheep
W-19	All Access Roads	Moose and Caribou
W-21	Construction Camps and Villages	Red Fox and Wolf

TABLE 3.69: PREDICTED DOWNSTREAM WATER TEMPERATURES (°C) FOR AN AVERAGE YEAR WITH PROJECT FLOWS[a]

Cross[b] Section	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LRX 68 (Portage Creek)	3.9	3.9	3.9	3.9	5.7	7.1	9.8	9.6	7.6	4.3	3.9	3.9
LRX 61	3.8	3.8	3.9	3.9	5.8	7.1	9.8	9.7	7.6	4.3	3.9	3.8
LRX 54	3.3	3.5	3.7	4.0	6.1	7.5	10.1	10.1	7.7	4.2	3.5	3.5
LRX 47	3.0	3.2	3.6	4.1	6.2	7.8	10.2	10.3	7.8	4.2	3.4	3.3
LRX 41 (Gold Creek)	2.9	3.2	3.6	4.1	6.3	7.9	10.3	10.4	7.8	4.2	3.3	3.2
LRX 34	2.6	2.9	3.4	4.2	6.5	8.2	10.5	10.7	7.9	4.1	3.0	2.9
LRX 27	2.1	2.5	3.3	4.3	6.8	8.6	10.7	11.0	8.0	4.1	2.7	2.5
LRX 21	1.7	2.3	3.2	4.4	7.0	8.9	10.9	11.3	8.1	4.0	2.5	2.2
LRX 15	1.1	1.8	3.0	4.5	7.3	9.4	11.2	11.8	8.2	3.9	2.1	1.7
LRX 9	0.5	1.4	2.8	4.7	7.7	9.9	11.5	12.2	8.3	3.8	1.7	1.3
LRX 3 (Talkeetna)	0.1	1.1	2.6	4.8	7.9	10.3	11.7	12.6	8.4	3.8	1.4	0.9
Discharge Below DC (cfs)	10514	8883	8072	7903	9344	10288	9070	8665	6972	7403	9425	11864

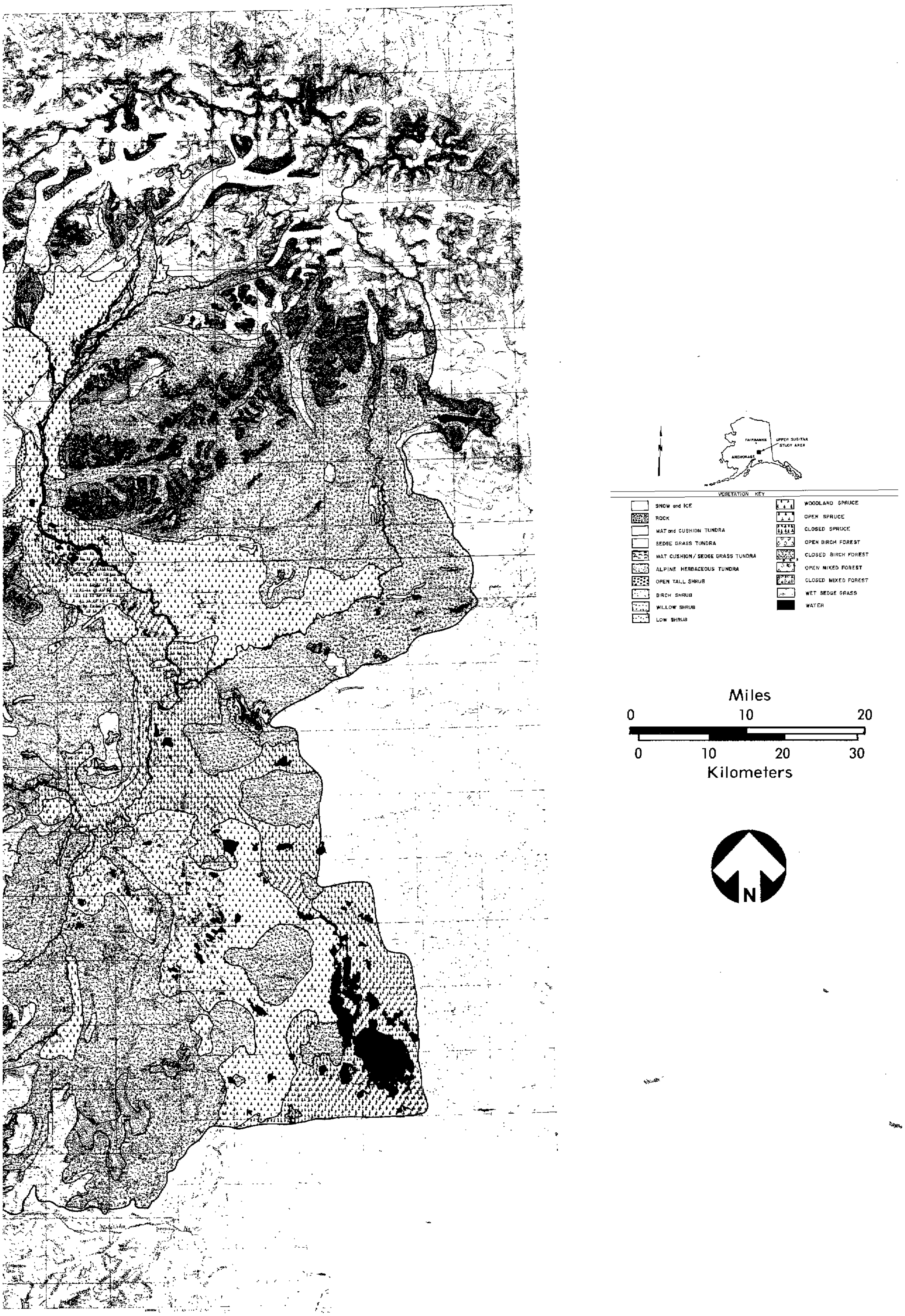
a. Assumes operation for maximum power production, a floating intake at Watana, and a single level intake at 21.3 m (70 ft) at Devil Canyon.

b. LRX refers to R&M river cross sections.



VEGETATION MAP OF THE UPPER SUS

S/UNIVERSITY OF ALASKA



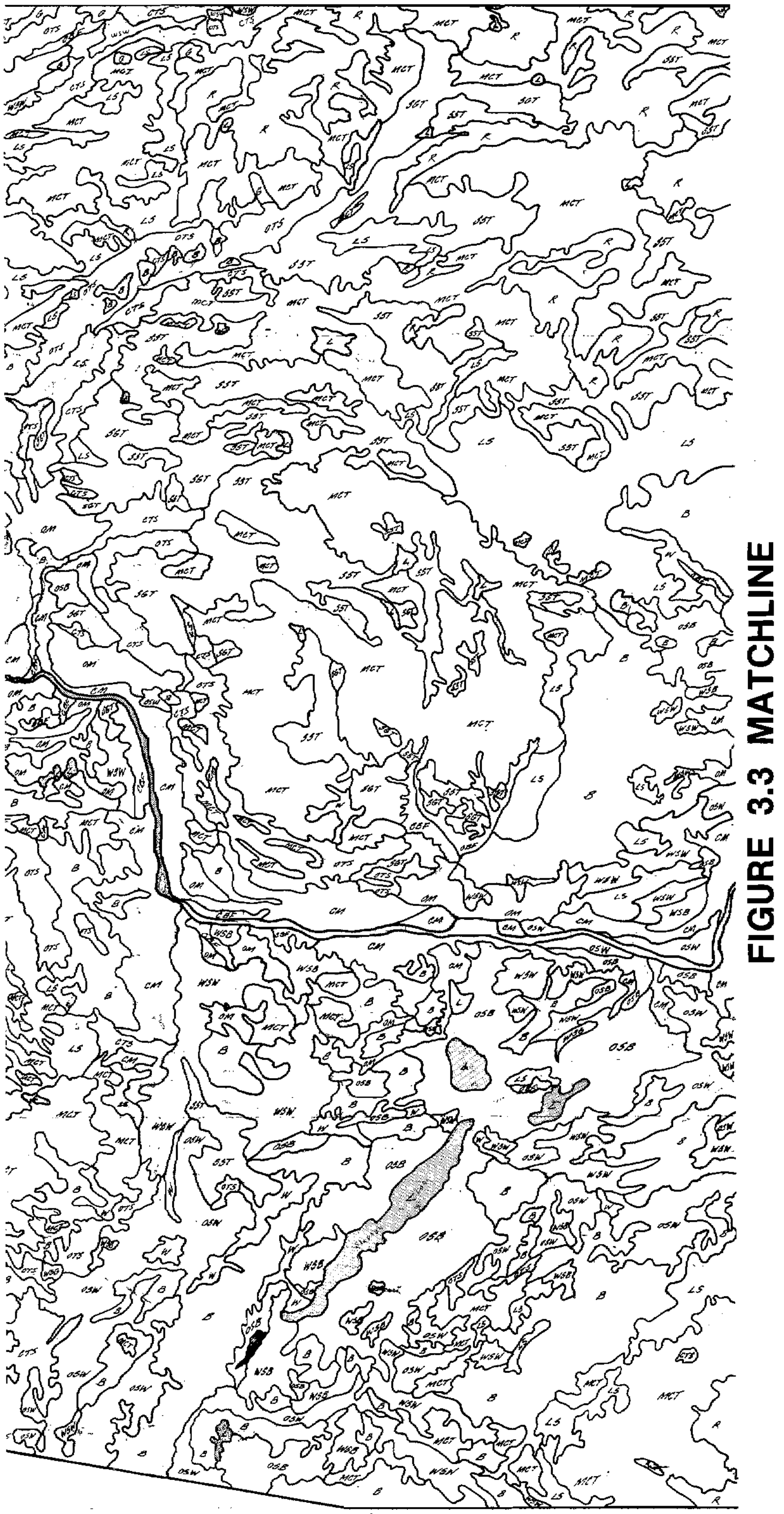
ŠITNA RIVER BASIN

FIGURE 3.1

ACRES

VEGETATION / HABITAT MAP OF AN AREA WITHIN 16 KM OF THE

UNIVERSITY OF ALASKA



VEGETATION KEY

R	ROCK
S	SNOW and ICE
MCT	MAT and CUSHION TUNDRA
SGT	SEDGE GRASS TUNDRA
SST	SEDGE SHRUB TUNDRA
WSG	WET SEDGE GRASS
OSB	OPEN BLACK SPRUCE
WSB	WOODLAND BLACK SPRUCE
OSW	OPEN WHITE SPRUCE
WSW	WOODLAND WHITE SPRUCE
CBF	CLOSED BIRCH FOREST
OBF	OPEN BIRCH FOREST
CP	CLOSED BALSAM POPLAR
OP	OPEN BALSAM POPLAR
CM	CLOSED MIXED FOREST
OM	OPEN MIXED FOREST
CTS	CLOSED TALL SHRUB
OTS	OPEN TALL SHRUB
B	BIRCH SHRUB
W	WILLOW SHRUB
LS	LOW SHRUB
G	GRASSLAND
L	LAKES
D	DISTURBED

N

0 1 2 3 Miles

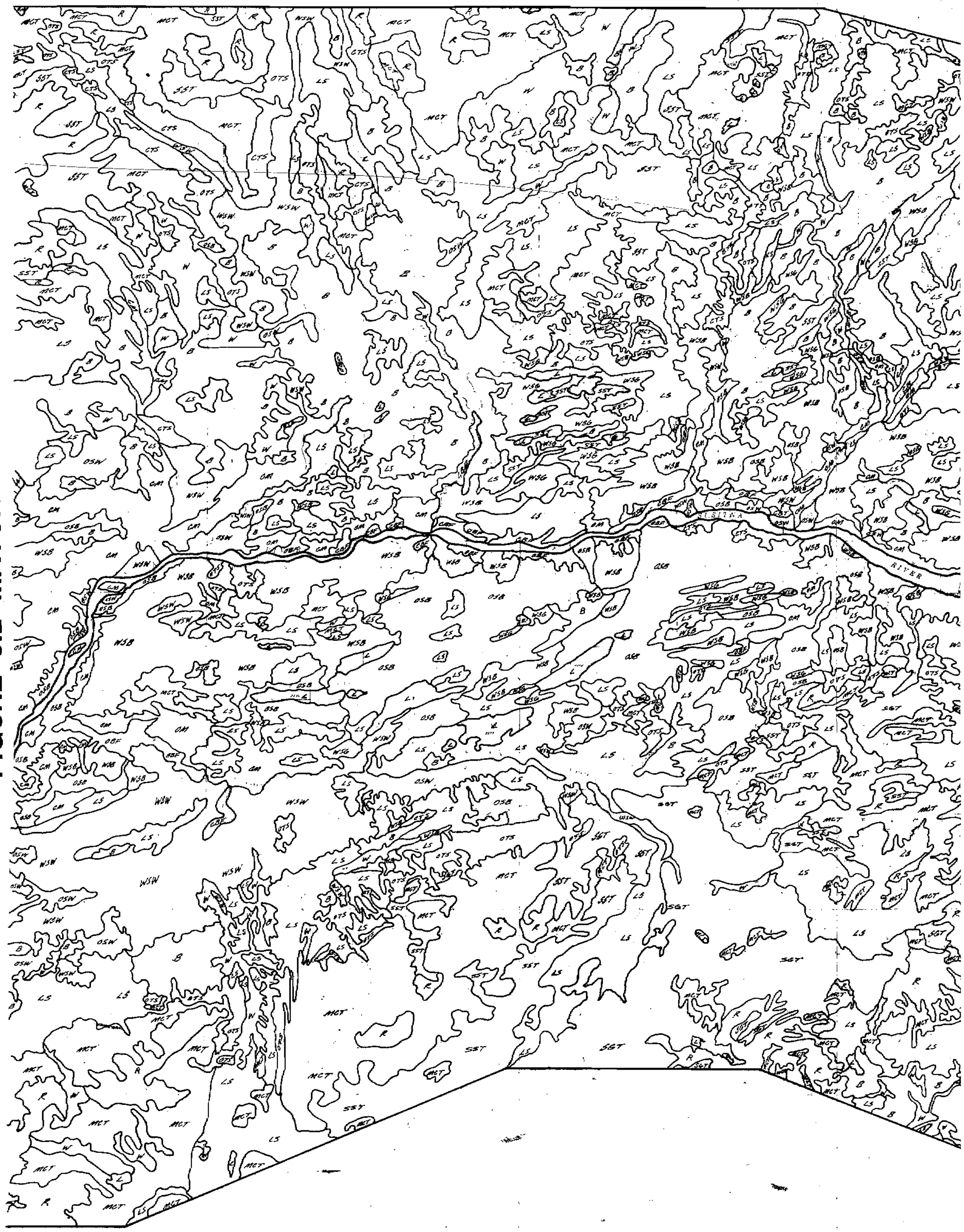
0 1 2 3 4 5 Kilometers

UPPER SUSITNA RIVER, WESTERN PORTION

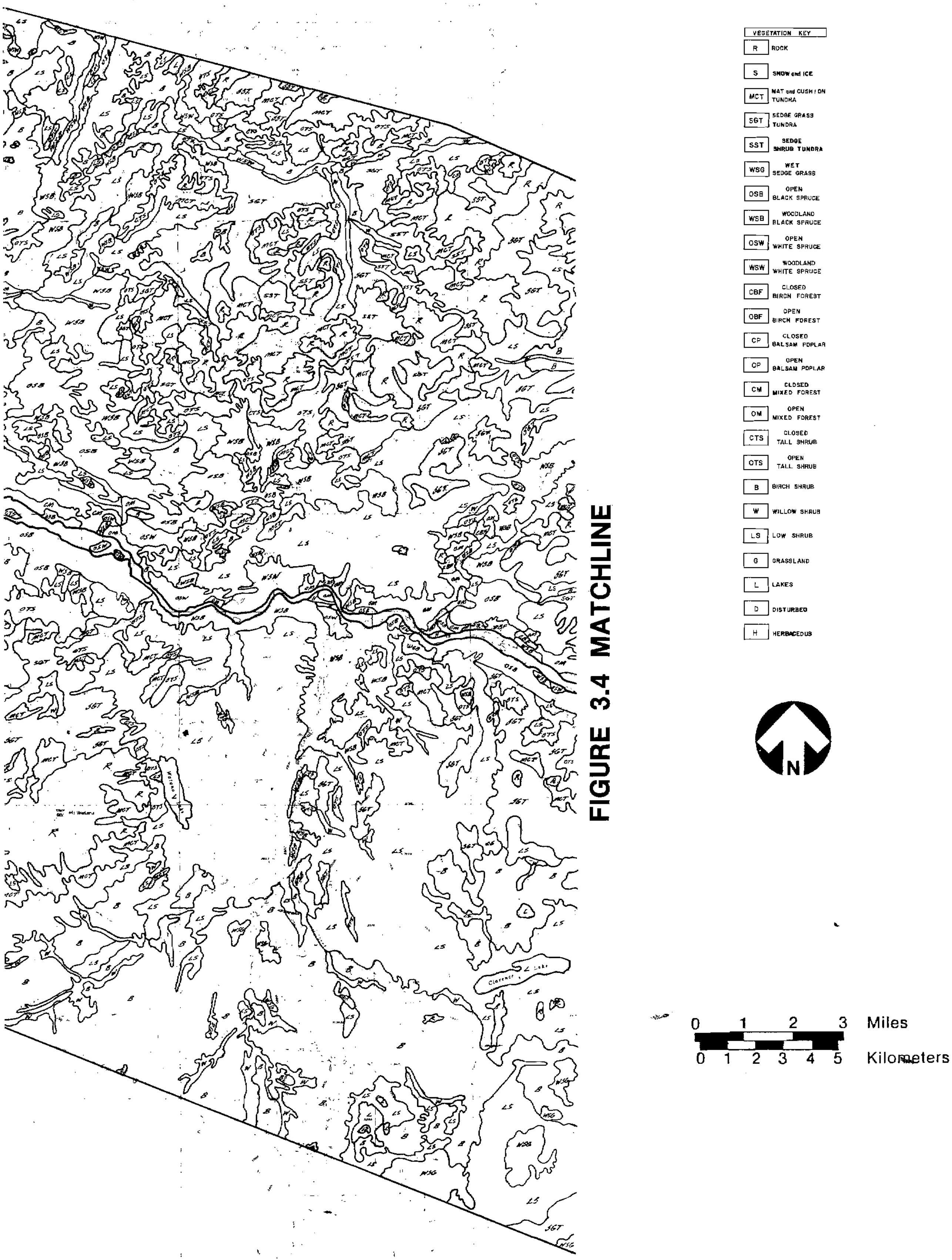
FIGURE 3.2

ACRES

FIGURE 3.2 MATCHLINE



VEGETATION / HABITAT MAP OF AN AREA WITHIN 16 KM OF THE



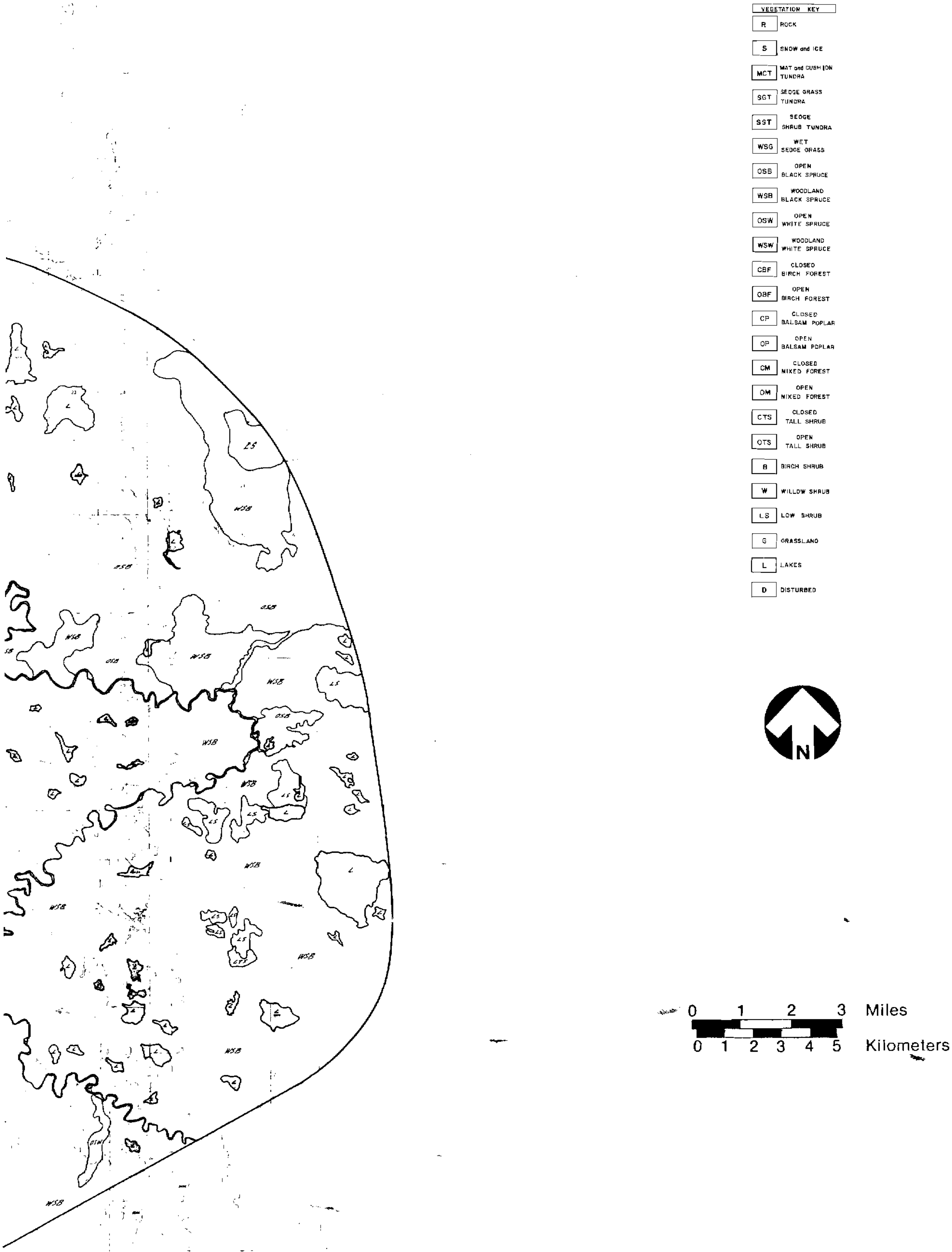
UPPER SUSITNA RIVER, CENTRAL PORTION

ACRES

FIGURE 3.3

FIGURE 3.3 MATCHLINE

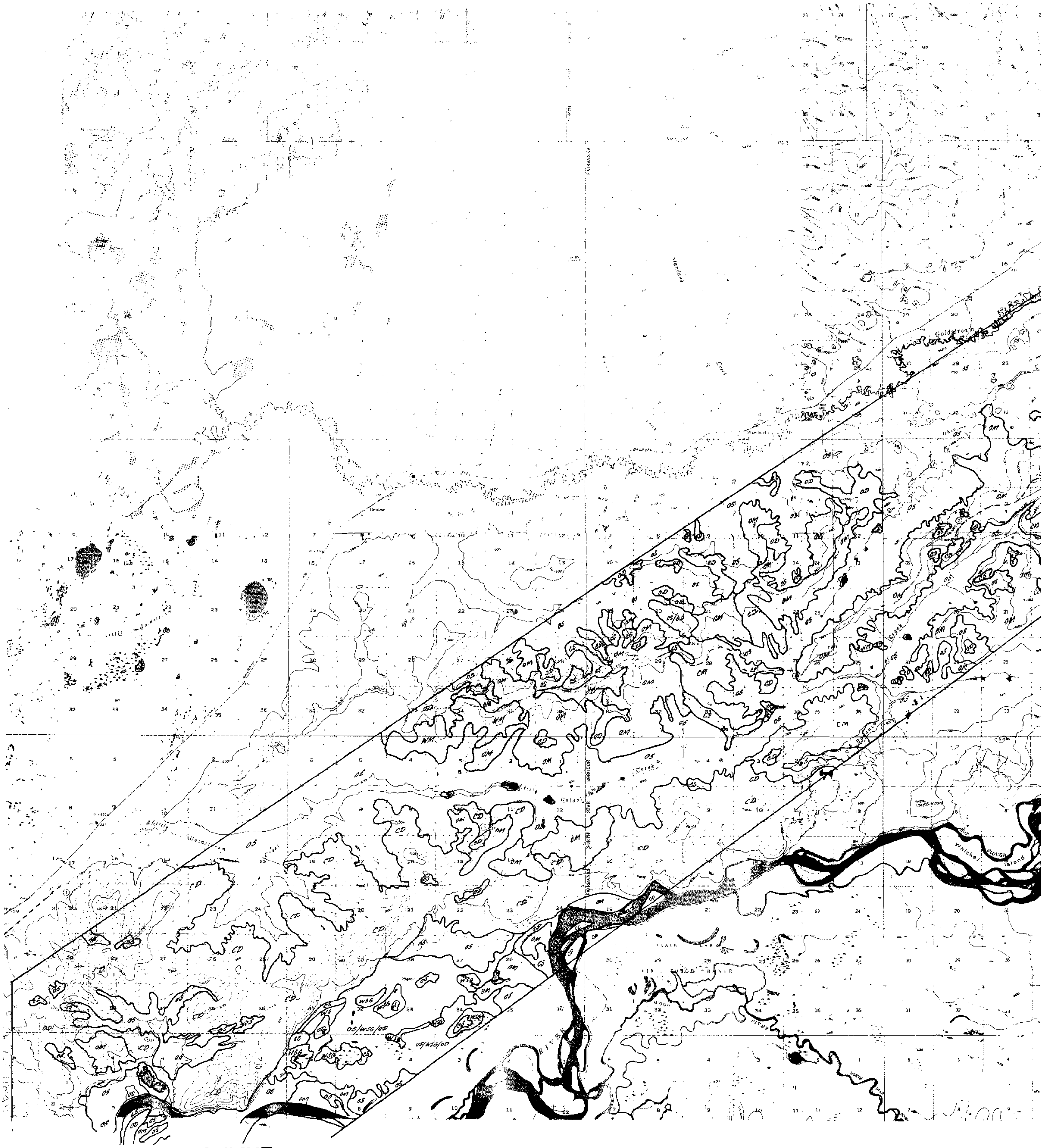
VEGETATION / HABITAT MAP OF AN AREA WITHIN 16 KM OF THE



UPPER SUSITNA RIVER, EASTERN PORTION

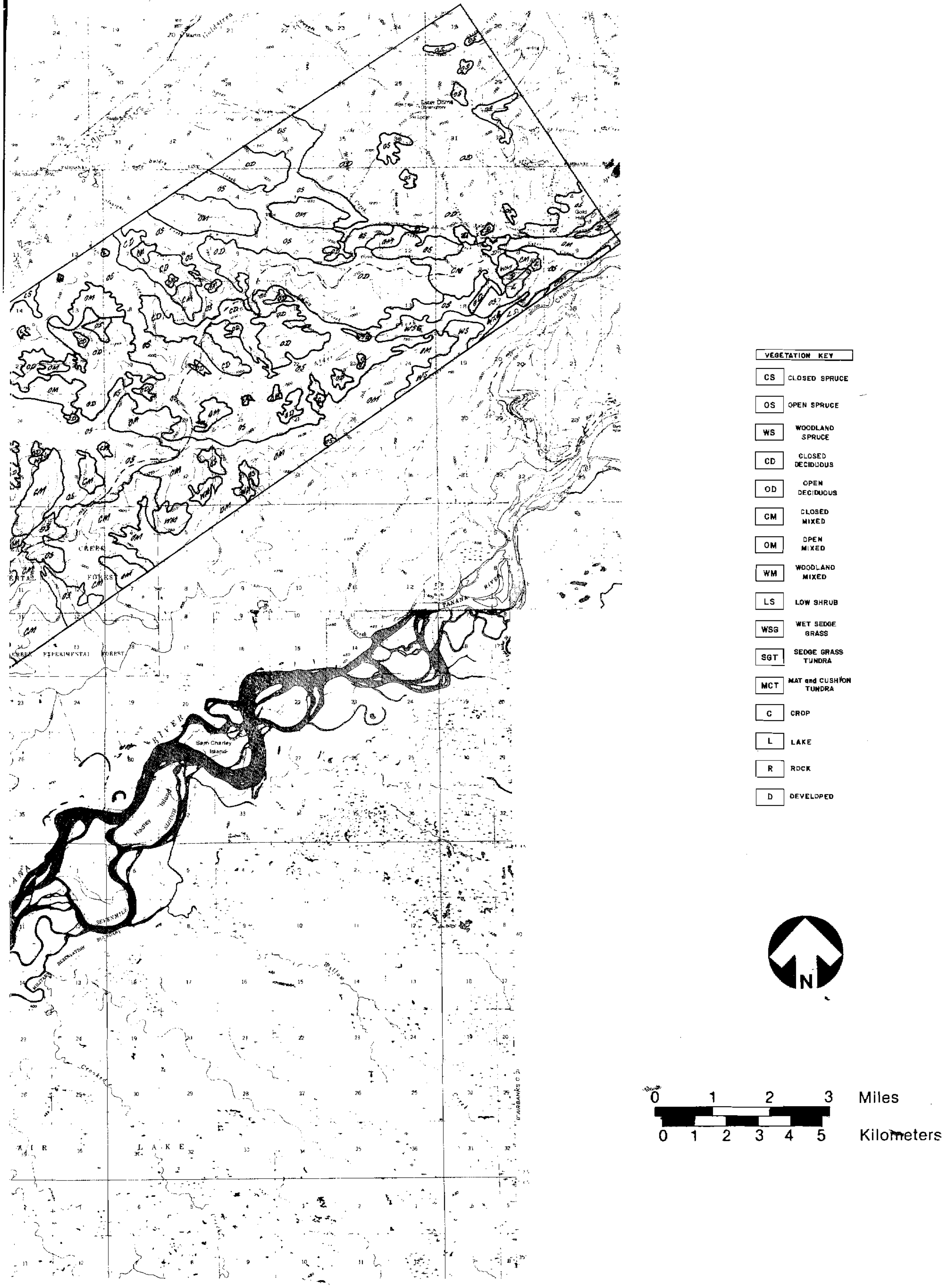
FIGURE 3.4

ACRES



VEGETATION / HABITAT MAP OF HEALY TO FAIRBANKS TRA

PREPARED BY TES / UNIVERSITY OF ALASKA



ISSION CORRIDOR, NORTHERN PORTION

FIGURE 3.5

ACRES

FIGURE 3.5 MATCHLINE

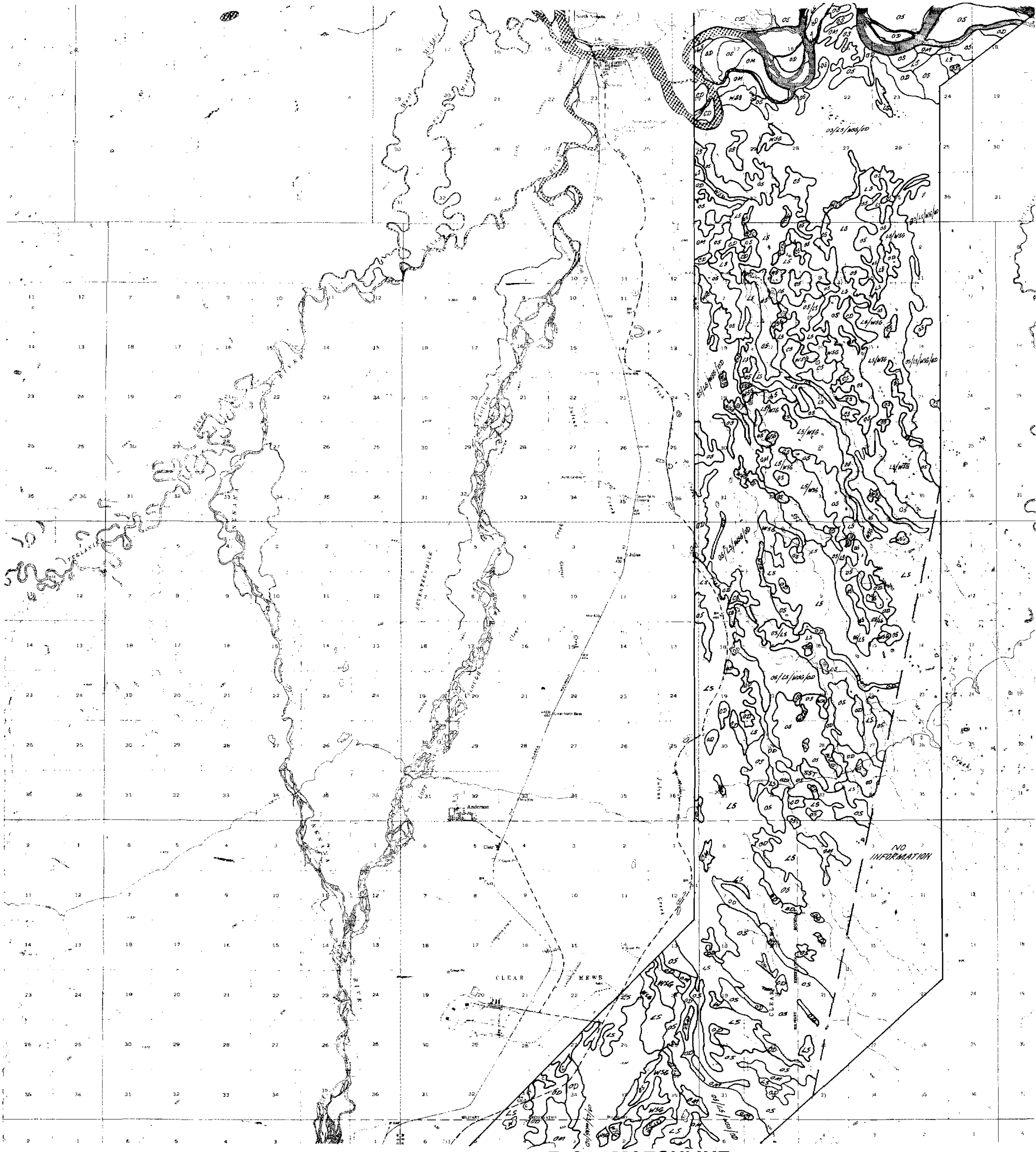
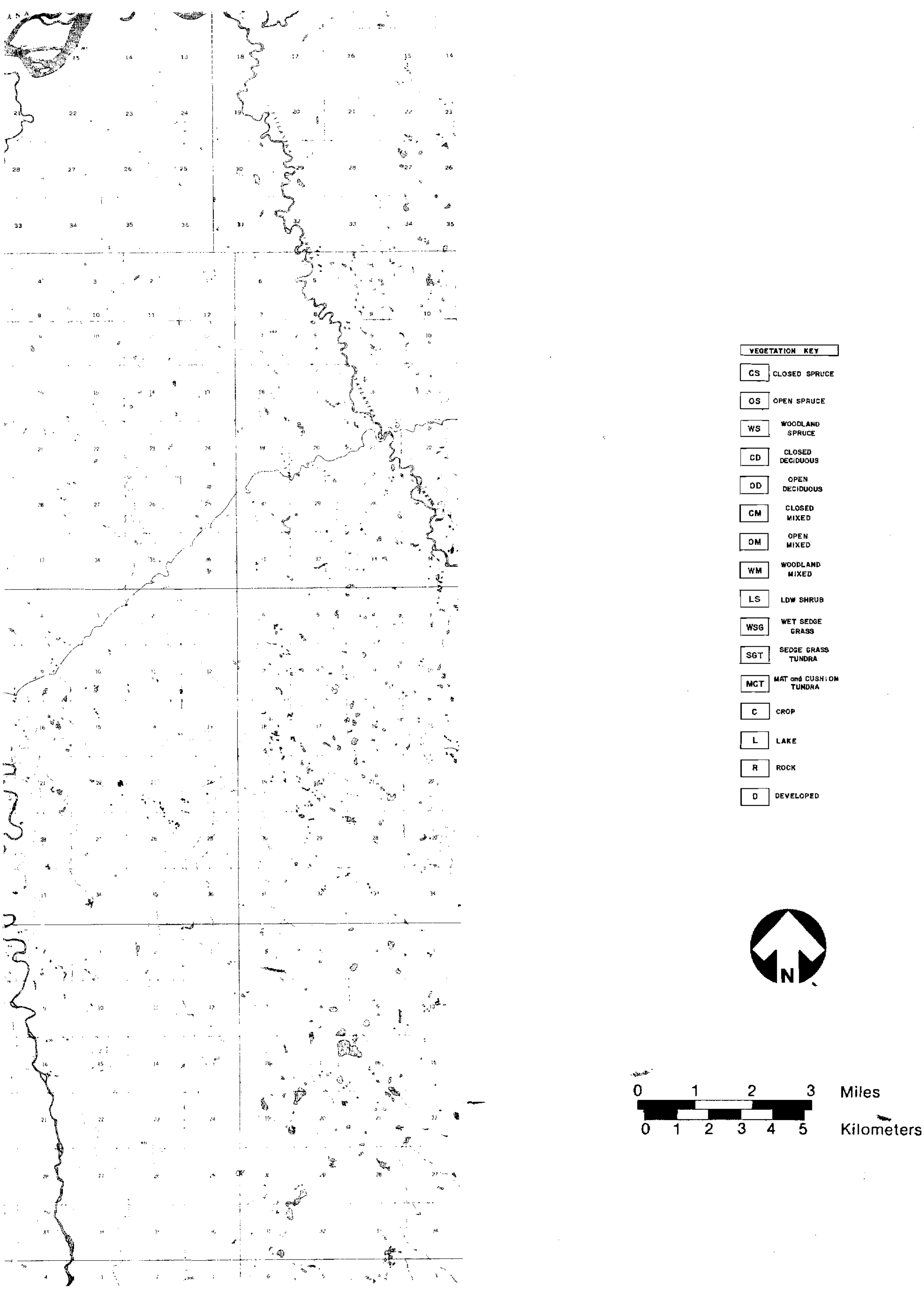


FIGURE 3.7 MATCHLINE

VEGETATION / HABITAT MAP OF HEALY TO FAIRBANKS TRA

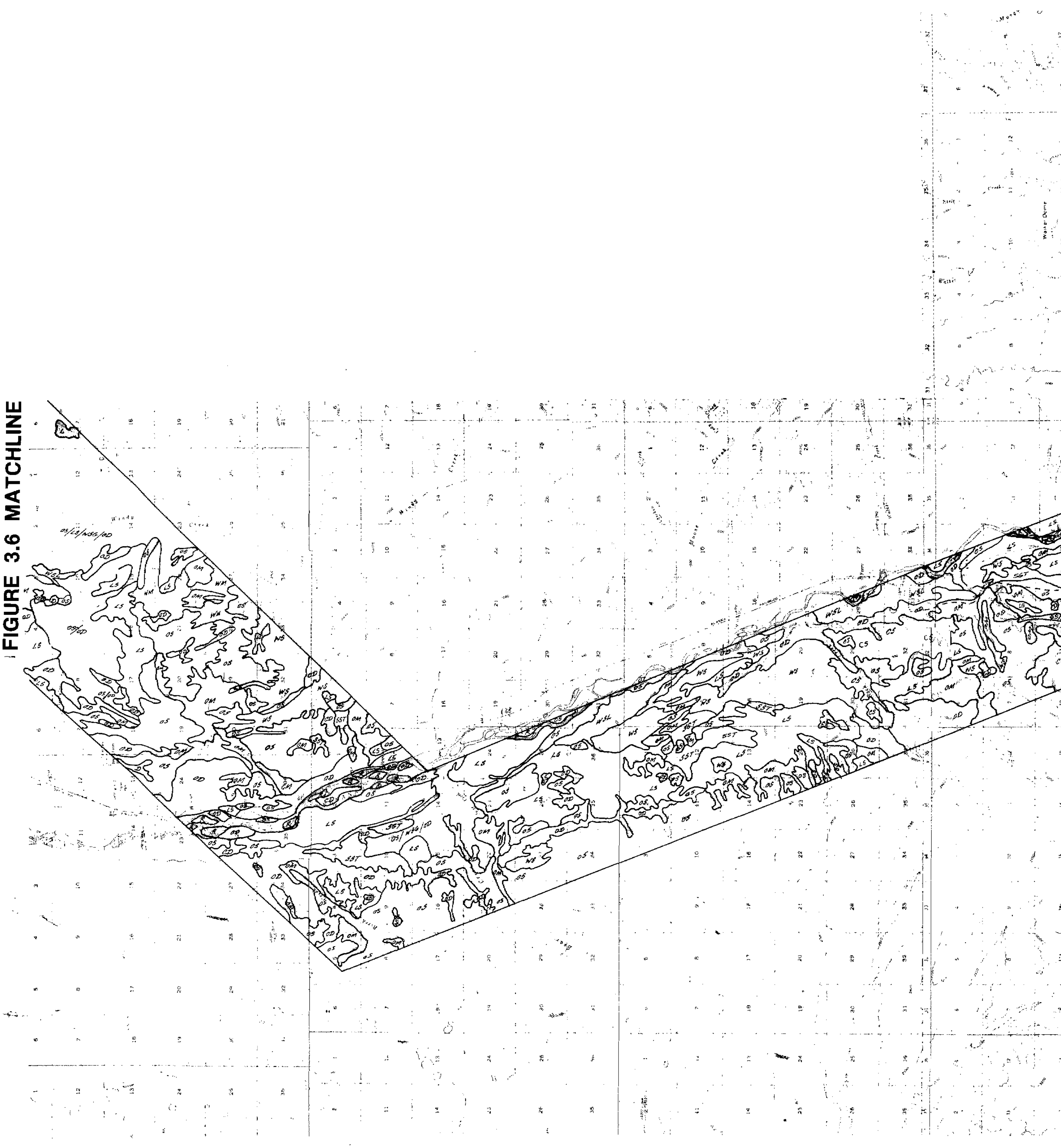
PREPARED BY TES / UNIVERSITY OF ALASKA



IISSION CORRIDOR, CENTRAL PORTION

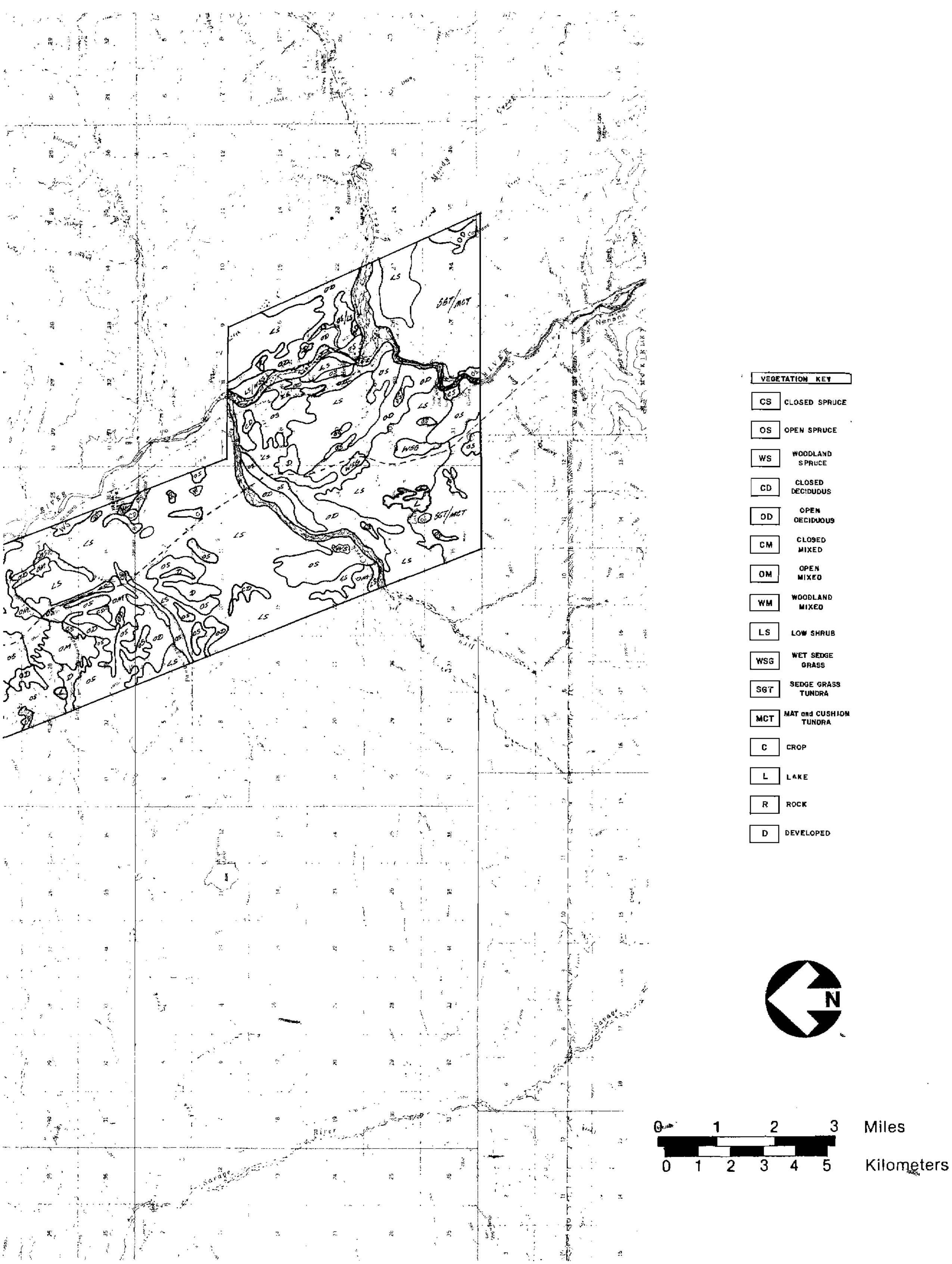
FIGURE 3.6

ACRES



VEGETATION / HABITAT MAP OF HEALY TO FAIRBANKS TRA

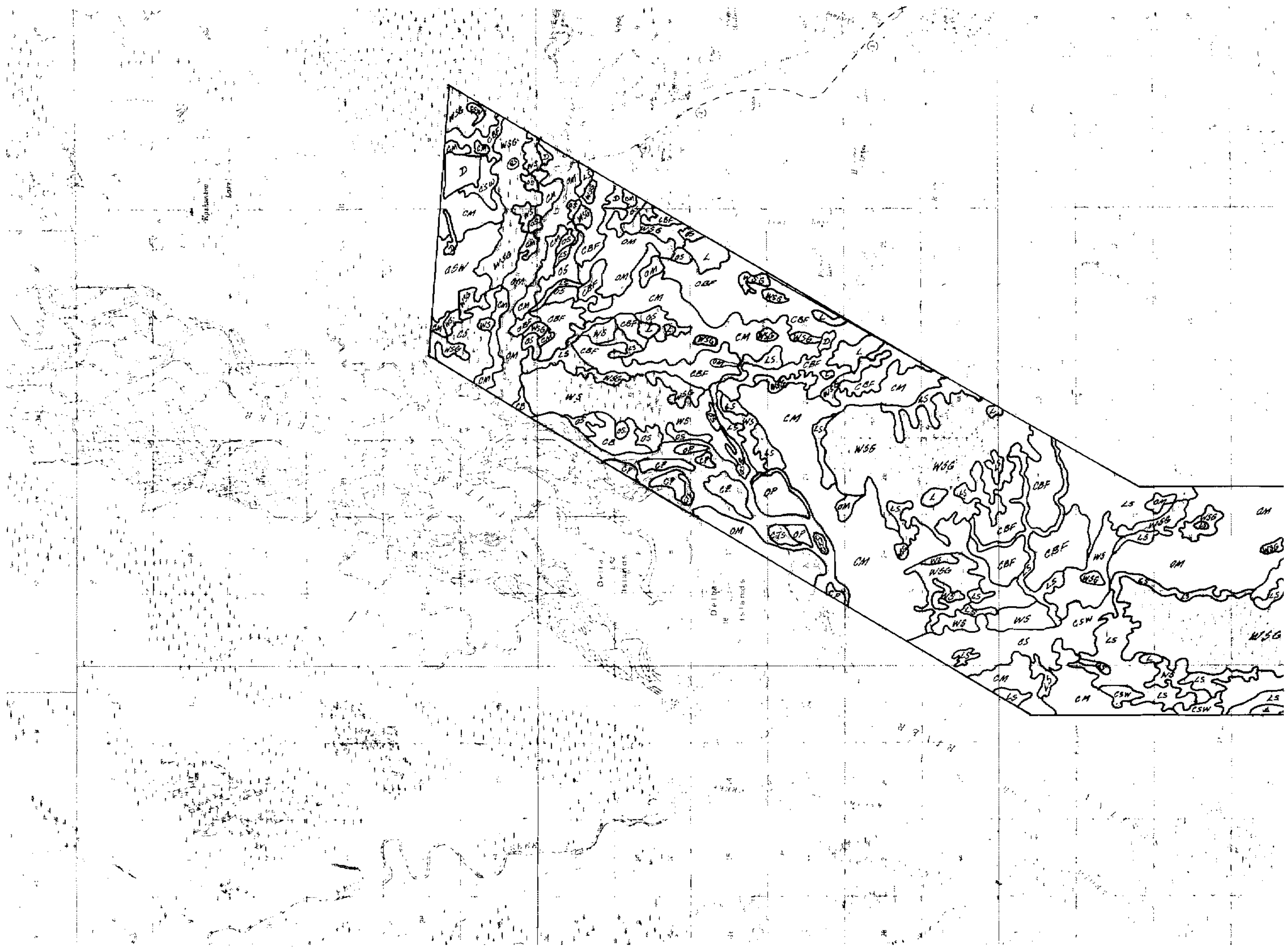
PREPARED BY TES / UNIVERSITY OF ALASKA



SSION CORRIDOR, SOUTHERN PORTION

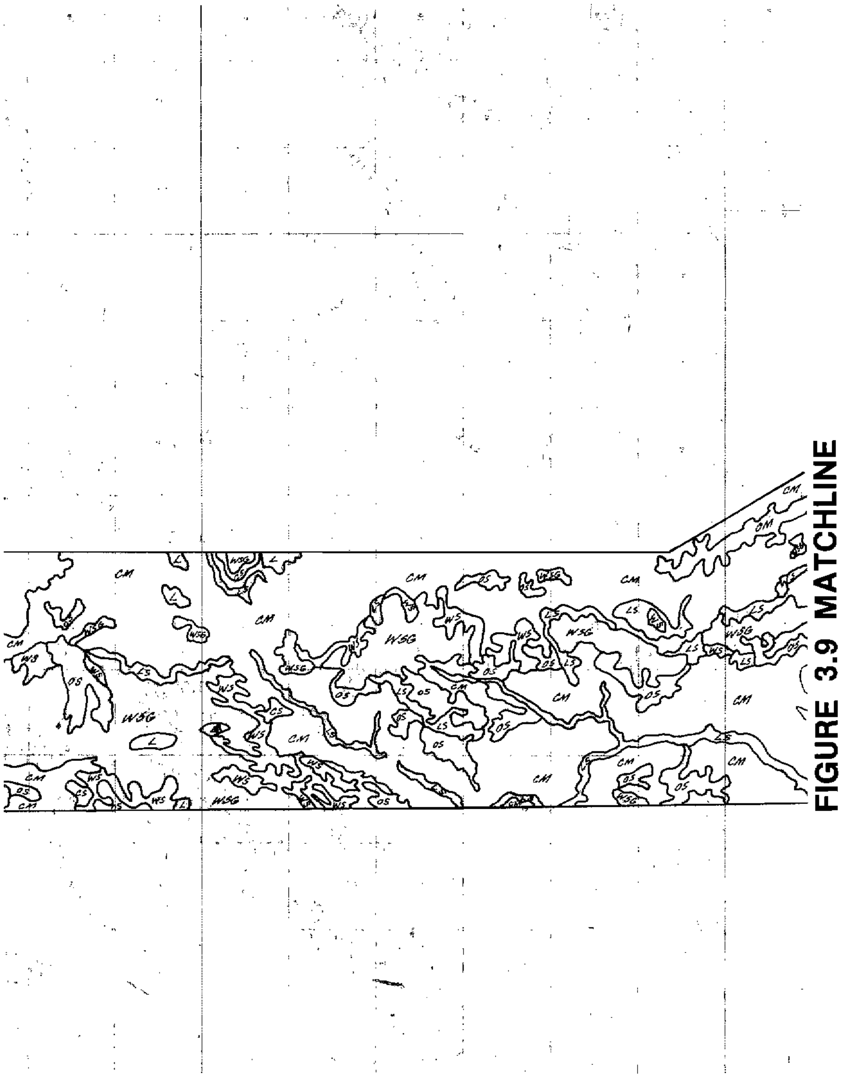
FIGURE 3.7

ACRES



VEGETATION / HABITAT MAP OF WILLOW TO POINT MAC KENZIE TRA

NIVERSITY OF ALASKA



VEGETATION KEY

CS	CLOSED SPRUCE
WSG	WET SEDGE GRASS
OS	OPEN SPRUCE
WS	WOODLAND SPRUCE
CBF	CLOSED BIRCH FOREST
OBF	OPEN BIRCH FOREST
CP	CLOSED BALSAM POPLAR
OP	OPEN BALSAM POPLAR
CM	CLOSED MIXED FOREST
OM	OPEN MIXED FOREST
CTS	CLOSED TALL SHRUB
LS	LOW SHRUB
D	DISTURBED
L	LAKES

N

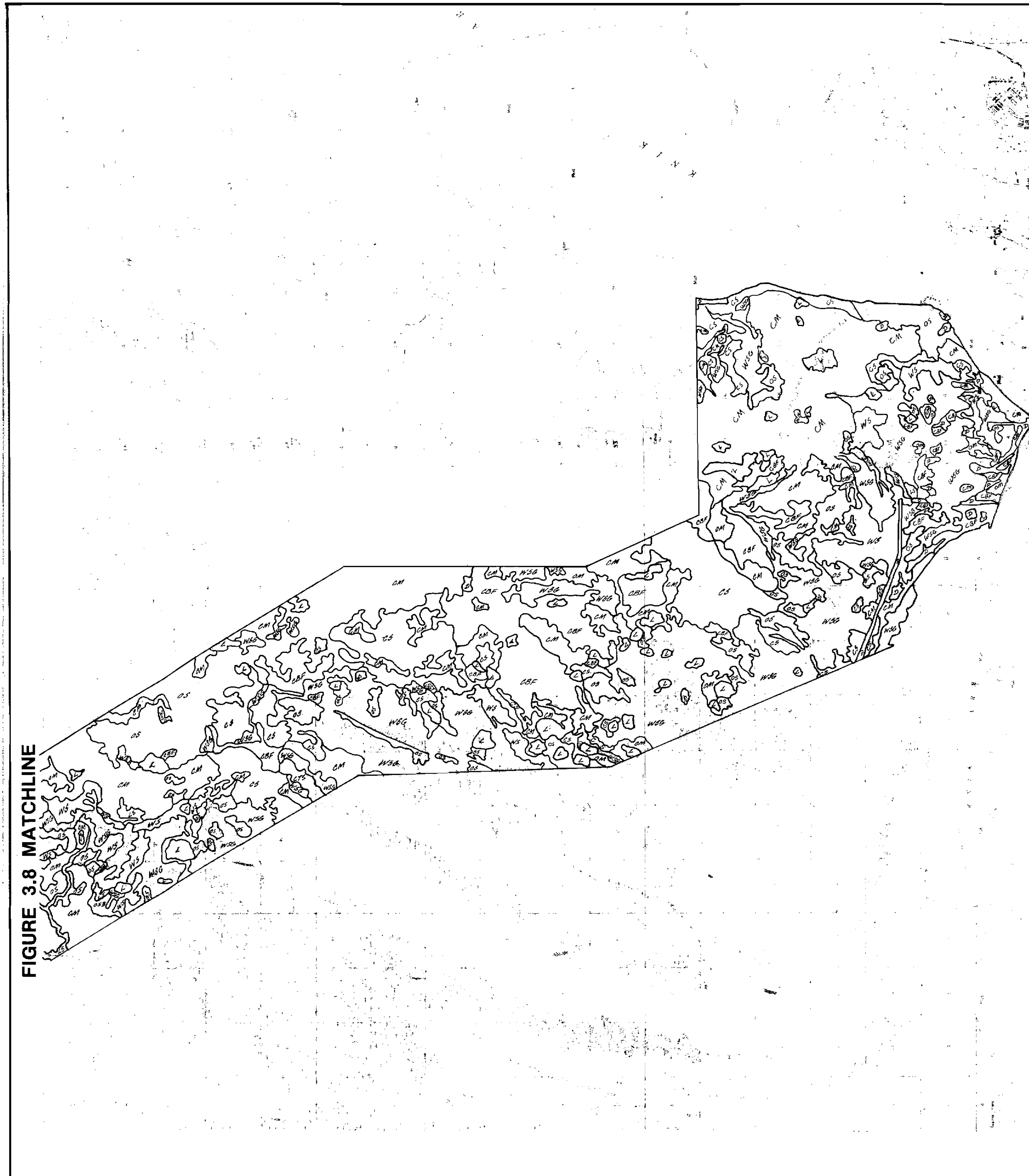
0 1 2 3 Miles

0 1 2 3 4 5 Kilometers

NSMISSION CORRIDOR, NORTHERN PORTION

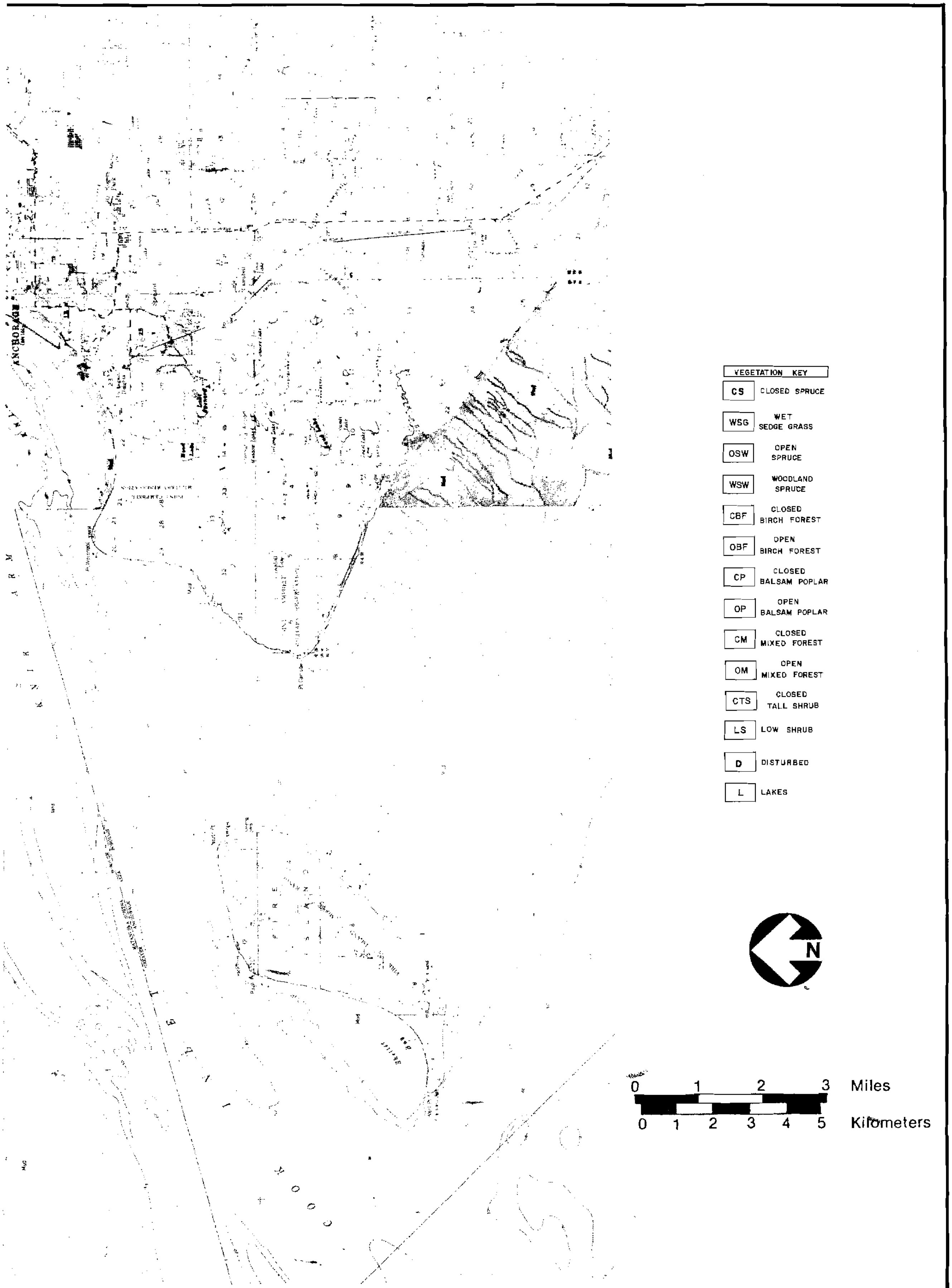
FIGURE 3.8

ACRES



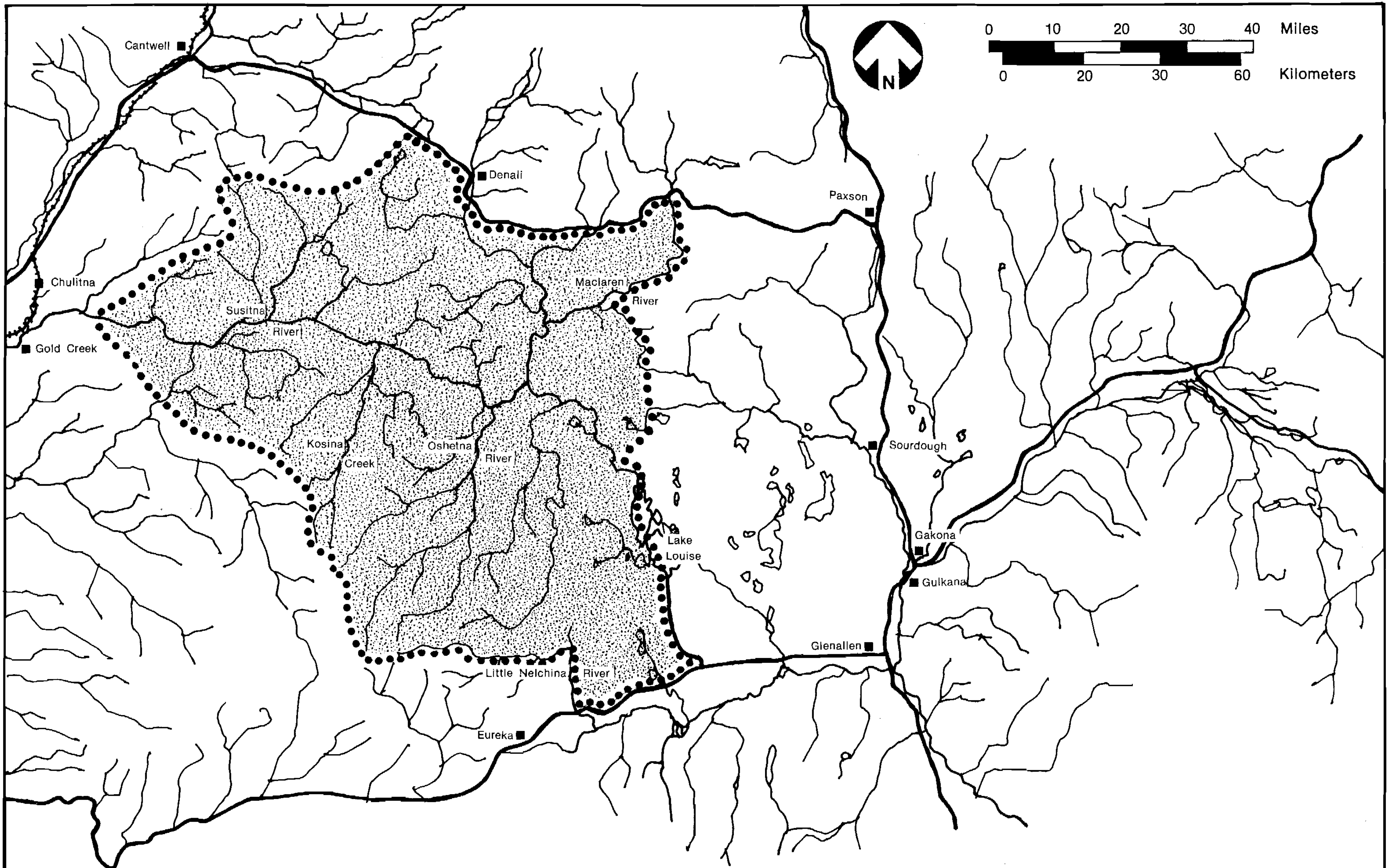
VEGETATION / HABITAT MAP OF WILLOW TO POINT MAC KENZIE

PREPARED BY TES / UNIVERSITY OF ALASKA



NSMISSION CORRIDOR, SOUTHERN PORTION

FIGURE 3.9

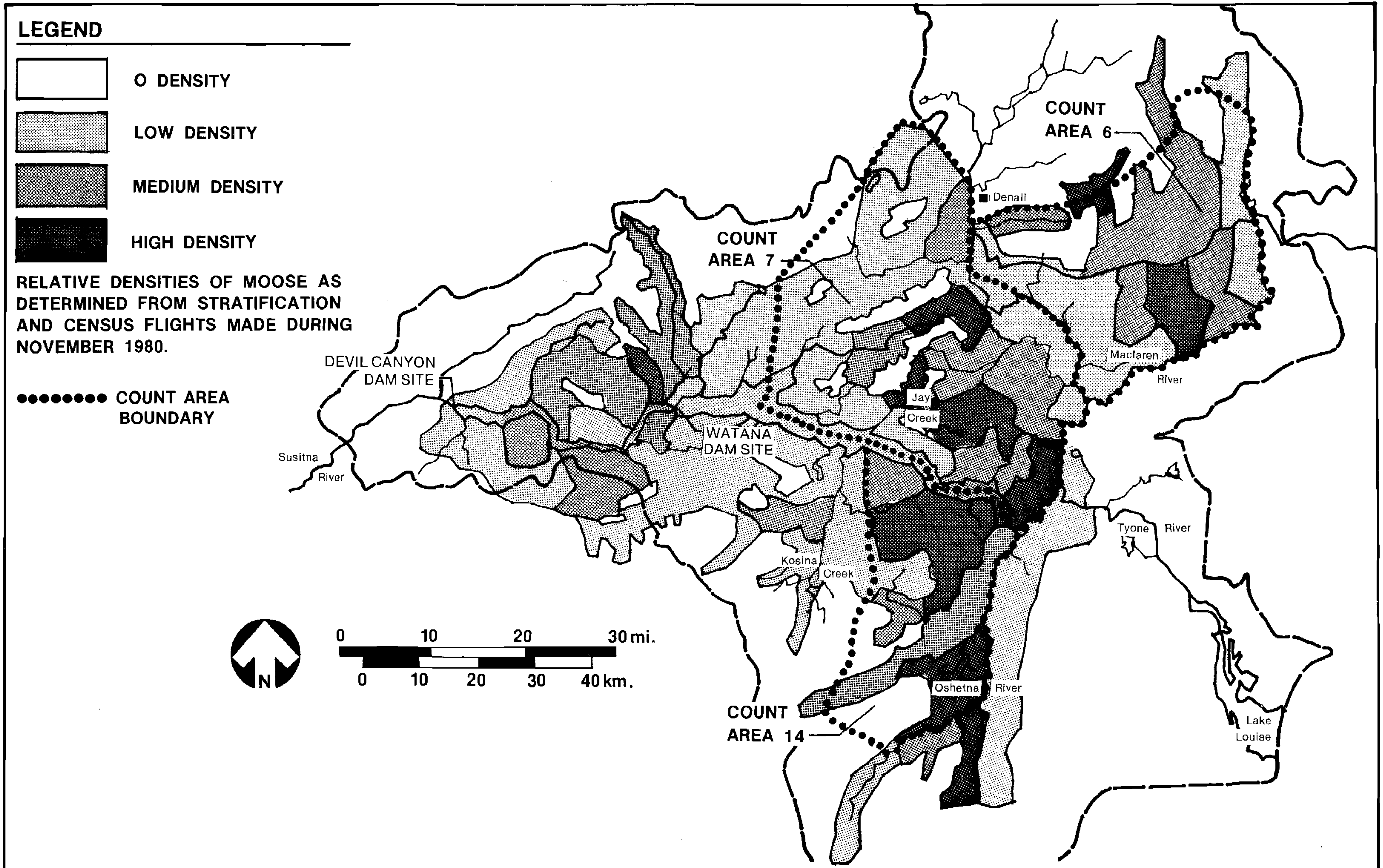


BOUNDARIES OF THE SUSITNA MOOSE STUDY AREA - UPSTREAM

PREPARED BY TES / ADF&G

FIGURE 3.10

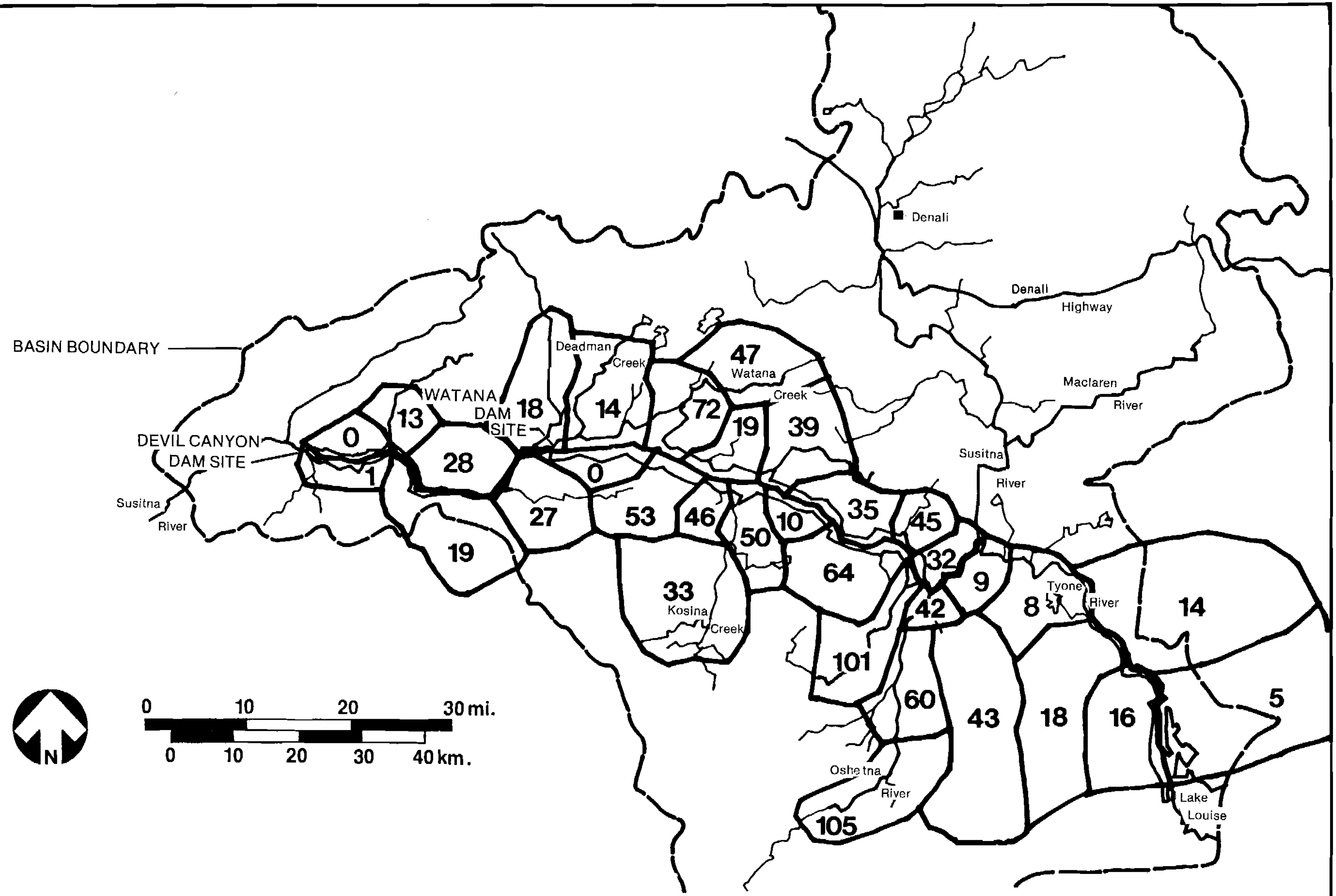
ACRES



BOUNDARIES OF ESTABLISHED MOOSE COUNT AREAS

PREPARED BY TES / ADF&G

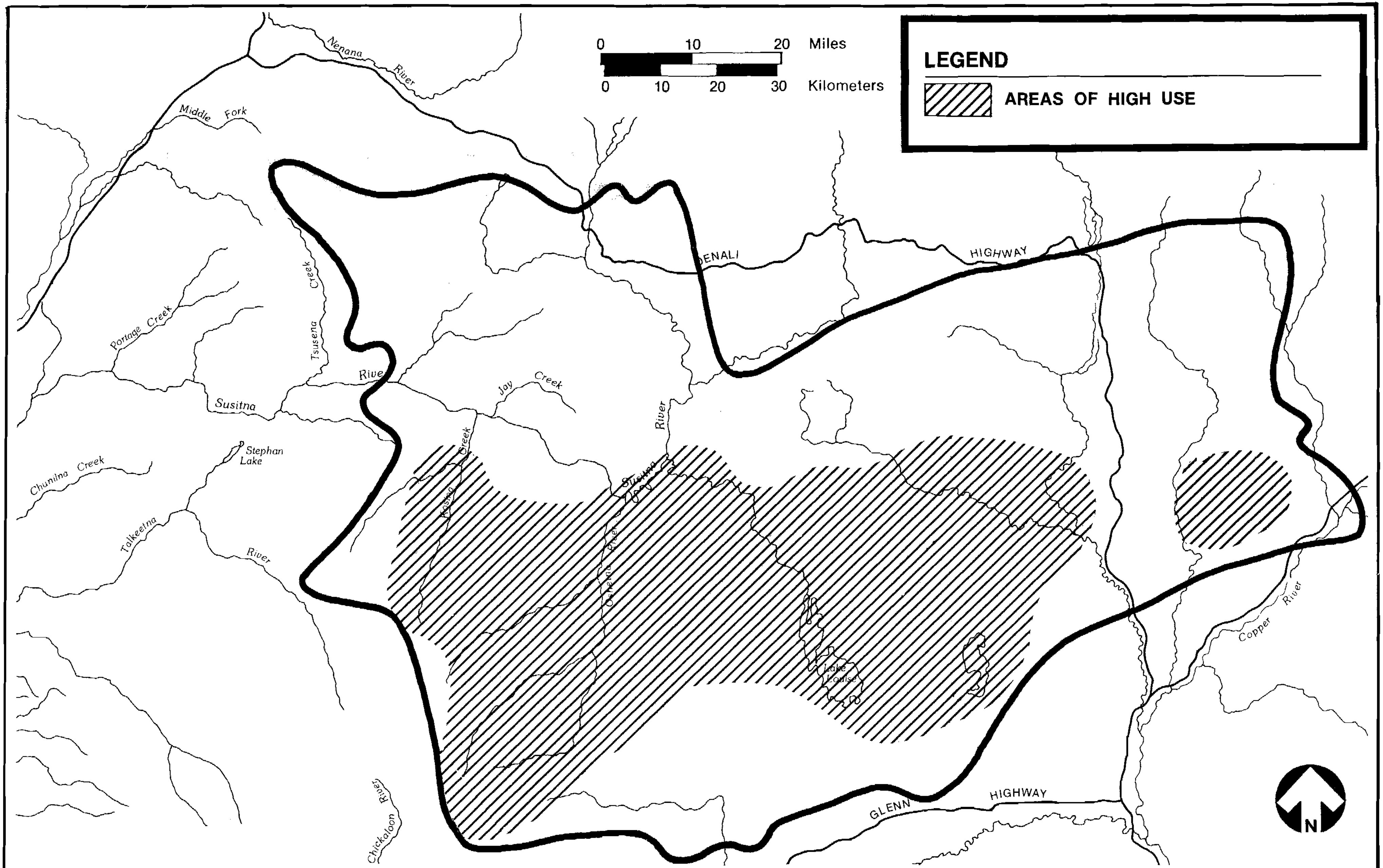
FIGURE 3.11



RELATIVE DISTRIBUTION OF MOOSE OBSERVED DURING A WINTER DISTRIBUTION SURVEY CONDUCTED FROM 4 THROUGH 25 MARCH 1980

PREPARED BY TES / ADF&G

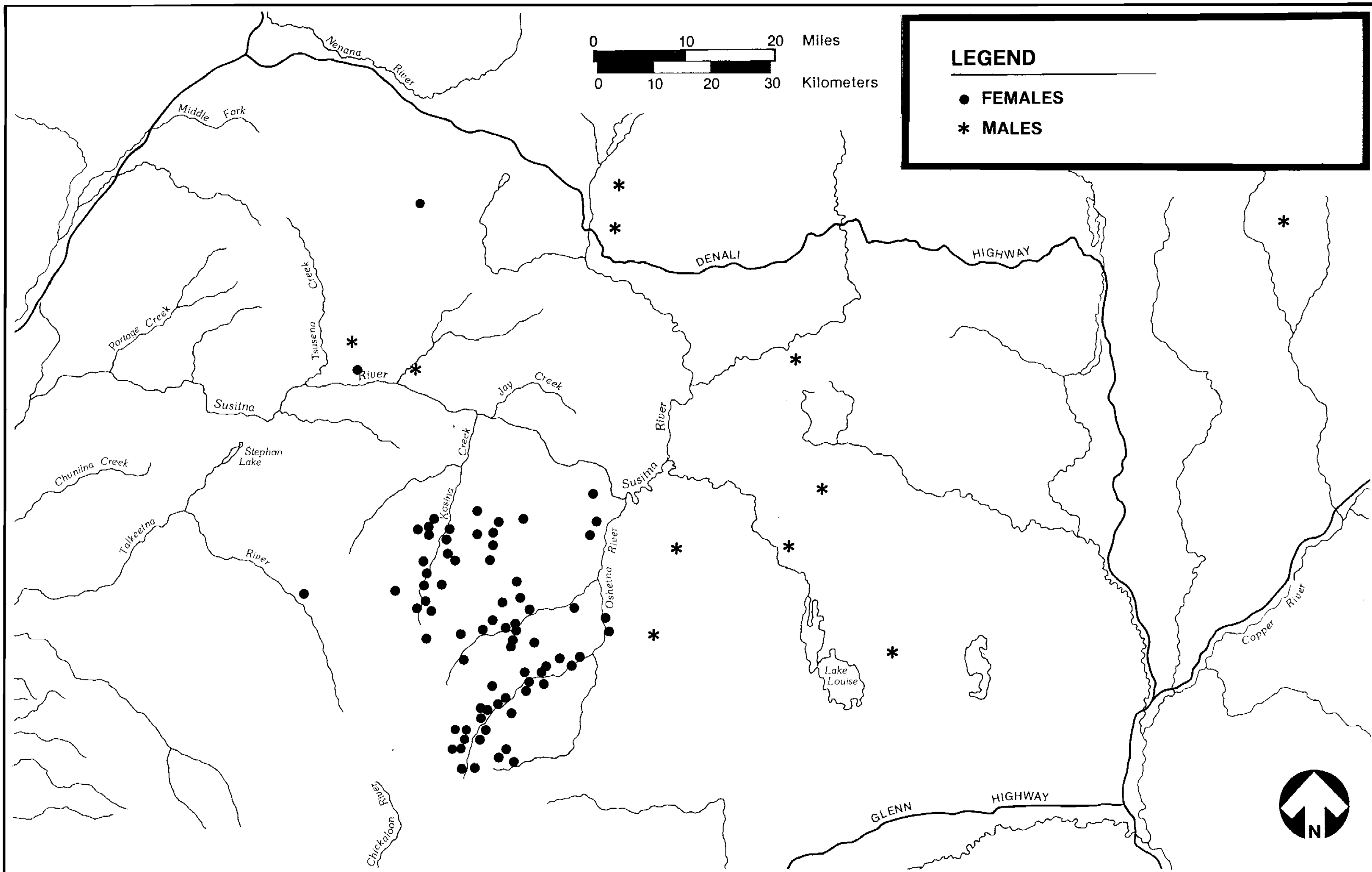
FIGURE 3.12



DISTRIBUTION OF MAIN NELCHINA RADIO-COLLARED CARIBOU,
14 APRIL 1980 THROUGH 29 SEPTEMBER 1981

PREPARED BY TES/ADF&G

FIGURE 3.13

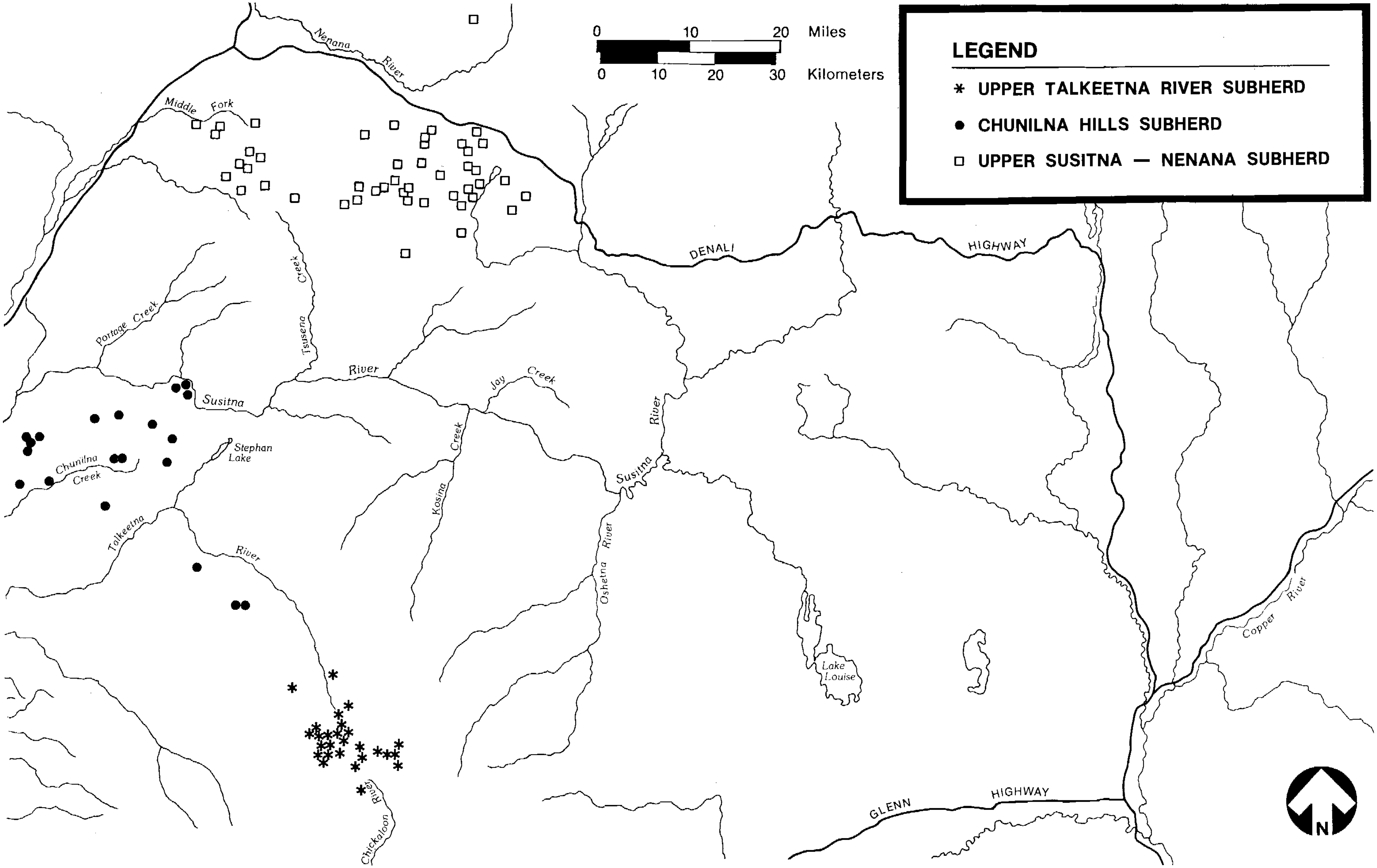


DISTRIBUTION OF NELCHINA RADIO-COLLARED CARIBOU
DURING THE CALVING PERIOD, 15 MAY THROUGH 10 JUNE, 1980 AND 1981

PREPARED BY TES / ADF&G

FIGURE 3.14

ACRES

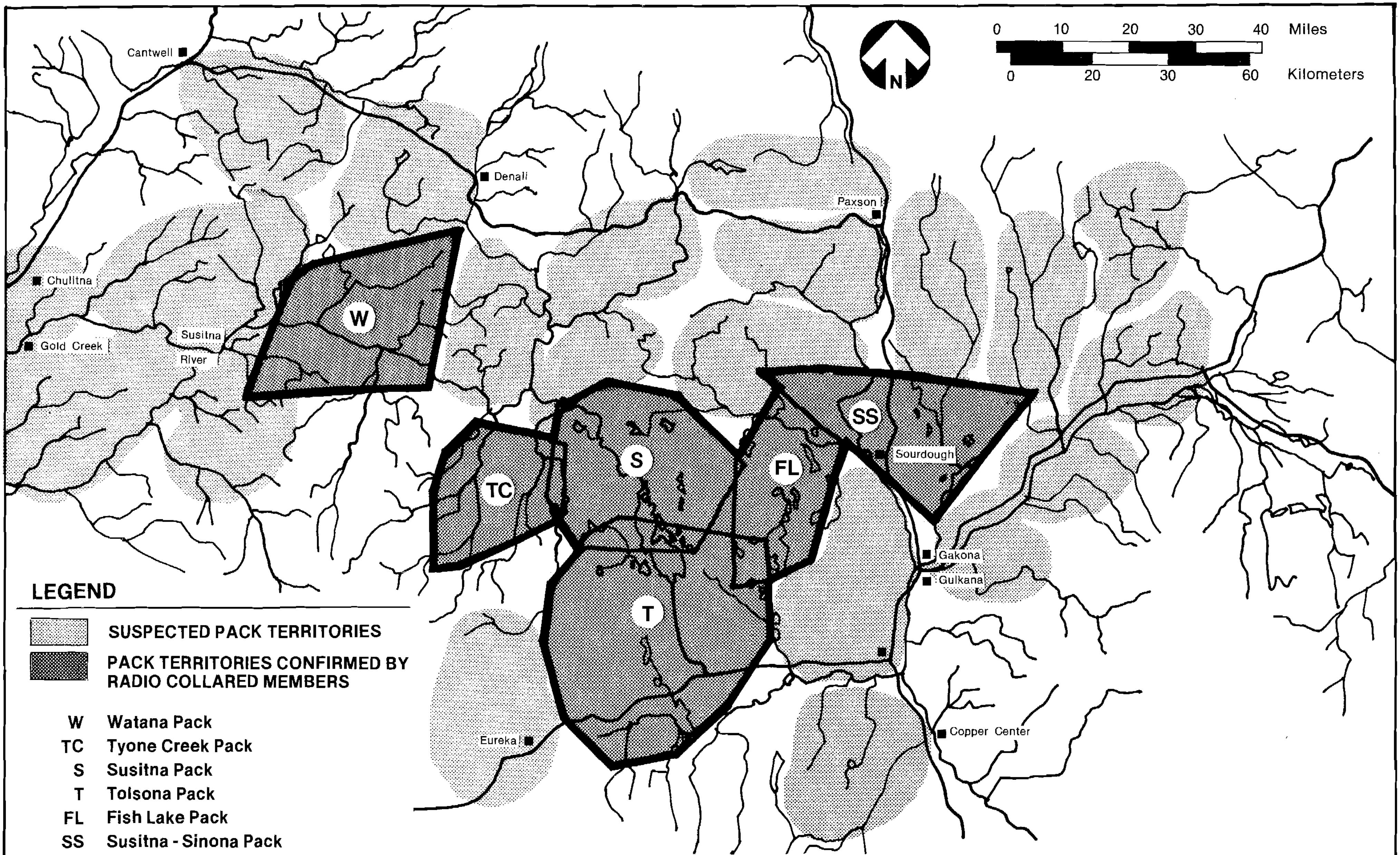


LOCATION OF RADIO-COLLARED CARIBOU IN SUBHERDS,
9 MAY 1980 THROUGH 22 SEPTEMBER 1981

PREPARED BY TES / ADF&G

FIGURE 3.15

ACRES



SUSPECTED LOCATIONS AND TERRITORIAL BOUNDARIES
OF WOLF PACKS DURING 1980 and 1981

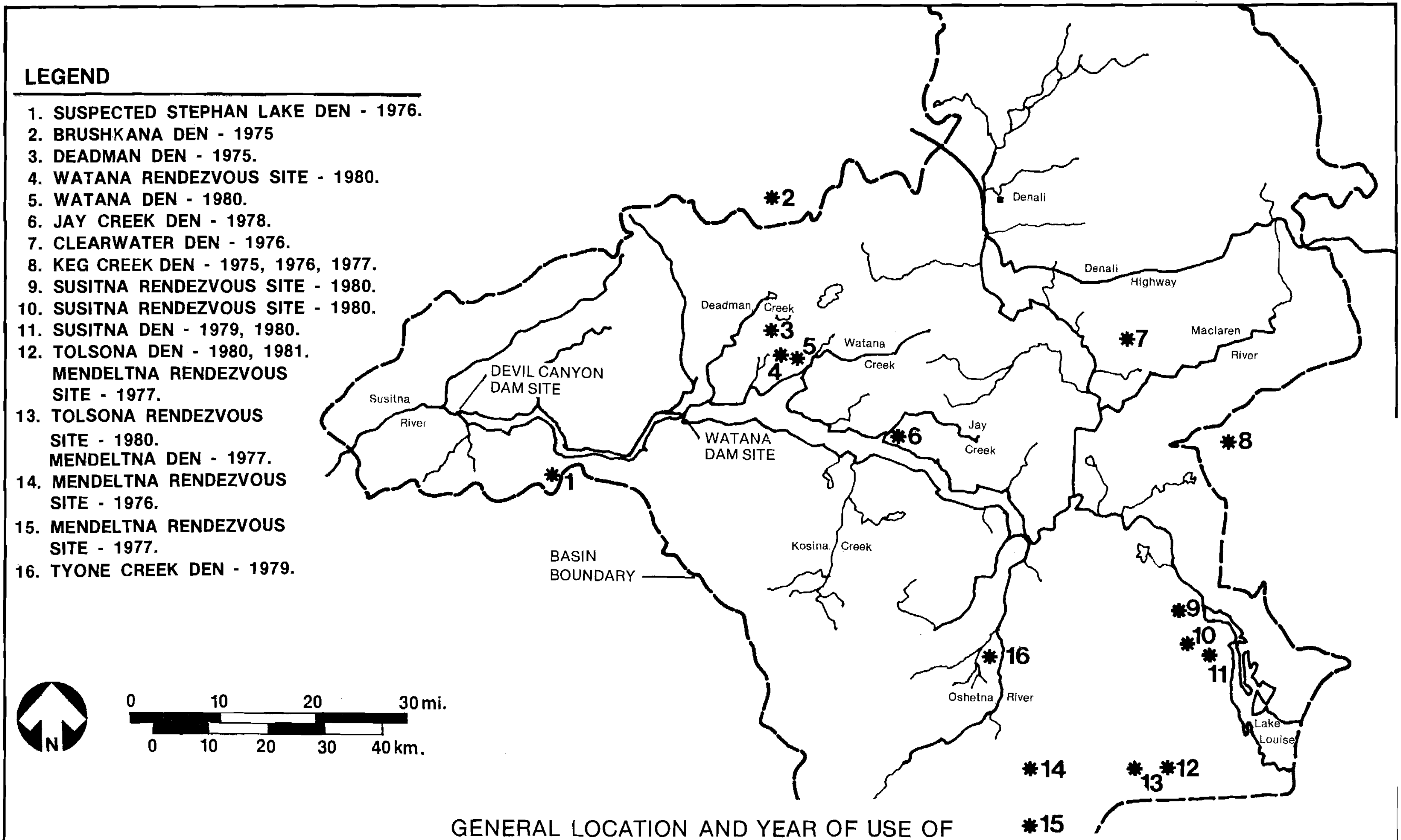
PREPARED BY TES / ADF&G

FIGURE 3.16

ACRES

LEGEND

1. SUSPECTED STEPHAN LAKE DEN - 1976.
2. BRUSHKANA DEN - 1975
3. DEADMAN DEN - 1975.
4. WATANA RENDEZVOUS SITE - 1980.
5. WATANA DEN - 1980.
6. JAY CREEK DEN - 1978.
7. CLEARWATER DEN - 1976.
8. KEG CREEK DEN - 1975, 1976, 1977.
9. SUSITNA RENDEZVOUS SITE - 1980.
10. SUSITNA RENDEZVOUS SITE - 1980.
11. SUSITNA DEN - 1979, 1980.
12. TOLSONA DEN - 1980, 1981.
    MENDELTNA RENDEZVOUS SITE - 1977.
13. TOLSONA RENDEZVOUS SITE - 1980.
    MENDELTNA DEN - 1977.
14. MENDELTNA RENDEZVOUS SITE - 1976.
15. MENDELTNA RENDEZVOUS SITE - 1977.
16. TYONE CREEK DEN - 1979.

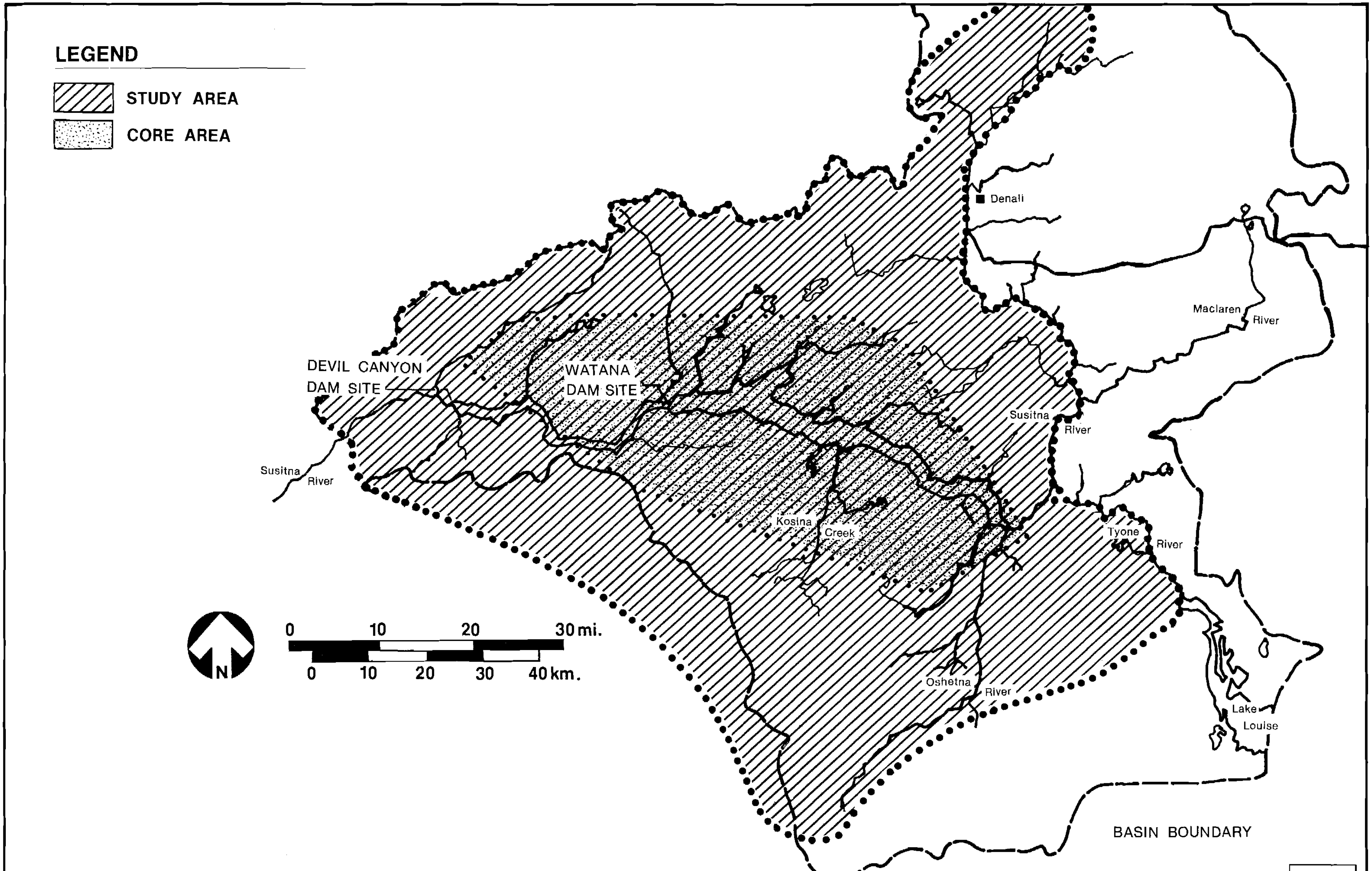


GENERAL LOCATION AND YEAR OF USE OF OBSERVED WOLF DEN AND RENDEZVOUS SITES DISCOVERED IN THE SUSITNA HYDROELECTRIC PROJECT AREA FROM 1975 THROUGH 1981

PREPARED BY TES / ADF&G

FIGURE 3.17

ACRES

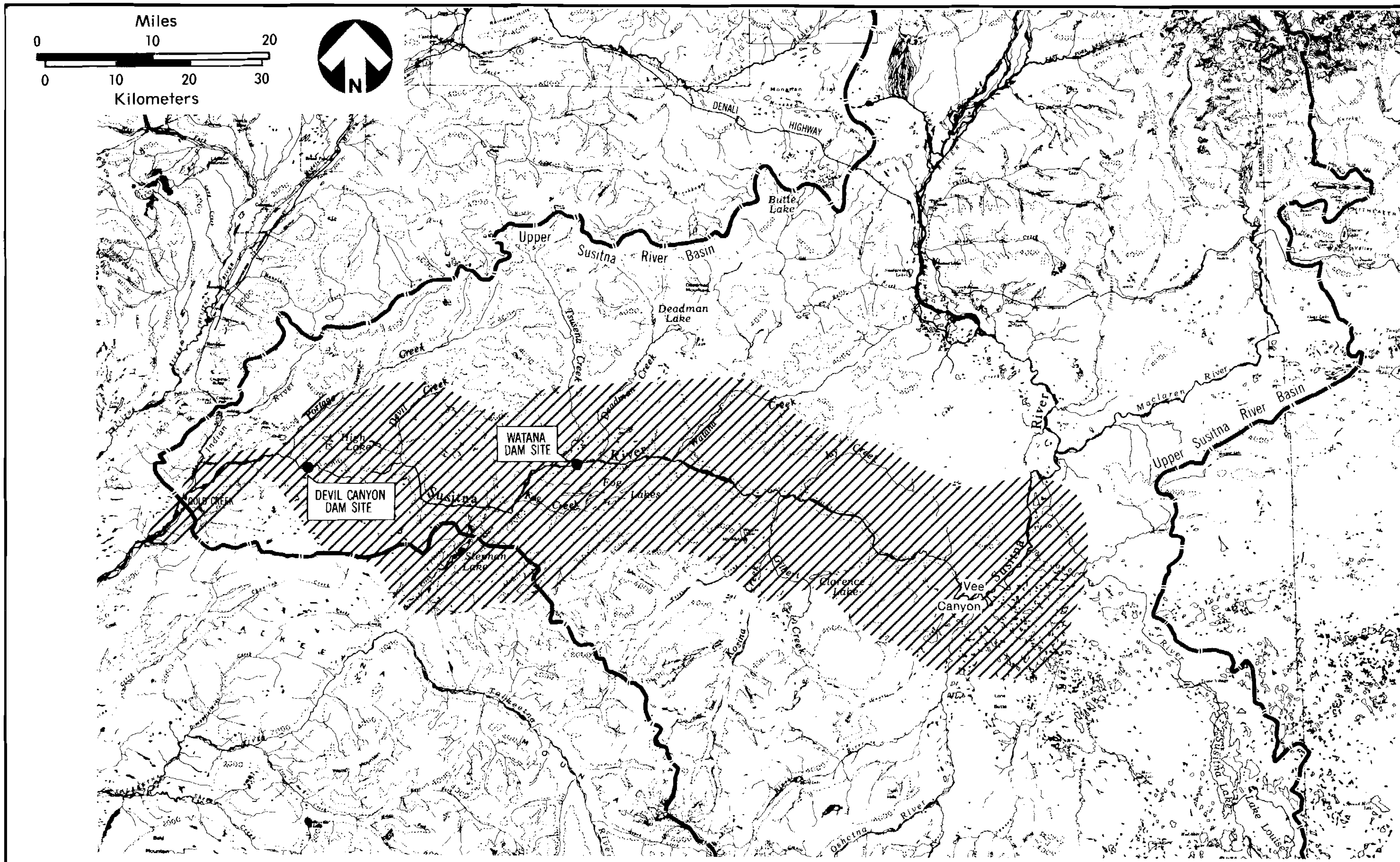


WOLVERINE STUDY AREA

PREPARED BY TES / ADF&G

FIGURE 3.18

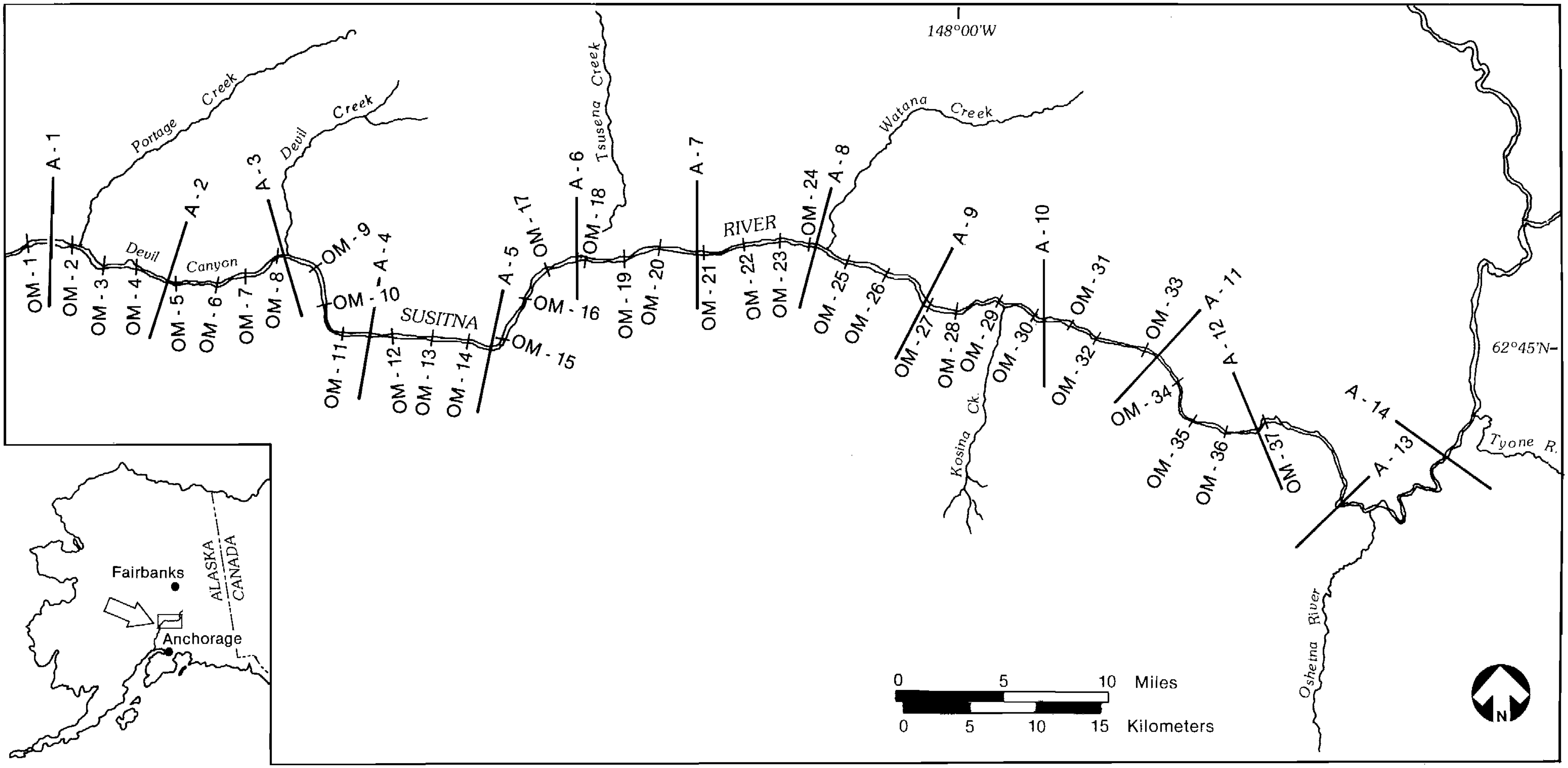
ACRES



FURBEARER STUDY AREA - UPSTREAM

PREPARED BY TES

FIGURE 3.19

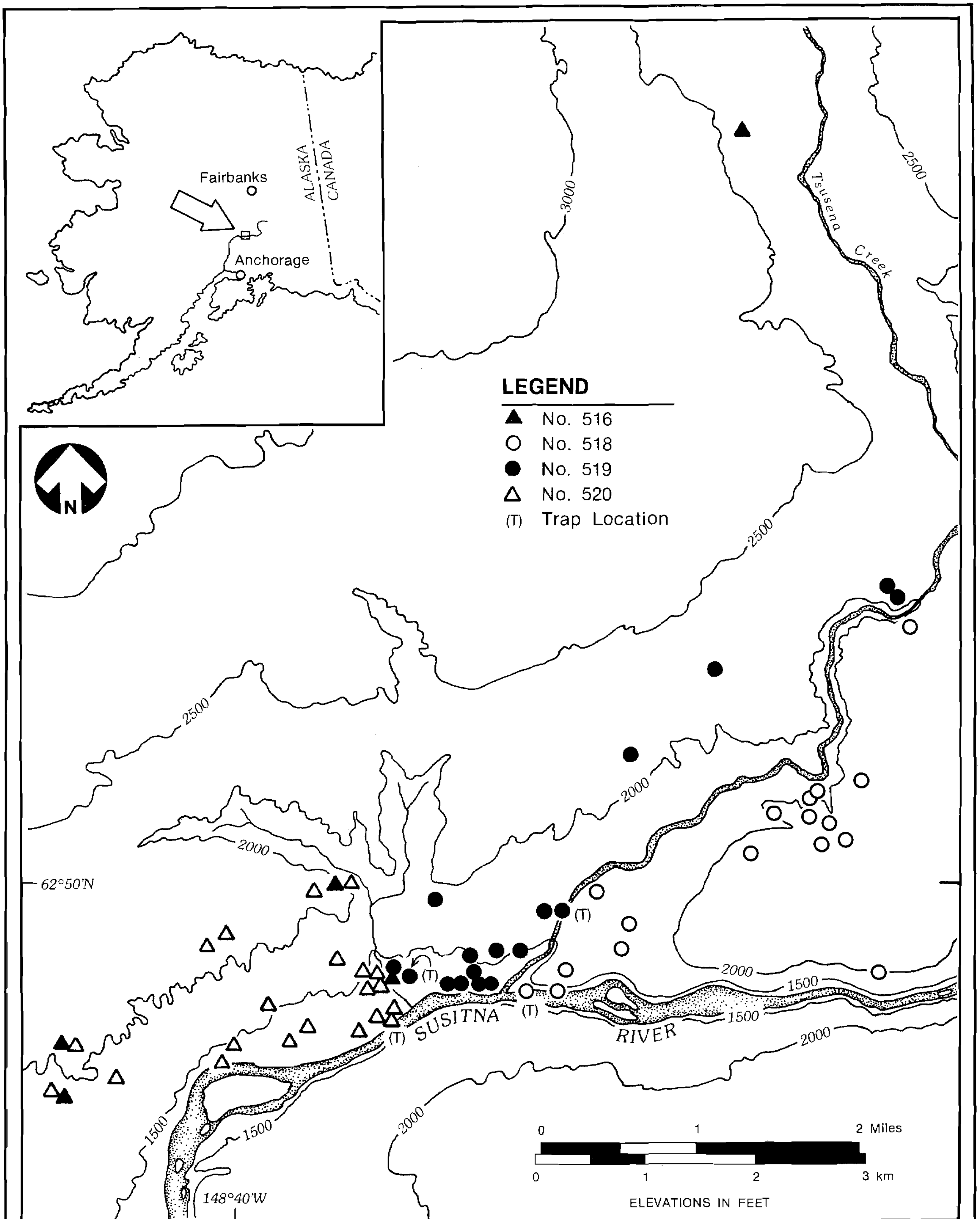


AERIAL TRANSECTS FOR FURBEARERS (A) AND CHECKPOINTS FOR SIGNS OF OTTER AND MINK (OM)

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.20

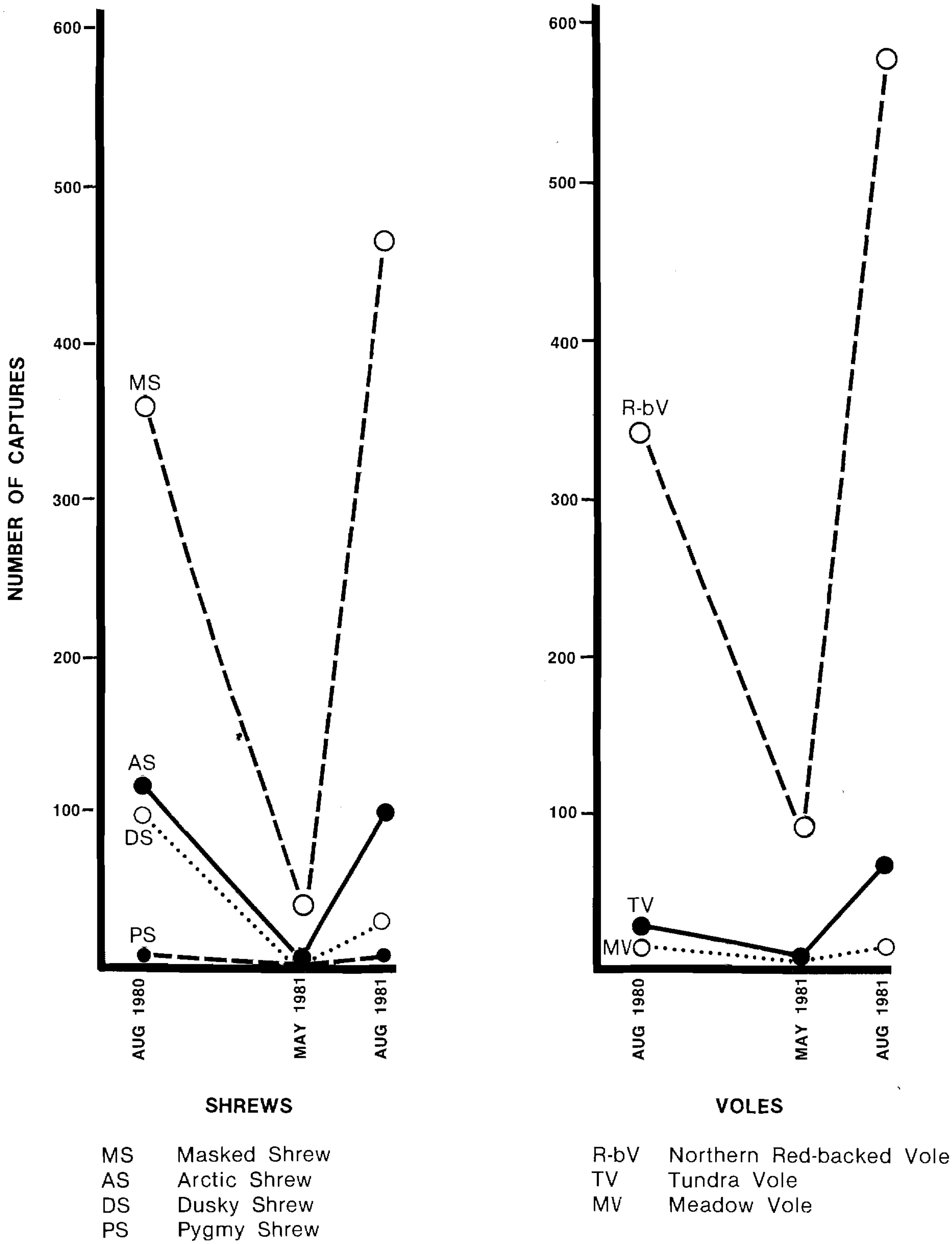
ACRES



TRACKING LOCATIONS FOR FOUR RADIO-COLLARED MALE MARTEN, 1980

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.21

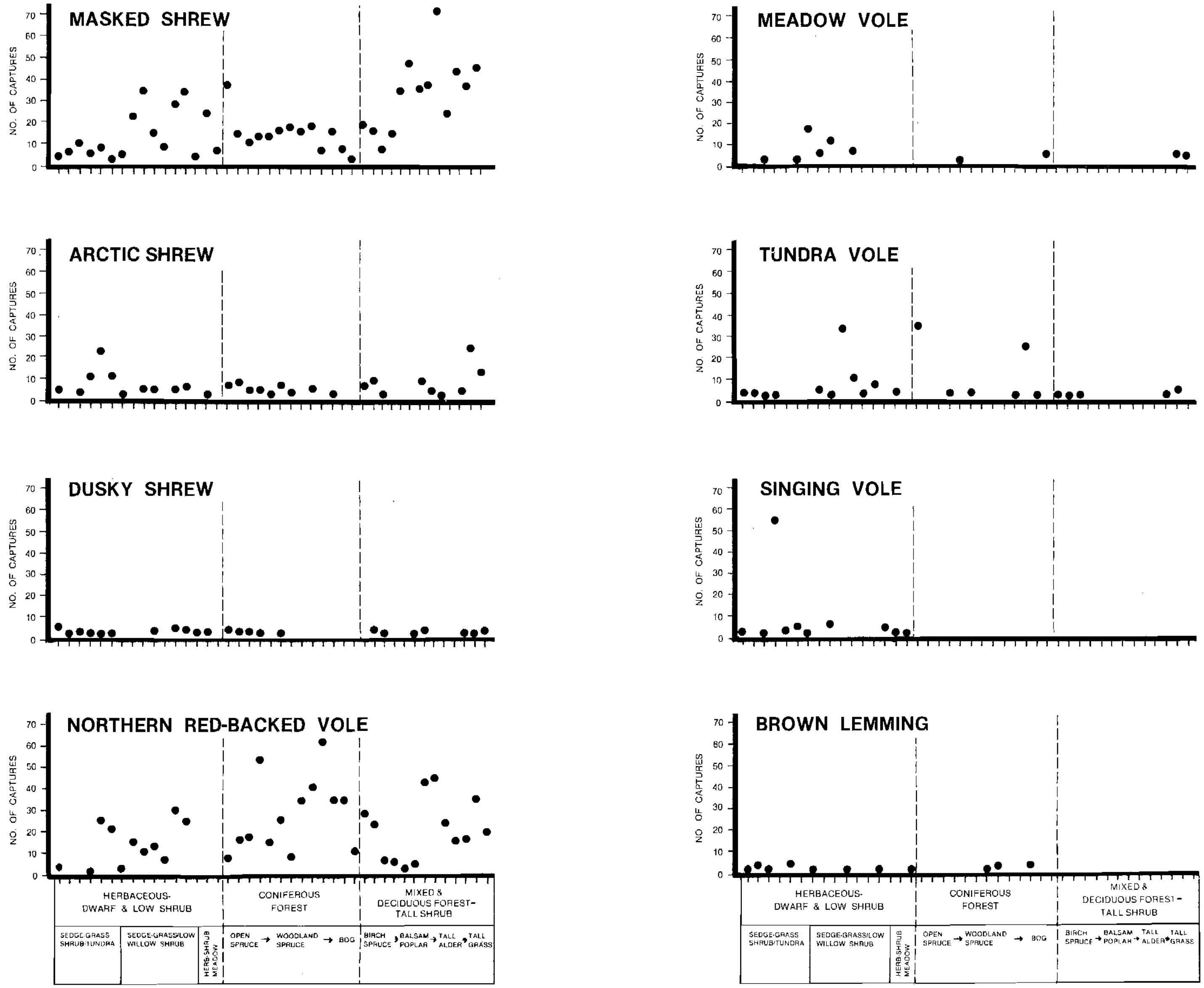


TEMPORAL VARIATION IN NUMBERS OF SMALL MAMMAL CAPTURES AT 12 SITES IN THE UPPER SUSITNA RIVER BASIN, ALASKA

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.22

ACRES

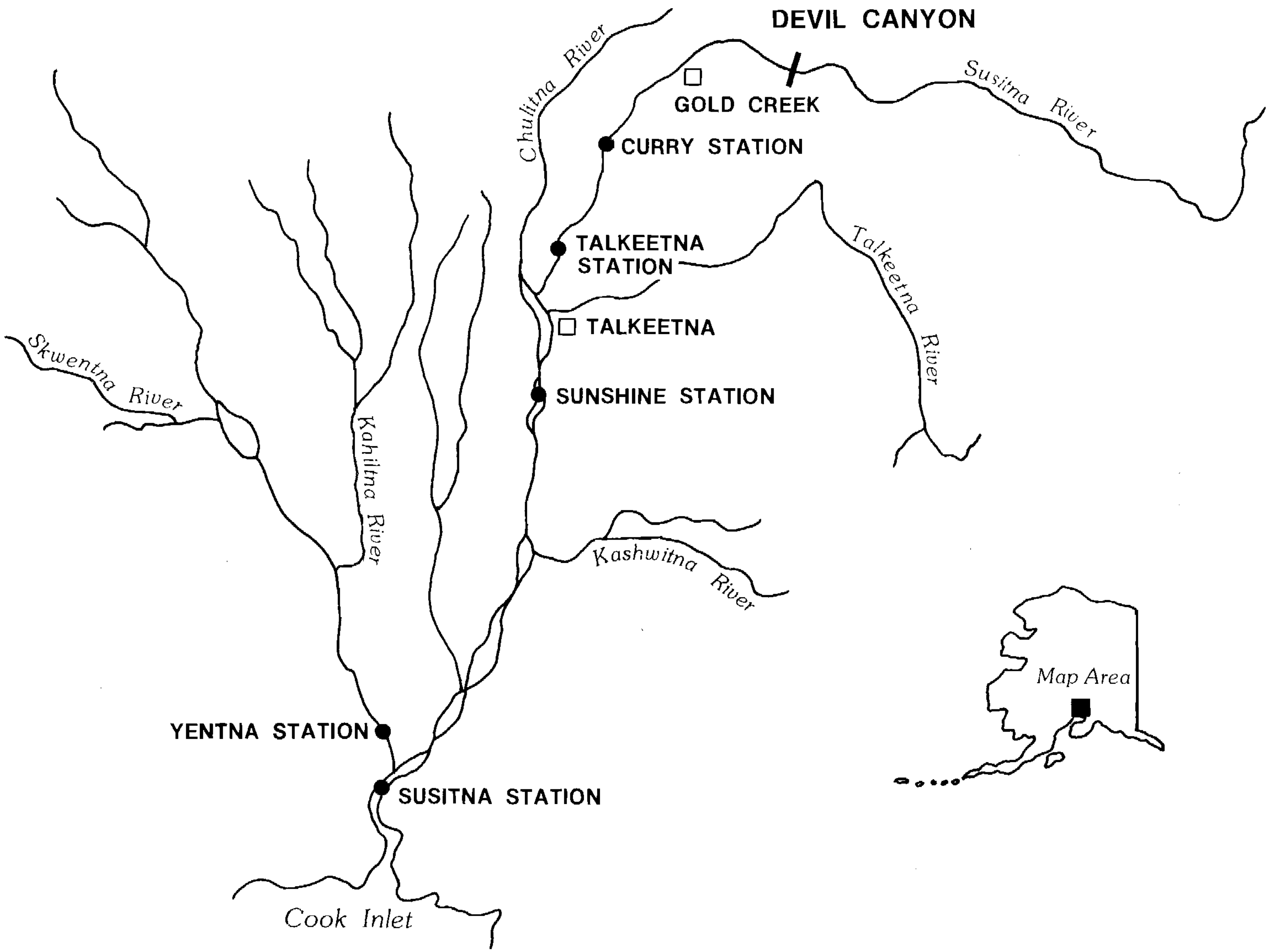


ABUNDANCE PATTERNS OF EIGHT SMALL MAMMAL SPECIES RELATIVE TO VEGETATION TYPES AT 42 SITES IN THE UPPER SUSITNA RIVER BASIN, ALASKA 29 JULY - 30 AUGUST 1981

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 3.23

ACRES

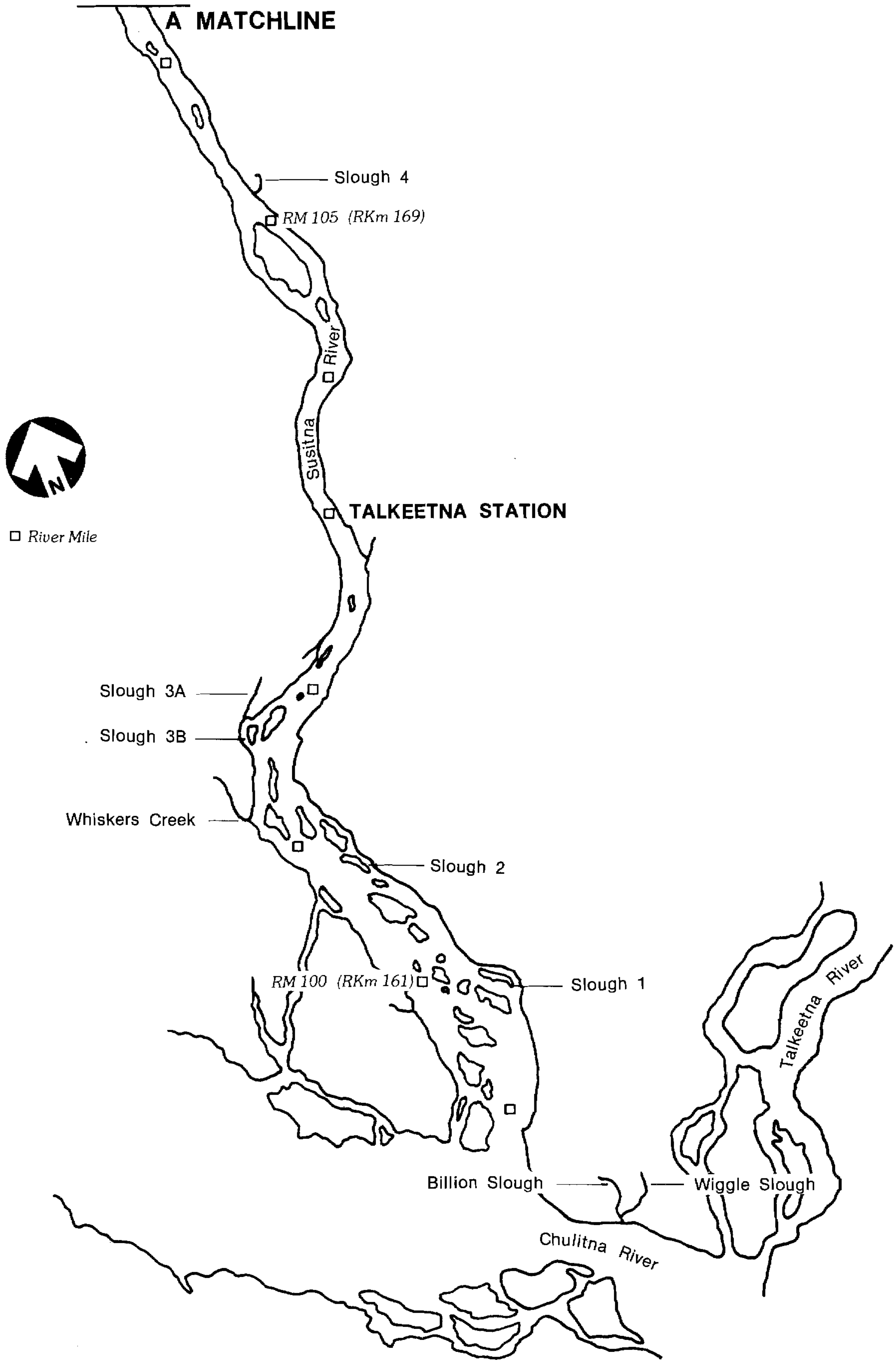


FIELD STATIONS, ADULT ANADROMOUS INVESTIGATIONS, ADF&G SUSITNA HYDROELECTRIC STUDIES, 1981

PREPARED BY TES / ADF&G

FIGURE 3.24

ACRES

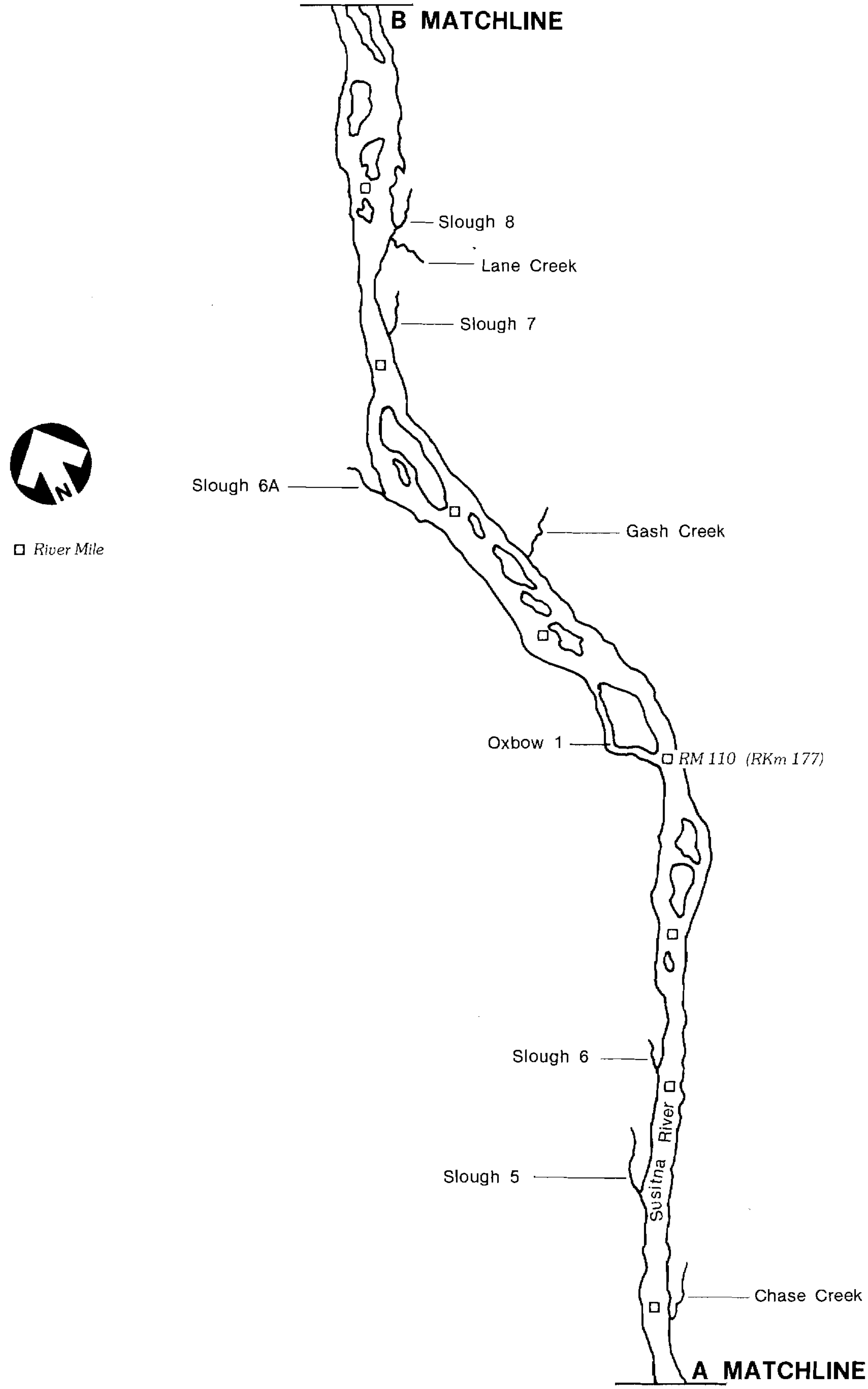


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER FROM ABOVE THE CHULITNA RIVER CONFLUENCE TO SLOUGH 4 (RKm 168)

PREPARED BY TES / ADF&G

FIGURE 3.25

ACRES

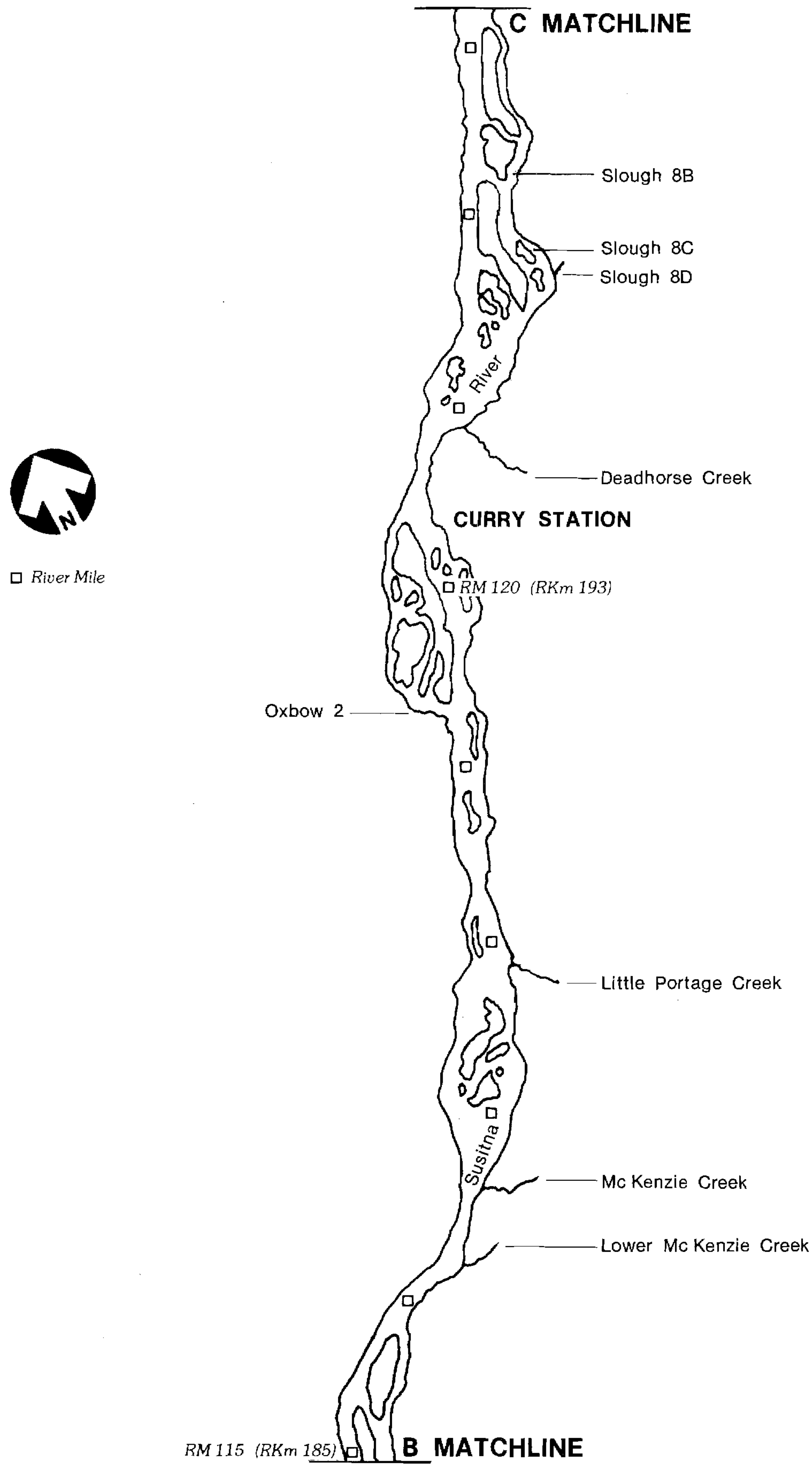


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN
CHASE CREEK AND SLOUGH 8

PREPARED BY TES / ADF&G

FIGURE 3.26

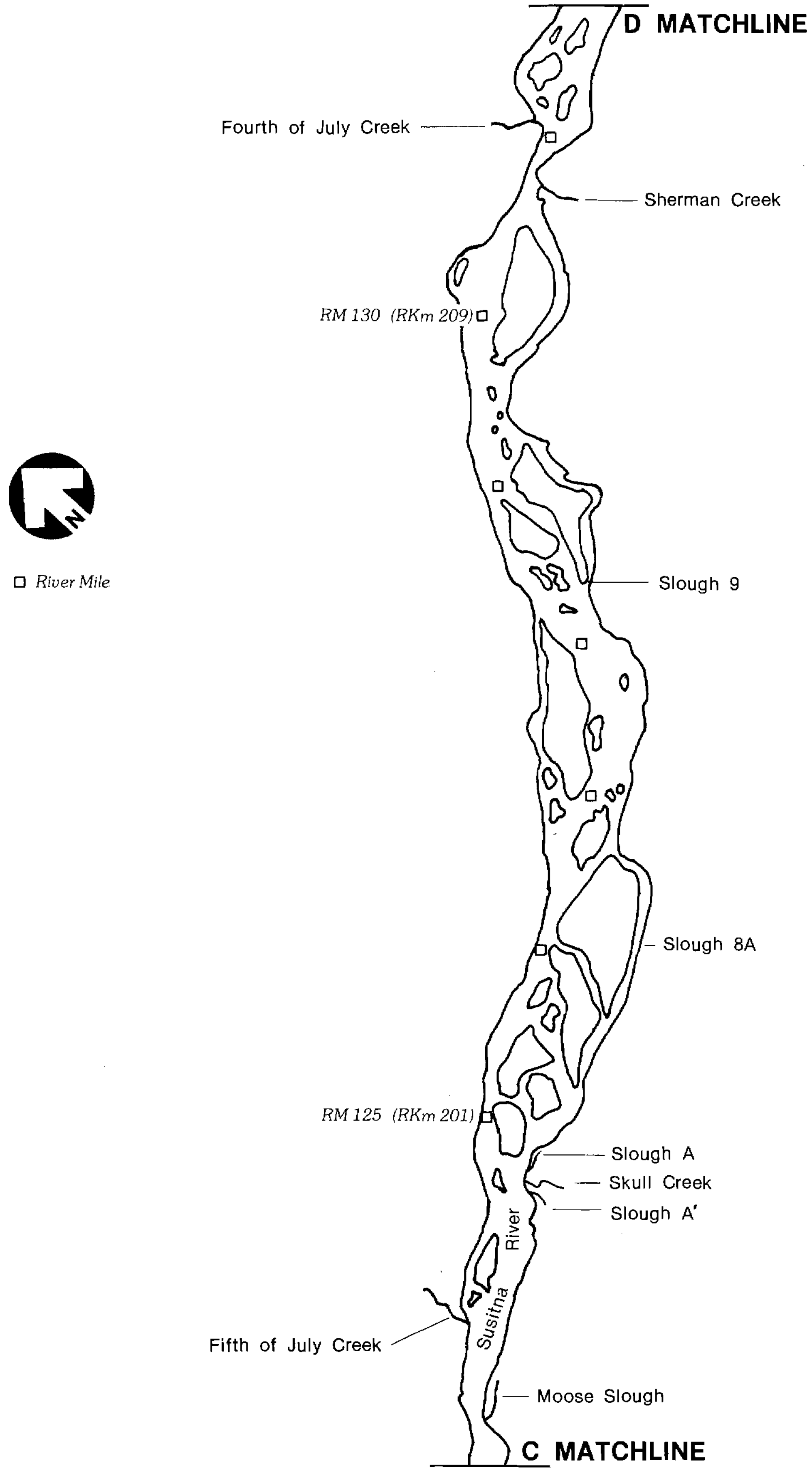
ACRES



SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN LOWER
MCKENZIE CREEK AND SLOUGH 8B

PREPARED BY TES / ADF&G

FIGURE 3.27

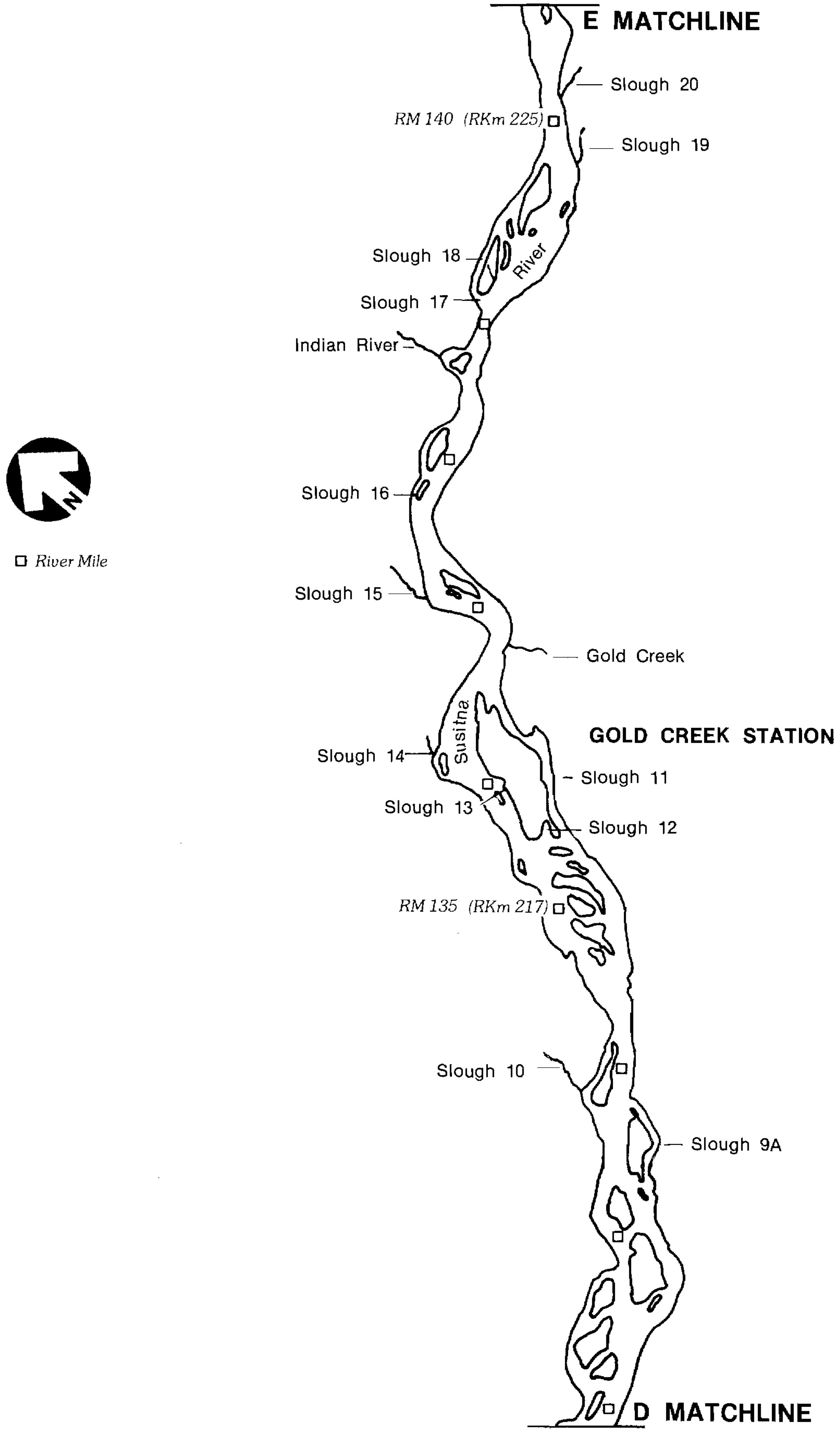


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES OF THE SUSITNA RIVER BETWEEN MOOSE SLOUGH AND FOURTH OF JULY CREEK

PREPARED BY TES / ADF&G

FIGURE 3.28

ACRES

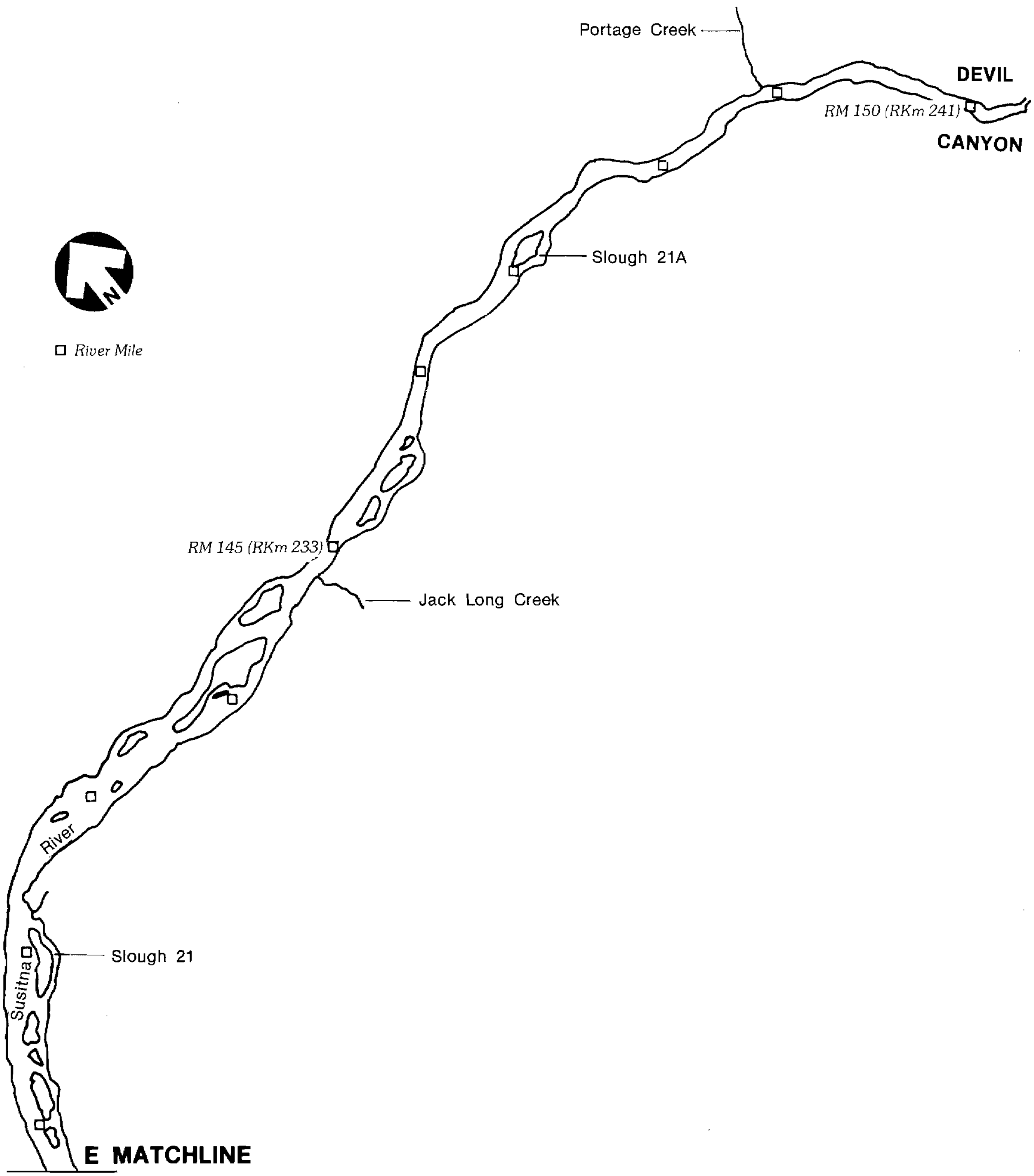


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN
SLOUGH 9A (RKm 214) AND SLOUGH 20 (RKm 225)

PREPARED BY TES / ADF&G

FIGURE 3.29

ACRES

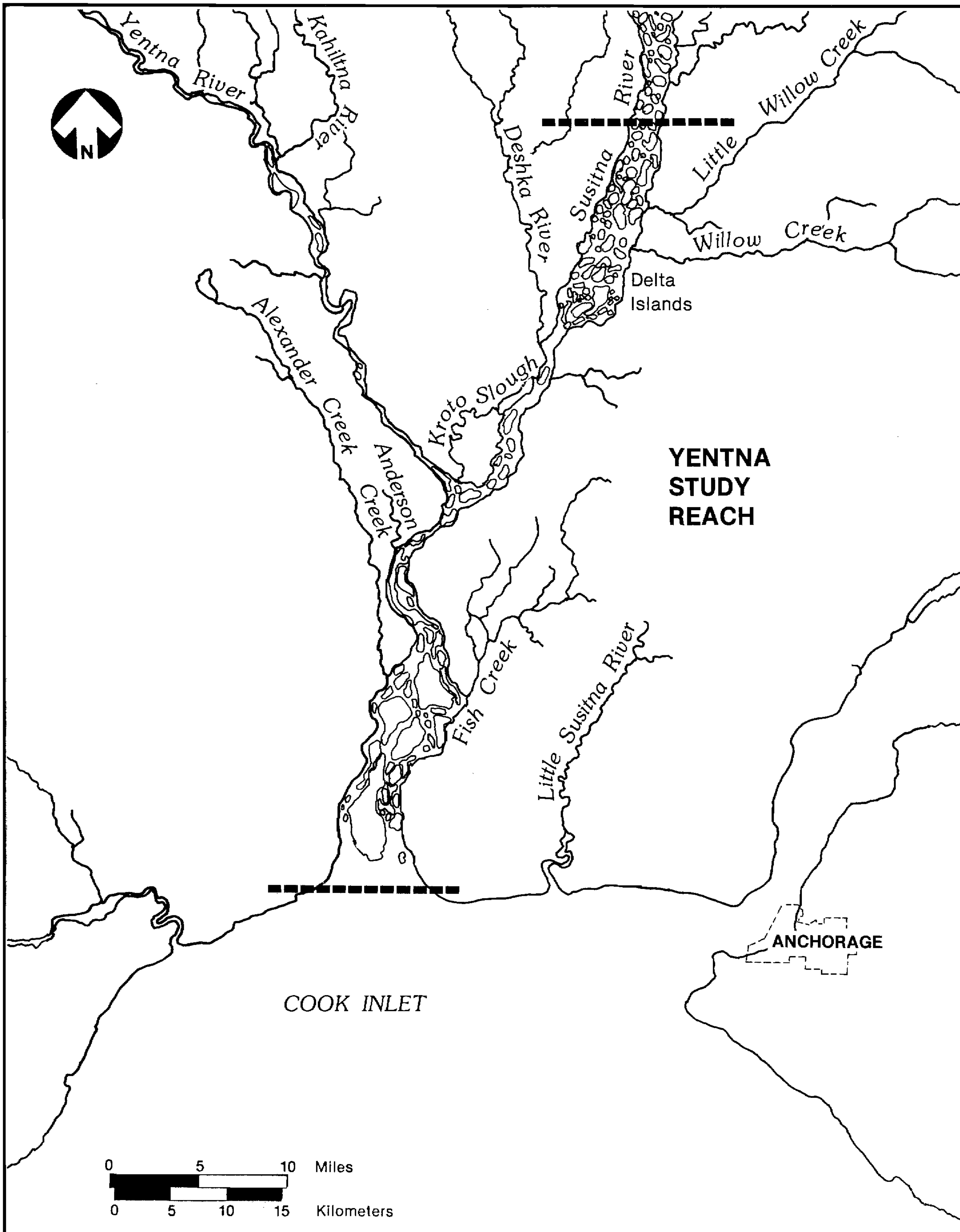


SLOUGH LOCATIONS AND PRIMARY TRIBUTARIES
OF THE SUSITNA RIVER BETWEEN
SLOUGH 21 (RKm 227) AND DEVIL CANYON

PREPARED BY TES / ADF&G

FIGURE 3.30

ACRES

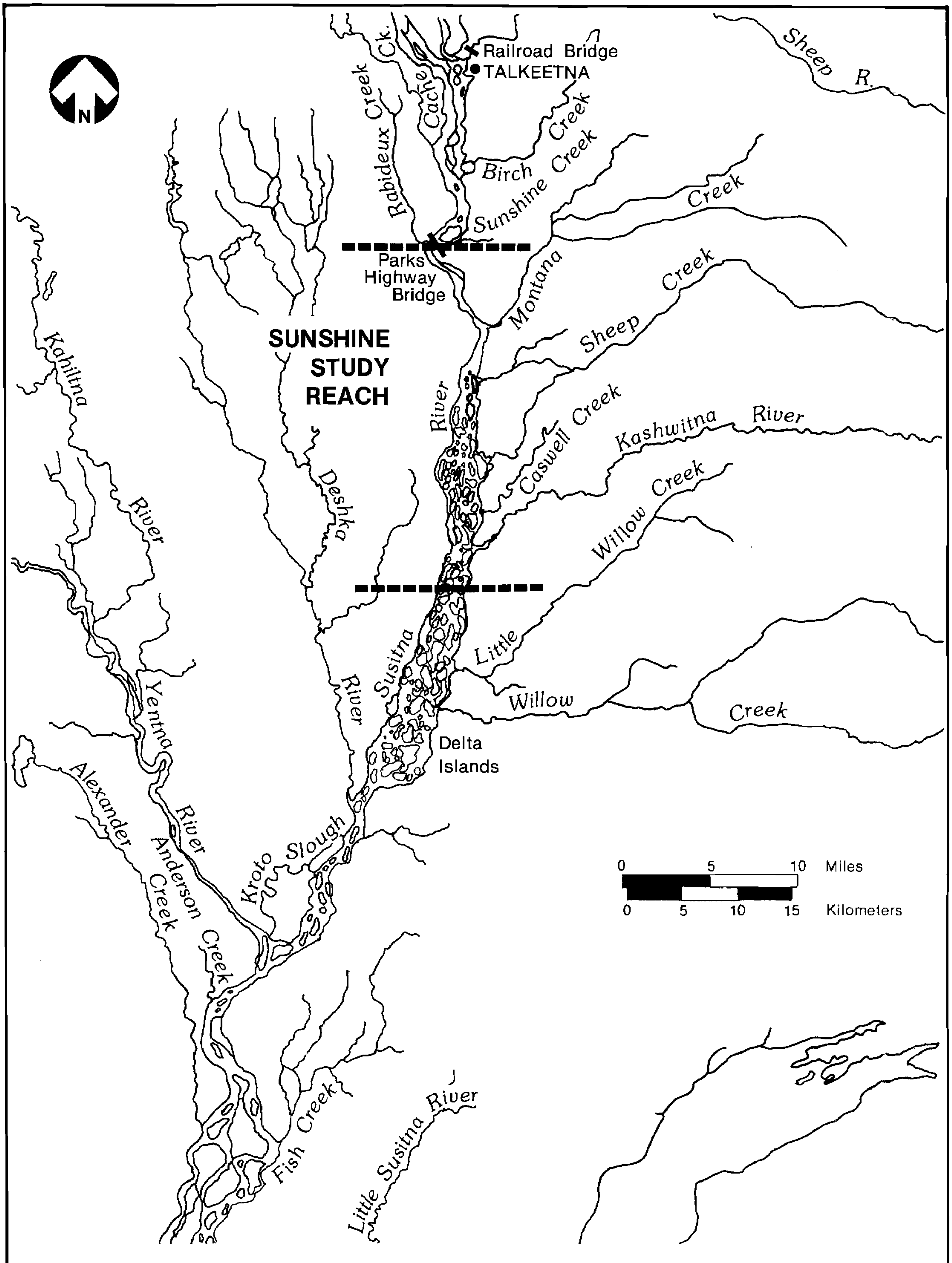


YENTNA STUDY REACH

PREPARED BY TES/ADF&G

FIGURE 3.31

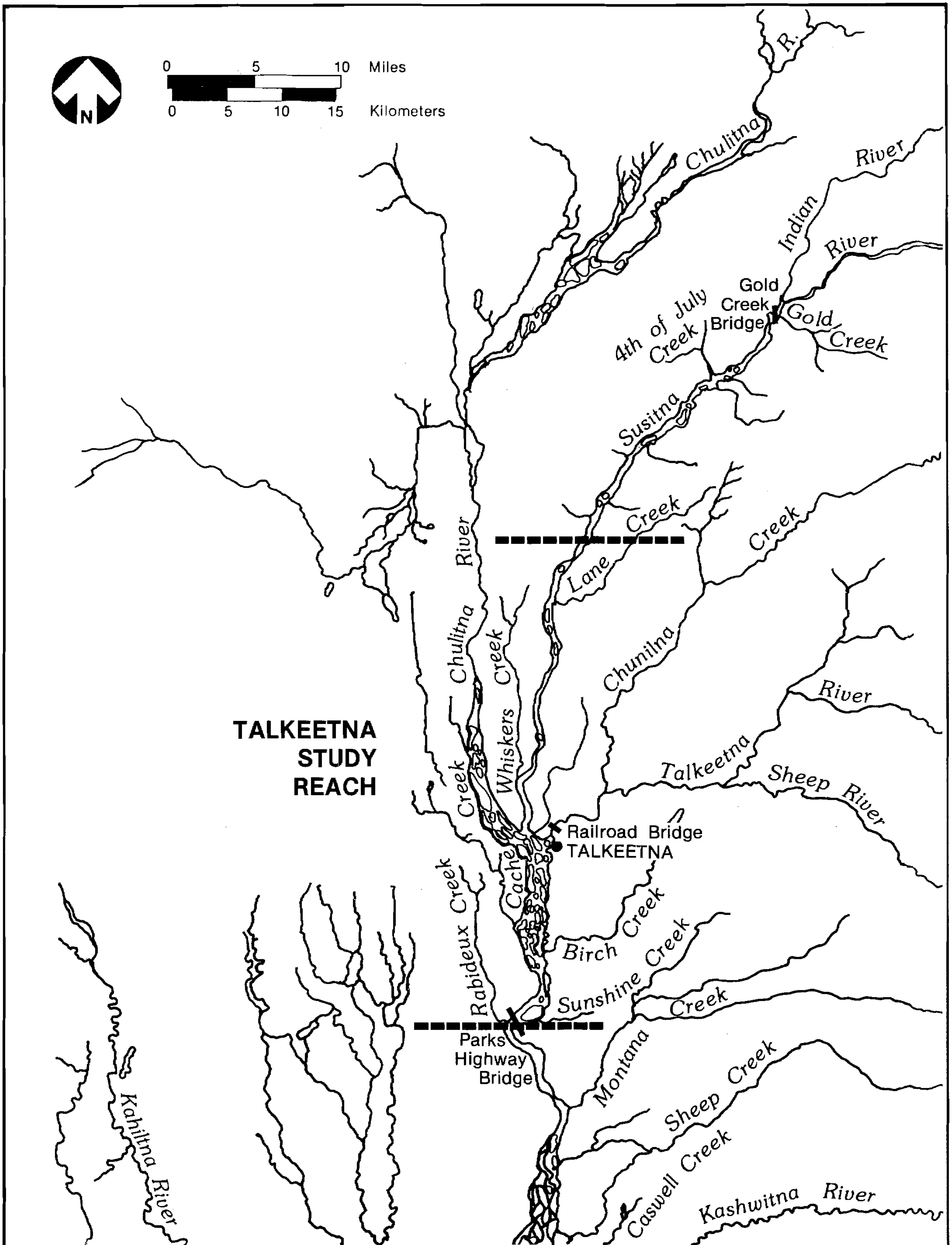
ACRES



SUNSHINE STUDY REACH

PREPARED BY TES/ADF&G

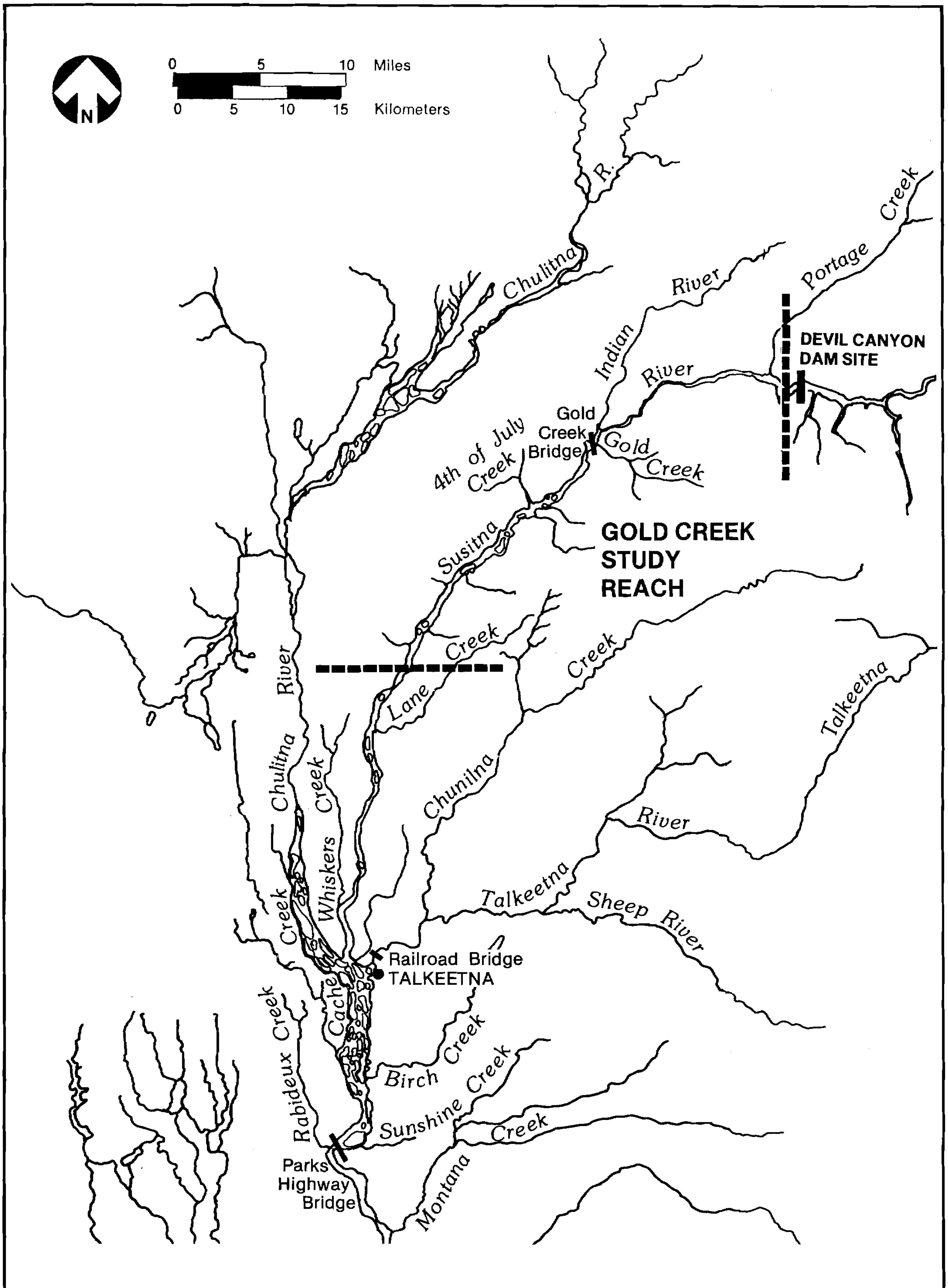
FIGURE 3.32



TALKEETNA STUDY REACH

PREPARED BY TES / ADF&G

FIGURE 3.33

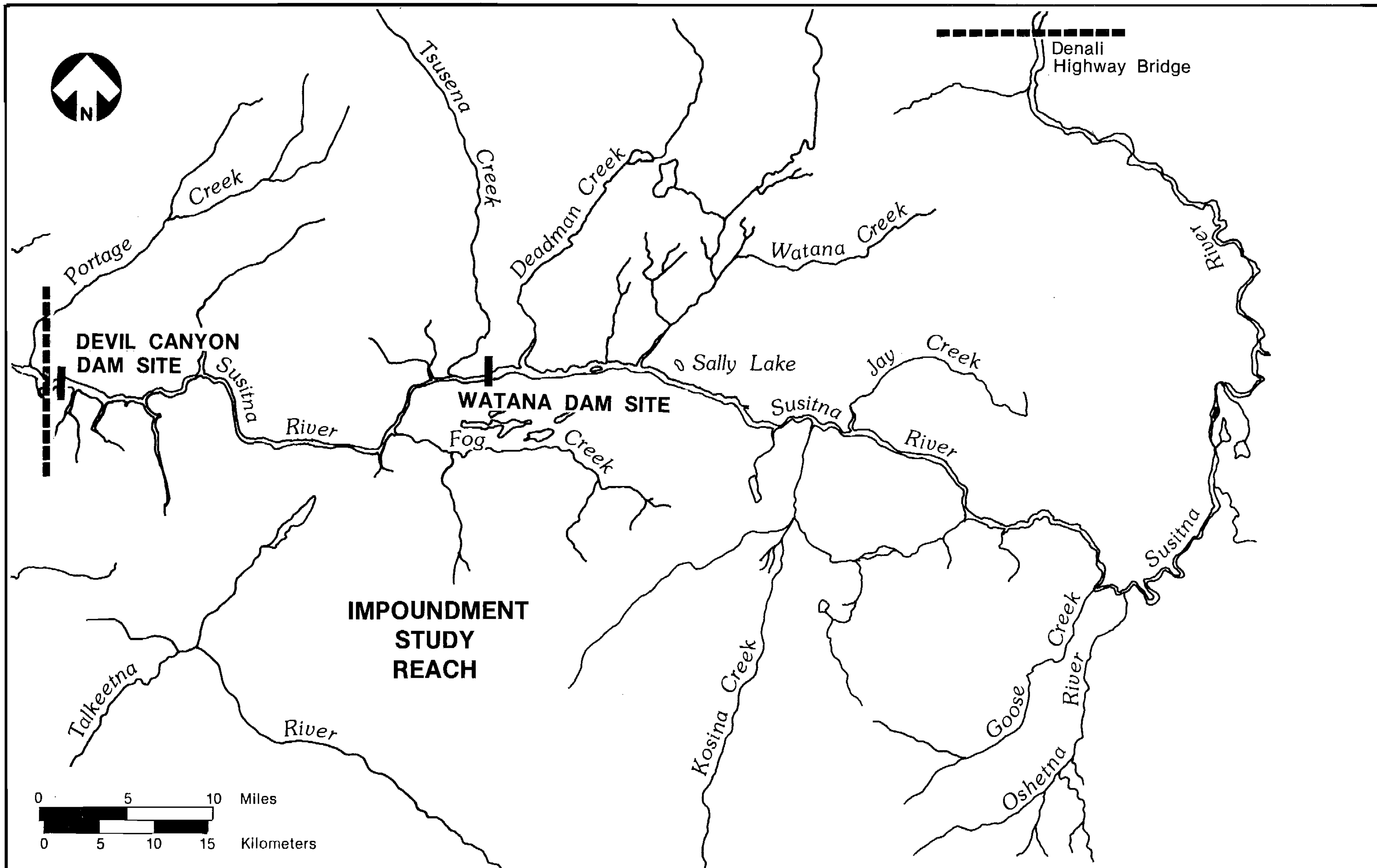


GOLD CREEK STUDY REACH

PREPARED BY TES/ADF&G

FIGURE 3.34

ACRES

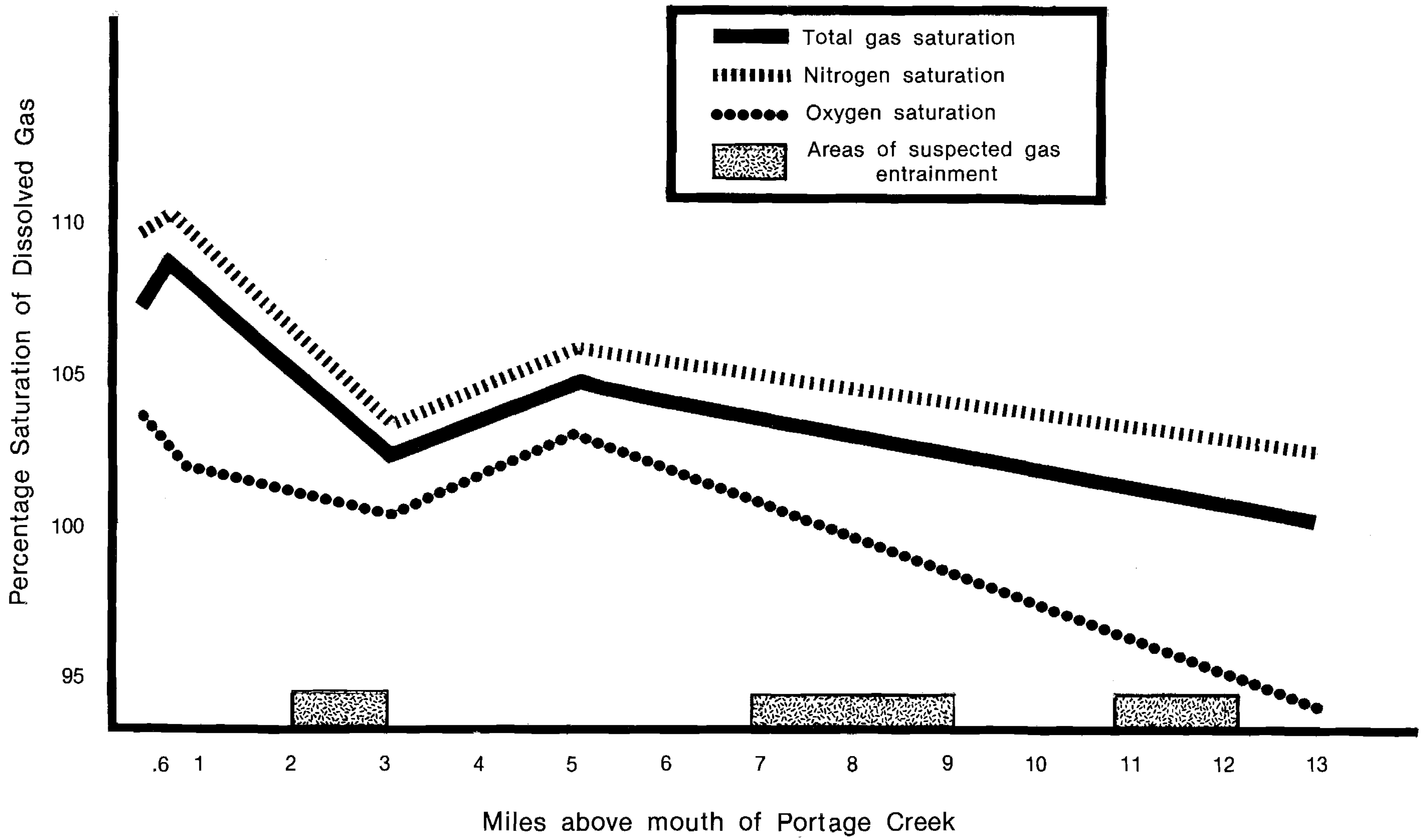


IMPOUNDMENT STUDY REACH

PREPARED BY TES/ADF&G

ACRES

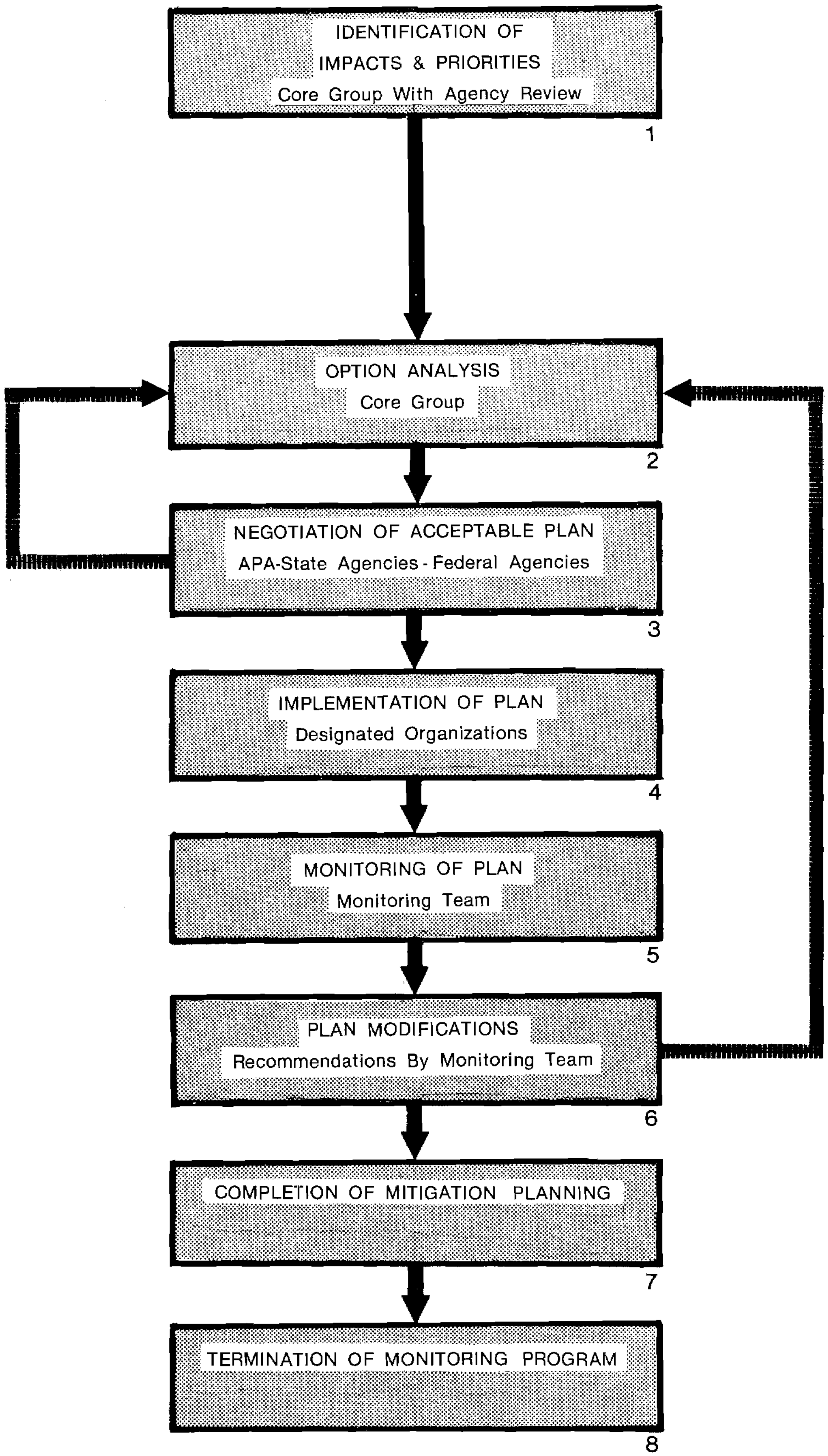
FIGURE 3.35



DISSOLVED GAS SATURATION IN VICINITY OF DEVIL CANYON,
12 JUNE 1981

PREPARED BY TES

FIGURE 3.36

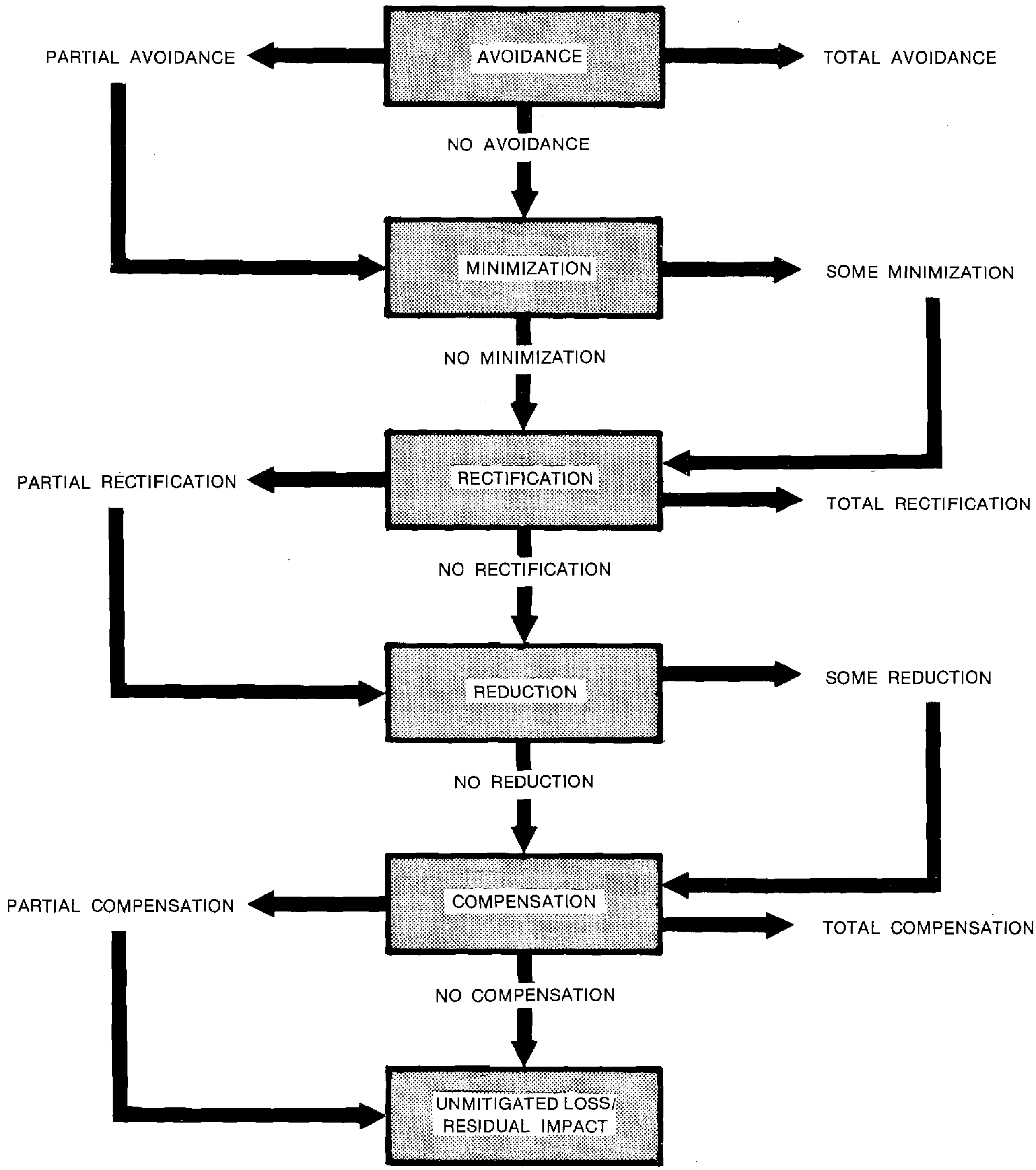


FISH AND WILDLIFE MITIGATION PLAN
DEVELOPMENT AND IMPLEMENTATION

PREPARED BY TES/ACRES

FIGURE 3.37

ACRES



OPTION ANALYSIS

PREPARED BY TES

FIGURE 3.38

ACRES

4 - REPORT ON HISTORIC AND ARCHEOLOGICAL RESOURCES

4.1 - Agency Consultation

(a) Consultation Methods

Archeological and historical resources must be identified for federally funded or licensed projects such as the Susitna Hydroelectric Project (FERC 1981). Before any archeological testing can be conducted, appropriate federal and state permits must be obtained. Moreover, no other project-related ground-disturbing activities (e.g. geotechnical) can be performed until the sites are cleared for cultural resources by an archeologist with the appropriate federal and state archeological permits.

The University of Alaska Museum obtained a Federal Antiquities Permit. Formal application, including vitae of support and supervisory individuals, was made to the National Park Service and the necessary permits received for 1980-81. In addition to the Federal Antiquities Permit, a State Antiquities Permit was obtained for land within the study area, designated "State Selected", that is, lands chosen by the State of Alaska as part of the Alaska Native Claims Settlement Act of 1971.

Through both oral and written communications, the State Historic Preservation Officer and State Archeologist have been advised of cultural resource investigations associated with the Susitna project. Copies of the Procedures Manual (APA 1980), Plan of Study (Acres 1980), and the 1980 Annual Report for the Cultural Resources Investigation (APA 1981a) were submitted for their review and comment and to document compliance with appropriate state and federal legislation.

(b) Summary of Comments

Comments concerning the Federal Antiquities Permit applications were in the form of stipulations to the permits by the National Park Service, the Bureau of Land Management, and the U.S. Fish and Wildlife Service. These comments specified the conditions of the permit.

The research design (Plan of Study, Procedures Manual) and the 1980 Cultural Resources Investigation Annual Report were reviewed by Mr. Robert Shaw, State Historic Preservation Officer (SHPO), and by Mr. Douglas Reger, State Archeologist. They concluded that the Annual Report documents the survey activities conducted during 1980 and adequately accomplished the tasks outlined in the proposed work plan. The SHPO considers the work to date, however, to be preliminary; reconnaissance and testing should continue for areas not yet examined. In addition, specific areas of disturbance and ancillary facilities must still receive archeological clearance. Access roads and material sites must still be examined in detail for cultural resources, and a mitigation plan must be formulated. Both authorities feel that FERC should, and probably will, include mitigation provisions when a permit is issued. Finally, the SHPO and the State Archeologist must review the final report when it becomes available.

4.2 - Survey Methods

(a) Objectives

The cultural resource program [see 4.2 (b) (ii)] had two objectives. The first was to identify and document archeological and historical sites in the Susitna study area. An archeological site is any area or structure dating prior to 1897 and important to native Alaskan cultures. An historical site dates from 1897, with the first native contact with western culture, to 1949. The sites examined to meet this first objective were in the impoundment zones, along portions of transmission line corridors, along the routes of proposed access roads, in borrow areas, and in any other areas with the potential for experiencing ground disturbance.

The second objective of the cultural resource program was to test and evaluate resources found in any of these areas, to address site significance, assess impact, and propose mitigation measures.

(b) Methods

(i) Study Areas

The cultural resources investigation involved three geographic sections: the central, southern, and northern study areas. The central study area, in which most of the efforts were concentrated, included an area from approximately 3 km below Devil Canyon on the west to the Tyone River on the east and extended approximately 2 km outside of the proposed Devil Canyon and Watana impoundments on the Susitna River. Areas affected by the other subtasks' ongoing studies were also included in this study area (APA 1981a).

This central study area for cultural resources also includes the transmission line alternatives from the dam sites to Gold Creek and parts of some of the access road corridor alternatives. The transmission line study areas also included northern and southern sections. Descriptions of the alternative corridors can be found in the Transmission Line Subtask 8.01 Close Out Report (Acres 1981). In brief, the northern section, approximately 8 km wide, is a corridor from Healy to Ester; the southern section is an approximately 8-km-wide corridor from Willow to Knik Arm; and the central study area is from Watana dam west to the intertie.

The access road study area consisted of a number of alternative corridors. One commenced on the Parks Highway near Hurricane; another enters the study area from the Denali Highway; and the last alternative provides access from Gold Creek. The Access Route Selection Report, Subtask 2.10 (R&M 1981), and the Environmental Analysis of Access Road Alternatives (APA 1981b) provide detailed descriptions of the access route alternatives.

(ii) The Five-Step Program

In order to comply with regulations pertaining to cultural resources and to provide the data necessary for preparation of the

Feasibility Report and the Federal Energy Regulatory Commission license application, a five-step program was implemented.

Prefield Tasks -- Step 1: Federal and state permits were applied for and received. Federal Antiquities Permits (#80AK-23, #81AK-209) and State of Alaska Permits (#80-1, #81-11) were obtained for the project [see Section 4.1 (a), Consultation Methods]. A literature review of available documents pertaining to the history, prehistory, ethnology, geology, flora, and fauna of the study area was conducted (APA 1981a, Appendix A and B). Using this information, a research design and strategy was formulated. The research design integrated current data into a tentative cultural chronology, which explicated hypotheses that could aid in the evaluation of sites located during survey and testing (APA 1980, 1981a). The research strategy was structured to predict, within the limits of contemporary archeological method and theory, archeological site locations in relation to physical and topographic features (APA 1981a).

Archeological sites occur in direct relation to associated physical, topographic, and ecological features. Based on the analysis of site locational data from regions adjacent to the study area, the features characteristically associated with archeological site occurrence are: areas of high topographic relief; natural constrictions that would tend to concentrate game animals; well-drained, relatively level areas; and lake, stream, and river margins. Such areas were included in the survey locales selected for examination.

Based on the delineated cultural chronology, documented topography, ecological settings for sites within each culture period, and geological evaluation of the study area, 119 survey locales were identified within the central study area as having relatively high potential for archeological site occurrence. Aerial photography interpretation was also conducted to delineate regional geology and survey locales and to assess archeological potential.

Reconnaissance Testing -- Step 2: Reconnaissance-level archeological testing consists of searches for cultural resources on and below ground surface. Surface testing usually involves the visual examination of areas where the soil is exposed, deflated, or eroded. Sub-surface testing generally includes digging a hole approximately 30 cm by 30 cm (a shovel test) and examining the excavated soil for artifacts.

Archeological and historical sites within the central study area were located and documented by using this technique. Detailed site-specific information was recorded, including the geomorphic feature on which the site was located, topographic setting, elevation, slope, exposure, view, and stratigraphy as well as details concerning the surrounding terrain. Survey forms were used to record data on each site located as well as on each survey locale investigated (APA 1980, 1981a).

As specified in 36 CFR 66, a reconnaissance-level survey should be used only as a preliminary to intensive survey, since a reconnaissance level survey and testing program is not intended to cover 100% of the area. With this in mind and based upon the standard cultural resource research strategy, a limited but representative portion of the study area, considered as having high probability for archeological sites, was tested for cultural resources. In addition, locales associated with proposed borrow sources, access routes, transmission corridors, and areas affected by geotechnical and other preconstruction studies were also examined at various levels of intensity for cultural resources.

Reconnaissance-level testing, in and immediately surrounding the proposed Devil Canyon and Watana impoundment zone, in proposed borrow areas, and in other areas affected by geotechnical and other preconstruction studies, consisted of surface and subsurface tests as described above (APA 1980). For the proposed access corridors, testing and surveys consisted of the identification of potential cultural resource sites through the analysis of aerial photographs and topographic maps and through limited, on-the-ground examination of natural exposures.

For the proposed southern and northern transmission corridors, a cursory, four-hour fly-over was conducted to identify areas with potential for cultural resource sites; on-the-ground examination of natural exposures was limited to a few sites here. Data from the reconnaissance-level testing in and around the impoundment zone and from the access road routing analysis was used to evaluate the cultural resources probability of transmission corridors in the central study region. Also used in this analysis was information from the State Archeologist's Office files regarding the locations of known archeological sites in the central, southern, and northern transmission corridors (Acres 1981).

Systematic Testing -- Step 3: After a site is located by reconnaissance-level testing, a few selected square meters of the site are intensively excavated. All artifacts and features are recorded, using standard archeological field methods. Systematic testing was used to collect data to address site significance and impact prior to developing individual mitigation measures and a general mitigation plan (see Sections 4.4 and 4.5). Systematic testing required transit surveys of sites, topographic mapping, and excavation of selected units using standard archeological methods. Since the number of sites that could be tested was limited, those sites were given precedence that had the greatest potential for producing data that would assist in developing an overall cultural chronology for the upper Susitna River valley. This method enabled extrapolation to other sites not subject to this level of testing.

Analysis and Report Preparation -- Step 4: This process entailed compiling the individual reports for each phase of the cultural resources investigation as well as synthesizing and evaluating all data gathered. Part of the evaluation included dating carbon samples gathered from sites, using radiocarbon analysis. Step 4 also involved preparing and submitting reports on the progress and results of the cultural resource studies.

As part of the process of analysis and prior to recommending mitigation measures, it is first necessary to determine if the site or group of sites is significant. Determination of significance is based on the application of National Register of Historic Places criteria (36 CFR 60.6), which define significant sites as follows:

> "The quality of significance in American history, architecture, archeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, materials, workmanship, feeling and association and:
> (a) That are associated with events that have made a significant contribution to the broad patterns of our history; or
> (b) That are associated with the lives of persons significant in our past; or
> (c) That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
> (d) That have yielded, or may be likely to yield, information important in prehistory or history."

A site or group of sites is eligible for inclusion in the National Register of Historic Places if it is determined to be significant. FERC regulations require a description of impacts on sites or properties either listed in, or recommended as eligible for, the National Register of Historic Places. The management plan for the mitigation (including avoidance) of impacts on historical and archeological sites and resources is to be based upon recommendations from the SHPO and the National Park Service. The applicant may include an explanation of variations from those recommendations (FERC 1981).

To locate and document sites for this project, a program of reconnaissance-level testing was implemented. In order to gather sufficient data on which to base an evaluation of significance, systematic testing was employed. In most cases (a notable exception being historic cabins), systematic testing is necessary to assess significance. To date, relatively few of the known archeological sites have been systematically tested; therefore, a determination of significance for most sites is not possible.

Significance implies a frame of reference; a problem orientation; a geographic, temporal, or other context against which significance is evaluated. Sites can be significant on several levels. Through application of National Register criteria, a site may be evaluated either as a single entity or in terms of its relationship to a group of sites; that is, it may have relative significance. If all of the sites within a drainage system such as the upper Susitna were known and the region itself well studied (which it is not), relative significance of sites or groups of sites could be established with some degree of confidence. When a site or group of sites is located, however, in an area like the Susitna basin, which is relatively unknown archeologically, it is difficult to establish relative significance.

Significance itself is also a relative term, used in an historic context dependent on the current state of knowledge, on the method and theory employed, and on research questions asked. New techniques and methods have enabled archeologists to collect new and different types of data, which, in turn, allow new questions to be formulated and addressed. Currently, National Register criteria for significance pertaining to archeological sites generally emphasize research potential, site integrity, and/or public appreciation; however, these criteria are subject to ongoing modification.

Although all the sites located as a result of this study are related geographically and many, no doubt, temporally, determination of the exact relationships awaits further study. Most of the sites were found associated with one or more of three tephras, which will provide limiting dates for most of the sites in a restricted geographic context. Those dated sites will, in turn, provide a unique and scientifically important opportunity to construct the first cultural chronology for the upper Susitna River basin. It may be appropriate to state that all sites are significant and collectively hold the potential for defining the prehistory for this region of Alaska, a task which has not yet been accomplished. All the sites may, therefore, be eligible for inclusion in the National Register.

Curation -- Step 5: As required by federal law, all cultural material was catalogued and accessioned to the University of Alaska Museum along with all supporting documentation. The University of Alaska Museum was designated on the Federal Antiquities Permit as the repository for cultural material and documentation resulting from this study. All artifactual material and supporting documentation is, therefore, housed at the University of Alaska Museum, Fairbanks, Alaska.

4.3 - Historical and Archeological Sites in the Project Area

(a) Central Study Area

During the summers of 1980 and 1981, in an effort to examine as much of the study area as possible, 111 of the 119 possible survey areas were surveyed and tested, employing both surface and subsurface testing techniques. Examined were areas associated with the Watana and Devil Canyon dams and impoundments, proposed borrow sources and associated facilities, geotechnical areas, access routes and transmission line, and areas containing archeological sites as reported by project personnel. A total of 116 sites were actually located and documented during the two field seasons (Figures 4.1 through 4.3). Because of the large area covered and the number of sites located, however, it was only possible to systematically test 18 of those 116 sites.

Analysis of the field data presented is preliminary. As confirmed by the SHPO, the number of sites found in the upper Susitna basin was unexpectedly large (Shaw 1981 pers. comm.). Preliminary analysis of faunal material from both reconnaissance and systematic testing indicates that the majority identified represent caribou. Three volcanic ash layers (tephras) were found in the study area. Radiocarbon testing has produced preliminary limiting dates for these three layers. Although not all the dates from similar stratigraphic units correspond, the radiocarbon dates suggest that the upper layer is between 1800 and 2300 radiocarbon years B.P.; the middle layer, 2800 to 3200 radiocarbon years B.P.; and the lower layer, older than 4700 radiocarbon years B.P. The ability to correlate most archeological sites and individual components within sites with the volcanic ash layers is highly significant, because it is virtually unprecedented that so many sites could be accurately dated without the uniform presence of carbon. Thus, all sites collectively can provide information concerning the history and prehistory of the upper Susitna valley (see Section 4.4). Preliminary analysis of the data indicates that collectively, at least, all of the archeological sites may be eligible for listing in the National Register of Historic Places. Impacts on these sites are identified in Section 4.4 and a preliminary mitigation plan is presented in Section 4.5.

As described above, prior to any field work and as part of the overall research design, a tentative cultural chronology for the upper Susitna basin was developed. This cultural chronology which was based upon a literature search, appears in the Cultural Resources Procedures Manual (APA 1980) and 1980 Annual Report (APA 1981a). The chronology suggested that sites spanning the past ca. 10,000 years would be found in the study area. Preliminary analysis of cultural resources located during the two field seasons of this project indicates that sites representing all culture periods outlined in the tentative chronology occur in the study area. A literature review of the archeology of central Alaska is also presented in these reports.

Historical sites consist mostly of trappers' cabins. One collapsed cabin might have been a line cabin used by Oscar Vogel in the 1930's and 1940's. Another site, consisting of a cabin, kennels, and an outhouse, was the trapping headquarters of Elmer Simco. The cabin was built in the early 1930's. At the mouth of Portage Creek is an inscription carved in the rock and dated 1897, with the names of William Dickey and three other individuals. Dickey was one of the first white men in the region. These sites may meet some of the National Register criteria. The Simco cabin, for example, may be considered to "embody the distinctive characteristics of a type, period, or method of construction." The Dickey inscription, if genuine, may perhaps be considered to be "associated with the lives of persons significant in our past". None of the historical sites in the area, however, have yet been determined to be eligible for the National Register.

(b) Southern and Northern Study Areas

Results from the southern and northern portions of the transmission line route are presented in Figures 4.4, 4.5, and 4.6. The cultural resource sites indicated on these figures were determined from the files of the State Archeologist. One site, located on the edge of a northeast-southwest trending terrace overlooking the Nenana River near Alaska Railroad Mile Number 383, was discovered during a helicopter review of the proposed transmission line routes. Areas of high potential for the discovery of cultural resources are also illustrated in these figures.

4.4 - Impacts on Historic and Archeological Sites

To define the levels of impact that the Susitna Hydroelectric Project will have on specific sites or groups of sites, the definition of the Advisory Council on Historic Preservation was used. That [36 CRF 800.3 (a)] definition states:

> "Direct effects are caused by the undertaking and occur at the same time and place. Indirect effects include those caused by the undertaking that are later in time or farther removed in distance, but are still reasonably forseeable. Such effects may include changes in the pattern of land use, population or growth rate that may affect on properties of historical, architectural, archeological, or cultural significance."

In terms of the Susitna Project, sites directly affected are those which will experience ground disturbing activities associated with preconstruction, construction, operation, overall land modification, and ancillary development of the project. These include dam construction sites, spillways, access roads, borrow areas, camps, villages, transmission line rights-of-way, staging areas and railroad yard, airstrip, and reservoirs behind the Devil Canyon and Watana dams (Figure 9.7). A further consideration is the types of activities that will take place in these areas.

Indirect impact will occur on sites affected by altered tributary hydrology (erosion and soil saturation) brought about by the filling and lowering of the reservoirs, by greater access to remote areas, by increased population in the area during and after construction, by some project maintenance and related activities, and by ancillary development expected to occur as a result of the project. While some indirect results of the project on surrounding sites are virtually assured, others are more difficult to predict. An impact to sites or groups of sites can be predicted to occur, for example, as a result of expected recreational development or activity.

The archeological profession has a third level of impacts called potential. Potential impact is connected with possible future development resulting from the project but which can not at present be predicted. Potential impact could become direct or indirect depending on how these activities affect the areas containing cultural resources.

(a) Central Study Area

Cultural resouce sites found in the central study area are located on Figures 4.1 through 4.3. Those sites to be either directly or indirectly affected by the project are distinguishable on these figures.

(i) Watana Dam and Impoundment

Two historic sites and 24 archeological sites will be directly affected. One historic site and 23 archeological sites may be indirectly affected.

(ii) Devil Canyon Dam and Impoundment

One historical and seven archeological sites will be directly impacted. Three sites (one archeological, two historical) including the Dickey inscription may be indirectly affected.

(iii) Borrow Areas, Associated Facilities, and Areas Disturbed by Geotechnical Testing

One historic site and 10 archeological sites will be directly affected by activities associated with these areas. Three archeological sites may receive indirect impact. In any case, many of these sites will have been directly or indirectly affected by the Watana dam and reservoir.

(iv) Access Route

Although no historic sites are known to occur in the access road corridor, eight archeological sites will be directly impacted unless mitigative actions are taken. Six archeological sites may be indirectly affected. Sites spared direct impact by minor realignment of the route would still be subject to indirect impact.

(v) Transmission Lines

Currently proposed transmission line routes contain seven known archeological sites that could be directly impacted. An additional seven sites may be indirectly impacted. Direct impacts (but not necessarily indirect impacts) can be avoided by the actual routing of the right-of-way.

(vi) Other Areas

The category "other areas" includes archeological sites identified outside of the study area in addition to those sites within the study area that will not be directly or indirectly affected by the project. There are 42 such sites. They are placed in the potential impact category since future impacts cannot at present be predicted. As required by the FERC license application guidelines, these sites are identified so that early in the planning stages of the Susitna Hydroelectric Project all current data on cultural resources are available to project planners. For example, if Borrow Area F (along Tsusena Creek) were to be further enlarged to the north, a number of cultural resource sites would likely be directly or indirectly impacted. Other sites near Big Bones Ridge (east of the Oshetna River), have a much more remote possibility of being directly or indirectly impacted.

(b) Southern and Northern Transmission Corridors

Figures 4.4 through 4.6 illustrate known archeological sites along the proposed transmission corridors in the southern and northern study areas. The information regarding these sites was obtained from the files of the State Archeologist. Known sites were a consideration in the transmission line routing. These figures also illustrate areas with a high potential for containing cultural resources, which were also a consideration in the routing.

As discussed previously [see Section 4.2 (b)], no reconnaissance-level testing for cultural resources was conducted. Therefore, undiscovered sites may occur in the route. Although a potential does exist for impacts on such sites, it may be possible to avoid at least the direct impacts during alignment of the actual right-of-way.

4.5 - Mitigation of Impacts on Historic and Archeological Sites

(a) Mitigation Policy and Approach

It is mandated by federal law (FERC 1981, United States 1974) that the effect of any federal project or federally licensed project on cultural resources must be assessed and mitigation measures developed to lessen or avoid the impact on these resources. Mitigation is a basic management tool, providing options for either preserving, avoiding, or excavating cultural resources. Although the concept of mitigation continues to be refined, it clearly consists of three options: avoidance, preservation, and investigation.

(i) Avoidance

Avoidance consists of any measures that avoid adverse effects of a project on cultural resources. Avoidance in and of itself may not be totally effective if not coupled with a preservation program. The program should ensure that an historic or archeological site is protected from the immediate adverse effect of the project (direct impacts) and is not inadvertently damaged in the future as a result of the project (indirect impacts). For the Susitna Hydroelectric Project, potential damage may result from, but is not limited to, operation of the facilities, increased access to remote areas, recreational activities, induced private development, and the induced transfer of lands from federal and state governments to corporate or private parties (and vice versa). Therefore, avoidance must be considered in terms of both short and long-range goals, the latter aimed at protecting cultural resources beyond the immediate construction phase of the dam and its ancillary facilities.

(ii) Preservation

Preservation is any protective measure that results in the reduction or avoidance of impacts on cultural resources through physical maintenance or that prevents their further deterioration or destruction. Preservation, as with avoidance, implies both short-term and long-term measures. Preservation may consist of such techniques as stabilization, reconstruction, construction of a barrier around the site, patrolling and monitoring the site, public education, or the establishment of an archeological preserve. Of all the preservation options available for the Susitna project, public education may have the greatest potential for long-term preservation not only of a particular site or group of sites but also of all cultural resources in general.

(iii) Investigation

Investigation (systematic excavation) aims at collecting and conserving archeological data in a scientific manner that addresses significant questions about the past (USDI 1980b). A program of this type means that data recovery procedures are developed for each site or group of sites, analyses of materials collected are undertaken, and the results are disseminated to professional and public audiences. In addition to investigation as a method of avoiding adverse effects, a site could be investigated, either partially or in whole if it appears to fit the research needs of the overall cultural resource management program; it contains information critical to the larger mitigation program; or it cannot be protected from indirect impacts that may result from an increase of off-the-road traffic, recreational use, the number of people in the area, or site visibility.

(b) Mitigation Plan

Any mitigation plan must be based on an evaluation of project consequences to the total resource, including both known and undiscovered sites. Therefore, because only a portion of the area to be affected by the Susitna Hydroelectric Project has been surveyed and investigated, any mitigation plan must include a program to examine the entire area and to mitigate adverse effects on all significant sites.

FERC regulations (FERC 1981) require that final recommendations be submitted to the Alaska State Historic Preservation Officer for review and comment. Following this step, a mitigation plan will be submitted as part of the Susitna project's application. Prior to actually implementing any mitigation plan, however, project managers must permit the Advisory Council on Historic Preservation to comment on the plan's efficacy. Compliance with recommendations to mitigate the effect of the Susitna Hydroelectric Project on cultural resources is the responsibility of the Alaska Power Authority.

(i) Details of Plan (Preliminary)

Mitigation of the impact on all sites that will be adversely affected by the dams, impoundments, and ancillary facilities of the Susitna Hydroelectric Project, either directly or indirectly, can be accomplished by investigation as described above. Avoidance and preservation may be a viable option for minimizing some indirect impacts. Mitigation of potential impacts on sites in the Other Areas category [Section 4.4 (a) (iii)], as well as impacts of the access road and the transmission routes, can likely be achieved by avoidance with an accompanying protection plan as described above.

- Impoundment Zones and Ancillary Facilities

Mitigation of the direct impact on eight sites and the indirect impact on two sites in the Devil Canyon dam and impoundment area can be accomplished by investigation; the Dickey inscription can be avoided and preserved. Likewise, mitigation of the direct impact on 26 sites and indirect impact on 24 sites in the Watana dam and impoundment zone can also be achieved by investigation. Finally, mitigation of the direct effects to 11 borrow area sites and indirect impact on three other such sites can be accomplished by investigation. Avoidance and preservation may also be a viable alternative for mitigating indirect impacts to some sites.

- Access Route

Mitigation of the direct impact of the project on eight sites and indirect effects on six sites along the access route can be accomplished by investigation. If realignment of the route can be accomplished in certain areas, mitigation of direct impacts by avoidance is possible; preservation or investigation could then mitigate indirect impacts.

- Transmission Route

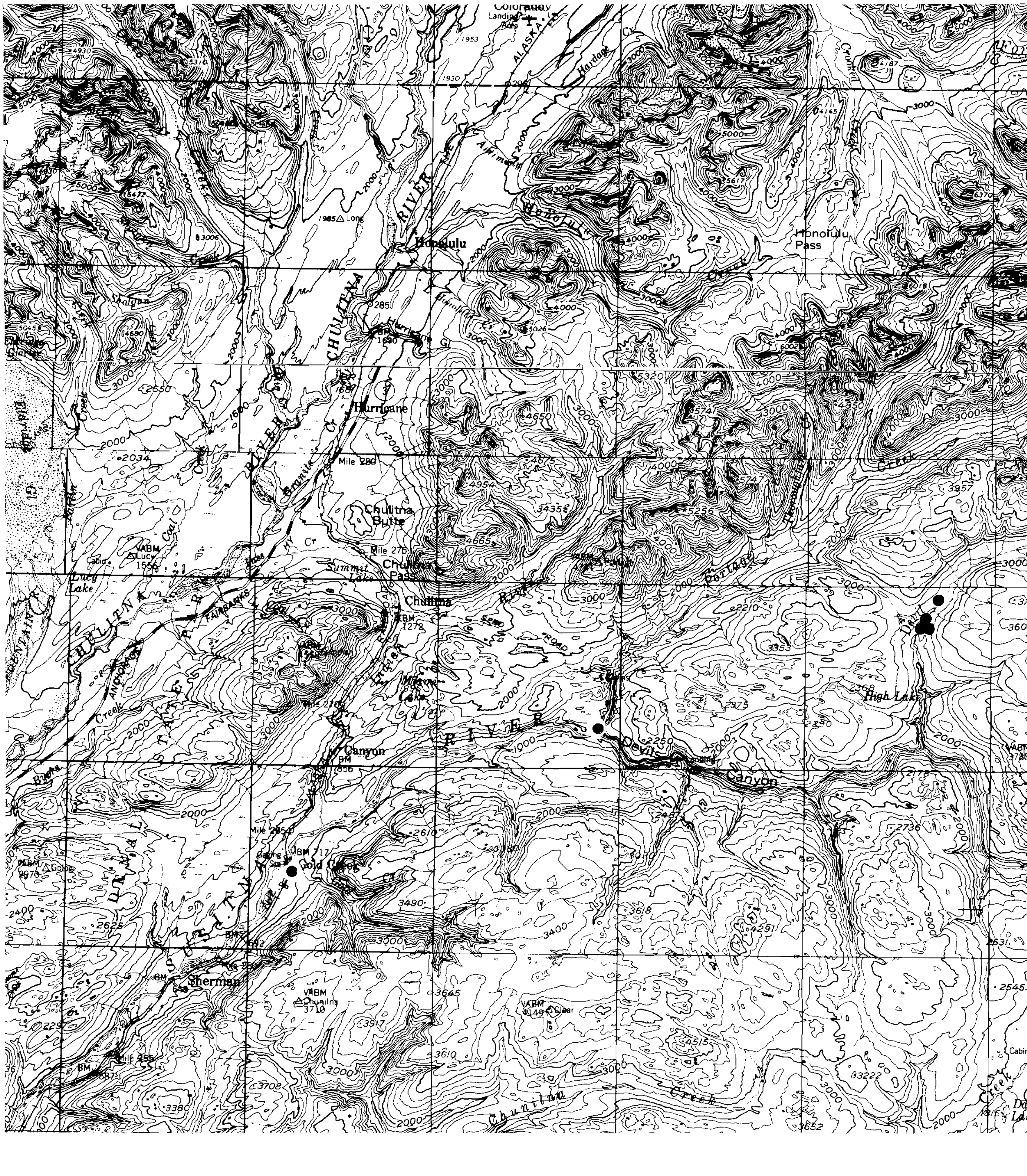
In the central study area, investigation, avoidance, and/or preservation would mitigate the direct impact on seven sites and indirect impact on seven sites; avoidance may mitigate the direct impacts, but not necessarily the indirect impacts, so preservation (or even investigation) would likely still be needed. Currently, available data do not enumerate the sites that may be directly or indirectly affected by the transmission line in the southern and northern study area. It is assumed that once a transmission route is surveyed, a reconnaissance-level survey will be conducted. Since the transmission line right-of-way can, in most cases, be aligned to skirt any cultural resources located, mitigation of known sites can be accomplished primarily by avoidance and preservation. The effects on those sites that cannot be avoided by aligning tower locations and/or access roads can be mitigated by investigation.

- Other Areas

The 42 cultural resource sites included in "Other Areas" are in the category of potential impacts. One reason for including them in any mitigation plan is that if either the proposed project or future land use changes in any way, then a site previously deemed unaffected may, in fact, experience some consequences. In that event, impacts would then be direct or indirect. Thus, the existence of these areas should be recognized, and mitigation should involve avoidance or preservation. If these measures do not appear likely to be effective, investigation is possible.

(ii) State and Federal Agency Recommendations and Applicant's Variation from these Recommendations

Final mitigation recommendations and the mitigation plan itself will be submitted to the State Historic Preservation Officer and the National Park Service for review and comment. Their comments and recommendations will be included in the FERC license application.



KNOWN CULTURAL RESOURCES SITES, C

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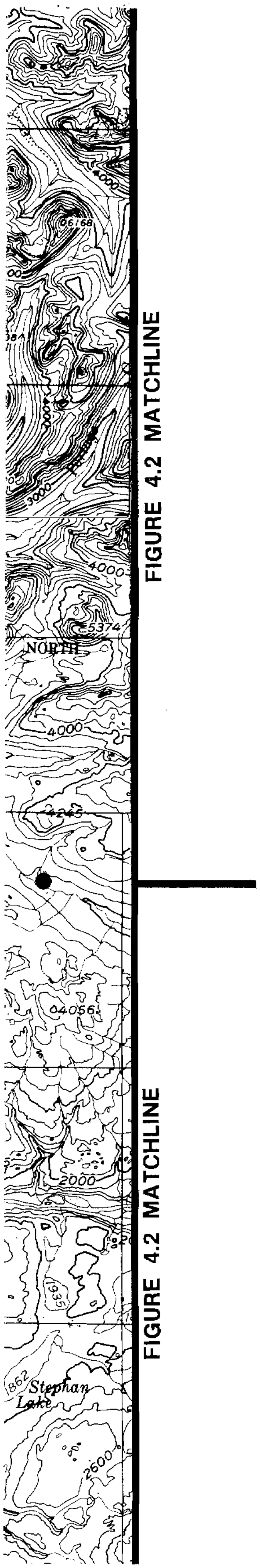
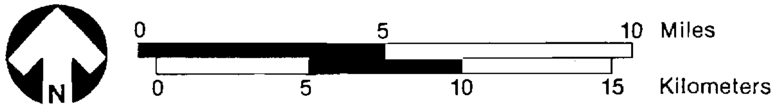




LEGEND

● SITES DIRECTLY OR INDIRECTLY IMPACTED
○ SITES OUTSIDE OF IMPACT AREA

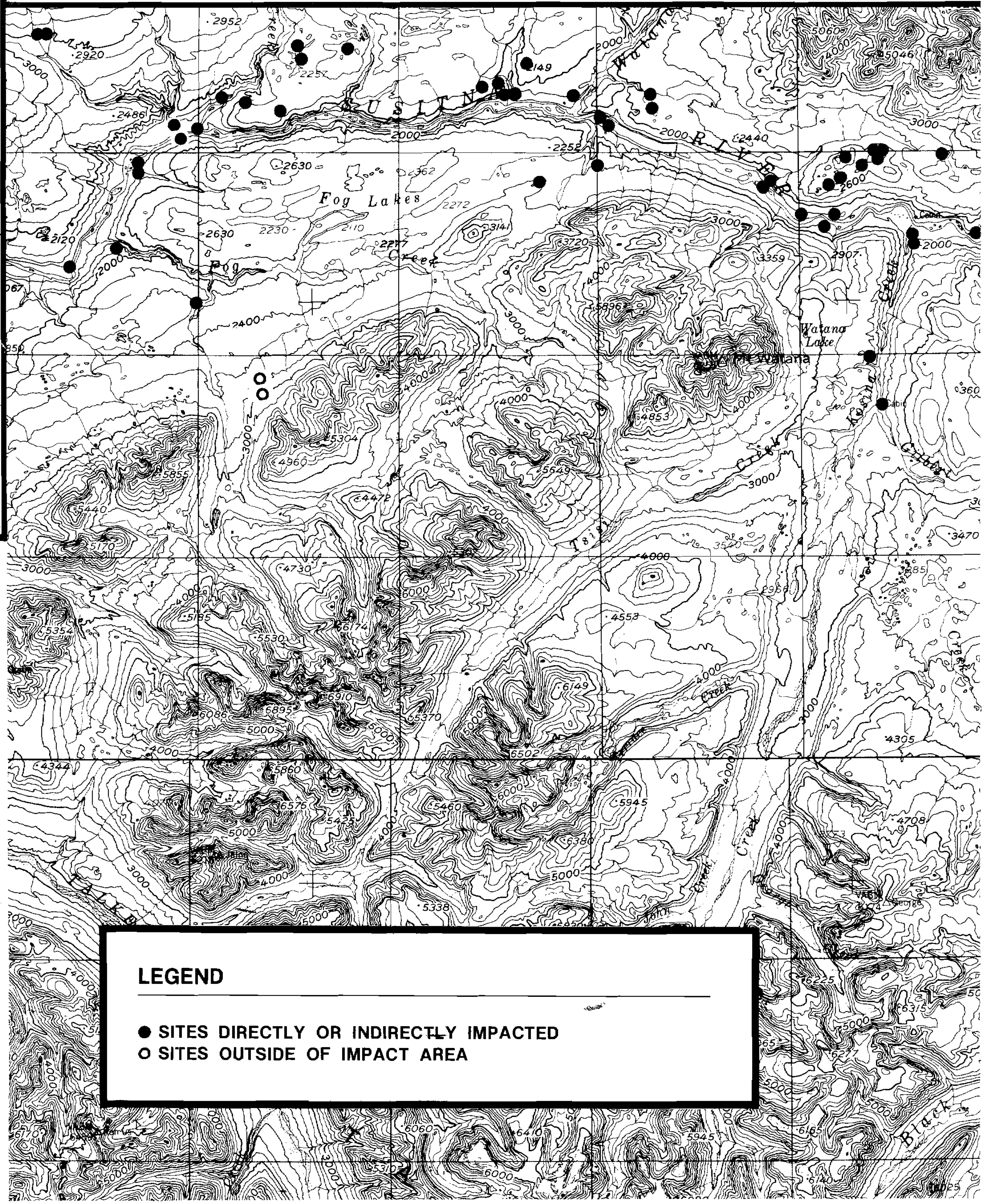
AL STUDY AREA - MAP I

FIGURE 4.1

ACRES

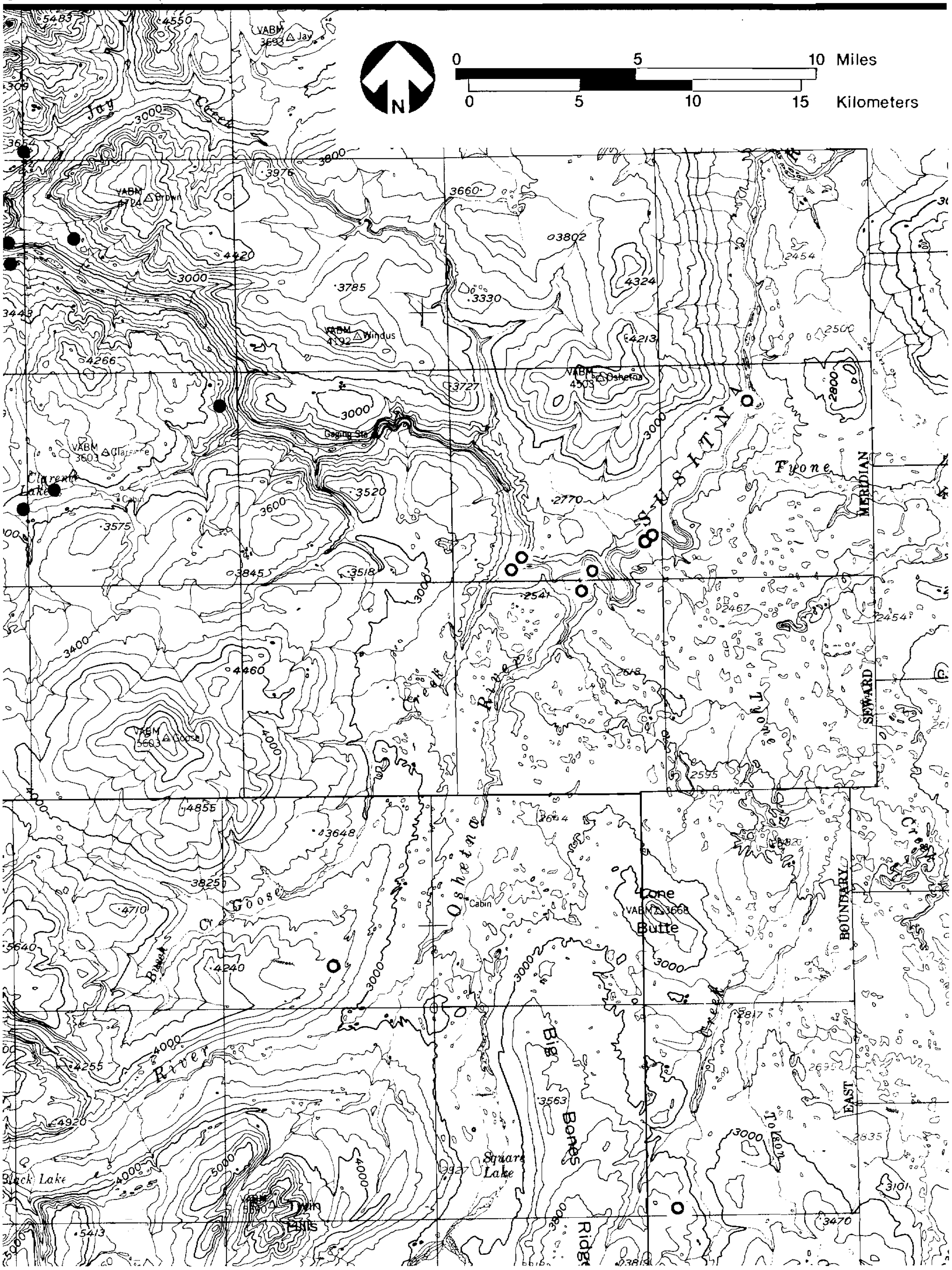
FIGURE 4.3 MAT

FIGURE 4.1 MATCHLINE



KNOWN CULTURAL RESOURCES SITES, CENTR

CHLINE



AL STUDY AREA - MAP II.

FIGURE 4.2

ACRES

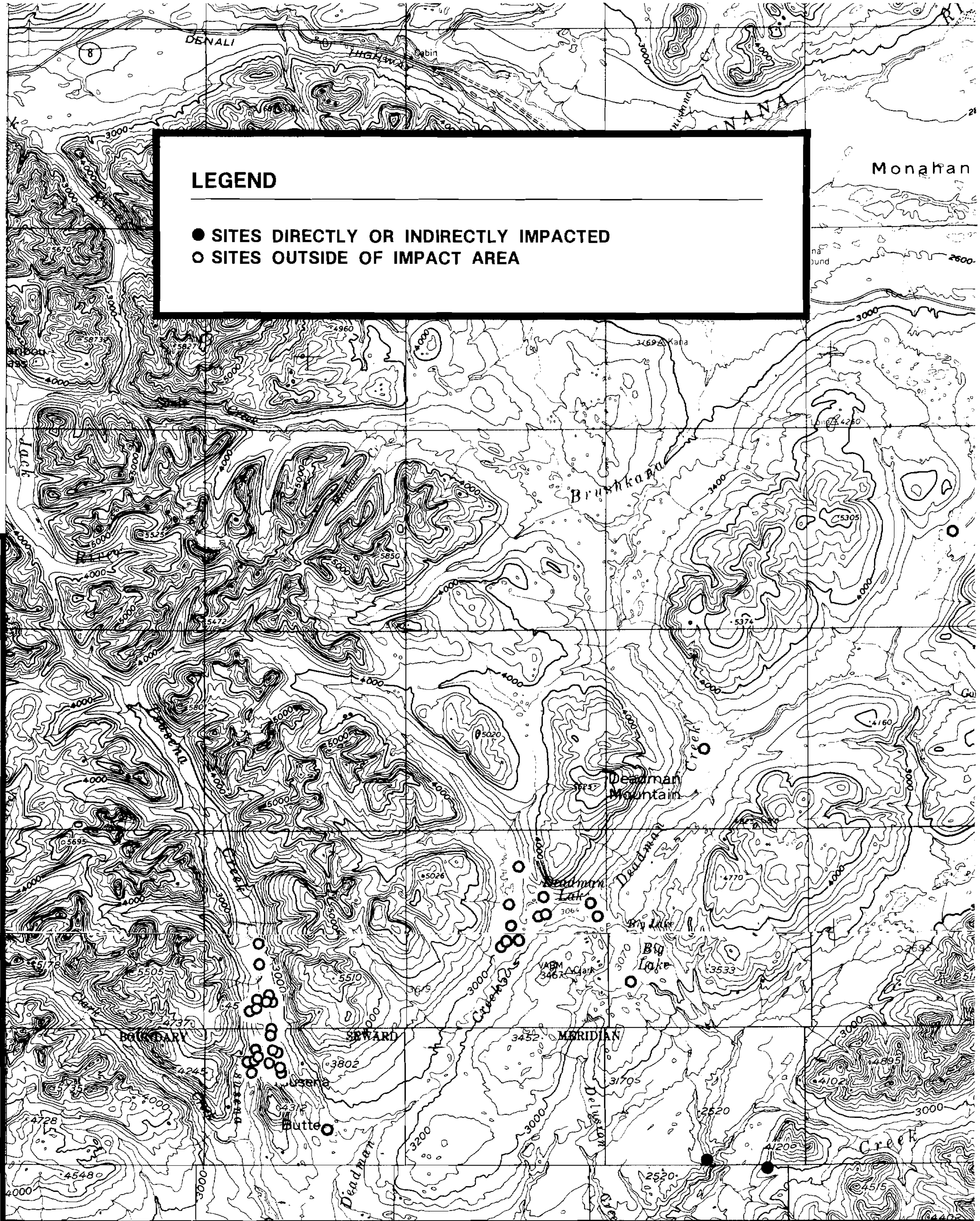


FIGURE 4.1 MATCHLINE

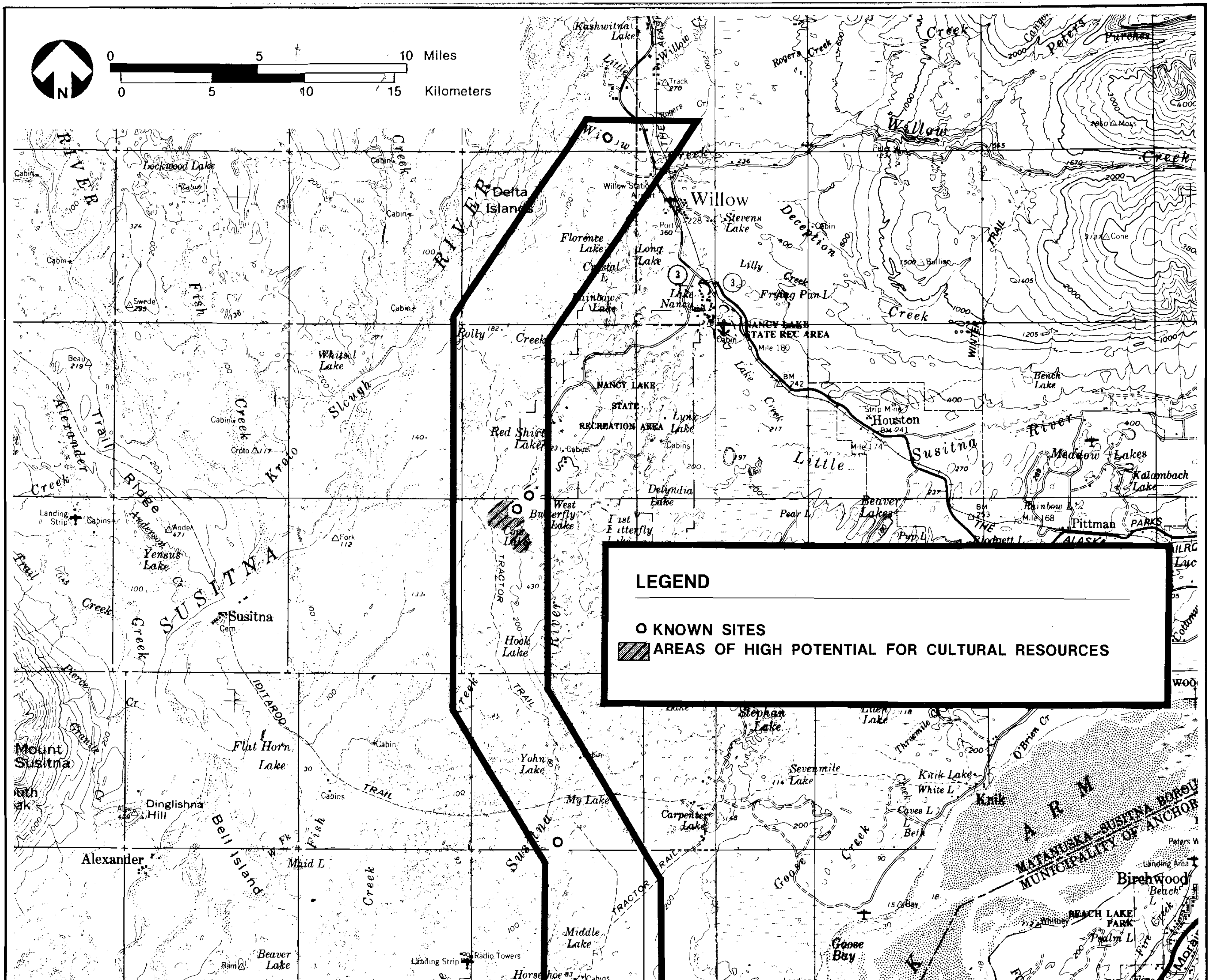
FIGURE 4.2 MATC

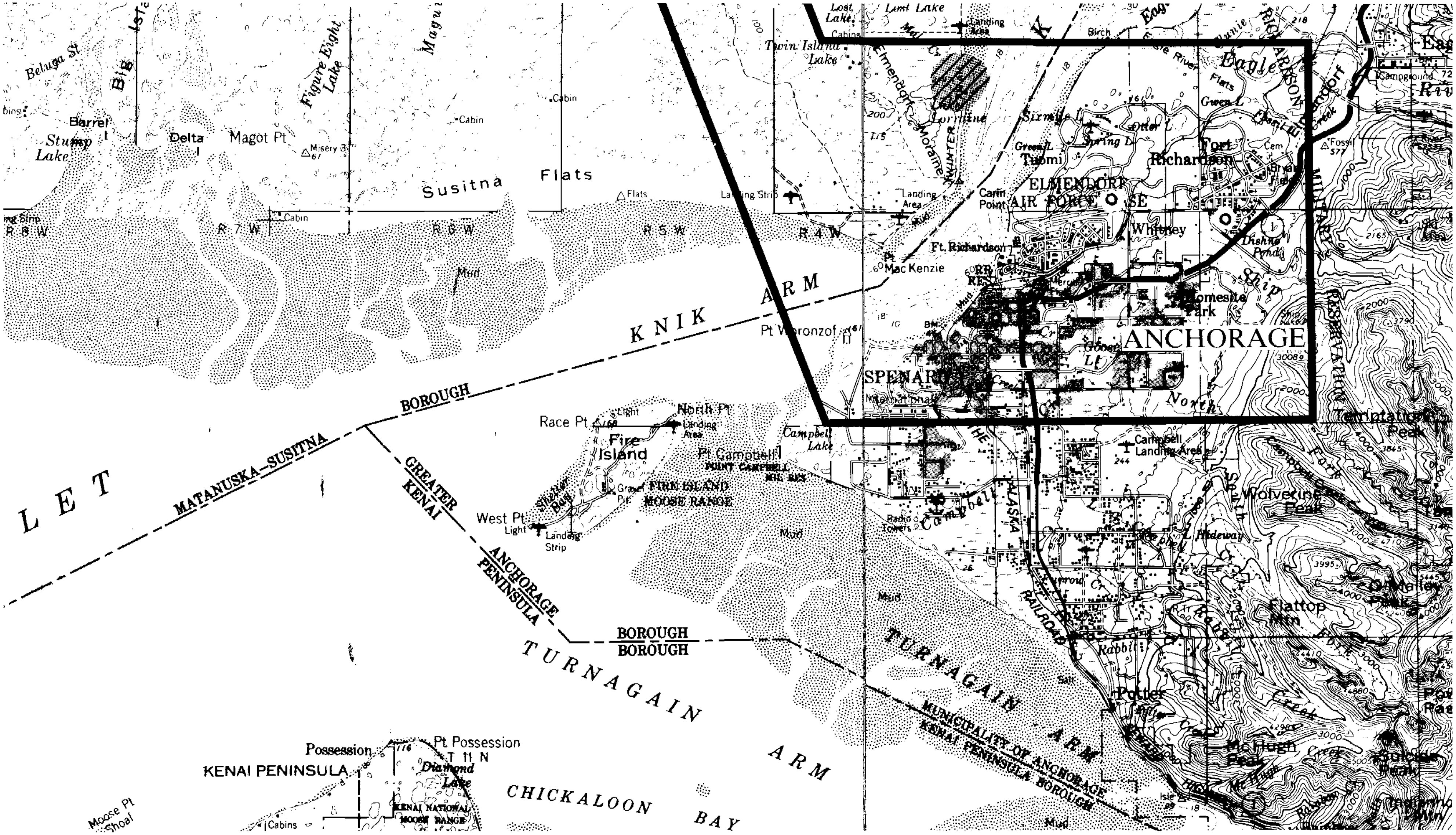
KNOWN CULTURAL RESOURCES SITES, CENTR

HLINE

AL STUDY AREA - MAP III.

FIGURE 4.3


0
5
10 Miles
0
5
10
15
Kilometers
N
LEGEND
KNOWN SITES
AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES
Willow
Willow Creek
Delta Islands
Florence Lake
Long Lake
Stevens Lake
Deception Creek
Lilly Creek
Frying Pan L
NANCY LAKE STATE REC AREA
NANCY LAKE STATE RECREATION AREA
Mile 180
Houston
Little Susitna River
Meadow Lakes
Kalambach Lake
Pittman
Red Shirt Lake
West Butterfly Lake
Delyndia Lake
Lockwood Lake
Whitsol Lake
Slough
Fish Creek
Krato Creek
Alexander Creek
Trail Ridge
Yensus Lake
SUSITNA
Susitna
Hock Lake
TRACTOR TRAIL
IDITAROD TRAIL
Flat Horn Lake
Yohn Lake
My Lake
Mount Susitna
Dinglishna Hill
Bell Island
Alexander
Maid L
Middle Lake
Beaver Lake
Radio Towers
Landing Strip
Stephan Lake
Sevenmile Lake
Knik Lake
White L
Caves L
Carpenter Lake
Goose Creek
Goose Bay
Knik
K N I K   A R M
MATANUSKA-SUSITNA BOROUGH
MUNICIPALITY OF ANCHORAGE
Birchwood
BEACH LAKE PARK
Peters Creek
Bench Lake
Rogers Creek
Kashwitna Lake



KNOWN SITES AND AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES, SOUTHERN STUDY AREA

PREPARED BY TES

FIGURE 4.4

ACRES

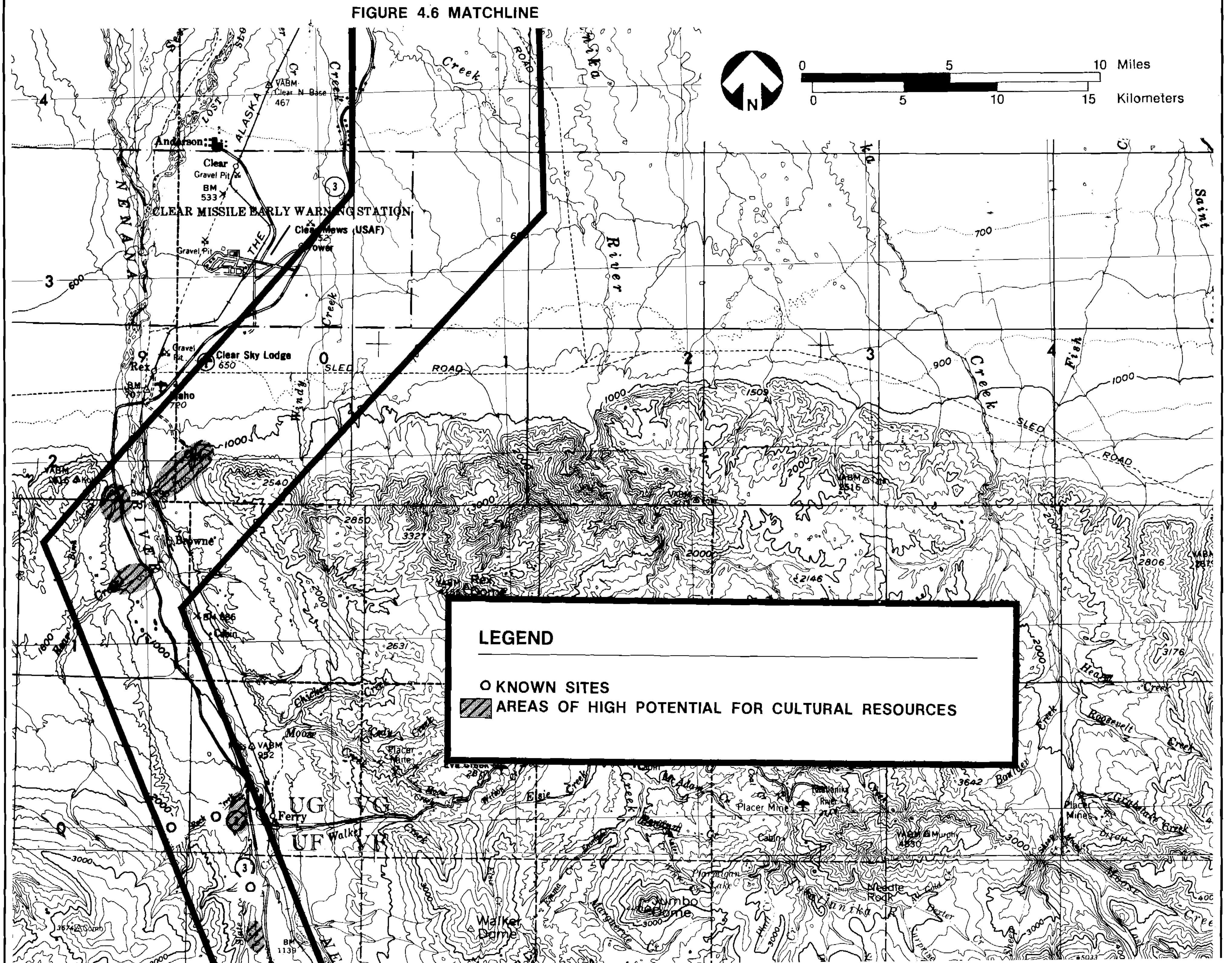
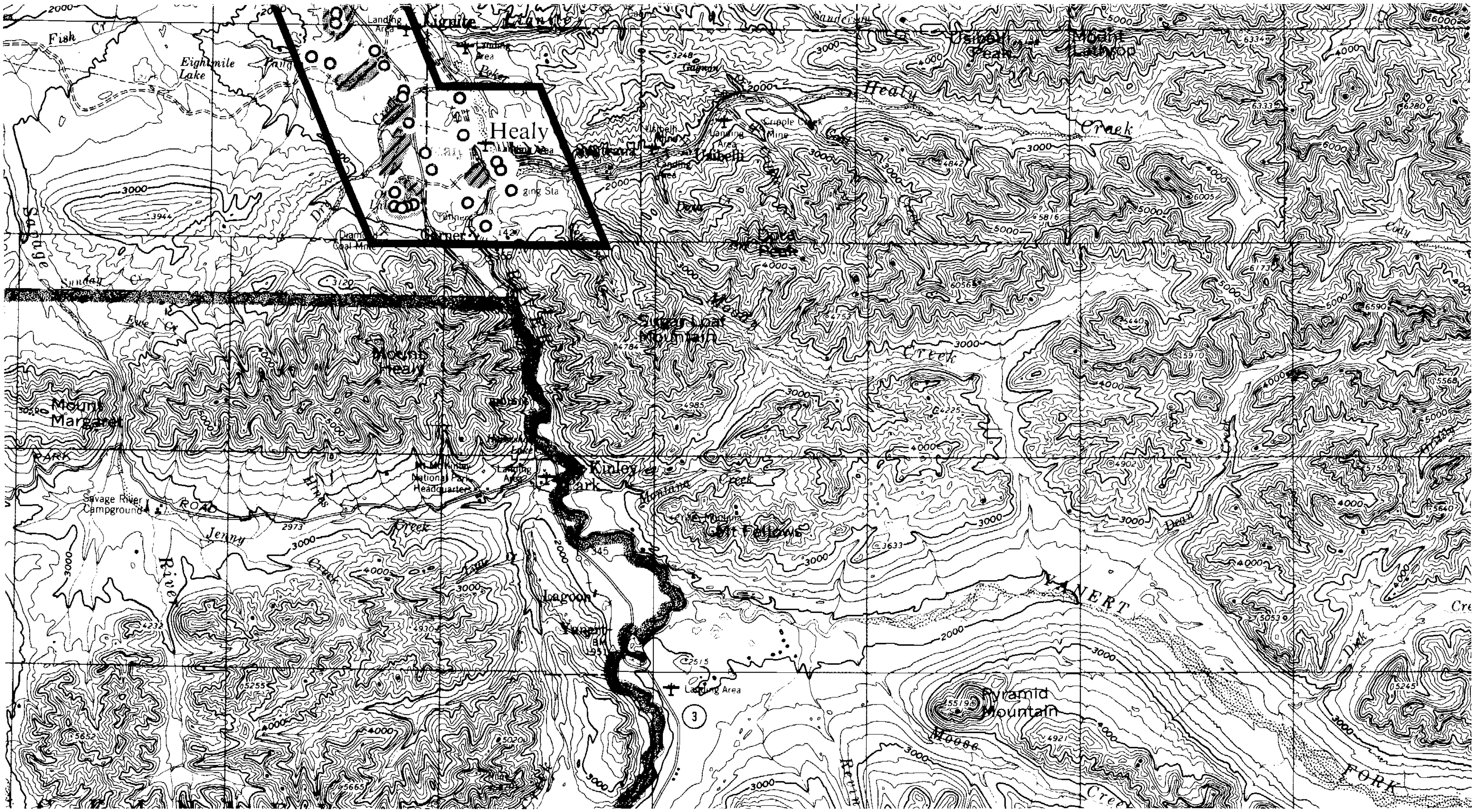


FIGURE 4.6 MATCHLINE
0 5 10 Miles
0 5 10 15 Kilometers
N
LEGEND
KNOWN SITES
AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES
CLEAR MISSILE EARLY WARNING STATION
Clear Mews (USAF)
Anderson
Clear
Gravel Pit
Clear Sky Lodge
Rex
Browne
Cabin
Ferry
Placer Mine
Walker Dome
Jumbo Dome
NENANA
RIVER
SLED ROAD
Creek
Fish
Saint

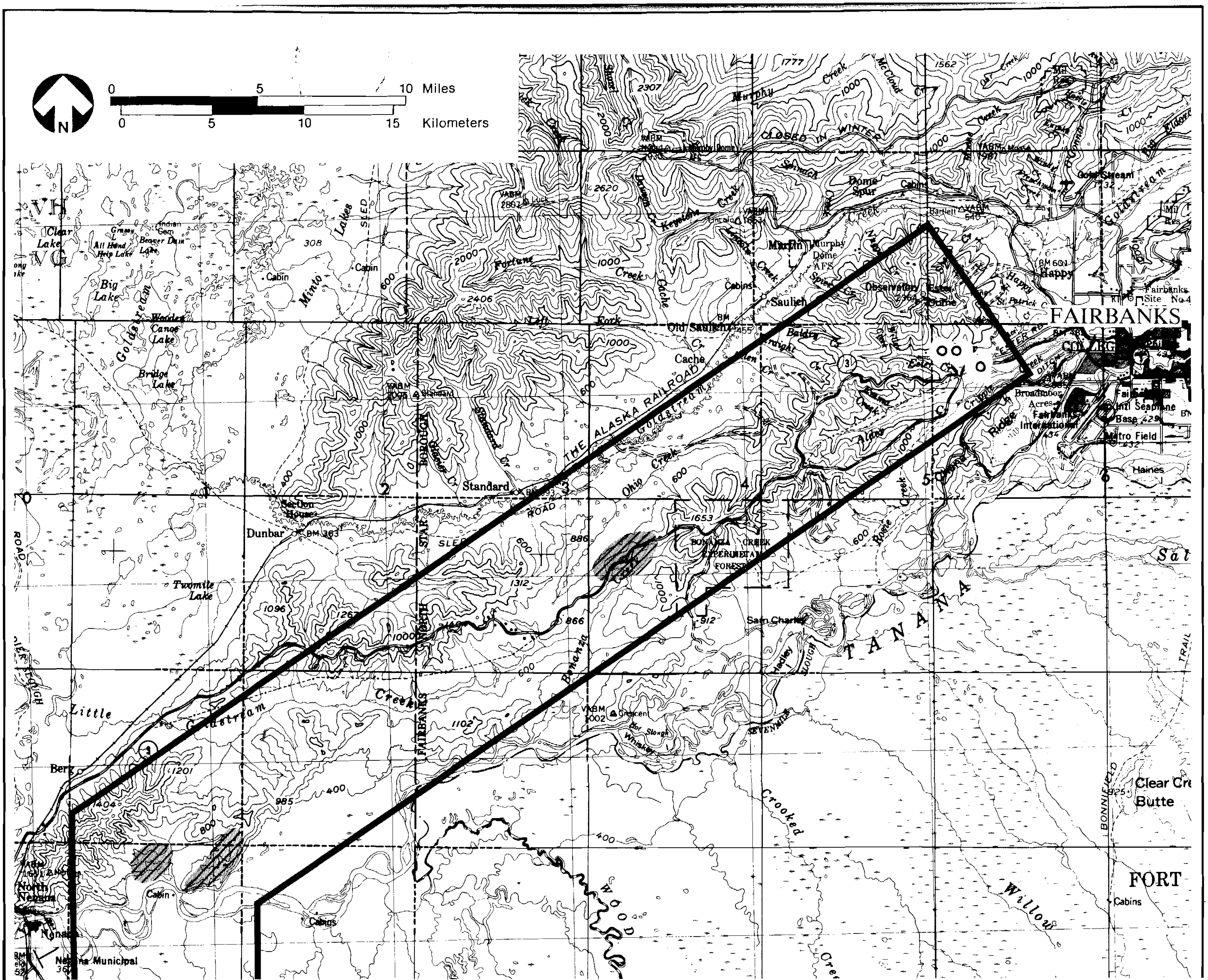


KNOWN SITES AND AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES, NORTHERN STUDY AREA - MAP I

PREPARED BY TES

FIGURE 4.5

ACRES



N
0 5 10 Miles
0 5 10 15 Kilometers
FAIRBANKS
THE ALASKA RAILROAD
Goldstream
Standard
Dunbar
Section House
Twomile Lake
Big Lake
Wooden Canoe Lake
Bridge Lake
Minto Lakes
Clear Lake
Murphy Dome AFS
Saulich
Old Saulich
Cache
Ohio Creek
Alder Creek
Bonanza Creek
BONANZA CREEK EXPERIMENTAL FOREST
Sam Charley
TANANA
Little Goldstream Creek
Berg
North Nenana
Nenana
Nenana Municipal
Cabins
Cabin
Crooked Creek
WOOD
Willow
FORT
Clear Creek Butte
BONNIFIELD
Haines
Metro Field
Fairbanks International
Broadmoor Acres
Intl Seaplane Base
Gold Stream
Happy
Dome Spur
Murphy Creek
Fortune Creek
Keystone Creek
Crescent
Whiskey
Bar Slough
SEVENMILE SLOUGH
Hadley Slough
Ridge
FAIRBANKS NORTH STAR BOROUGH
CLOSED IN WINTER
Observation

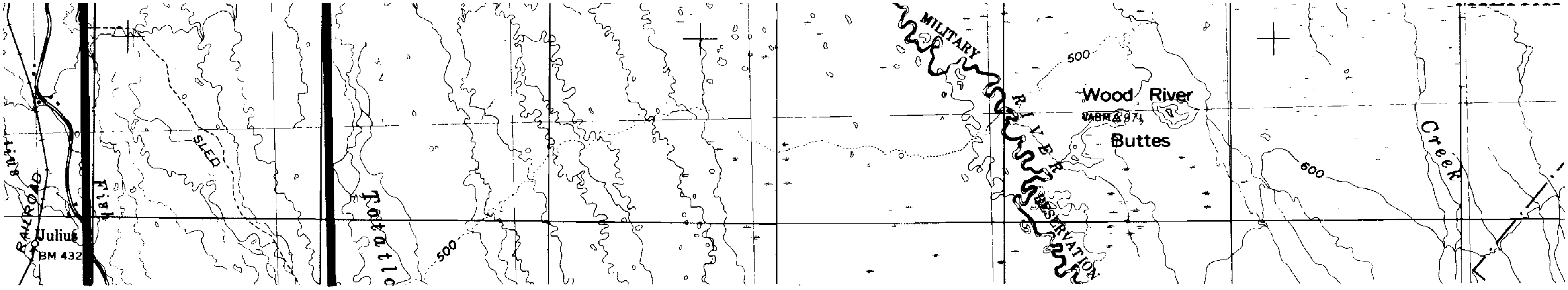


FIGURE 4.7 MATCHLINE

LEGEND

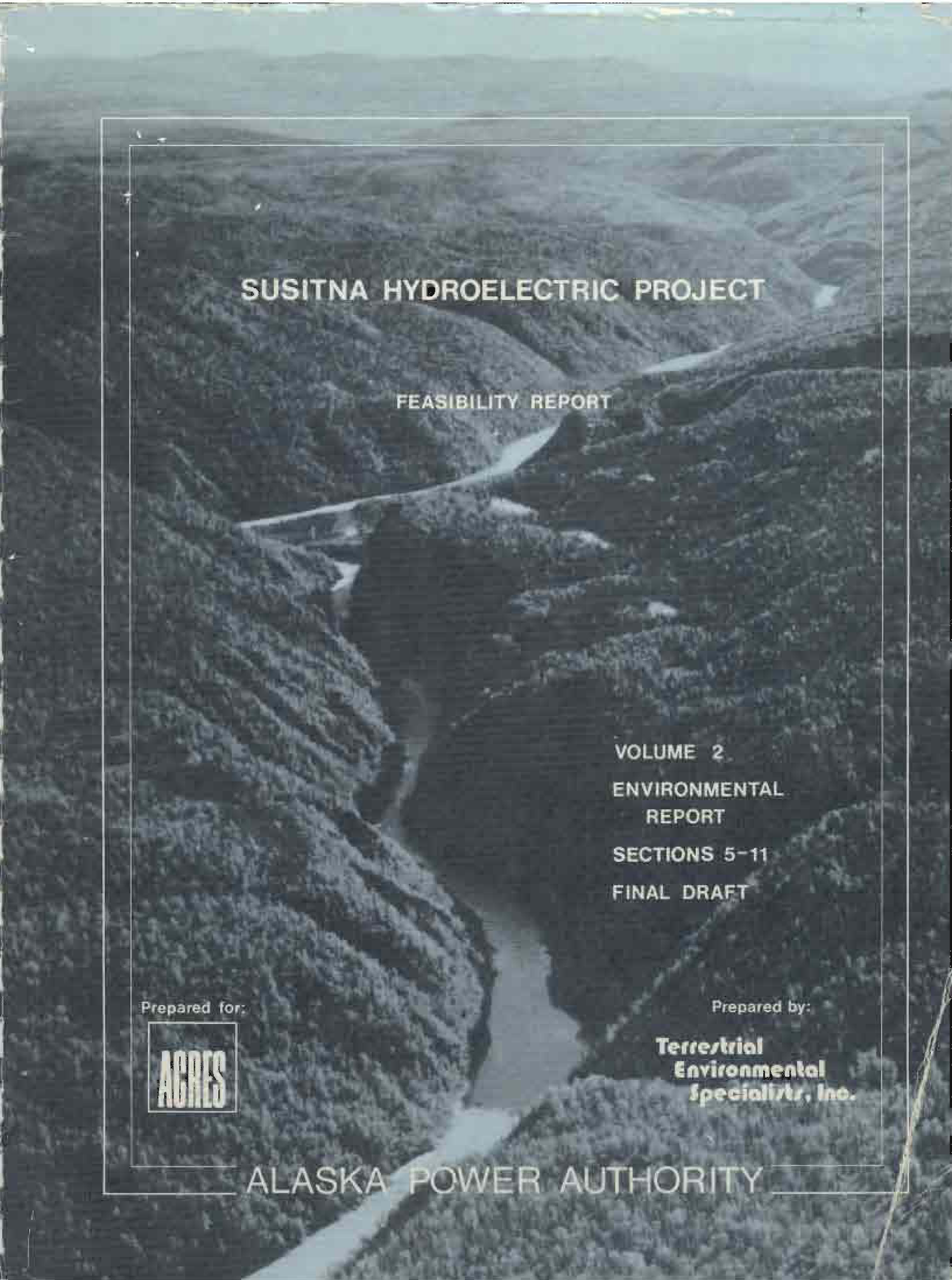
- O KNOWN SITES
- AREAS OF HIGH POTENTIAL FOR CULTURAL RESOURCES

KNOWN SITES AND AREAS OF HIGH POTENTIAL FOR
CULTURAL RESOURCES, NORTHERN STUDY AREA - MAP II

PREPARED BY TES

FIGURE 4.6

ACRES



SUSITNA HYDROELECTRIC PROJECT

FEASIBILITY REPORT

VOLUME 2

ENVIRONMENTAL REPORT

SECTIONS 5-11

FINAL DRAFT

Prepared for:

ACRES

Prepared by:

Terrestrial Environmental Specialists, Inc.

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

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Note: Sections 1 to 4 are bound under separate cover.

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LIST OF FIGURES (Cont'd)

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5 - REPORT ON SOCIOECONOMIC IMPACTS

This socioeconomic analysis is designed to provide an assessment of socioeconomic changes that could occur if hydropower is developed from the Susitna River. The analysis involved: 1) a literature review; 2) determination of data availability; 3) definition of impact areas; 4) a description and analysis of baseline conditions and trends; 5) development of baseline forecasts; 6) development of impact forecasts; 7) a comparison of baseline and impact forecasts; and 8) determination of significance of project socioeconomic changes. The availability of time-series data for different geographic areas of Alaska was determined. The data available limited the choice of assessment methods because it was not possible to collect a significant amount of primary data.

Impact areas were defined based upon data availability, worker residence and commuting patterns and probable locations of most socioeconomic changes. Because this project involves a construction community and due to the vastness of Alaska, the impact areas defined in this study are larger than most impact areas reviewed in the literature.

To better understand the impact areas and make baseline forecasts, recent socioeconomic conditions were described and analyzed. These included employment, population, income, housing, facilities and services, fiscal aspects, land use, and other socioeconomic elements.

Baseline forecasts were made for each socioeconomic element. Baseline forecast refers to forecasting the baseline socioeconomic elements over time given anticipated growth in the absence of the construction of the hydroelectric project. A brief description of the forecasting technique used for each element and sub-element is displayed in this section. Forecasts were made for the years 1981-2000.

Impact forecasts, which refer to forecasting changes in socioeconomic conditions caused by construction of the hydroelectric project, were also made for each socioeconomic element listed above. An accounting model was developed to accommodate the several labor categories and geographic disaggregations. This model was computerized to provide for efficient analysis and to make sensitivity analysis feasible. A brief description of the impact forecasting techniques used for each element and sub-element is shown on the following page. The impact forecasts were made from 1983, the year in which construction is to begin, to 2000.

Finally, baseline and impact forecasts were compared and contrasted to identify project-induced changes in the forecast baseline conditions. The significance of these changes are analyzed and discussed in the final section of this report.

BASELINE FORECASTING TECHNIQUES

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State and Region	Time-series econometric[a]
Census Division	Linear regression
POPULATION	
State and Region	Time-series econometric[a]
Census Division	Linear regression
Community	Population Share (judgmental)
INCOME	
State, Region and Census Division	Trend analysis and judgment
HOUSING	
Region and Census Division	Person per household trend multiplier
FACILITIES AND SERVICES	
Census Division and Community	Per capita planning standards
FISCAL	
Census Division and Community	Per capita multiplier

IMPACT FORECASTING TECHNIQUES

ELEMENT	
EMPLOYMENT	
State, Region and Census Division	Accounting model
State and Region	Time-series econometric (for comparison purposes only) [a]
POPULATION	
State, Region and Census Division	Accounting model
State and Region	Time-series econometric (for comparison purposes only) [a]
INCOME	
State, Region and Census Division	Accounting model
HOUSING	
Region and Census Division	Person per household trend multiplier
FACILITIES AND SERVICES	
Census Division and Community	Per capita planning standards
FISCAL	
Census Division and Community	Per capita multiplier

a. Results from Institute of Social and Economic Research's Man-in-the Arctic Model, October, 1981.

5.1 - Summary of Impacts

Potential impacts of the Susitna Hydroelectric Project are summarized below. The magnitude and geographic distribution of these impacts are determined in large part by a series of judgments and assumptions. Some of the key assumptions include: (1) the number of construction workers that will relocate from outside the Railbelt region (Impact Area 3) or outside Alaska to communities in the Railbelt region; (2) the number of workers that will relocate from various areas of the Railbelt region to communities of the Matanuska-Susitna (Mat-Su) Borough; and (3) the number of workers that will remain at place of relocation after construction employment is terminated. These and other assumptions are elaborated upon in Section 5.4.

- The project will provide approximately 6,365 new jobs at the peak of construction activity in 1990; of this amount, 3,500 will be on-site and 2,865 will be direct and induced.

- Between 1983 and 2002, an estimated $418 million will be spent in the Railbelt region by construction workers; of this amount, $67 million will be spent in the Mat-Su Borough.

- The population of the Mat-Su Borough will increase moderately due to construction (the peak population influx will equal 1,112 in 1990). The greatest population impacts are estimated to occur in Trapper Creek and Talkeetna, where the populations will increase by 107 percent and 26 percent, respectively, over baseline forecast levels between 1983 and 1990.

- Short-term housing shortages, and rapid residential construction are expected to occur in Trapper Creek and Talkeetna. Housing conditions in other areas of the Mat-Su Borough and Railbelt region are not expected to be significantly affected.

- Schools and transportation systems will be the most burdened public services in Mat-Su Borough as a result of the project. These effects will be most apparent in the greater Trapper Creek-Talkeetna area.

- The access road could be a major addition to the Mat-Su Borough's road system, possibly contributing to more mineral development and recreational activity in the area.

- Fiscal impacts will be generally twice as great in 1990 (Watana peak) as they will be in 1999 (Devil Canyon Peak); however, in all cases these impacts will be small, both absolutely and relatively.

- The Mat-Su Borough will experience relatively more fiscal impacts than will incorporated communities in the Borough.

- The dominant fiscal impact that could be experienced by the Mat-Su Borough will result from cash-flow cycles. Initially, the costs of service delivery will be accelerated and will not be matched by an immediate parallel increase in revenues. However, the tax base is expected to expand enough to generate sufficient additional revenues to affect project-induced expenditures.

- There are many opportunities within current fiscal structures to raise local revenues to offset increasing costs in the event that State Revenue Sharing decreases.

- Trapper Creek, and to a lesser extent, Talkeetna, may experience rapid inflation caused by increased demands of incoming project-induced population and the competitive pay scales of the project.

- Local government informal community organization in the communities nearest the site will likely develop to respond to rapid growth. Planning and community organization may themselves change the nature of the communities.

- There is potential for conflict between the values and lifestyles of local residents and newcomers in the greater Trapper Creek area.

- Increases in the incidence and nature of many "people problems" (for example, rise in alcoholism, drug abuse, crime, divorce, and the lack of trained medical and counseling personnel), likely associated with stress related to rapid changes may occur in the small communities that experience the highest project-induced population growth rates.

5.2 - Identification of the Socioeconomic Impact Area

Hydroelectric development in the upper Susitna basin will cause employment, population and related changes for a significant part of Alaska. Due to current and likely future "without project" population levels and distributions, and probable "with project" inmigrant residence and commuting patterns, most of these changes will occur in the Railbelt corridor. These changes will be most significant where project-induced population changes are large relative to future ("without project") population levels.

(a) Local-Impact Areas 1-2

The Borough is designated as the "local" impact area (also referred to as Impact Area 2). It is the smallest statistical area for which relevant time-series economic and socioeconomic data are available and is large enough to contain a population sufficient in size to allow for the organization of social life for the pursuit of one or several common interests and to provide for necessary support systems. Project-induced population changes could be large relative to future ("without project") population levels in the Matanuska-Susitna (Mat-Su) Borough and in several communities within this Borough. Potential project-induced changes in the Borough's communities are addressed (although more data are available for some communities than others) to provide for an approximation of the geographic distribution of changes.

The local impact area also includes Impact Area 1: the construction sites, access road, transmission line corridor from the dam sites to the Intertie, some staging areas, impoundment areas and lands to be utilized for the construction camps and villages.

(b) Regional-Impact Area 3

Eight Census Divisions, including the Matanuska-Susitna Borough, make up the "regional" impact area. These are the Anchorage, Kenai Cook Inlet, Seward, Valdez-Chitina-Whittier, Mat-Su and Southeast Fairbanks Census Divisions, and part of the Yukon-Koyukuk Census Division (see Figure 5.1-1). Population changes could be significant in the seven Census Divisions that surround the Mat-Su Borough, particularly the Anchorage Census Division and the Fairbanks North Star Borough (also a Census Division). Some of the physical inputs and many of the labor inputs for construction and operation will be drawn from Anchorage and the Fairbanks North Star Borough.

For analytical purposes, Impact Area 3 is divided into three regions: Anchorage, Fairbanks and Valdez. The Anchorage, Kenai-Cook Inlet, Seward and Matanuska-Susitna Census Divisions comprise the Anchorage region; the Fairbanks North Star Borough and Southeast Fairbanks Census Division comprise the Fairbanks region, and the Valdez-Chitina-Whittier Census Division comprises the Valdez region. The portion of the Yukon-Koyukuk Census Division that is in Impact Area 3 is considered separately from these regions.

(c) State-Impact Area 4

The fourth impact area is the State of Alaska. Socioeconomic changes that could occur outside of the regional impact area, combined with regional changes, provide an approximation of statewide socioeconomic change.

5.3 - Baseline Description

Baseline conditions and trends in the impact areas are addressed in this section. Tables 5.1 and 5.2 indicate resident population and components of change in local, regional and state impact areas and data on the available labor force and unemployment for these areas.

(a) Local

The Mat-Su Borough's trends in population, employment and per capita income are displayed graphically in Figure 5.2. Differences in 1980 population figures for the Mat-Su Borough are a result of discrepancies in the 1980 Census data and a Borough population survey. The latter were used as the basis for forecasting population.

(i) Population

The Borough's population has grown rapidly since 1970, largely reflecting construction of the trans-Alaska pipeline and the evolution of Borough areas into bedroom communities for the Municipality of Anchorage. From 1970 to 1980 the population of the Borough grew 175 percent. Table 5.3 shows population in the Borough by community. Palmer and Wasilla stand out as the largest communities, with 1981 populations of approximately 2,567 and 2,168, respectively.

Approximately 90 percent of the Borough's estimated 1981 population of 22,339 resides within a 20-mile radius of Wasilla. The bulk of the remainder is distributed along the Parks Highway and railroad corridor. Several hundred inhabitants are scattered throughout the Borough's wilderness regions accessible primarily by water or air; these inhabitants include the few Borough residents of the upper Susitna basin in the vicinity of the proposed impoundments.

(ii) Housing

Table 5.4 shows 1981 housing stock estimates and vacancy rates, by areas of the Mat-Su Borough. A recent survey by the Borough shows total housing stock of 8,582 units, of which 79.4 percent or 6,814 were occupied. Most of the housing units were in the Palmer-Wasilla area.

An earlier survey, by Policy Analysts (1979-1980) showed that single-family housing units predominate in the Borough, representing 83 percent of the total; mobile homes account for 11 percent and multi-family units five percent. The dominant pattern in the Borough is ownership of one's residence.

Housing vacancy rates fluctuate rapidly, with a five percent rate seen by local authorities to be healthy and growth-promoting. Some surveys of Mat-Su Borough housing stocks include a significant number of recreational units not occupied year-round and thus serve to artificially inflate the vacancy rate. During the summer of 1981, vacancy rates in the incorporated cities ranged from 6.7 percent to 10 percent; more remote communities such as Talkeetna and Trapper Creek experienced very low vacancy rates of between one and two percent.

Population per household for selected communities in the Borough averages 3.07 according to 1980 Census data. This is considerably higher than the national and state averages.

(iii) Fiscal Condition of Local Government

The Mat-Su Borough is a second class Borough and, as such, has the areawide powers of taxation, education and planning, platting and zoning. In addition, the Borough has non-areawide (outside incorporated cities) powers of solid waste disposal and libraries. The Borough is admin-istered under a part-time Mayor-Manager-Assembly form of government.

In addition, there are currently three incorporated communities in the Borough. Palmer is a first class, home-rule city, and operates its own police, fire, water and sewage treatment facilities. Wasilla and Houston are both second class cities.

The Mat-Su Borough Budget FY81/82 appropriated $38,419,973 in expenditures consisting of the following funds and their respective portion of total revenues: General Fund (36 percent); Service Areas Fund (three percent); Land Management Fund (three percent), and Education Operating Fund (58 percent). Property taxes currently provide almost 50 percent of total General Fund Revenue. The mill rate for fiscal 1982 is 6.7 per $1,000 assessed valuation. It provided $5,388,356 in total property tax revenues.

	Mill Levy
General Government	0.06
Parks and Recreation	0.08
Ambulance Service	0.24
Community College	0.07
Subtotal	.45
Education	6.25
Total	6.70

Currently, no taxes are raised for capital projects due to abundant State funding from petroleum revenues. The current ratio of bonded indebtedness to total assessed valuation is 0.075, based on a total assessed property value of $893,591,412 as of January 1, 1981. This ratio represents the maximum total bonded indebtedness desired by the Borough Administration.

Current per capita expenditures for FY81/82 in the Mat-Su Borough Budget are provided in Table 5.5 based upon a total areawide population of 22,285.

The school district budget for FY81/82 is the single largest category of revenues and expenditures across all services provided within the Borough and within the incorporated communities. The composition of revenues for the School District budget for FY81/82 is:

State Sources	68%	$17,434,148
Local Sources	26%	6,560,949
Federal Sources	6%	1,448,000
Total		$25,443,097

The distribution of school budget dollars by function is as follows:

Regular Instruction	33%
Vocational Education	4%
Special Education	6%
Support Services	18%
Operations and Maintenance	19%
Pupil Transportation	8%
Other	12%

The City of Palmer Budget FY82 consists of a General Fund, and separate funds for water, sewer and capital projects. The composition of General Fund Revenues is local taxes 35 percent (property tax 23 percent based upon four mills per $1,000 assessed valuation; sales tax 12 percent based upon two percent retail sales tax); intergovernmental revenue 25 percent; service charges 30 percent and miscellaneous 10 percent. The current ratio of bonded indebtedness to total assessed valuation is 0.04, based on a total assessed property value of $64,710,668. This ratio is not anticipated to increase over time. Per capita expenditures for the City of Palmer are provided in Table 5.5.

The City of Wasilla Budget FY81/82 consists of a General Fund, Library Fund, and Capital Project Fund. As a 2nd class city, Wasilla does not levy a property tax and is dependent upon intergovernmental transfers of revenues from the Borough, the State and the Federal Government. The City has just completed a central water supply system and will be floating its first local bond issue in Spring 1982. Other local funding for this project will be derived from a property assessment only on lots that will benefit from this improvement. Expenditures for services are provided in Table 5.5.

The City of Houston Budget FY81/82 obtains revenues from a variety of State and local grants which generally specify a portion of the use to which the funds are put. Expenditures for the services provided by the City of Houston are listed in Table 5.5.

The communities of Talkeetna and Trapper Creek and other small communities do not have formal local government. The Mat-Su Borough provides existing services including ambulance, fire protection, solid waste disposal and road maintenance and repair. These services are administered by the Borough and paid for by Borough funds derived both locally and from the State. Property located within the service boundary is liable for taxes levied to cover the costs of service delivery.

(iv) Public Facilities and Services

Current usage and capacity of public services, including water supply, sewage, solid waste disposal, transportation, police, fire, health care services, education and recreational services, in the Mat-Su Borough are displayed in Table 5.6.

- Water

The cities of Palmer and Wasilla have water supply and chlorination treatment systems with peak capabilities of 1,368,000 gallons per day (gpd) and 864,000 gpd, respectively. Other areas are provided with water on an individual basis, by wells, or by a community water system.

- Sewage

Palmer has a city-wide sewage facility. Residents of other areas rely on septic tanks, waste from which is trucked to Anchorage for disposal by private companies. Borough voters have authorized construction of a treatment plant in the Borough. Some Borough areas are served by small public sewage systems: 43 Class A systems serve subdivisions and trailer parks;

77 Class B systems serve schools and businesses, and 45 Class C systems serve duplex and triplex structures. Ratings are by the Alaska Department of Environmental Conser-vation and relate to the number of people served.

- Solid Waste

The Borough has non-areawide solid waste management authority and operates nine landfills. The Borough intends to close most of these and set up transfer stations for bringing the waste to an 80-acre central site, near Palmer, for final disposal.

- Transportation

The Parks Highway is the principal surface transport route within the Borough, linking it to both Fairbanks and Anchorage. The Borough is also connected with Valdez and the Al-Can Highway via the Glenn and Richardson Highways. During the summer months, the 180-mile unpaved Denali Highway connects the Parks and Richardson Highways. Many major Borough communities are connected by the Alaska Railroad which also provides access to a number of small communities which have no road access. The largest airport in the Borough is the Palmer Municipal Airport. There are a number of airstrips.

- Police

Police protection in the Borough is provided by Alaska State Troopers, 17 stationed in Palmer and three in Trapper Creek. Four other troopers are responsible for fish and wildlife protection and enforcement. The City of Palmer has police powers and maintains a force of eight officers and several civilian support personnel. There are three detention and correctional facilities in the Borough: a temporary detention facility maintained by the Palmer Police Department; McLaughlin Youth Center in Wasilla, and the Adult Correctional Facility near Sutton. Borough correctional facilities serve the whole Anchorage region.

- Fire

There are nine operating fire service areas in the Mat-Su Borough. Costs of fire protection are funded by special millage rates on assessed valuations within the service areas. In the interest of achieving a rating of eight from the Insurance Service Organization (ISO), the maximum rating for areas without community water systems, the Borough's fire chiefs in 1981 prepared a fire protection plan which proposes 12 additional stations and the purchase of new equipment for existing stations.

Residents of the Borough not within the boundaries of the fire service areas rely on their own resources and neighbors' volunteer assistance for fire protection.

Fire stations in Palmer, Wasilla and Houston are city-maintained; there are two paid employees in Palmer and one in Wasilla. The Borough maintains other stations which rely completely on volunteer staffing.

- Health Care

The 23-bed Valley Hospital, built in Palmer in 1954, provides acute and some long-term care. The hospital is staffed by eight doctors. There is a satellite x-ray facility in Wasilla. A plan for a hospital addition which will add 7 beds and additional space for equipment to the Valley facility has been approved and will enable the hospital to serve a Borough population of up to 30,000. Another addition of 30 beds could be built at a later date.

Ambulance service in the Borough is provided through the Palmer Fire Center on a 24-hour basis. The 911 emergency service number is connected directly to the amublance dispatch center at the Palmer Fire Station and to the Valley Hospital.

Public health centers in the Borough are the Palmer Health Care Center, Wasilla Health Care Center and Cook Inlet Native Association Health Care Center (Wasilla). Langdon (Wasilla) and the Mat-Su Mental Health Center (Wasilla) provide individual and group therapy, family and marital counseling and alcohol and drug consulta tion. The Palmer Pioneer Home provides long-term nursing and non-nursing care for the elderly.

- Education

The Mat-Su Borough operates 17 schools: 12 elementary schools, two junior high schools and three high schools. At the beginning of the 1981-1982 school year, enrollment totalled 4,515 students. Plans call for expansion of existing facilities and construction of three new schools: an elementary school serving 400 pupils in Wasilla, a permanent elementary school in Trapper Creek for up to 150 students and a secondary school initially accommodating 300 in the Houston area. The School District also offers correspondent education to any resident of the State.

The Matanuska-Susitna Community College, a branch of the University of Alaska, provides academic and vocational courses to area residents. Enrollment totalled 1,500 full and part-time students in 1980-1981.

- Recreational Facilities

Opportunities for outdoor recreation abound in the Borough and surrounding areas. The largest attraction in the region is Mount McKinley National park and the surrounding Denali National Park and Preserve. Entrance to the park is off the Parks Highway north of the Borough.

Denali State Park, located within the Borough, will eventually offer a variety of summer and winter recreational activities. Nancy Lake Recreation Area south of Willow, the Lake Louise area in the southeastern part of the Borough and the Big Lake area between Willow and Wasilla include other popular recreational sites.

There are relatively few local public recreational facilities in the Borough, but plans call for future development of playgrounds and neighborhood parks in conjunction with school complexes.

(v) Economic Base

Table 5.7 describes business locations and types in Mat-Su Borough communities. The economy of the Borough reflects the influence of nearby Anchorage and the Borough's economic dependence on Anchorage. Dominant sectors of the Borough economy are connected with tourism, recreation and residential construction. Businesses involved in support and service sectors predominate.

The Borough is encouraging economic development and is concentrating on the Point MacKenzie area across Knik Arm from Anchorage. Development there is to focus on dairy farming, an industrial complex and a possible petrochemical complex.

Agriculture has played an important part in the historical development of the Borough. Up until the early 1960's, commercial agricultural production continued to increase. Since then the number of farms and volume of production has declined. The Borough government is attempting to reverse the decline through various means, including the Point MacKenzie Project.

Outside of the major communities in the Borough, economic activity is related to mining, timber products and recreational services, in addition to agriculture. Two of the traditional mining districts are of particular relevance to the proposed Susitna Dam: The Susitna-Chulitna portion of the Yentna Mining District where deposits of molybdenum, gold, copper, lead, silver and antimony are found, and the Upper Susitna River area where the Denali copper prospect has been discovered but not yet mined. However, the major mineral resource in the Borough is coal. The U.S. Forest Service has classified 1,295,000 acres in the Borough as commercial forest land.

(vi) Employment

Virtually all employment in the Mat-Su Borough, as reflected in Table 5.8, is in the government, services and support sectors. Total employment by place of employment has risen steadily from 1,145 in 1970 to 3,078 in 1979, an increase of 169 percent. Employment in the first three quarters of 1980 averaged 3,224. The Borough has consistently had high unemployment rates (20 percent in 1970 and 13.8 percent in 1979) because employment opportunities have not kept pace with the growth of the labor force. The rate is often the highest in the state; in addition, the Borough is more dependent on seasonal employment than are larger population centers, such as Anchorage.

The Mat-Su Borough has an extremely high ratio of population to employment (by place of employment), averaging around 5.5 during the years for which complete data exist. This figure is more than twice as high as the overall Anchorage Region's population to employment ratio of 2.5. The lower rate for Anchorage is mostly due to the emergence of the southern part of the Borough as a bedroom community for Anchorage; approximately 40 percent of all employed Mat-Su residents commute to jobs outside the Borough. Another, lesser factor contributing to the high population to employment ratio in Mat-Su is the high unemployment rate prevailing in the Borough.

(vii) Income

Trends in per capita personal income are shown in Table 5.9. Personal income rose substantially in the Mat-Su Borough in 1970's and stabilized as the trans-Alaska pipeline was completed. Personal income rose from $3,957 per capita in 1970 to $9,032 per capita in 1977 and declined to $8,878 in 1979. The increase between 1970 and 1979 was, therefore, 124 percent. However, using the Anchorage Consumer Price Index - Urban as a measure of inflation, personal income in 1979 was only 19 percent higher than that of 1970 in real terms. The mean household income for Matanuska-Susitna Borough in 1980 was $30,627, despite one of the highest unemployment rates in the state.

(viii) Land Use

Status of land in the Borough is a complicated and on-going issue, increasing in importance as the Borough continues to experience substantial growth concentrated in the southern portion.

Of the 14,720,000 acres in the Borough, 25 percent are Federal lands, 68 percent State lands, 2.5 percent Borough lands, one percent Native-owned land and 3.5 percent privately owned land. Of 525,836 acres of taxable land in the Borough, only 16 percent (84,838 acres) contain any type of improvements. The current amount of private land, though small in proportion to the total, has been more than sufficient to meet the recent and present demand for land.

Both the State and the Borough have been pursuing land disposal programs which put additional land into private hands. These programs are expected to continue in the future.

Much of the land involved in the proposed Susitna Hydroelectric Project has been selected by the Cook Inlet Region, Inc. (CIRI) and its member village corporations. Future use of this area will depend largely on future ownership and owner's policies regarding land use.

Some land near the Susitna Hydroelectric project site has been included in two recent State land disposals in the Indian River area. The Indian River subdivision disposal is comprised of 700 acres in 139 parcels. The Indian River remote disposal contains 1,500 acres. Two additional sites may be disposed of in FY83: one of these consists of 2,000 acres near the Indian River subdivision.

Land use planning powers in the Borough for the most part reside with the various land owners. The Borough, however, does exercise overall planning authority for all lands within its boundaries. Roughly half of the Borough is designated as a special use district permitting multiple use of the lands within the district.

The Borough's traditional reluctance to allow zoning to be implemented is beginning to change, and planned growth is being advocated as a way to avoid strip development and conflicting land use, and to protect wildlife and wildlife habitat.

(ix) Sociocultural Conditions

This section of the report (Section 5.3(a)(ix)) is Frank Orth & Associates, Inc.'s summary of a sociocultural study conducted by Stephen R. Braund & Associates for the Susitna Hydroelectric Project. It describes and analyzes baseline sociocultural conditions in those communities most likely to be directly affected by the project. For the southern communities of Talkeetna, Trapper Creek and the northern railroad communities, categories addressed include settlement patterns, economic conditions and values, political systems and community response capacity and local attitudes toward growth, change and development. Findings and conclusions relative to the more northern communities of Cantwell and McKinley, which are relatively remote from the chosen access route and project area, will be briefly summarized.

- Southern Communities

  - Settlement Patterns

    Talkeetna, Trapper Creek and the railroad communities north of Talkeetna have experienced considerable population influx, noteworthy in that they are too remote from Anchorage to serve as bedroom communities and offer litle or no economic opportunity.

    Growth of these communities occurred in several distinct phases. At the extreme, settlers can be classified into two groups: those who came primarily to develop and extract and those who came primarily to enjoy the natural resources. All residents share the desire to live in a non-industrial, relatively rural setting.

Talkeetna, located 114 miles north of Anchorage, is the former site of an Indian village. It became a mining community after the discovery of gold in 1896, serving as a base of operations for prospectors operating in the Yentna Mining District West and Northwest of town. Some miners spent the winter trapping, which was a significant part of the local economy until the 1940's. Construction of the Alaska railroad spurred growth, increasing access to the area by miners, trappers and travelers. Upon construction of the Talkeetna airfield and FAA(CAA) facility in 1940, young families began moving to the area to work for the government, changing the character of the community, which had previously been populated predominately by older bachelors.

Beginning in the 1950's, a new period of growth began, based on tourism and recreation. Talkeetna became the center for mountaineering expeditions to Mt. McKinely. Construction of the Parks Highway and Talkeetna Spur Road in 1965, paved the way for rapid change in the community. Recreational use of the area increased as did land sales and home construction for a growing population of young families.

New residents in the 1960s and 1970s sought the best of two worlds: life in a rural wilderness setting coupled with relatively easy automobile access to services offered in Anchorage and Wasilla.

Old-time residents of Talkeetna are accustomed to and inured to change, having experienced successive waves of growth. Some newcomers, however, feel that change in the form of encroaching urbanization and industrialization is in direct conflict with the rural, relatively self-sufficient lifestyle they moved to Talkeetna to pursue.

Trapper Creek was settled post-1950, initially by homesteaders. Upon construction of the Parks Highway and the operation of the State's

Open-to-Entry (OTE) land disposal program (1968-1973) a new group of residents moved to the area, some acquiring five-acre parcels for recreational use, others seeking a year-round life in the wilderness. As in Talkeetna, many of the newer residents moved to the area for the sake of natural beauty and isolation and are skeptical about future change and development.

Railroad communities north of Talkeetna include Chase, Curry, Sherman and Gold Creek. Early residents worked for the railroad, operated mines or homesteaded. Many of the settlers who moved to the area during the OTE program were young people of the turbulent 1960's who found in these areas an alternative lifestyle in a wilderness setting which coincided with their rejec tion of industrialization and urbanization. As in earlier waves of settlement, many of the settlers did not remain, but of the 300 to 400 settlers who arrived in the early 1970's, plus more recent arrivals, 80 to 150 are still permanent residents. The summer population is greater, consisting of many recreation sites and absentee landowners in addition to year-round residents.

There has been some friction between new and older settlers in the Talkeetna area, with some older residents skeptical of the motivations of newer settlers, claiming that the new, young, counter-culture type of resident relies on food stamps and other asistance rather than seeking a true subsistence lifestyle. With time, however, social relations between the groups have improved, and all can be said to share the desire to live in a rural, relatively undeveloped wilderness or small town environment.

- Economic Overview

Economic opportunities in Talkeetna, Trapper Creek and the railroad communities north of Talkeetna are few, and unemployment is high. Recent arrivals seem to choose first to live in these rural communities, then worry about how to support themselves there. Lack of local jobs forces many men to leave the area to work on the North Slope, in Wasilla or Anchorage. Retail businesses in Talkeetna and Trapper Creek are generally associated with tourism and recreation. Some government employment is present. Some residents seek governmental subsidies in the form of food stamps, energy assistance, aid to dependent children or other grants to help them cope with the lack of employment opportunities. Additionally, people in all communities produce arts and crafts which they sell. Also, in all communities, residents rely on local fish and game, gather firewood as well as berries and other greens, and raise gardens.

Talkeetna has the largest number of businesses and employers in the area. Most commercial estabishments are oriented toward tourists and recreationists. Main employers in town are said to be the school, Alascom, the railroad, FAA and the local stores. There are many more people than jobs in Talkeetna. Most businesses are owner-operated and hire few employees. Many residents rely on recreational guiding for income. In 1979, some of these individuals formed a guiding asociation called Denali Wilderness Treks, a non-profit association which books clients and advertises for its members.

Trapper Creek also has limited job opportunities, with many residents working seasonally in other areas. There is some local mining, logging and farming. Some local people are artists, craftsmen and guides.

Job opportunities in the railroad communities north of Talkeetna are almost non-existent. Population density makes pure subsistence living impossible. Thus most people who live permanently north of Talkeetna must rely on a combination of sources to maintain their lifestyle. A typical household may depend on the following: seasonal construction work out of the area, supplemented with food stamps and unemployment, the harvest of local fish and game resources and personal gardens. In some respects the lack of an economic or employment base in the railroad communities gives residents the appearance of being a transient population. People are continually coming and going for seasonal jobs, supplies and services. In addition, many other users of the area are, in fact, highly transient (sports hunters, fishermen and absentee land and cabin owners.)

- Politics and Response Capacity

There are very few local political organizations in Talkeetna, Trapper Creek, and the railroad communities north of Talkeetna. While rural Native communities often struggle to determine which organization has control of what activity, the general trend in the southern study communities has been a reluctance to form political groups. Typically, in rural Alaskan native villages, numerous political organizations exist or have influence in each community (i.e., regional profit corporations, regional non-profit corporations, cities, boroughs, traditional councils, and village corporations). Because none of the southern study communities are Native villages under the Alaska Native Claims Settlement Act (ANCSA), they do not have Native corporations or traditional councils. Also, because none of the study communities have incorpor ated under State law, there are no cities in the study area. The only State recognized political organization in the area is the Matanuska-Susitna Borough, incorporated as a second class borough in 1964, which encompasses the entire study area except Cantwell and McKinley.

In the past few years, as more and more people have moved into the area, there has been a tendency toward the formation of political organizations in Talkeetna, Trapper Creek, and Chase. This trend is primarily the result of proposed developments (the Capital move, the Susitna Project, and the Intertie), State land disposals, anticipated population growth, and the growing belief that local participation and control is necessary to maintain present values. On the other hand, the formation of, and participation in, political groups is contrary to the philosophy which motivated most people to settle in this rural area--individualism, a desire for isolation, and a lack of governmental controls on one's life. This section addresses local political organizations in the area, their formation, and associated social divisions in the community, as well as community response capacity.

Organizations active in Talkeetna include the Talkeetna Historical Society, the Parent-Teachers' Association, six churches, a local library board, road and fire service area boards and the Talkeetna Chamber of Commerce. The Chamber of Commerce has a leadership role in local affairs and has incorporated in order to be eligible to pursue grants and enter into contracts with the Borough. In a hotly contested election, Talkeetna voters rejected, in 1981, a move to incorporate as a first class city. Both newcomers and long-time residents opposed incorporation, agreeing that the results of incorporation, including taxation, bureaucracy caused by another level of government, and additional regulations threatening their independent lifestyle, were undesirable.

Trapper Creek has a Community Council formed three years ago. It is designed to bring local issues into the open, afford residents the opportunity for maximum participation in community self-government and to influence higher levels of government related to community development and services. The Community Council was pre-dated by a Tokosha Citizens Council which unsuccessfuly sought, in 1978, to enact a proposal calling for transforming 144 square miles of territory into a unique residential and recreational roadless area. The spirited public debate on this issue clearly established two opposing attitudes toward economic development in the area and served to alert residents of the need to become involved in the political process. The Trapper Creek Community Council is recognized by the Mat-Su Borough as an advisory body and has been associated with acquisition of community facilities and services desired by the community. Most of the impetus for such services has come from newer residents, and some older homestead families feel costs of added services are too great compared to the relatively low population of the area.

The railroad communities have tended to avoid involve ment in political organizations, due to their residents' propensity for isolation, individualism and anarchism. It was not until 1979 that the first political group, the Chase Community Association, emerged. Residents formed this non-profit corporation primarily to resist the proposed Chase II State land disposal in their area. This disposal was for a subdivision of 5-acre lots, and residents feared it would create too great a population density to allow their semisubsistence lifestyle. The Association has also responded to other potential developments which its members believe threaten their rural, semi-remote way of life. These developments include the Susitna Hydroelectric Project and the Intertie power line. The Association seems to represent 50 to 75 percent of the permanent local residents. Many residents of the area are very involved in Talkeetna politics and were vocal in their opposition to Talkeetna incorporation.

Residents of all the southern communities generally agree that small, rural towns or wilderness areas are more favorable places to live than more urban environments, but residents do not agree on either community priorities or what should be done to protect common values. There is no consensus of opinion in the area; individualism and self-reliance are prevalent. However, because division weakens the local ability to control, the trend toward political organization may continue as rural residents band together to protect their environment.

Presently, none of the communities has an adequate system by which to respond to development impacts, though Trapper Creek is building an organization of interested people actively representing the community and recognized by the Borough. The Chase Community Association has an image as anti-development, which lessens its effectiveness with higher levels of government. The Susitna Project could tend to encourage additional political organization in the southern study area communities. Capable leaders reside in all the communities, but the need for political organization conflicts with their local rural values. Many of them moved to the area to escape government and congestion, and find active participation in the political process to be in conflict with their individualistic values.

- Attitudes toward Growth, Change, and Economic Development

Two different philosophies toward economic development and rural growth emerged in the southern communities. Because these two factions, which represent extremes on a continuum of attitudes and opinions, were found in Talkeetna, Trapper Creek, and the railroad communities north of Talkeetna, all communities are discussed together in this section. These different attitudes toward economic development and growth in rural environments include:

1. On one end of the continuum, residents have a desire to protect rural, small-town, and wilderness atmospheres; minimize change; and avoid industrial development in the area; as well as preserve wildlife and recreational areas. Residents in this group take issue with the charge that they are against growth and economic development. Rather, they point out that economic development does not only mean industrial growth. They believe that the real, long-range value for the upper Susitna valley is not its minerals or hydro potential, but its untapped potential for visual and recreational enjoyment, both summer and winter. These residents argue that a recreational/tourist economy caters to people who enjoy the land without defacing it, which is preferred to a commercial, industrial economy which does scar the landscape. These people tend to be opposed to the Susitna Hydroelectric Project as well as other large-scale development schemes in the area.

2. On the pro-development end of the continuum, residents do not necessarily desire industrial development in the area, but they cannot identify with what they feel is a no-growth attitude. Residents with an extreme development view tend to favor roads to open up additional country and believe that progress (including hydroelectric dams, more people, and roads) will come regardless of what they, or anyone else, want. Generally, long-time residents, many of whom have already witnessed considerable change in the area, do not view future developments as necessarily undesirable (see <u>Settlement Patterns</u> above). Most of these people are generally in favor of the Susitna project because they perceive that it will provide a needed economic boost to a depressed area.

   It should be pointed out that these residents do not generally desire to see their community radically changed, neither do they necessarily wish for industrial development to become the economic base in the area. Like their neighbors, they enjoy small-town qualities and desire to live in a non-industrial, relatively isolated, rural environment. But, they view change as inevitable, feel the local economy will benefit from development, and as long as there is no danger to life, not necessarily lifestyle, the Susitna project is acceptable.

Few people, in recent years, have moved to Talkeetna, Trapper Creek, or the area north of Talkeetna for economic or job opportunities. In fact, according to many local residents, one of the largest limits for growth in Trapper Creek and Talkeetna is the lack of local jobs. Some of these residents with a conservative attitude towards economic development, maintain that if jobs were available, they would not want to live in the area because the increased job opportuni ties would attract more people. This population influx would, for these residents, make Trapper Creek and Talkeetna less desirable as rural places to reside. Others, for example homesteaders who raised their families in Trapper Creek or long-time Talkeetna residents, desire economic development in the area so their children will have access to local employment. Generally, the difference between whether a resident is in favor of or opposed to the Susitna dam depends on how he perceives it will impact the area. If it is characterized as a massive, unnecessary project that will provide excess energy and lead to total industrialization of the area, which some people believe, then very few rural residents are in favor of it. But, on the other hand, if the project's impacts will be relatively minor, and it will provide constant and cost-stable electric power in the area as well as jobs, then more people are pro-Susitna. Consequently, consensus related to the Susitna Project may likely only emerge once residents of this subregion have more information about the project and its impacts upon which an intelligent dialogue can ensue and decisions can be made.

Based on the recent settlement patterns in the southern study area, it appears as though the trend is towards those who favor the development of tourism and recreation, minimum disruption of small-town qualities, the reasonable preservation of local wildlife and fish, and the enjoyment, not deterioration, of the natural environment. Concomitantly, these people oppose industrial development, rapid growth, and urbanization in the area.

- Land Availability

Between 1979 and 1981, the State of Alaska offered seven disposals in the Talkeetna area (four agricultural, two subdivisions, and one remote parcel). In 1980-81, six disposals (one agricultural, four subdivisions, and one remote parcel) were offered in the Trapper Creek area. In 1980, the State of Alaska offered the Chase Remote Parcel area and in 1981, the Chase II subdivision. Similarly, the State offered the Indian River Remote Parcel area in 1980 and the Indian River Subdivision in 1981. Thus, the State of Alaska had offered a total of 17 land disposals in the Talkeetna, Trapper Creek, Chase, and Hurricane area in the past three years. (This is in addition to the early Open-To-Entry Program which was in effect from 1968 to 1973.)

Although not all of the lands are accessible by road, these land disposals as well as numerous large unsubdivided homesteads and other tracts in the Trapper Creek and Talkeetna area provide a more than adequate land base for substantial growth. In addition, if the highway is relatively close, subdivision roads are relatively inexpensive to construct in this area, and large tracts can be converted into subdivisions fairly quickly. Given any economic incentive for development, it is likely that more subdivisions will appear in the upper Susitna basin.

Related to the state land disposals, a relatively common trend in residents' attitudes has developed in the study area. Once an area is opened up to settlement (either recreational or residential), those people who first acquire land are generally opposed to any further land disposals in the immediate area that would increase the population density to levels beyond what they believe the land can support. Most people were attracted to these land disposals because the land is relatively isolated in a wilderness area. Generally, persons who acquire a remote parcel or establish residency on the land wish to preserve the unpopulated, wilderness flavor of the area. They perceive that additional state land disposals, especially subdivisions, conflict with this desire. Although at first this may seem like a selfish motive, it should be kept in mind that the State of Alaska has made several recent public land disposals in this area (seventeen in three years). During interviews, some people claimed they had known what the State had in store for this region, they might not have acquired this remote land in the first place. (Many newer absentee land owners from Anchorage do not fall into this category.)

- Northern Communities

Similarities between Cantwell and McKinley account for both their stance and likely responses to aspects of the Susitna project.

The growth of both communities is severely limited by the unavailability of land and employment; there is an un avoidable interaction between lack of lands and lack of employment. Employment in Cantwell is based, in the main, on direct public employment--transportation, communications, public health and safety, and education. The small private sector is based upon services to public sector employees and to the seasonal visitors to the general recreation area. Employment in McKinley is based almost exclusively on year-round maintenance of the Park and seasonal visitation to the Park. Many more persons would and could live in these communities were only land and employment more available.

Both communities have undergone considerable growth in the past few years due to major improvements of the road system, the communications system, government expenditures, and the growth of visitation. This has resulted in a greater ability to remain in the communities year-round, rear children, obtain supplies, and withstand the physical hardships of weather and isolation. These changes have sustained a larger permanent population than has been carried historically and may be reaching or exceeding the physical carrying capacity of adjacent lands and wildlife.

This is the critical stage in the life of each community, in terms of attitude toward growth, forms of economic development, tolerances of change, community organization and identity, and attachments to the non-rural world. Introduction of the Susitna Hydroelectric Project and the Willow-Healy Intertie is only one of several forces that appear in these communities' perceived range of opportunities and risks; these energy projects are, however, most immediate realities.

Both communities are desirous of long-term economic development, not merely short-term economic growth. Cantwell and McKinley differ significantly in their perceptions and stance toward these energy projects, based on differences in history, geography, economics, population, and values. Cantwell sees itself at the center of these energy projects as well as secondary industries leading to long-term development of population, economy, and employment. If lands around Cantwell can be made available to accommodate the thousands of workers anticipated to be associated with these projects, then economic growth of Cantwell is possible.

The orientation and interest of McKinley is almost totally with the Intertie (and other physical altera tions in the highway-railroad corridor) since it finds itself too distant from any direct relationship with the Hydroelectric Project, other than a generalized environmental concern. Given the lack of land and services and the distance from the Hydroelectric Project, McKinley sees little that would change.

McKinley residents are also extremely concerned about the growth of visitation within the park as an environmental impact, and growth outside the park as damaging to current lifestyles. If more land becomes available, they fear a huge growth in recreational housing; if land remains restricted, they fear continued inability to remain employed and housed in the area. Land unavailability is also predictive of continued escalation of property values and eventual conversion of highway residential properties (most residences are adjacent to the highway) to strip commercial properties, altering both the values and character of the community.

Both communities feel that their futures are dependent upon the decisions made by urban interests and that they are generally helpless in the face of these interests. Each appears hopeful but not optimistic that its interests, values, and character will be protected in these decisions and also by the historical volatility and uncertainty of Alaska development, which has variously produced huge projects and abandoned projects. Each would prefer more gradual, planned, and certain forms of economic development, but they are not politically or economically organized to assure this kind of development.

(b) Regional

The Railbelt Region, Impact Area 3, includes the greater Anchorage area, the Fairbanks area and the Valdez-Chitina-Whittier area. Data on employment, population and per capita income in the Railbelt Region, 1970-1980, is displayed in Figure 5.3.

(i) Population

Population in the Railbelt Region rose from 204,523 in 1970 to 284,166 in 1980. The Railbelt contains 70 percent of the State's population, with the majority centered in the greater Anchorage area. Anchorage and Fairbanks are the largest cities in the Region.

(ii) Housing

Housing stock available in the Municipality of Anchorage (1981 data) and in Fairbanks and the Fairbanks-North Star Borough (1978 data) is shown by type in Tables 5.10 and 5.11.

In 1981, the Municipality of Anchorage contained 65,771 civilian housing units. Of this total, 46 percent were single-family units; 12 percent were mobile homes, and 42 percent were in multi-family buildings. The vacancy rate in the Municipality was approximately 14 percent in 1980. The vacancy rate for housing units in apartment buildings with five or more units was nearly twice that for single-family homes.

Housing stock of the Fairbanks-North Star Borough totalled 13,738 in October, 1978, with 54 percent of the units located in the City of Fairbanks. Single-family housing accounted for 50 percent of the Borough's housing stock; duplexes for seven percent; multi-family units for 28 percent and mobile homes for 15 percent. Within the city limits, multi-family units represented 43 percent of the total, and mobile homes only two percent.

Vacancy rates in the Fairbanks-North Star Borough have risen in the post-pipeline period, from a low of 0.4 percent in 1976 to 9.1 percent in 1980. Vacancy rates were lowest for single-family houses.

(iii) Employment

Table 5.12 presents non-agricultural employment data for Impact Area 3. Employment increased by 39 percent between 1970 and 1975, and by an additional 14 percent between 1975 and 1979. Construction, service and support sectors represent large percentages of employment in the Railbelt. Employment in the Anchorage Region acounted for 69 percent of Railbelt employment in 1979.

The Municipality of Anchorage has generally represented 87 to 90 percent of employment in the Anchorage Region, with Kenai-Cook Inlet representing seven percent, Mat-Su, three percent, and Seward, one and one-half percent.

(c) State

Data on employment, population and per capita income in the State of Alaska, 1970 to 1980, is presented in Figure 5.4.

(i) Population

The population of Alaska has risen steadily since the 1940's, yet this largest of the United States is still the least populous with an estimated 1980 population of 400,331. Alaska's population grew 32 percent between 1970 and 1980, jumping by 50,000 between 1975 and 1976 alone. Most of the population is in the Southcentral Alaska-Fairbanks region (the Railbelt), and half of the State's citizens reside in Anchorage.

(ii) Employment

Alaska's economy has historically been dependent upon development of its natural resources, primarily fisheries, minerals and timber. As a result, employment has been oriented towards these consumptive and extractive industries. The military has played a major role since World War II. In recent years, employment in state and local government has increased dramatically. In addition, employment in service and support sectors of the Alaska economy is increasing, reflecting the maturation of the State's economy.

Impact of the trans-Alaska pipeline is evident in employment figures. Between 1970 and 1975, a pipeline-induced growth spurt caused employment to increase by 75 percent. From 1975 to 1980, however, total employment increased by only 2.9 percent.

(iii) Income

The average per capita personal income in the State rose from $4,638 in 1970 to $10,254 in 1976. Since completion of the pipeline, however, the pace of increase has slowed. Per capita income in the State averaged $11,150 in 1979. The real increase in per capita personal income during the nine-year period was 27 percent.

5.4 - Project Elements Influencing Change (Methodology and Results)

(a) Manpower Requirements and Payroll

Tables 5.13-5.15 display the projected total number and origin of on-site construction and operations manpower for Watana and Devil Canyon dams from 1983-2005. For the construction work force, manpower has been divided into the categories of laborers, semi-skilled/skilled, and engineering/administrative. As displayed in Table 5.13, the peak construction year occurs in 1990 with an estimated construction work force of 3,498.

The Watana dam will be constructed in two phases with an ultimate generating capacity of 1,020 megawatts (MW). The first installment of 680 MW's will be completed in 1993, at which time operations manpower will total 70 persons. The additional generating capacity will reach completion in the following year, 1994, and will result in a total operations work force of 145. Analysis of construction manpower requirements for the 600 MW Devil Canyon dam is based on construction beginning in 1994, with this facility coming on-line in the year 2002. The total on-site operations work force for both dams will equal 170 during the year 2002 and thereafter. Construction of the Watana and Devil Canyon dam facilities entails an overlap of one year in construction.

As can be seen in Figure 5.5, the first phase of the Watana dam requires a significantly greater number of workers than both the second phase of Watana and Devil Canyon combined. This difference can be attributed to the additional labor requirements in the initial years for the construction of the work camps, villages, and access road and to the more labor intensive nature of a gravel fill dam (Watana) than a concrete thin arch dam (Devil Canyon). Dramatic decreases in work force requirements (relative to the preceding years) occur between 1991 and 1996.

Total payroll is an important consideration in that it defines the parameters of monetary impacts resulting from direct on-site construction and operations work force expenditures. Based on the on-site construction and operations requirements outlined above, the total yearly project payroll from 1983-2005 were derived and are displayed in Table 5.16. These totals were derived by matching wage figures to the respective trades, assuming that for construction workers there are 1,825 worker hours in the year (54 hours per week and an average of 29 weeks per year) and for the operations work force there are 2,496 working hours in the year (48 hours per week and 52 weeks per year). The payroll in 1990, the peak year, totals $97.8 million.

Tables 5.17 and 5.18 display estimates of construction and operations work force payroll expenditure patterns in the various Census Divisions of Impact Area 3. Using the total construction and operations payroll figures calculated above, taxes and savings were subtracted and estimates were made concerning the amounts of disposable income that would be spent in different areas of Impact Area 3. The methodology for determining payroll expenditure patterns is built upon the basic premise that place of residence is the primary factor determining where payroll is spent.

(b) Numbers and Residence of Work Force and Associated Population Influx

The level of impact of the proposed Susitna hydroelectric facility on the communities surrounding the project is proportional to the size of the inmigrant work force related to direct project employment and subsequent indirect and induced employment. These individuals create the short-term, peak demand for services that has the most significant impact. The size of the inmigrant work force depends on the extent of the primary local labor supply, that is the availability of craft and professional labor currently residing in the area from which the labor force could be drawn (Impact Areas 1, 2 and 3). This section of the report addresses the issue of work force origin, relocation, and population influx and is divided into two sections: work force origin; and work force inmigration and associated population influx.

(i) Work Force Origin

Labor supply is highly idiosyncratic, and the amount of available labor from the immediate labor pool depends upon the projected size and craft mix of the future labor force, labor force participation rates, demands placed upon the labor force from other projects, the match of craft labor available to craft labor required by the Susitna project, and the differing policies and geographic spheres of each craft. In addition, the supply and demand conditions will vary from craft to craft. All of these variables make it difficult to project the number of locally available construction trade and other workers who will become employed on the Susitna Hydroelectric Project.

"Local" versus "non-local" labor supply is the common terminology used in literature referring to the origin of a construction work force. The use of "local" in this sense is not to be confused with impact area definitions and the "local impact area."

Given that there are no union hiring halls in Mat-Su Borough (Impact Area 2), manual craft labor for construction and operations and maintenance will likely be acquired through a combination of both the Anchorage and Fairbanks union hiring halls. Based on this and limited observations of current construction worker commuting practices in Alaska, the immediate or "local" labor pool is defined as that residing in Impact Area 3 (seven census divisions: Anchorage, Fairbanks, S.E. Fairbanks, Mat-Su Borough, Kenai-Cook Inlet, Valdez, and Seward).

As noted earlier, preliminary manpower requirements for construction and operations of both the Watana and Devil Canyon dams indicate that there will be a total peak on-site construction work force of 3,498 in 1990. Requirements for operations and maintenance manpower commence in 1993 at 70 workers and increase to 170 in the year 2001.

The local availability of construction labor was analyzed according to the total manpower requirements, which have been divided into the categories of laborers, semi-skilled/ skilled, and engineering/administrative. The percentage of jobs which can be filled by the local available work force varies with each classification. In general, a greater portion of laborers than engineers and administrators will be supplied "locally."

The basic assumptions for on-site construction work force as previously displayed in Table 5.14, are: for laborers, 85 percent will be supplied locally, five percent from other areas of the state, and 10 percent will originate from out-of-state; 80 percent of semi-skilled/skilled workers will be supplied from Impact Area 3, five percent from other areas of the state, and 15 percent from out-of-state; and for the administrative/engineering category, 65 percent will come from Impact Area 3, five percent will come from other areas of the state, and 30 percent will be from out-of-state. For the indirect and induced manpower requirements it is assumed that the percentage of jobs to be filled by inmigrants in Impact Area 3 ranges from zero in Seward to 45 percent in the Mat-Su Borough. Approximately 25 percent of the indirect and induced jobs in Anchorage will be filled by inmigrants.

The allocation of the construction work force's residences among the various census divisions and within Mat-Su Borough communities is initially based on a calculation of the total current proportion of workers, by classification and census division, to total construction work force in Impact Area 3. The percentage distributions so derived are then applied to the projected Susitna manpower requirements to determine the likely residence distribution of the work force at the beginning of the project. These percentage distributions are adjusted to reflect proximity to the project site, and the percentages change over time as certain areas become more attractive as places to reside, and work force migration occurs.

Table 5.19 displays the residence distribution of the on-site construction work force within Impact Area 3 prior to factoring in inmigration and relocation.

(ii) Work Force Inmigration and Associated Population Influx

As indicated earlier, the amount of work force inmigration is directly responsible for the degree of impacts on the various communities in Impact Area 3. Table 5.19 in the previous section displayed the number and residence of the work force associated with on-site construction. Based on the assumptions of locally available on-site construction work force outlined earlier, estimates can be made on the number of inmigrants necessary to fulfill the projected manpower requirements. Table 5.20 displays the results of these assumptions and includes relocation of construction work force currently residing within Impact Area 3.

Table 5.21 displays similar information to that illustrated in Table 5.19, but added to direct on-site construction employment is indirect and induced work force by place of residence in Impact Area 3. These residence factors are based on the assumptions of available local work force for indirect and induced manpower requirements outlined earlier. Table 5.22 then displays total inmigration and place of relocation of the work force associated with direct, indirect and induced employment.

Inmigration into Impact Area 3 at the peak of construction activity will represent 13 percent of the total direct construction, indirect and induced work force of 6,365. When considering only direct on-site construction work force at the peak, 3,500 in 1990, the percentage of inmigrants to total is even lower, representing approximately 5 percent. This low percentage of inmigration of on-site construction workers is directly related to the availability of local labor and of the remote location of the dam sites and the provision of temporary camp and family village facilities.

During the peak of construction activities, 828 inmigrant employees, associated with direct, indirect and induced employment, will be living in Impact Area 3. Of this total, 170 workers are related to direct on-site construction employment. About 50 percent of the inmigrant employees whose employment on the project is completed after 1990 are expected to remain in the area. After construction activity peaks at the Watana site in 1990, inmigration subsides until 1997-2000 at which time construction activity peaks at the Devil Canyon site.

As construction activity is completed in the year 2002, approximately 12 percent of inmigrants to Impact Area 3 are expected to remain. For the Mat-Su Borough, the figure is much higher with approximately 60 percent of the inmigrants remaining. The majority of the inmigration to the Borough consists of workers originating from Anchorage, Kenai-Cook Inlet and Fairbanks Census Divisions; it is assumed that 100 percent of these individuals who move to the Borough will remain even after their work on the project is completed. When considering Impact Area 3 in its entirety, the percentage of workers that remain is much smaller, since Alaska non-local and out-of-state workers make up a large percentage of the total. It is assumed that the majority of these workers will not remain in the area after their work on the project is completed, consequently only 12 percent of total inmigrants to Impact Area 3 remain after 2002.

Within the Mat-Su Borough, the settlement of inmigrants is expected to contrast sharply from the settlement patterns of the existing population. Accordingly, inmigrants will establish residence in the communities of Talkeetna and Trapper Creek with greater frequency. A great deal of settlement will also occur in "other" areas of the Borough, which corresponds to the areas outside of designated cities or towns, such as Montana Creek, Caswell and Willow. At the peak of construction activity, approximately 89 on-site construction, indirect and induced workers will inmigrate to Talkeetna, 117 to Trapper Creek, and 128 to other areas of the Borough (Table 5.22).

Table 5.23 contains data on the total population influx into Impact Area 3, by Census Division and for selected Mat-Su Borough Communities, precipitated by direct, indirect and induced employment. These projections are based on assumptions that, for the direct construction work force, 95 percent of inmigrants will be accompanied by dependents and that an average of 2.11 dependents will come with each inmigrant worker who is accompanied. For the indirect and induced work force, the Alaska State average number of persons per household figure was used to calculate population influx. Total population influx into Impact Area 3 during the two peak periods (1990 and 1999) equals 2,324 and 1,228, respectively. Of the total population influx associated with direct, indirect and induced employment in 1990, 2,214 or 95 percent, will relocate to the Anchorage region. The remainder is expected to relocate to the Fairbanks-North Star Borough, especially to the City of Fairbanks, and to the Valdez Chitina-Whittier Census Division.

Within the Anchorage region, it is projected that Kenai-Cook Inlet, Anchorage, and Fairbanks will experience a slight net outmigration of population during various stages of construction activity as outmigration to the Mat-Su Borough exceeds inmigration from other areas. The totals increase as the project ends as a result of a portion of the inmigrant workers and their families returning to other areas of Alaska and to out-of-state locations.

During the peak constuction period at Watana (1990), the total project-induced population increase to the Mat-Su Borough totals 1,112, which accounts for 48 percent of the total to Impact Area 3. Of this total, 694 are expected to remain in the Borough at the end of construction in 2002.

In 1990, Talkeetna, Trapper Creek and "other" areas of the Borough experience 89 percent of the total population influx to the Mat-Su Borough: Trapper Creek 31 percent; Talkeetna 24 percent and; "other" areas 34 percent. These projections represent considerable population increases relative to the baseline forecasts for each of these areas. Conversely, Palmer, Wasilla and Houston will experience only moderate increases in population. At the conclusion of the project, total population increases to Trapper Creek, Talkeetna and "other" equal 175, 173 and 257 respectively.

The number of school age children accompanying inmigrant direct, indirect and induced workers into Impact Area 3 will total 562 during the peak of construction. Of this total, 304 will be primary school age and 258 will be of secondary school age. Tables 5.24, 5.25 and 5.26 display data on the projected timing and geographic distribution of school age children accompanying inmigrant workers.

5.5 - Socioeconomic and Sociocultural Project Impacts

This section provides information on probable impacts of the project for each Impact Area, and for selected communities within Impact Area 2 (Trapper Creek and Talkeetna). Attention is focused on the peak construction years (1990 and 1999) and on the transition to the operations phase of the Devil Canyon facility (approximately 2002-2003); it is felt that impacts of the project will be greatest at these points in time. It should be noted, however, that the changes discussed for those years are expected to build over several-year periods.

(a) Local

It is anticipated that the impacts on socioeconomic conditions in the Mat-Su Borough will be greatest on the communities of Trapper Creek and Talkeetna, due to their proximity to the work sites and their relatively small size. Accordingly, impacts of the project on these communities are discussed separately.

(i) Mat-Su Borough

Table 5.27 presents an overview of impacts of the project on the Borough as a whole. Impacts on the incorporated communities of Palmer, Wasilla and Houston are summarized in Tables 5.30, 5.32 and 5.34.

- Population

The population of the Mat-Su Borough will increase moderately as a result of construction of the project, but this will be only one of several factors contributing to the Borough's projected rapid rate of growth over the next twenty years; the dominant factor behind this growth will be spillover from Anchorage.

Population in the Mat-Su Borough, unrelated to the Susitna hydroelectric project, is projected to increase by 16,982 people between 1983 and 1990. In contrast, population influx into Borough communities associated with the project is estimated to be approximately 1,112 during the same period. This population influx will represent a 2.6 percent increase over the baseline forecast population level in 1990.

As the Watana peak is completed, a slight decrease in inmigrant population associated with the project is expected to occur; however, the overall Borough population will continue to grow rapidly in the 1990's. In 1999, the population impact forecast (forecast with project) of 67,204 represents only a one percent increase in population over the baseline forecast (without project).

The population influx into the incorporated communities is expected to be small; between 1983 and 1990, the project will result in an increase of approximately 40 people in Palmer and Houston, each, and 50 in Wasilla. Over 50 percent of the inmigrant population in the Borough is expected to settle in the Trapper CreekTalkeetna area, and the remainder will probably establish homes in the Willow-Montana Creek area, the suburban area surrounding Palmer and Wasilla, and possibly in the newly available Indian River subdivision (near Hurricane).

In addition to this increase in population in Mat-Su Borough communities, there will be an additional peak amount of 1,464 people from out-of-state and other areas of Alaska who will be living at the work camp/village full-time in 1990. This segment of the population influx is expected to have a limited effect on conditions in the Borough, as a result of the planned provision of housing and other facilities and services by the construction contractor. Their major impact will be related to expenditures made in Trapper Creek, Talkeetna, and other Borough communities.

- Housing

  A total of approximately 374 project-induced households are expected to settle in the Mat-Su Borough between 1983 and 1990, the height of construction activity at the Watana site. Based upon an average five percent vacancy rate, there will be a projected 2,336 vacant housing units in the Borough in 1990, or about six times as many units as inmigrant households. Thus, the in-migration is not likely to cause any dislocations in the Borough's housing market as a whole.

  The availability of housing in some of the small communities closest to the project will be much tighter than the above figures indicate, since communities nearest to the project typically have the fewest units of available vacant housing. In general, the forecasts for housing need presented in Tables 5.27 through 5.38 should be considered housing demand by inmigrants. If the supply of housing in a given community is not adequate to meet the demands, the remaining inmigrant households are assumed to locate their residences elsewhere in the Borough.

- Fiscal Impacts on Local Government

  The methodology used in the fiscal impact analysis is the per capita multiplier method, an average cost technique that assumes current per capita revenues and costs are a good approximation of future flows, other variables remaining constant. It is implicit, therefore, that any revenue or expenditure projections based on per capita amounts will vary in direct proportion to changes in population. The fiscal impact analysis is to be viewed as a set of trend indicators of future fiscal flows, and not as a predictor of actual receipts and costs to be incurred. The analysis is not comprehensive in that it focuses on major sources of revenue and major categories of service costs. Therefore, projections could be either higher or lower varying primarily as a result of public policy decisions and budgetary allocations.

  - Matanuska-Susitna Borough Budget

    Baseline and impact forecasts for the major sources of revenue and expenditures for selected funds in the Mat-Su Borough budget are provided in Table 5.28. The impacts of the project are greater in

1990 during the peak construction year of the Watana dam than those to be experienced in 1999, the peak construction year of the Devil Canyon dam. Total revenues between 1990 and 1999 will increase approximately 50 percent with or without the project, over 1990 levels.

The Service Area Fund will be impacted most by the project, causing a 28 percent increase in revenues over baseline in 1990, while other funds will average a 2.6 percent change due to the project. However, even in the absence of the project, Service Area Fund revenues will rise 114 percent by 1990 over 1981 levels, increasing at a faster rate than the population increase of 93 percent. Changes in the 1999 impact forecast over baseline forecast will be 50 percent less than those in 1990, averaging 1.3 percent for all funds excluding the Service Area Fund. However, Service Area Fund revenues in 1999 will remain a constant 25 percent over those forecast without the project. This is consistent with the population settlement forecasts that the majority of the population influx will reside in the outlying areas of the Borough.

The Borough will have to increase substantially the delivery of services to service areas. These include basic services such as sanitary land fill, library, fire protection, ambulance, and road construction and repair.

The Borough administration will experience a short-term impact from the lag between receipt of revenues and outlays for service costs. There may be an initial net deficit due to the costs of delivering services to substantially larger client groups and receiving additional revenues, both local and state. Increases in local revenues will be generated in the form of property taxes and service user charges.

The increased population will indirectly expand the tax base through changes of land ownership, whereby more Borough lands will be in private ownership. (See section (a)(ii) for example of impacts on a service area.)

Currently property taxes account for 30 percent of total Service Area Fund revenues; however, this may change depending upon the mill levy rate per $1,000 assessed valuation, the ratio of assessed value to real market value, and the proportion of total Service Area Revenues attributed to property taxes. There is usually a lag between the time new property is placed on tax rolls and is assessed, and the receipt of tax revenues. However, over time, increases in the tax base are anticipated to offset the increases in service delivery cost. In addition, there is a lag in the receipt of State revenues; however, these will continue to increase as long as allocation formulas are based upon population.

Certain General Fund sources of revenues will be impacted more than others: property tax revenues with the project will rise nearly 5 percent in 1990 and 3.6 percent in 1999 over the baseline forecast. Actual property tax revenues will double by 1999 for both forecasts. These are based on a 4 percent annual real rate of increase in property values and a mill levy of 6.75 mills per $1000 assessed valuation. Per capita share of property taxes declines from $261 in 1981 to $195.40 in 1990, and $179.23 in 1999 under the baseline forecast. Declines in per capita share of property taxes with the project are $199.82 in 1990 and $184.20 in 1999, over 1981 levels.

State funds for school debt service reimbursement increase from 30 percent of total revenues in 1981 to 37.5 percent in 1990, when 100 percent of local school capital project debt is anticipated to be reimbursed by the state. This represents a 150 percent increase in 1990 over 1981 levels and 50 percent increase in 1999 over 1990 levels with the project forecast. Miscellaneous sources of revenue for the general fund will decline 10 percent in 1990 with the project over those required without the project; the reduced requirements in 1999 will be approximately 7 percent with the project over the baseline forecast. This reduction in miscellaneous sources of revenue is due to the increases in Municipal Assistance Funds and property tax revenues, which are a function of changes in population.

Total bonded indebtedness for the Mat-Su Borough is not anticipated to exceed 7.5 percent of total assessed valuation. By 1990 total bonded indebtedness for the Mat-Su Borough could reach $95.3 million (baseline forecast) or $97.8 million with the project. By 1999 this could increase to approximately $136 million.

Expenditure forecasts are based upon average per capita expenditures found in the FY81/82 budget. The cost of delivering services almost doubles by 1990 and increases by only 50 percent in 1999 over 1990 levels with or without the project. The vast majority of impacts will be experienced in the increase in delivery of services to service areas with particular emphasis on communities experiencing a large population influx, such as Talkeetna and Trapper Creek. Total differences between baseline and impact forecasts in the costs of service average 2.6 percent in 1990, and only 1.3 percent in 1999. Costs for administration, fire service, and road maintenance and repair are likely to experience the largest increases. Service user changes are anticipated to rise proportionately to the increases in the costs of service delivery.

- Matanuska-Susitna Borough School District Budget

The school district budget for FY 81/82 is the single largest category of revenues and expenditures across all services provided within the Borough and within the incorporated communities. Table 5.29 provides baseline and impact forecasts of major revenues and expenditures for the school district budget. Total revenues double by 1990 and increase 60 percent by 1999 over 1990 levels with or without the project. This is consistent with increases in the school age population. The impact of the project in 1990 results in an overall 2.5 percent average increase over the baseline forecast.

Total State revenues comprise approximately 75 percent of total school revenues with State Foundation Program revenues accounting for 86 percent of total State funding. Local property taxes provide approximately 15 percent with the remainder of revenues coming from Federal sources. Local property taxes for school revenues are based on a mill levy of 6 mills per $1000 assessed valuation. School Debt Service Reimbursement monies from the State go to the General Fund to pay for major capital projects, and thereby make up the shortfall found between total expenditures and total revenues. The lag between reimbursement of funds and expenditures to be paid produces a short-term impact on fiscal cash flows. This condition would prevail even in the absence of the project.

Total expenditures will follow a similar trend as revenues, increasing by 125 percent in 1990 over 1981 levels and 62 percent over 1990 levels without the project. With the project, increases in expenditures between 1981 and 1990 will average 130 percent and 64 percent between 1990 and 1999. In either case, expenditures for education will be rising at a faster rate than the increase in revenues. Regular instruction comprises 30 percent of total expenditures, with special and vocational education accounting for 10 percent and 2 percent, respectively. Special education is anticipated to increase substantially from 6 percent in 1981 due to the passage of PL 94142. Current plans for capital projects for educational facilities take into account the possible increases in school-age population which will be associated with the project. It is anticipated that school facilities will have sufficient capacity to adequately handle the influx. Average costs of education excluding capital projects are assumed to increase by 5 percent in real dollars by 1990. Average per pupil expenditures excluding capital projects are assumed to be $3,003 per elementary pupil and $3,728 per secondary pupil.

- City of Palmer

The effects of the Susitna hydroelectric project on fiscal flows in the City budget will be negligible. Total increases in revenues will vary from one percent in 1990 and 0.5 percent in 1999 over the baseline forecast (Table 5.31). In general, increases average 50 percent in 1990 over 1981 and 36 percent in 1999 over 1990 levels assuming normal growth. Between 1990 and 1999 the impacts on fiscal flows will be the same with or without the project averaging a 36 percent increase over 1990 levels.

Local sources of revenue provide 35 percent of total General Fund revenues: property taxes account for 52 percent of total local revenues and are based on a mill levy of 4 mills per $1000 assessed valuation; sales tax revenues represent the balance of local revenues based upon a 2 percent gross retail sales tax assuming average per capita expenditures of $4,674 per year for retail consumption. In addition, Palmer provides services based upon user-fees to help cover the cost of service delivery. These user fees are assumed to increase 3 percent in real dollars by 1990 and represent 30 percent of total General Fund revenues. There are separate funds for sewer services and water supply with sewer revenues rising at a faster rate than those for water. Both funds levy service user fees.

The ratio of total bonded indebtedness to assessed valuation is currently 4 percent and is not anticipated to exceed this ratio. Total possible bonded indebtedness under these assumptions would be $3.8 million in 1990 and $5.4 million in 1999, with little variation between the baseline and impact forecasts.

Expenditures, like revenues, are not noticeably impacted by the changes in population influx due to the project. Expenditures for social services and facilities rise approximately one percent over the baseline forecast in 1990 at a slightly greater rate than increases in total revenues. Total expenditures increase from $2.3 million in 1981 to $4.2 million in 1990 and reach $5.7 million in 1999 without the project. Expenditures with the project in 1999 will increase approximately half of one percent over the baseline forecast. Between 1990 and 1999 expenditures will average a 36 percent increase among all services with or without the project; This is consistent with population increases of 36 percent between 1990 and 1999. No sudden large capital improvements are anticipated for the City of Palmer with or without the project. Expansion or additions to existing facilities and services appear to be well integrated into the current planning process.

- City of Wasilla

Fiscal impacts on the City of Wasilla will vary due to normal growth and growth attributed to the population influx associated with the project will be negligible. Actual increases in revenues

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and expenditures will average about 90 percent with or without the project, for each decade.

Actual impacts associated with the project will be very small, with increases in revenues and expenditures averaging about 1.2 percent over the baseline forecast in 1990 and about 0.5 percent over the baseline forecast in 1999. The majority of revenues comprise State shared taxes and State revenue sharing. Locally derived revenues from licenses and fines account for only four percent of total revenues, though additional revenues are to be generated from an assessment on lots directly benefitting from a new centralized water supply system. The City of Wasilla does not levy property taxes and it does not utilize service user fees to cover costs of service delivery. In addition, capital projects are funded primarily through State and local grants.

Expenditure forecasts are derived from actual average per capita costs of service, with each service accounting for the following share of total expenditures, excluding capital project costs: parks and recreation seven percent, library 15 percent, fire service 11 percent, local government administration 39 percent, and road maintenance and repair 28 percent. These proportions are assumed to remain fairly constant over the period of the forecasts, with possible increases in administration and road repairs due to the increased population influx.

- City of Houston

The overall impact of the project in 1990 will raise revenues and expenditures approximately 2.7 percent over the baseline forecast and will increase fiscal flows slightly less than one percentage point in 1999 over the baseline forecast. Total revenues and expenditures will rise at the same rate as population increases, doubling approximately every eight years. Houston does not raise any funds locally, either through property assessments or service user fees. Current revenues are derived from State and local grants; this pattern is expected to continue, however, many local revenue generating alternatives are available to the residents within Houston City limits.

As the community grows, it is likely to provide additional services for which it may choose to levy taxes, set user charges or other forms of recipient fees. As petroleum revenues decline in the 1990's and State funding cuts back, local communities and cities will have to find increasingly creative methods of raising funds to cover the costs of service delivery. Local taxes and user fees are the predominant methods used by local fiscal officials.

Expenditures for local government administration represent 47 percent of total expenditures, and road maintenance 29 percent, with fire service comprising 15 percent. This distribution of expenditures is similar to that of the cities of Wasilla and Palmer reflecting similar local priorities. Other major services are provided by the Mat-Su Borough.

- Public Facilities and Services

Public facility and service impacts have been estimated using the following approach: (1) Appropriate per capita standards were developed, based upon an extensive literature review and the input of local officials; (2) the adequacy of existing facilities and services were assessed; and (3) estimates of future needs related to natural growth and to project-induced population influx have been compared with present and planned capacity. With the exception of Trapper Creek, substantial increases in public facilities and services will be needed to accommodate baseline forecast growth, and population influx related to the project will only add slightly to these needs. In contrast, the large proportional increase of population in Trapper Creek will have substantial impacts on the needs for public facilities and services.

- Water Supply

The water supply needs of the project and of the work force and families living at the Watana and Devil Canyon sites will be provided for by the contractors. There will be no impact on public facilities in the Mat-Su Borough.

The population influx associated with the project will have only a slight impact on the public water systems in the Borough. In Palmer, water consumption at the peak of construction at the Watana site (1990) will rise one percent over the baseline forecast level of 608,000 gallons per day; water consumption attributable to the population influx during the Devil Canyon site construction peak (1999) will represent a 0.5 percent increase over the baseline level of 917,650 gallons per day. There will be no additional need for pipe associated with this slight increase in water consumption, as these families are expected to move into vacant housing units, where presumably water lines are already hooked up.

In Wasilla, water consumption is expected to increase by 1.1 and 0.5 percent during the two construction peaks, over the baseline forecast consumption levels during those years. This increase in population will not have major impacts on the Wasilla water system; however, it may contribute slightly to the population density in Wasilla, and thereby contribute to the need for an expansion of the water system (the present system currently serves only the downtown area).

- Sewage

The sewage treatment needs of the work force and families living at the construction sites will be provided for at the work camp and family village. No impacts on the local public facilities are expected.

Population influx into Palmer will result in an increase in sewage treatment requirements of 5,000 gallons per day (0.9 percent) above the 1990 baseline forecast level and 4,013 gallons per day (0.5 percent) over the 1996 baseline forecast level. The population influx during 1983-1990 will occur at a time when existing facilities are already reaching their limits, and a third sewage treatment cell will be required.

Sewage treatment requirements in Wasilla are currently handled by individual septic tanks, but as the city population grows, a city-wide system will be needed with or without dam construction.

- Solid Waste

The solid waste requirements of personnel and dependents living at the construction work sites will be provided for at the camp and village, and will have no significant impacts on public facilities in the Mat-Su Borough.

The population influx into the Borough communities associated with the project will increase the annual landfill needs of the Borough by .069 hectares (ha) (.17 acres) in 1990 and .073 ha (.18 acres) in 1999. This represents 2.5 percent and 1.3 percent increases over the baseline forecast levels in those years. This population increase may contribute to a slight advance in requirements for additional landfill acreage, which is expected to be needed under the baseline forecast conditions around 1994-1995.

- Law Enforcement

The population influx into Mat-Su Borough communities that is associated with the project will increase the requirements of State Troopers by one to two officers over the baseline forecast need of 38 in 1990, the year of peak construction activity.

The project construction contractors will provide for police protection around the dam sites, but it is possible that the State Trooper force in Trapper Creek may be enlarged somewhat to reflect the growing population in the northern part of the Borough during the construction phase of the project.

- Fire Protection

Fire protection planning in rural areas such as the Mat-Su Borough is more dependent on the distance of facilities from population centers than on the size of population. Since inmigrants are expected to settle into existing vacant housing, there will be little impact on fire protection facilities in most communities. Firefighters will continue to be, for the most part, volunteers.

The project facilities and work camp/family village will be protected by firefighting equipment and services at the work sites; there will be little impact on the existing governmental facilities and services.

- Health Care

  The work camp/family village at the construction site will provide facilities for health care, including a 20-bed hospital. It is expected that there will be little impact of the construction-site population on the Mat-Su Borough's health facilities, with the exception of cases of major illness or accidents which cannot adequately be handled by the site hospital.

  The population influx into the Mat-Su Borough communities associated with the project is expected to raise the number of hospital beds needed in 1990 by about one bed. This population influx may contribute to a slightly accelerated need for a new hospital, a development which was projected to be required around 1990 under baseline forecast conditions.

- Education

  School-age children at the construction site will be educated at project facilities and hence will not have an effect on the Mat-Su Borough School District. There will be an increase of 159 primary school children and 133 secondary school children accompanying inmigrants into communities in the Mat-Su Borough during the Watana peak, representing about three percent of the baseline forecast levels. These figures will decline to 127 and 106, respectively, during the Devil Canyon peak. There will be a need of about seven additional primary school classrooms and teachers and seven secondary school classrooms and teachers in 1990, in addition to the 216 primary school and 230 secondary school classrooms which will be needed to accommodate growth without the project.

- Public Recreation Facilities

  Recreational facilities will be provided at the construction site for use by project employees and their families. Thus, residents of the work camp are not expected to have much of an impact on public recreational facilities, although some increase in visits to the national and state parks near Mt. McKinley, and to other parks can be expected. Residents can also be expected to engage in outdoor recreation activites in portions of the upper Susitna basin where no public facilities now exist.

The project-induced population influx into Borough communites will represent 2.6 percent of Borough population in 1990 and 1.3 percent in 1999. This additional population will have a slight impact on the requirements for public recreational facilities.

- Transportation

  The Susitna hydroelectric project includes the construction of a road into an area that currently has no auto access. If policymakers decide to allow public access to this road, the result will be a major addition to the local transportation system. The ultimate status of the road is unsettled at this point, due to environmental concerns.

  It is anticipated that the majority of project-related supplies and equipment will be transported by rail to Gold Creek, and then by truck to the work sites. The rail system is currently underutilized and the increased revenues are expected to benefit the railroad.

  An increase in vehicular traffic on the Parks Highway and nearby roads will result to the extent that pri vate automobiles are allowed to use the access road to the sites. This increase in road traffic could include workers commuting to and from the site, and traffic related to potential recreational activity in the impoundment areas.

- Business Activity

The potential for displacing residences and businesses in Impact Area 1 and for enhancing business activity in the Borough are discussed in this section.

- Residences

  Although some cabins used intermittently by hunters, trappers and recreationists will be displaced by the project, no permanent residences are expected to be inundated or totally displaced. Some residents of the upper basin are expected to voluntarily leave the area for other wilderness regions in response to increased construction and recreational activity.

- Businesses

Most business activities in Impact Area 1 (proximity to dams, access roads and transmission lines) are dependent upon abundance and location of fish and game species. These activities include guiding, lodging, trapping, salmon fishing and other recreation. Short term dis placement of such enterprises by construction activity may occur, but in the long run increased access to the area may increase business opportunities.

Guides are expected to have to adjust to changes in abundance and location of fish and game species, but may benefit from improved access to wilderness areas. Lodges catering to hunters and fishermen will be affected by the same factors, but may find new opportunities to offer access to sports such as cross country skiing or to provide facilities for business conferences. Trappers will be affected by loss of habitat for furbearers. Salmon stocks will be affected by changes in species mix and numbers of fish, but long term impacts on Cook Inlet commercial fishermen, recreational fishermen and other user groups are expected to be minor. Impacts on other types of recreation will include the loss of sections of Susitna River to white-water kayaking, but general recreational use is expected to increase as a result of improved access.

One active mining site is expected to be totally displaced by the project and one inactive site partially displaced. However, the project may prove beneficial to other mining activities by improving access, hence allowing existing claims to be worked more profitably and facilitating discovery of new deposits.

Business activity will increase in the Borough during the mid to late 1980s as a result of road and dam construction at the Watana site. Businesses that supply construction materials such as sand, gravel, fuel, etc., will have increased sales as will firms that provide transportation services such as trucking, helicopter, and airplane support services. Further, it is estimated that by 1990 more than 400 support sector jobs will be created by the project. Existing support sector businesses such as restaurants, service stations, lodging establishments, retail food stores, etc., will expand and new businesses will be started. Most of this activity will be concentrated along the Parks Highway from Wasilla to Cantwell.

- Employment

The Susitna project will dramatically increase the employment opportunities in the Mat-Su Borough. At the peak of project construction in 1990, direct on-site work force requirements of the project will total 3,500, and an additional 428 indirect and induced jobs are expected to be created in the Borough. Altogether, this will represent an increase of 57 percent over the baseline forecast of employment in the Borough (by place of employment).

It is expected that Mat-Su Borough residents will account for over 10 percent of the on-site construction employment and over 85 percent of the indirect and induced employment related to the project.

- Income

At the peak of project employment in 1990, it is estimated that approximately $97.8 million (1980 dollars) in payroll will be distributed to the on-site construction work force. As previously displayed in Section 5.4, Table 5.17, this payroll will be spent in various Census Divisions in Impact Area 3 based on expenditure assumptions. In 1990 it is estimated that approximately $8 million of on-site construction payroll will be spent in Mat-Su Borough; in total, between the years 1983-2002, the figure is $67 million. This payroll spent in the Borough will, in turn, stimulate an increase in indirect and induced business activity and employment.

(ii) Trapper Creek

Impacts of the project on the community of Trapper Creek are summarized in Table 5.36.

- Population

The population influx associated with the project is projected to result in a doubling of the population of this small community by the peak year of project activity (1990), from the baseline forecast (without project) of 320 to the impact forecast of 661 for that year. As the Watana peak winds down and the project work force is cut, about half of the workers and their families will leave the area (166 persons between 1990 and 2002). If new sources of employment do not develop, this exodus could be somewhat larger.

- Housing

The population influx into Trapper Creek between 1983 and 1990 will result in an increased demand for approximately 114 housing units over the baseline forecast level of 107. This is likely to cause a substantial short-term housing shortage. To the extent that this doubling in housing needs cannot be met, it is expected that inmigrants will seek housing in nearby areas of the Borough.

Traditionally, the availability of vacant housing in Trapper Creek has been extremely limited. Under baseline forecast conditions, this trend is expected to continue, as additional housing is built only to satisfy definite needs. Thus, only one or two vacant housing units are expected to be available in 1990, far short of the 114 needed.

It is possible that speculative activity prior to the construction peak period will result in additional housing units being available to meet part of the increase in demand. Some families may reside temporarily in cottages or rooms owned by lodges in the area, and part of the housing needs may be met quickly by purchase of mobile homes and trailers, to be used on individual lots or in trailer parks. While there is not a great deal of private land in the Trapper Creek area, there is a sufficient amount to support the expected population influx.

- Fiscal Impacts

Any analysis of fiscal impacts for Trapper Creek and other small communities would have to fall under the Mat-Su Borough budget as revenues and expenditures are collected and administered by the Borough. Changes in revenue receipts would affect the Borough government directly, and the delivery of services to communities indirectly. The Borough has the power to levy property taxes on service areas to cover the costs of service delivery. These could be impacted due to costs of service delivery which over time could be offset by increases in the tax base.

In FY81/82, the areawide mill levy was 6.7 per $1000 assessed valuation and the non-areawide (service areas only) mill levy was 0.52 per $1000 assessed valuation.

It is assumed that neither Trapper Creek nor other small communities will incorporate before 2000. Although population increases will be substantial, the actual size of the total community is assumed not to be sufficiently large to warrant incorporation. Therefore, the Mat-Su Borough government will remain responsible for the provision of services and facilities to the extent necessary.

The Borough is assumed to levy a total property tax of 6.5 mills per $1000 assessed valuation until 1989 and 6.75 mills from 1990-2000. This will include a mill levy of 0.5 for 1981-89 and 0.75 for 1900-2000, for non-areawide services such as fire and road service. Ambulance service is assumed to continue operating on a user fee basis. Projections of estimated local taxes to cover the costs of capital projects can not be made as this will depend upon the size of the project, the availability of State and Federal grant monies, local preferences, and the Mat-Su Borough's bonding capabilities.

The dominant fiscal impact experienced by the Borough Administration will be the result of cash-flow cycles. Initially the costs of service delivery will be accelerated and these will not be matched by an immediate parallel increase in revenues. It is anticipated there will be a two-year lag between the receipt of revenues and the outlay for additional service costs. This lag is a function of the time it takes to input new property owners on the tax rolls, for the property assessments to be made, and taxes collected.

- Public Facilities and Services

- Water, Sewage and Solid Waste

  Water and sewage needs are met by individual wells and septic tanks, and solid waste is disposed at a nearby landfill run by the Borough. No adverse impacts caused by the population influx as such are probable.

  It is anticipated that Borough and State oversight of growth of Trapper Creek could prevent any problems of hastily built housing developments that do not meet health standards for wells, septic tanks and trash disposal.

- Transportation

  Increased vehicle traffic on the Parks Highway is expected. The addition of housing units may result in additional roads to serve them, and the increased population may add to the need for additional paved or gravel roads.

- Police Protection

  It is possible the project and the increased population in the northern part of the Borough will induce an enlargement of the State Trooper substation at Trapper Creek, thus resulting in an increased police presence in the community.

- Fire Protection

  The population influx into Trapper Creek will exacerbate the need for active fire facilities in the community. It is possible that the additional population added to the natural growth over the 1983-2000 period could stimulate the Borough to create a fire service area for Trapper Creek.

- Health Care

  With the exception of an ambulance, no health care facilities are currently available in Trapper Creek. The population influx associated with the project is not expected to have an effect on health care for Trapper Creek residents.

- Education

  The planned six-classroom elementary school in Trapper Creek will have a capacity of 150 students. It is anticipated that the population influx associated with the project into Trapper Creek and the surrounding area could bring the school's enrollment close to capacity by the peak year of construction at the Watana site. The combination of natural population growth and the continued presence of over half of the inmigrants associated with the project will result in a need for additional classroom space in the 1990's.

- Business Activity

It is not expected that business activity will change appreciably in Trapper Creek during the 1980s if the dams are not built. By 1990, project-induced demand for services will equal or exceed that of the forecast baseline population. With dam construction it is very likely that Trapper Creek will have service types and levels similar to those of Talkeetna today. Because Trapper Creek is on the Parks Highway, it could even have more service businesses than present-day Talkeetna by 1990.

- Employment

The Susitna project will present vastly increased employment opportunities for residents of Trapper Creek, both in terms of on-site construction, and in terms of jobs in the support sector.

- Income

Income spent in Trapper Creek is anticipated to increase sharply during the construction phase of the project, as a result of the increased employment of local residents and the inmigrant population, and as a result of expenditures made by work camp residents on items such as food, beverages, gasoline and recreation.

(iii) Talkeetna

Table 5.37 displays a summary of the expected impacts of the project on Talkeetna. In general, this analysis refers to the area that was proposed for incorporation in 1981.

- Population

Between 1983 and 1990, an estimated population influx of 263 is expected to occur as a result of the project. This will represent a 26 percent increase over the baseline forecast of 1,000. By 1999, 210, or 80 percent of the earlier population influx will remain. A further moderate decline in population of 37 is expected between 1999 and 2002.

- Housing

The population influx related to the Watana construction phase will result in an addition of 87 households between 1983 and 1990 to the Talkeetna area. As in Trapper Creek, a shortage of available housing is probable. Under baseline forecast conditions, only six vacant housing units will be available in that year. This estimate is based on the community's historically low vacancy rate.

The expected short-term shortfall in housing supply may be made up by speculative advance construction, temporary residence in local lodges/hotels, the use of mobile homes and trailers, and rapid construction. To the extent that the housing supply cannot meet demand, it is likely that some inmigrant families will find housing elsewhere in the northern part of the Borough.

- Fiscal

Baseline and impact forecasts for revenues generated by or on behalf of the Talkeetna Service Areas for the Mat-Su Borough Administration are shown in Table 5.35. Due to substantial population changes caused by the project, there will be a 26 percent increase in revenues from property taxes in 1990 over the baseline forecast for 1990. The change due to normal growth would increase revenues by 134 percent without the project and 196 percent with the project, over 1981 levels. Increases of 13 percent between 1990 and 1999 with the project are consistent with other trends where the changes due to the project are twice as large in 1990 as they are in 1999. Property tax revenues are based upon a non-areawide mill levy of 1.5 mills in 1990 and 1.75 mills in 1999 per $1000 assessed valuation.

State General Revenues for fire service areas are based upon population and therefore will follow the same trend as property tax revenues, increasing 26 percent in 1990 and increasing 13 percent in 1999 over the baseline forecast. Revenues for road maintenance and repair are assumed to increase 10 percent per year in 1981, consistent with assumptions regarding all revenues for maintenance of roads within the Borough that will experience significant increased use.

Total revenues to the Borough will increase 116 percent from 1981 to 1990, and 130 percent from 1990 to 1999 without the project. Total revenues to the Borough with the project will increase 10 percent in 1990 and four percent in 1999 over baseline forecast.

The community of Talkeetna is assumed not to incorporate before 2000 if the Susitna project is not built. Under these conditions the Matanuska-Susitna Borough will continue to provide services, including ambulance, fire protection, solid waste disposal, and road maintenance and repair. Police protection will continue under State Troopers. Services will be administered by Borough officials and paid for by the Borough government out of funds derived both locally and from the State. Property located within the service boundary will continue to be liable for taxes levied to cover the costs of service delivery. The mill levy for education is assumed to remain constant at 6.0 mills per $1,000 assessed valuation. The nonareawide tax mill levy is assumed to increase, thereby generating additional revenues over and above those that result form real increases in the value of property over time.

In addition to stimulating revenues and raising expenditures for service delivery, the impact of the Susitna hydroelectric project is likely to accelerate the time-table in which the Talkeetna community will decide to incorporate. The increased population influx will act as an impetus for the community to organize itself such that it can control the delivery of necessary services. The City of Talkeetna would be able to levy taxes to cover the costs of government administration and service operations, functioning either as a second class city or a Home Rule city. The city is likely to elect to provide its own fire and ambulance services and as a second class city, would continue police protection under State Troopers. The Mat-Su Borough would continue to provide services to the road service area which would exclude the city limits of Talkeetna. Local government would then be responsible for providing road maintenance and repair within the City limits. The Borough would continue to levy non-areawide taxes for services delivered under non-areawide powers. The areawide tax would also be levied to cover the costs of education provided by the Mat-Su Borough School District.

Any additional fiscal expenditures are not anticipated. It is assumed that individual septic tanks will continue to be the mode of sewage disposal. Water supply systems are anticipated to remain as wells on individual lots. However, should city lot sizes prove to be inadequate for individual wells, the residents may elect to build a community well. The costs of this would most likely be borne by those residents who directly benefit from the improvements. Solid waste will likely continue to be disposed of at the Borough land fill sites. The majority of funding for capital projects is assumed to be grant monies derived from either Borough or State funds. Local shares will likely be paid for by monies derived from taxes levied on residents who benefit directly or by issuing municipal bonds.

- <u>Public Facilities</u>

  . <u>Water and Sewage</u>

  As in Trapper Creek, it is possible that quickly constructed housing will need to be closely supervised to ensure compliance with health standards regarding wells and septic tanks.

  . <u>Solid Waste</u>

  The peak population influx into Talkeetna associated with the project will occur just around the time that the Borough's landfill near Talkeetna is expected to be closed (1987-89). A new landfill or a transfer station will be needed at that time. The additional population is not expected to have any adverse impacts.

- Transportation

  Construction of new housing may result in the need for additional roads to serve these new units.

- Police Protection

  As Talkeetna grows, there may be a community desire for a police presence closer than the Trapper Creek substation. The additional 26 percent population influx associated with the project between 1983 and 1990 and the proximity of the work camp to the community may further reinforce this tendency.

- Fire Protection

  Increased population is not expected to affect firefighting facilities in the area; these are planned on the basis of distance between the station and population centers, and on the availability of pumped water. The planned addition of equipment to the Talkeetna fire station should be sufficient to serve the community until such time as a community water system is put into place.

- Health Care

  Residents of Talkeetna currently use the health care facilities in the southern part of the Borough and Anchorage. The population influx related to the project is not expected to have any adverse impacts.

- Education

  The population influx associated with the project will include approximately 38 primary school-age children by 1990, just as the enrollment in the elementary school in Talkeetna is projected to exceed its capacity of 120. Additional classroom space and teachers will be needed.

  Between 1990 and 1999, facilities for an additional 76 elementary school children will need to be built, as a result of baseline forecast growth. The Susitna project is expected to have limited impacts during this period.

There will be an additional 31 secondary students associated with the project attending Susitna Valley High School in 1990 over the baseline forecast level. By 1999, this will decline to 26.

- Business Activity

By 1990, without the project, the demand for services will almost double. It is expected that existing businesses will operate at fuller capacity and some will expand their services. A few new businesses will emerge to meet the increased demands. Some of these might offer services not currently available in Talkeetna.

The project is expected to have a significant impact on Talkeetna's business activity as new residents and workers from the project spend their income in Talkeetna. The new residents will have spending patterns similar to those residents now living in Talkeetna, and the workers who come to Talkeetna for short visits will be expected to concentrate their expenditures on food, beverages, lodging, and related items. If workers make visits to Talkeetna frequently (this would be probable if workers are allowed to fly to and from the construction site), the demand for services could be double that implied by the 1990 baseline forecast of population.

- Income

Income spent in Talkeetna is anticipated to increase somewhat during the construction phase of the project, but at a more moderate level of increase than that anticipated for Trapper Creek. The increase in income and expenditures will be primarily in the form of local residents obtaining employment on the project and due to the inmigrant workers and families. In that Talkeetna is situated off of the Parks highway and that the proposed access route does not go through Talkeetna, there will be fewer purchases of supplies and other goods and services made by work camp residents in Talkeetna. However, if workers are able to fly into Talkeetna from the work camp, then considerably more income could be spent in Talkeetna, particularly for food, beverages and lodging.

(iv) Sociocultural Impacts

The sociocultural impacts discussed in this section (Section 5.5(a)(iv) are extracted from a study prepared by Stephen R. Braund & Associates for the Susitna Hydroelectric Project. The impacts are based on population, school-age children, and housing stock projections. In this section, the Base Case refers to baseline forecasts (i.e. future projections without the Susitna Project). These Base Case projections are then compared to the forecasts of population, school-age children, and housing stock in the local communities which have resulted from the project. The difference between the two forecasts results in the project impacts. These community level forecasts are only available for Trapper Creek and Talkeetna; therefore, the discussion of impacts related to the railroad communities north of Talkeetna is totally qualitative.

For purposes of analysis, only the population projections specifically allocated to Trapper Creek and Talkeetna were used. If those project-related people who locate outside of the immediate cities and communities (See the "Other" category in Table 5.23) are proportionally allocated to the greater Trapper Creek and Talkeetna "areas", the impacts discussed below would be greater.

The Susitna Project will cause a 61 percent population increase in Trapper Creek from 1986 to 1987. (The project adds 175 residents to a Trapper Creek Base Case population of 285 for a total population of 460). Included in this one year population influx are 45 school-age children. By 1990, the Watana peak, Trapper Creek is projected to have a population of 661, over twice as many people as without the project (320). Included in these cumulative figures for 1990 are an additional 88 school-age children (a 117 percent increase over the 75 Base Case projections). Also, by 1990, project-related families who move to Trapper Creek will require an additional 133 housing units over the Base Case housing stock.

As Watana winds down, the work force is reduced, and some families leave the area. The low point between Watana and Devil Canyon construction occurs in 1995, when project-related population in Trapper Creek drops to 198 (from a high of 341 in 1990). As a result, Trapper Creek's population drops from a high of 661 in 1990 to a low of 588 in 1995 (11 percent drop). (Although 143 project related people leave the community, Base Case growth adds 70 persons during the same period.

Consequently, a total of 213 move in and out of Trapper Creek.) At the peak of Devil Canyon construction in 1999, the project accounts for 245 of Trapper Creek's 701 people (a 54 percent increase over the Base Case population of 456). By the end of the project forecast period (2002), 70 project-related people (29 percent of the 1999 peak) leave Trapper Creek. It is assumed that Base Case growth accounts for 57 additional inmigrants for a net population loss of 13 people between 1999 and 2002.

Although the long time frame of the Susitna Project will cushion any final decline (one is hardly noticeable by the year 2002), the projected rapid influx of project-related persons in Trapper Creek between 1986 and 1990 will result in a boom situation for the community. According to Davenport and Davenport (Boom Towns and Human Services, University of Wyoming Publications, Laramie, Wyoming, 1979) a "boom town" is defined as:

1. A community experiencing above average economic and population growth;

2. which results in benefits for the community, e.g. expanded tax base, increased employment opportunities, social and cultural diversity;

3. but which also places or results in strain on existing community and societal institutions (e.g. familial, education, political, economic).

Not all impacts associated with boom towns are negative. For example, positive consequences include substantial benefits to the local economy such as more jobs, more businesses, higher pay scales, increased prosperity, and an increased tax base. In addition, an expanded and updated educational curriculum may result from the new demands made by incoming students and their parents. Generally, the benefits associated wtih rapid growth caused by a large development project are primarily economic. In the case of Trapper Creek, for the segment of the population which is not primarily motivated by economic advancement, the negative effects of rapid growth will likely overshadow any benefits.

Among the consequences and human costs associated with boom towns, the following major problem areas have been identified ("The Sociological Analysis of Boom Towns". In Boom Towns and Human Services, Davenport and Davenport, eds, 1979):

- Demands for and strain on existing facilities and services, including human services such as marital, child abuse, and delinquency counseling, that exceed the capacities of local systems to meet them.

- Economic problems centered around high inflation caused by increased demands of large numbers of incoming project-related personnel and families (increased cost of living, especially for housing; new pay scales beyond the limits of some local business; more formality in conducting business; and hardships associated with inflation on those living on fixed incomes such as the elderly or chronically unemployed).

- Increases in the incidence and nature of many "people problems" (rise in alcoholism, child abuse, crime, suicide attempts, divorce, and the lack of trained medical personnel), likely associated with stress related to rapid change.

- Potential conflict between the values, norms, beliefs and lifestyles of local residents and the newcomers.

- Local government is forced to take a more active and expansive role in the lives of community residents as it tries to expand services and respond to rapid growth. Generally, a time lag exists between the demand for services and their availability.

Based on its lack of infrastructure, its small rural nature, and the characteristic that a significant portion of its residents are not primarily motivated by economic advancement, most of the preceding general comments related to boom town problems seem to apply to Trapper Creek. In addition, the problems are compounded by the 1995 lull and a second project peak in 1999. Based on the projections, Trapper Creek will experience a boom (1986-1990), a downswing (1991-1995), an upswing (1996-1999), and a slow decline in project-related persons beginning in 2000. The lull in the early 1990's could be especially problematic as workers (especially indirect and induced) will live in anticipation of another project. This period will likely be easier for direct construction workers, as they will probably go elsewhere to work.

Uncontrolled rapid growth generally results in negative consequences. Local residents who live in the small community prior to the growth tend to blame the developer and the new residents for problems associated with population influxes. These problems are exacerbated if the community does not have the infastructure to accommodate the new growth. Resentment between current residents and newcomers may develop because the former often bears the burden of the expense for new facilities and services, often in the form of higher taxes. The result is often citizen against citizen; the town against the developer; and local government against higher levels of government (Borough and State).

One way to diffuse many of these potential conflicts is to distribute the costs and benefits of the project equitably (Jirovec. "Preparing a Boom Town for the Impact of Rapid Growth." In Boom Towns and Human Services, Davenport and Davenport, eds., 1979). In this case, those who gain the benefits (the developer, the state) help pay the costs. In this way, those who generally pay the costs (the rural community resident) are protected and their quality of life preserved.

Generally, a town facing rapid growth desires to develop the local capability to assure that the effects of growth will be as beneficial as possible. Controlling the impacts of rapid growth on small, rural towns within the context of local values begins with community planning, community organization, and research. As Jirovec points out, urban planning techniques may not apply; a rural community needs rural planning. The success of any plan depends on community support and organization. In addition, it requires the developer to share with the community detailed information about the project. Finally, a community requires time (i.e. 2 years) for planning and preparation for rapid growth.

Even if it is effectively managed, boom growth apparently results in increased urbanization and modernization of the rural style of living -- the population becomes more diverse; current residents know a smaller percentage of their neighbors; more and more interactions between people become formal and con-tractual rather than personal and face-to-face (Cortese and Jones, 1979). Planning and community organization to prepare for the boom become part of the problem. The planning process typically adds anonymity, differentiation, bureaucratization, impersonalization, and so forth (Cortese and Jones, 1979). In effect, in rural communities, the solution can become the problem. According to Jirovec (1979) prospective boom towns must choose between uncontrolled rapid growth (with many negative side-effects), managed or controlled rapid growth (with greater urbanization and modernization), or moderate or no growth (which would maintain the status quo). From the community perspective, local residents do not always have the latter choice.

Based on the population forecasts (both Base Case and project-related), the most significant feature of Talkeetna's future is the constant growth without the project. Whereas Trapper Creek experiences a boom between 1986 and 1990, Talkeetna's project-related population, during the same period, only increases 6.5 percent per year over the Base Case projections. During the biggest year of project impact, 1986-1987, the project adds 138 persons to a Base Case population of 862. This represents a one year increase of 16 percent where Trapper Creek had a 61 percent project-related increase in the same year. The forecast situation in Talkeetna emphasizes that although project impacts are much less than Trapper Creek, the cumulative effect of both the Base Case population increase and the project-induced growth is significant and represents the real change with which Talkeetna must contend.

Without a community effort to identify and implement common goals, this growth in Talkeetna may result in the community losing its small-town, rustic, frontier flavor which attracts many tourists. It will likely continue as a tourist town and staging area for McKinley climbing parties. The increased population and access related to the project will likely result in increased rate of decline in local wildlife populations, which local residents value highly. Increased human populations in the work camps and increased aerial activity will likely contribute to this trend.

It is possible that many more people than are anticipated will move to Talkeetna as a result of the project. This partially depends on the new work schedule, whether Trapper Creek successfully accommodates its projected growth, and the possibility that people find Talkeetna, despite its aditional 30 miles from the project, a more desirable place to live. Because Talkeetna and Trapper Creek are similar communities, all of the potential problems discussed for Trapper Creek increasingly apply to Talkeetna as its population (both with and without the project) increases, and therefore are not discussed here.

Although there is an abundance of land available, primarily due to the State land disposals, it is unlikely that the permanent population in the Chase/Curry area will increase dramatically, either with or without the project. Without the project, employment opportunities will likely remain relatively non-existent, and the main attraction to the area will continue to be recreational for most people and residential for only a few persons. In this area, the recreational impact, again both with and without the project, could be significant. Without the Susitna project, recreation seekers will continue to use the area as Talkeetna continues to promote tourism. As more and more people visit this subregion, the chances that they will apply for some of the surplus available State land increases. The railroad will continue to provide access into the area, and although it will likely remain relatively unpopulated, seasonal recreationists will probably increasingly visit it. As more and more of the existing residents in this area have families, they will likely desire additional services, such as a school and better access to Talkeetna.

With the Susitna project, recreation in the area will more than likely significantly increase (i.e. more than without the project). Workers and their families who move to the area will certainly hunt, fish, and participate in other outdoor activities. Improved access to and increased awareness of the area east of the Susitna River due to the project, will likely attract more recreationists. The proposed access road will provide vehicle access to the east side of the Susitna River and therefore make the general area more accessible to more people. (Policies related to public use of this road during and after project construction could postpone or prevent some or most of the impacts. As more and more people recreate in this area, the chances for conflict between them and local residents increase.

The Susitna project will result in increased employment for residents in this area, which will enhance the well-being in these communities by providing potential jobs. At the same time, the increased employment opportunity created by the project will attract more people into the general area. This population influx will likely have a negative effect on the existing small town or rural way of life for those people in the railroad communities who value relative isolation in a wilderness environment.

With the project, the Gold Creek area is likely to be the most heavily impacted. If the proposed access route is chosen, Gold Creek will be connected by an 18 mile road to the Parks Highway. The patented homesteads in the vicinity comprise a private land base that could accommodate future expansion and growth, a likely occurrence if the area becomes easily accessible by road. People affected by this potential development will be mainly local miners, a few local residents, and absentee, recreational property owners, all of whom value their wilderness retreat. If vehicular access occurs in this area, local residents and absentee landowners between Hurricane and Gold Creek, as well as entrants in the Indian River Remote Parcel land disposal will be subject to increased traffic, noise, and congestion.

Currently, no one lives in the Hurricane/Parks Highway area nor are any services available: however, three factors indicate that some development may occur here related to the project: it is the intersection of the proposed access road and the Parks Highway, private land is available, and it will be only 44 road miles from Devil Canyon. In the spring of 1981, the State of Alaska offered the Indian River subdivision. Located at the junction of the Parks Highway (Mile 168) and the Alaska Railroad (just south of Hurricane), access is available from both the Parks Highway and the railraod. The 140 separate four to five acre lots in this subdivision as well as the roads are surveyed and platted, although the roads within the subdivision are not constructed. Currently, none of the lots have any structures on them.

Because of their location, it is likely that some people will buy these lots, and, if the project proceeds, a small settlement will probably develop. Currently, there are no services here, and, even with the project, it is unlikely that a school will be constructed in the vicinity. Families that locate in the Hurricane area could use the Trapper Creek Elementary School and the Su-Valley High School; these facilities are 54 miles and 69 miles away respectively. Because of the relatively long distnce to these schools, it is unlikely that many families with children will locate in the Hurricane area. It is more reasonable to assume that single persons or couples without children will acquire lots in the Indian River subdivision and move a trailer or build a small cabin on their land.

Once the project begins, it is likely that a limited amount of services will appear near the subdivision: for example, a service station, restaurant, bar, and motel (lodge). Because no one currently lives in this area, this development will not impact an existing community. Without the project, people may purchase lots from the State, and a few persons may build recreational cabins. If the proposed access route becomes final, it is likely that people will purchase lots in the Indian River Subdivision for speculation. In this respect, the project, whether it is built or not, will influence land values in the area.

Cantwell, situated 85 road miles from Devil Canyon, lies at the extreme boundary for worker commutation to the construction site. However, in practical terms, the 41 highway miles between Hurricane and Cantwell are winding and seasonally hazardous. This distance, combined with lack of available private property, makes it unlikely for construction workers or secondary or induced work forces to make Cantwell their place of primary residence.

This is not to say that Cantwell will not see itself as significantly affected by the design of the project. Briefly, the growth and development of Cantwell is limited by unavailability of private land and of economic opportunity (jobs or business). As a consequence, neither incoming populations nor the school children of current residents perceive much opportunity to settle in this otherwise attractive locale. Many local residents rely on seasonal and/or nonlocal employment in order to continue to reside in Cantwell.

In order for Cantwell residents to participate effectively in the project, they will be compelled to move closer, individually, to the job site during the construction period (similar to workers coming from Anchorage or Fairbanks). While they may receive somewhat more highway traffic and highway business due to generally increased activity within the region as a whole, these benefits are likely to be offset by the personal, familial, and economic costs of temporary and permanent outmigration.

(b) Region

Table 5.38 summarizes the major impacts of the Susitna hydroelectric project on Impact Area 3 (the Railbelt).

(i) Population

The Susitna project is expected to stimulate a population influx of 2,324 between 1983 and 1990 into Impact Area 3. This will represent less than a one percent increase over the baseline forecast for that year. Of this total, 1,137 will relocate in the Municipality of Anchorage. The population impact on Fairbanks is expected to be slight. Few people are expected to settle in Cantwell due to the lack of available housing and of land to build on and distance to the project site.

(ii) Housing

No significant impacts of the project are expected on housing conditions in the Railbelt, outside of the Mat-Su Borough. The estimated vacant housing units in 1990 in Anchorage and Fairbanks alone, (4,033 and 1,200, respectively) should be far more than sufficient to accommodate the additional 482 households associated with the project.

(iii) Fiscal Impacts

Baseline and impact forecasts for expenditures in Anchorage and Fairbanks are provided in Table 5.39. The project has little impact on either city. Total expenditures in Anchorage are projected to increase one-half of one percent in 1990 due to the project and remain almost the same as baseline forecasts for 1999. Normal growth as measured by the baseline forecast will result in a 32% increase in expenditures by 1990 over 1981 levels and an 11% increase between 1990 and 1999. Increases are evenly distributed among all categories of service.

Total expenditures in Fairbanks increase eight-tenths of one percent over the baseline forecast for both 1990 and

1999. This constant rate of change is reflected by the fact that with or without the project the population in Fairbanks will increase 30 percent between 1981-1990, and 16 percent between 1990-1999. (The prevailing trend in Impact Area 2 has indicated a decrease of 50% in the total fiscal impacts between 1990 and 1999 due to a decreased rate of population growth.) Natural growth in Fairbanks without the project is projected to increase total expenditures by 35% in 1990 over 1981 levels, and by 17% in 1999 over 1990 levels. Once again, increases are evenly distributed among all categories of service.

(iv) Employment

The direct, indirect and induced employment opportunities in Impact Area 3 associated with the project are expected to reach a peak of 6,365 persons in 1990. This will result in a three percent increase over the baseline forecast level of 200,112 in that year. Residents of Impact Area 3 are expected to obtain approximately 80 percent of the new jobs created.

(v) Business Activity

The new employment opportunities created by the project will provide considerable stimulus to the Railbelt region economy during 1987-1990. Anchorage and Mat-Su Borough (particularly Trapper Creek and Talkeetna), will receive the most stimulus. Secondary manufacturing (reforming steel, for instance) could develop in Anchorage. Fairbanks, Kenai-Cook Inlet, and Palmer, Wasilla, and Houston will receive significant stimulus. Industry sectors that will be most affected include: construction, transportation, wholesale and retail trade, real estate, and services.

If the natural gas pipeline is constructed by 1987, it is probable that these sectors will experience a boom period, particularly in Fairbanks and Anchorage. Impacts elsewhere in Impact Area 3 would be much less pronounced. In this case, the employment opportunities made available by the Susitna project could serve to help prevent the Fairbanks and Anchorage economies from stagnating or possibly even retrenching upon completion of the pipeline.

(vi) Income

Construction of the Watana and Devil Canyon dams will generate approximately $834.3 million in direct on-site construction payroll during the years 1983 through 2002. Based on assumptions of construction work force expenditure patterns, it is estimated that approximately 50 percent, or $418 million, of this payroll distributed will be spent in Impact Area 3. This figure represents 80 percent of total expendable payroll after taxes and savings are subtracted. The income generated and expended in Impact Area 3 is a contributing factor to the indirect and induced employment opportunities in Impact Area 3 outlined above.

5.6 - Mitigation Process

Mitigation refers to the process of lessening the harsh or undesirable effects that transpire as a result of a certain action. The definitions of harsh and undesirable are purely subjective and are voiced as a community consensus. Each individual within the community will have different definitions and in all likelihood, each individual's definitions will change with time.

An individual's, or community's attitude toward change, and rate of change, is an important consideration in developing an effective mitigation plan. Attitudes toward change, ways of mitigating change, and developing mitigation plans are elements discussed below as they relate to potential socioeconomic changes resulting from the Susitna Hydroelectric Project.

(a) Attitudes Toward Change

Persons in Anchorage, Fairbanks, Cantwell, and in the major communities of the southern part of the Mat-Su Borough generally favor economic growth and development in their area. Some of the residents of Trapper Creek, Talkeetna and the "railroad communities" are in favor of economic growth and development and others are against it or undecided. Most of these residents are very concerned about the types and rates of project-induced changes.

The impact analysis results of Section 5.5 indicate that Trapper Creek and Talkeetna are likely to experience significant changes at a rapid pace. Given this analysis and the current range of attitudes toward changes in these communities, it would be appropriate to consider identifying means of mitigating the changes in those communities. Further, it would be appropriate to identify means of enhancing changes in Anchorage, Fairbanks, Cantwell, and the major communities of the southern part of the Mat-Su Borough. This could be done to the extent that the changes stimulated economic growth and development at appropriate rates.

Because project-induced changes will begin to occur in the mid to late 1980s in Trapper Creek and Talkeetna, and because there will be significant population growth in both of these communities between now and the mid to late 1980s, it would be appropriate to reevaluate any mitigation plans that might be developed in the near future. The reason for this is that persons who move into these communities may have attitudes different from the current consensus of attitudes, and current residents' feelings toward changes might be different in the future from what they are now. This argument also holds for other cities and communities that could be affected by the project.

(b) Ways to Mitigate Change

Changes in Trapper Creek and Talkeetna will be caused by influxes of new residents and frequent stops by construction workers and workers who supply materials for construction. Changes will include increased employment opportunities, increased revenues for service and related businesses, increased demand for housing, schooling, and other public facilities and services, increased vehicular traffic and population density, etc. Those changes that are considered harsh or undesirable are candidates for mitigation.

In general, population influx and workers stopping in these communities could be controlled or mitigated by establishing policies and associated regulations before, during, and after dam construction. Several policy issues to consider prior to construction include: (1) type and size of construction work camp and village; (2) type, origin, pick-up points and cost (to workers) of mass transit to construction sites; (3) camp rules (e.g., whether workers are allowed to drive personal vehicles or fly chartered planes to the construction site); (4) work schedule (e.g., four weeks on, one off; or seven weeks on, two off); and (5) public use of the access roads during and after construction. Decisions on these and other policy issues will influence both the magnitude and geographic distribution of changes. As these decisions are made, communities can begin to develop policies and plans to mitigate or enhance changes in their own area.

It should be noted that, as the baseline forecasts indicate, changes are going to occur in Talkeetna and Trapper Creek regardless of the hydroelectric project. It is as important for these communities to plan for these changes as it is for them to begin to consider mitigating and enhancing changes that could occur if the hydroelectric facility is built.

(c) Developing Mitigation Plans

Mitigation planning is a dynamic process. The plan must be flexible and reevaluated at regular intervals; attitudes change and potential and actual types and rates of changes might be significantly different from previously anticipated developments.

This implies that it is essential to monitor attitudes and changes and to update forecasts of changes. For example, the impact forecasts in this report are based on a series of assumptions. These assumptions were made using the best available information and thorough, systematic research and analysis. There is no doubt that more accurate forecasts of change could be made next year or in some later year. An accurate forecast is a prerequisite to a successful mitigation and enhancement plan. If the forecast were substantially inaccurate, then the mitigation and enhancement could be totally ineffective or, worse, could make conditions less desirable rather than better. Even with accurate forecasts, the plan could fail because it reflects old attitudes that have since changed.

Every mitigation plan development process should ideally be composed of at least the following:

1. Initial impact forecasts should be made.

2. Impact areas with appropriate representation (e.g., community council, community impact task force, etc.) should be clearly defined.

3. The roles and responsibilities of government institutions and contractors involved with the project should be clearly defined.

4. An effective communication system between (2) and (3) should be established.

5. Draft mitigation and enhancement plans should be developed based on initial impact forecasts.

6. Attitudes and changes should be monitored.

7. Forecasts should be updated based on changes to date and other new information.

8. Draft mitigation and enhancement plans should be revised to reflect new attitudes and revised impact forecasts.

9. Revision of plans should occur at regular intervals.

These elements will help insure the mitigation and enhancement plans are successful. The reason that most mitigation plans have failed or have been only partially successful is that one or more of these elements were neglected.

TABLE 5.2: TOTAL RESIDENT POPULATION AND COMPONENTS OF CHANGE BY IMPACT AREA: 1970-1980

	(a) Impact Area 2 Matanuska-Susitna Borough	(b) Impact Area 3 (d) Railbelt	(c) Impact Area 4 State
1980 Census	17,766	284,166	400,481
1970 Census	6,509	204,523	302,361
Net Change	+11,257	+79,643	+98,120
Percent Change	+173	+39	+32
Change in Military Pop.	+141	-4,730	-8,102
Natural Increase (Births & Deaths)	+1,430	+45,107	+61,142
Implied Net Civilian Migration	9,686	39,266	45,080

a. Includes Impact Area 1.
b. Includes Impact Area 2.
c. Includes Impact Area 3.
d. Fairbanks, S. E. Fairbanks, Mat-Su, Anchorage, Kenai Peninsula, and Valdez-Cordova Census Divisions.

Sources: U.S. Census Bureau and Alaska Department of Labor, Administrative Services Division. Alaska's 1980 Population: A Preliminary Overview. Juneau, Ak. p. 26.

(a)

TABLE 5.2: CIVIALIAN LABOR FORCE DATA AND PERCENT UNEMPLOYED FOR SELECTED AREAS

	1970		1975		1979	
Area	Labor Force	Percent Unemployed	Labor Force	Percent Unemployed	Labor Force	Percent Unemployed
State	116,800	10.3	155,104	6.9	180,000	8.9
Study Area 3	79,347	9.9	110,283	6.1	126,110	9.0
Anchorage	51,398	8.3	65,938	5.9	78,822	7.1
Fairbanks	18,003	10.4	24,989	4.8	20,537	12.3
Kenai-Cook Inlet	5,727	17.1	8,576	8.7	10,971	12.1
Seward	938	17.1	1,255	9.2	1,494	10.9
Southeast Fairbanks	(included in Fairbanks)		2,041	3.8	2,052	10.7
Matanuska-Susitna	2,130	20.3	4,784	11.1	9,018	13.8
Valdez-Chitina-Whittier	1,151	11.5	2,700	5.3	3,216	9.5

a. By place of residence

Source: 1970 data - Alaska Department of Commerce and Economic Development, Division of Economic Enterprise.

1975 and 1979 data - Alaska Department of Labor, Research and Analysis Section.

TABLE 5.3: COMMUNITY POPULATION: MATANUSKA-SUSITNA BOROUGH CENSUS DATA 1939, 1950, 1960, 1970, 1976, 1980, 1981

Community	1939	1950	1960	1970	1976 (a)	1980 (b)	1981 (a)
Talkeetna	136	106	76	182	328	265	640
Willow	N.A.(c)	N.A.	78	38	328	134	N.A.
Wasilla	96	97	112	300	1566	1548	2168
Palmer	150	890	1181	1140	1643	2143	2567
Montana	N.A.	N.A.	39	33	76	40	N.A.
Big Lake	N.A.	N.A.	74	36	721	412	2408
Butte	N.A.	N.A.	559	448	2207	N.A.	N.A.
Chickaloon	11	N.A.	43	22	62	20	N.A.
Eska Sutton	14	54	215	89	496	N.A.	N.A.
Houston	N.A.	N.A.	N.A.	69	375	325	600

COMMUNITY POPULATION: OTHER COMMUNITIES NOT IN MATANUSKA-SUSITNA BOROUGH

Community	1950	1960	1970	1976	1980 (b)
Nenana	242	286	382	493	471
Healy	N.A.	N.A.	79	503	333
Cantwell	N.A.	85	62	N.A.	95
Denali	N.A.	N.A.	N.A.	N.A.	3
Paxson	N.A.	N.A.	20	N.A.	30
Glennallen	142	169	363	N.A.	488
Copper Center	90	151	206	N.A.	213
Gakona	50	33	88	N.A.	85
Gulkana	65	51	53	N.A.	111

a. Mat-Su Borough Survey. The methodology for these surveys differs from U.S. Census data and hence the 1976 and 1981 figures are not comparable to Census data.

b. Alaska Department of Labor, Administrative Services Division. January 1, 1981. Alaska 1980 Population: A Preliminary Overview. Juneau, Ak.

c. N.A. = Not Available.

Source: Matanuska-Susitna Borough Planning Department. April 1978. Phase I: Comprehensive Development Plan. Palmer, Ak.

TABLE 5.4: 1981 HOUSING STOCK ESTIMATES AND VACANCY RATES, BY AREAS OF MATANUSKA-SUSITNA BOROUGH

Area	Number of Units	Percent of Total	Vacancy Rate
Talkeetna	196	2.3	1.0%
Houston	229	2.7	9.6
Big Lake Special Area	1,750	20.4	49.9
Wasilla	718	8.4	6.7
Suburban[a]	3,801	44.3	6.8
Palmer	872	10.2	10.2
Other Areas	1,016	11.8	52.8
Average Mat-Su	8,582	100.0	20.6%

a. Includes an area that is outside of Palmer and Wasilla's city limits and extends west to Houston and east to Sutton.

Source: Mat-Su Borough Planning Department.

TABLE 5.5

COMPARISON OF AVERAGE PER CAPITA EXPENDITURES FOR SELECTED SOCIAL SERVICES.

	LOCAL GOVT ADMIN	POLICE	FIRE	AMBLNC	PARKS & RECR	LIBRARY	HEALTH CARE	TRANS	SEWAGE SERVICE	SOLID WASTE DISPOSAL	WATER SUPPLY	PUBLIC WORKS	ELECTRIC UTILS	ROAD MAINT
ANCHORAGE	N/A	$153	$100	$19	$56	$21	$25	$84	$91	$21	$124	N/A	N/A	N/A
FAIRBANKS	N/A	$135	$142	N/A	$35	N/A	$32	N/A	$110	N/A	$83	$102	$360	N/A
MAT-SU BR	$750	N/A	$35	$30	$50	$32	N/A	N/A	N/A	$16	N/A	N/A	N/A	$33
PALMER	$190	$190	$50	$19	$23	$33	$31	N/A	$40	N/A	$80	$250	N/A	N/A
WASILLA	$122	N/A	$34	N/A	$22	$47	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$88
HOUSTON	$54	N/A	$17	N/A	$9	N/A	N/A	N/A	N/A	$1.50	N/A	N/A	N/A	$33

Compiled from data contained in tables providing individual city expenditure data for FY 81/82.

Note: The sum of individual entries may not equal totals due to independent rounding.

TABLE 5.6
COMMUNITY FACILITIES SUMMARY

	Schools			Water	Sewer	Solid Waste Disposal	State Trooper Post	Local Police	Court System	Fire Hall	Health Center	Long Term Care Fac.	Mental Health Facility	General Hospital	Roads	Railroad	Public Transportation	Airstrip	Library	Community Building	Post Office	Park System	Power	Telephone Service	Communication/Media	Government				
	Elementary	Secondary	Higher																							Home Rule	First Class	Second Class	Unincorporated	Unified Home Rule
Nenana	*	*		*	*	*	*			*	*				*	*		*		*	*	*	*	*	*		*			
Cantwell	*					*	*				*				*	*		*		*	*		*	*	*				*	
Trapper Creek						*	*								*						*		*	*	*				*	
Talkeetna	*					*				*					*	*		*	*	*	*	*	*	*	*				*	
Willow	*					*									*	*		*	*	*	*		*	*	*				*	
Houston						*				*					*	*							*	*	*			*		
Palmer	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*				
Wasilla	*	*	*	*		*				*	*		*		*	*		*	*	*	*	*	*	*	*			*		
Paxson						*									*			*					*	*	*				*	
Glennallen	*	*				*	*		*	*	*	*		*	*			*	*	*	*		*	*	*				*	
Copper Center	*		*			*				*	*				*			*		*	*		*	*	*				*	
Gakona						*									*			*		*	*		*	*	*				*	
Healy	*	*		*	*	*	*				*				*	*		*			*		*	*	*				*	
Gulkana				*	*	*					*				*					*			*	*	*				*	
Valdez	*	*		*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*				
Anchorage	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					*
Fairbanks	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				

TABLE 5.7

MAT-SU BOROUGH COMMUNITIES:

BUSINESS LOCATION AND TYPE

Standard Industrial Classification	Number in Community (a)					
	Big Lake	Houston	Palmer	Talkeetna	Wasilla	Willow
Agriculture, Forestry, Fisheries	3	-	22	-	-	-
Mining	-	-	2	-	-	-
Construction	19	3	50	3	91	4
Manufacturing	3	-	21	2	4	3
Transportation & Public Utilities	2	-	20	8	-	6
Wholesale Trade	-	-	11	-	-	-
Retail Trade	24	3	80	19	-	18
Finance, Insurance, Real Estate	-	1	22	2	37	3
Services	17	1	115	13	129	4
Public Administration	-	1	12	3	5	-
Nonclassifiable Establishments	6	-	19	1	98	-
Total	74	9	374	51	364	38

(a) SIC classifications were assigned by the OEDP staff for use in this table, and number of establishments must be considered approximations.

Source: Overall Economic Development Program Inc. July 1980. Volume II: Economic Conditions, Development Options and Projections. Palmer, AK. pp. 19-21.

TABLE 5.8: MATANUSKA-SUSITNA BOROUGH ANNUAL NONAGRICULTURAL EMPLOYMENT BY SECTOR

	1970		1975		1979		PERCENT OF STUDY AREA 3		
							1970	1975	1979
	Total	%	Total	%	Total	%	%	%	%
TOTAL - Nonagricultural Industries (a)	1,145	100.0	2,020	100.0	3,078	100.0	1.8	1.8	2.7
Mining	N.A. (b)	-	N.A.	-	11	.3	N.A.	N.A.	.0
Construction	120	10.5	188	9.3	184	6.0	2.3	1.1	2.2
Manufacturing	N.A.	-	30	1.5	40	1.3	N.A.	1.2	1.1
Transportation, Communiciation, & Utilities	114	9.6	218	10.8	316	10.2	1.9	1.8	2.6
Wholesale Trade	174	15.2	44	2.2	49	1.6	1.4	.8	1.0
Retail Trade			271	13.4	696	22.6		1.7	3.8
Finance, Insurance, and Real Estate	22	1.9	62	3.1	129	4.2	.8	1.3	2.1
Services	179	15.6	288	14.3	447	14.5	2.0	1.4	2.3
Federal Government	106	9.3	124	6.1	97	3.1	.9	1.0	.8
State and Local Government	376	32.8	758	37.5	1,101	35.8	3.2	4.3	5.2
Miscellaneous	N.A.	-	N.A.	-	21	.7	N.A.	N.A.	1.8

a. Figures may not total correctly because of averaging and disclosure limitations on data.

b. N.A.: Data unavailable due to disclosure policy.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, Ak.

TABLE 5.9 PER CAPITA PERSONAL INCOME IN THE MAT-SU BOROUGH IN CURRENT AND 1970 DOLLARS

Year	Per Capita Personal Income: Current Dollars	Per Capita Personal Income: In 1970 Dollars[a]
1970	3,957	3,957
1971	4,279	4,150
1972	4,539	4,286
1973	4,970	4,526
1974	6,068	5,011
1975	8,092	5,855
1976	8,542	5,718
1977	9,032	5,666
1978	8,939	5,231
1979	8,878	4,704

a. Discounted using the Anchorage Consumer Price Index - Unadjusted (CPI-U) as a measure of inflation.

Source: U.S. Department of Commerce, Bureau of Economic Analysis.

TABLE 5.10: 1981 CIVILIAN HOUSING STOCK IN THE MUNICIPALITY OF ANCHORAGE, BY TYPE

Type of Unit	Number of Units	Percent of Total
Single Family[a]	30,097	45.8
Duplex	6,040	9.2
3-4 Units	6,211	9.4
5-19 Units	9,356	14.2
20+ Units	6,036	9.2
Mobile Homes	8,031	12.2
In Parks	6,146	9.3
On Lots	1,885	2.9
Total	65,771	100.0

a. Excluding mobile homes

Source: Municipality of Anchorage Planning Department

TABLE 5.22: HOUSING STOCK IN FAIRBANKS AND THE FAIRBANKS-NORTH STAR BOROUGH BY TYPE, OCTOBER 1978

	Fairbanks-North Star Borough	Municipality of Fairbanks
Single Family[a]	6,849	3,312
Duplex	690	714
Multifamily	3,832	3,187
Mobile Homes	2,097	138
Total	13,738	7,351

a. Excluding mobile homes.

Source: Fairbanks North Star Borough Community Information Center. Community Information Quarterly: Summer 1980. Volume III, Number 2, p. 70.

TABLE 5.22: RAILBELT ANNUAL NONAGRICULTURAL EMPLOYMENT BY SECTOR

	1970 Total	1970 %	1975 Total	1975 %	1979 Total	1979 %	PERCENT OF STATE 1970 %	PERCENT OF STATE 1975 %	PERCENT OF STATE 1979 %
TOTAL[a] - Nonagricultural Industries	62,690	100.0	113,818	100.0	113,204	100.0	67.8	70.4	68.0
Mining	1,610	2.6	2,243	2.0	2,822	2.5	53.7	59.2	48.9
Construction	5,264	8.4	16,359	14.4	8,257	7.3	76.3	63.3	81.8
Manufacturing	1,850	3.0	2,596	2.3	3,705	3.3	23.7	26.9	28.9
Transportation, Communitication, & Utilities	6,021	9.6	12,094	10.6	12,062	10.7	66.2	73.4	72.2
Wholesale Trade			5,366	4.7	5,083	4.5		90.8	92.2
	12,111	19.3					79.2		
Retail Trade			15,965	14.0	18,309	16.2		78.6	76.7
Finance, Insurance, and Real Estate	2,520	4.0	4,696	4.1	6,139	5.4	81.3	77.9	76.7
Services	8,868	14.1	20,995	18.4	19,674	17.4	77.8	83.5	69.4
Federal Government	12,372	19.7	13,022	11.4	12,728	11.2	72.4	71.2	71.0
State and Local Government	11,585	18.5	17,799	15.6	21.130	18.7	62.6	60.9	57.7
Miscellaneous	52	.1	217	.2	712	.6	26	19.0	98.9

a. Figures may not total correctly because of averaging and disclosure limitations on data.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, Ak. (various issues)

TABLE 5.13: ON-SITE CONSTRUCTION AND OPERATIONS MANPOWER REQUIREMENTS, 1983-2005[a]

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
CONSTRUCTION												
LABORERS	140	55	562	843	1279	1693	1897	2369	2202	1723	894	549
SEMI-SKILLED/SKILLED	120	139	148	323	355	448	502	627	583	422	220	136
ADMINISTRATIVE/ENGINEER.	40	106	390	184	268	359	402	502	467	355	185	115
SUB-TOTAL CONSTRUCTION	300	300	1100	1350	1902	2500	2801	3498	3252	2500	1299	800
OPERATIONS AND MAINTENANCE												
ALL LABOR CATEGORIES											70	145
TOTAL	300	300	1100	1350	1902	2500	2801	3498	3252	2500	1369	945

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CONSTRUCTION											
LABORERS	338	539	844	1076	1144	1002	507	105			
SEMI-SKILLED/SKILLED	92	148	230	295	312	308	234	24			
ADMINISTRATIVE/ENGINEER.	71	115	176	229	243	187	159	22			
SUB-TOTAL CONSTRUCTION	501	802	1250	1600	1699	1497	900	151			
OPERATIONS AND MAINTENANCE											
ALL LABOR CATEGORIES	145	145	145	145	145	145	145	170	170	170	170
TOTAL	646	947	1395	1745	1844	1642	1045	321	170	170	170

(5)05

(a) Supplied by Acres American, Inc.

TABLE 5.14: ON-SITE CONSTRUCTION WORKFORCE: LOCAL, ALASKA NONLOCAL, AND OUT-OF STATE, 1983-2000

LOCAL	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
LABORERS (85%)	119	47	478	717	1087	1439	1612	2014	1872	1465	760	467	287	458	717	915	972	852	431	89
SEMI-SKILLED/ SKILLED (80%)	96	112	118	258	284	359	402	502	466	337	176	109	74	118	184	236	250	246	187	19
ADMINISTRATIVE/ ENGINEERING (65%)	26	69	254	120	174	233	261	326	304	231	120	75	46	75	114	149	158	122	103	14
SUBTOTAL LOCAL	241	227	850	1094	1545	2031	2276	2842	2642	2033	1056	650	407	651	1016	1299	1380	1220	722	122
NON-LOCAL																				
ALASKA NON-LOCAL																				
LABORERS (5%)	7	3	28	42	64	85	95	118	110	86	45	27	17	27	42	54	57	50	25	5
SEMI-SKILLED/ SKILLED (5%)	6	7	7	16	18	22	25	31	29	21	11	7	5	7	11	15	16	15	12	1
ADMINISTRATIVE/ ENGINEERING (5%)	2	5	20	9	13	18	20	25	23	18	9	6	4	6	9	11	12	9	8	1
SUB-TOTAL ALASKA NON-LOCAL	15	15	55	67	95	125	140	175	163	125	65	40	25	40	62	80	85	75	45	7
OUT-OF-STATE																				
LABORERS (10%)	14	6	56	84	128	169	190	237	220	172	89	55	34	54	84	108	114	100	51	11
SEMI-SKILLED/ SKILLED (15%)	18	21	22	48	53	67	75	94	87	63	33	20	14	22	34	44	47	46	35	4
ADMINISTRATIVE/ ENGINEERING (30%)	12	32	117	55	80	108	121	151	140	107	56	35	21	35	53	69	73	56	48	7
SUB-TOTAL OUT-OF-STATE	44	58	195	188	262	344	386	482	448	342	178	110	69	111	172	221	234	202	134	21
TOTAL NON-LOCAL	59	73	250	255	357	469	526	656	610	467	243	150	94	151	234	301	319	277	179	28
TOTAL	300	300	1100	1350	1902	2500	2801	3498	3252	2500	1299	800	501	802	1250	1600	1699	1497	900	151

TABLE 5.15: OPERATIONS WORK FORCE: LOCAL, ALASKA NON LOCAL, AND OUT-OF-STATE, 1993-2005

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Activity													
Watana (680 MW)	30	60	60	60	60	60	60	60	60	60	60	60	60
Watana (340 MW)		45	45	45	45	45	45	45	45	45	45	45	45
Devil Canyon (600 MW)										25	25	25	25
Dispatch Control	40	40	40	40	40	40	40	40	40	40	40	40	40
Total	70	145	145	145	145	145	145	145	145	170	170	170	170

TABLE 5.16: TOTAL PAYROLL FOR ON-SITE CONSTRUCTION AND OPERATIONS MANPOWER, 1983-2005
(IN THOUSANDS OF DOLLARS)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CONSTRUCTION (a)																							
LABORERS	3895	1258	16847	25323	38319	50739	56863	70984	65985	51529	26806	16543	10186	16141	25433	32211	34255	29892	14950	3114			
SEMI-SKILLED/ SKILLED	2607	3468	3671	9162	9441	11750	13169	16440	15282	10643	5475	3389	2383	3871	5952	7725	8189	8182	6438	574			
ADMINISTRATIVE/ ENGINEER	940	2342	8159	3810	5555	7436	8334	10404	9671	7362	3842	2378	1465	2374	3655	4737	5038	3946	3289	492			
SUBTOTAL CONSTRUCTION	7442	7068	28677	38295	53315	69925	78366	97828	90938	69534	36123	22310	14034	22386	35040	44673	47482	42020	24677	4180			
OPERATIONS (b)																							
ALL LABOR CATEGORIES											2684	5559	5559	5559	5559	5559	5559	5559	5559	6517	6517	6517	6517
TOTAL PAYROLL (7)02	7442	7068	28677	38295	53315	69925	78366	97828	90938	69534	38807	27869	19593	27945	40599	50232	53041	47579	30236	10697	6517	6517	6517

(a) Based on 1,825 working hours in the year.

(b) Based on 2,496 working hours in the year.

TABLE 5.17: TOTAL ON-SITE CONSTRUCTION WORK FORCE PAYROLL EXPENDITURE PATTERN[(a)]
(IN THOUSANDS OF DOLLARS)

PLACE OF EXPENDITURE	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL PAYROLL [(b)]	7442	7068	28677	38295	53315	69925	78366	97828	90938	69534	36123	22310	14034	22386	35040	44673	47482	42020	24677	4180
EXPENDABLE INCOME [(c)]	4149	3886	15760	21385	29757	39020	43729	54589	50746	38803	20157	12457	7838	12499	19553	25583	27789	26109	15517	2603
IMPACT AREA 3	3658	3282	13452	18946	26383	34588	38763	48390	44982	34417	17877	11046	6949	11079	17337	22750	24779	23495	13854	2339
ANCHORAGE REGION	2796	2509	10282	14480	20548	26947	30202	37709	35052	26815	13916	8588	5394	8613	13494	17715	19296	18293	10771	1795
ANCHORAGE	2045	1833	7525	10596	14104	18475	20698	25825	24010	18385	9576	5938	3756	5955	9289	12169	13250	12565	7429	1308
MAT-SUE REGION	433	399	1607	2228	4353	5728	6428	8042	7471	5696	2924	1778	1092	1784	2833	3741	4078	3856	2251	307
KENAI-COOK INLET	313	272	1130	1627	2051	2692	3017	3768	3502	2681	1389	856	536	858	1346	1770	1931	1836	1070	177
SEWARD	6	5	20	29	40	53	59	74	69	53	27	17	11	17	26	35	38	36	21	4
FAIRBANKS	796	716	2930	4119	5352	7008	7851	9794	9106	6971	3633	2255	1429	2262	3526	4618	5028	4769	2829	501
SE FAIRBANKS	5	4	18	25	36	47	52	65	61	46	24	15	9	15	23	31	33	32	19	3
VALDEZ-CHITINA-WHITTIER	62	54	223	321	447	587	657	821	763	584	303	187	118	188	294	386	421	401	235	40

(a) Table shows total expenditures by construction work force in Impact Area 3.

(b) Total construction payroll, all labor categories.

(c) Gross payroll minus 30 percent for taxes (federal, F.I.C.A., and unemployment/workman's compensation with self and one dependent) minus 10 percent for net income saved.

TABLE 5.18: TOTAL OPERATIONS WORK FORCE PAYROLL EXPENDITURE PATTERN[a]
In Thousands of Dollars

Place of Expenditure[b]	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Payroll[c]	2,684	5,559	5,559	5,559	5,559	5,559	5,559	5,559	5,559	6,517	6,517	6,517	6,517
Expendable Income[d]	1,691	3,502	3,502	3,502	3,502	3,502	3,502	3,502	3.502	4,106	4,106	4,106	4,106
Village	1,015	2,101	2,101	2,101	2,101	2,101	2,101	2,101	2,101	2,464	2,464	2,464	2,464
Anchorage	338	700	700	700	700	700	700	700	700	821	821	821	821
Fairbanks	85	175	175	175	175	175	175	175	175	205	205	205	205
Mat-Su	253	526	526	526	526	526	526	526	526	616	616	616	616

(a) Table shows total expenditures by operations work force in selected areas.

(b) Assumed that 60 percent of payroll to be spent at Village; 15 percent in the Mat-Su Brorough; 20 percent in Anchorage; and 5 percent in Fairbanks.

(c) Total Operations Payroll.

(d) Gross payroll minus 30 percent for taxes (federal, FICA, and unemployment/ workman's compensation with self and one dependent) minus 10 percent for net income saved.

TABLE 5.19: ON-SITE CONSTRUCTION WORK FORCE: PROJECT EMPLOYMENT AND RESIDENCE OF INDIVIDUALS CURRENTLY RESIDING IN IMPACT AREA 3

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
IMPACT AREA 3	241	227	850	1094	1545	2031	2276	2842	2642	2033	1056	650	407	651	1016	1299	1380	1220	722	122
ANCHORAGE REGION	178	168	627	808	1141	1499	1679	2097	1949	1500	779	480	300	480	750	959	1019	900	532	90
ANCHORAGE	135	127	475	612	864	1135	1272	1588	1477	1136	590	363	228	364	568	726	772	682	403	68
MAT-SU	16	15	58	74	104	137	153	191	178	137	71	44	27	44	68	87	93	82	49	8
KENAI-COOK INLET	27	25	94	121	172	225	253	315	293	226	117	72	45	72	113	144	153	135	80	14
SEWARD	0	0	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
FAIRBANKS	57	54	202	260	368	483	542	676	629	484	251	155	97	155	242	309	329	290	172	29
SE FAIRBANKS	0	0	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
VALDEZ-CHITINA-WHITTIER	5	5	18	23	32	43	48	60	55	43	22	14	9	14	21	27	29	26	15	3
MAT-SU COMMUNITIES																				
PALMER	2	2	6	7	10	14	15	19	18	14	7	4	3	4	7	9	9	8	5	1
WASILLA	1	1	5	6	8	11	12	15	14	11	6	4	2	4	5	7	7	7	4	1
HOUSTON	0	0	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
TRAPPER CREEK	0	0	1	1	1	1	2	2	2	1	1	0	0	0	1	1	1	1	1	0
TALKEETNA	1	1	2	3	4	5	6	8	7	5	3	2	1	2	3	4	4	3	2	0
OTHER	12	11	42	54	77	101	113	141	131	101	52	32	20	32	50	65	69	61	36	6

(11)05

TABLE 5.20: ON-SITE CONSTRUCTION WORK FORCE: INMIGRATION AND PLACE OF RELOCATION IN IMPACT AREA 3

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL IMPACT AREA 3	16	16	54	67	93	122	137	170	158	140	111	98	91	91	91	100	102	98	84	65
ANCHORAGE REGION	12	12	41	51	99	131	147	184	175	160	137	128	122	122	122	129	131	127	116	101
ANCHORAGE	5	5	17	20	-37	-51	-57	-73	-76	-80	-86	-89	-91	-91	-91	-89	-88	-89	-92	-97
MAT-SU	7	7	23	29	152	202	227	285	279	267	253	247	243	243	243	248	249	246	239	229
KENAI-COOK INLET	0	0	1	2	-14	-18	-20	-25	-26	-26	-27	-28	-28	-28	-28	-28	-28	-28	-28	-29
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	4	4	13	16	-8	-11	-12	-16	-19	-23	-29	-31	-33	-33	-33	-31	-30	-32	-34	-39
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MAT-SU COMMUNITIES																				
PALMER	0	0	1	1	6	8	9	11	11	11	10	10	10	10	10	10	10	10	10	9
WASILLA	0	0	1	1	8	10	11	14	14	13	13	12	12	12	12	12	12	12	12	11
HOUSTON	0	0	1	1	6	8	9	11	11	11	10	10	10	10	10	10	10	10	10	9
TRAPPER CREEK	2	2	6	7	38	50	57	71	70	67	63	62	61	61	61	62	62	62	60	57
TALKEETNA	2	2	6	7	38	50	57	71	70	67	63	62	61	61	61	62	62	62	60	57
OTHER	2	3	9	11	56	75	84	105	103	99	94	91	90	90	90	92	92	91	88	85

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TABLE 5.21: TOTAL LOCAL IMPACT AREA 3 EMPLOYMENT: ON-SITE CONSTRUCTION, INDIRECT AND INDUCED

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
IMPACT AREA 3	408	386	1475	1897	2664	3609	4043	5049	4768	3669	1907	1175	736	1176	1875	2399	2548	2288	1356	232
ANCHORAGE REGION	318	300	1156	1487	2099	2866	3212	4010	3751	2886	1499	923	579	925	1483	1897	2016	1792	1061	181
ANCHORAGE	250	236	917	1180	1608	2193	2456	3066	2851	2194	1142	705	444	706	1140	1457	1547	1368	812	142
MAT-SU	32	30	111	142	264	375	421	526	489	375	193	117	72	117	185	239	254	224	131	18
KENAI-COOK INLET	36	34	127	163	225	296	332	414	408	314	163	100	63	100	157	200	213	199	117	20
SEWARD	1	1	2	3	4	5	6	7	7	5	3	2	1	2	3	3	4	3	2	0
FAIRBANKS	83	79	294	378	521	684	766	957	942	725	377	233	146	233	363	464	493	460	273	47
SE FAIRBANKS	1	1	2	3	4	5	5	7	6	5	2	2	1	2	2	3	3	3	2	0
VALDEZ-CHITINA-WHITTIER	6	6	22	28	39	52	58	72	67	52	27	17	10	17	26	33	35	33	19	3
MAT-SU COMMUNITIES																				
PALMER	3	3	10	13	22	31	35	44	41	31	16	10	6	10	15	20	21	19	11	2
WASILLA	2	2	9	11	20	28	31	39	37	28	14	9	5	9	14	18	19	17	10	1
HOUSTON	1	1	4	5	10	14	16	20	18	14	7	4	3	4	7	9	9	8	5	1
TRAPPER CREEK	1	1	2	3	10	15	17	22	20	15	8	5	3	5	7	10	10	9	5	0
TALKEETNA	2	2	7	9	29	43	49	61	57	43	22	13	8	13	21	27	29	26	15	2
OTHER	22	21	79	101	172	243	272	341	317	243	125	76	47	77	120	155	165	145	85	13

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TABLE 5.22: TOTAL INMIGRATION INTO IMPACT AREA 3: ON-SITE CONSTRUCTION, INDIRECT AND INDUCED

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
IMPACT AREA 3	64	62	236	300	425	592	664	828	783	621	361	252	188	245	345	425	448	409	269	96
ANCHORAGE REGION	55	53	205	261	401	562	630	787	739	574	363	267	209	261	353	424	444	406	281	129
ANCHORAGE	43	41	164	210	211	302	337	419	382	273	98	25	-19	24	100	155	170	139	44	-72
MAT-SU	10	10	34	42	196	268	301	378	365	335	287	267	255	263	275	289	293	285	262	231
KENAI-COOK INLET	2	2	7	9	-5	-6	-6	-8	-6	-11	-19	-23	-25	-23	-20	-18	-17	-17	-22	-28
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	8	8	30	37	19	25	27	33	37	20	-7	-18	-24	-19	-11	-4	-2	-2	-17	-35
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	2	2	3	4	4	5	5	4	2	1	1	1	2	2	3	3	2	0
MAT-SU COMMUNITIES																				
PALMER	0	0	1	2	7	10	11	14	14	13	11	10	10	10	11	11	11	11	10	9
WASILLA	0	0	2	2	9	12	13	17	16	15	14	13	13	13	13	14	14	13	13	12
HOUSTON	0	0	1	1	7	9	10	13	13	12	11	10	10	10	10	11	11	11	10	9
TRAPPER CREEK	3	3	9	12	60	83	93	117	112	100	80	71	67	71	77	82	84	81	71	58
TALKEETNA	2	2	7	9	46	63	71	89	86	80	70	65	63	65	67	70	71	69	64	58
OTHER	4	4	13	16	67	90	102	128	124	115	102	96	93	95	98	102	103	101	94	85

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TABLE 5.23: TOTAL POPULATION INFLUX INTO IMPACT AREA 3: DIRECT, INDIRECT AND INDUCED

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
IMPACT AREA 3	182	178	672	852	1203	1671	1867	2324	2191	1735	1014	714	535	690	957	1170	1228	1122	743	278
ANCHORAGE REGION	157	152	583	739	1139	1589	1777	2214	2075	1669	1027	761	602	742	986	1177	1229	1122	788	378
ANCHORAGE	122	117	463	590	578	826	919	1137	1030	725	242	42	-77	35	240	385	425	339	84	-225
MAT-SU	28	29	99	123	580	789	886	1112	1074	988	852	796	763	784	817	856	866	844	778	694
KENAI-COOK INLET	6	6	21	26	-16	-20	-23	-28	-22	-37	-60	-70	-76	-71	-64	-57	-55	-54	-68	-85
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	24	24	85	107	52	66	72	88	96	49	-26	-57	-75	-62	-41	-20	-14	-15	-56	-107
SE FAIRBANKS	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	1	1	5	6	8	11	12	15	14	11	5	3	2	3	5	7	7	8	5	1
MAT-SU COMMUNITIES																				
PALMER	1	1	4	5	22	30	33	42	40	38	33	31	30	31	32	33	33	33	31	28
WASILLA	1	1	5	6	26	36	40	50	49	46	41	39	37	38	39	40	41	40	38	35
HOUSTON	1	1	3	4	20	27	31	38	37	35	32	31	30	30	31	32	32	31	30	28
TRAPPER CREEK	8	8	27	34	175	242	272	341	327	291	235	212	198	209	225	241	245	236	209	175
TALKEETNA	6	7	22	27	138	186	209	263	254	236	208	196	189	193	199	207	210	205	191	173
OTHER	11	11	37	46	199	268	301	378	366	342	304	288	278	284	291	302	305	299	280	257

(23)06

TABLE 5.24: TOTAL SCHOOL-AGE CHILDREN ACCOMPANYING IMMIGRANT WORKERS: ON-SITE CONSTRUCTION, INDIRECT AND INDUCED[a]

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
TOTAL IMPACT AREA 3	44	43	160	203	286	400	449	562	533	426
ANCHORAGE REGION	37	36	138	175	273	382	430	538	507	412
ANCHORAGE	29	27	108	137	127	183	206	257	234	163
MAT-SU	7	8	26	32	152	207	233	292	283	262
KENAI-COOK INLET	1	1	5	6	-5	-7	-8	-10	-8	-12
SEWARD	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	6	6	21	27	11	14	15	19	20	9
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	1	1	2	2	3	3	3	2
MAT-SU COMMUNITIES										
PALMER	0	0	1	1	6	8	9	11	11	10
WASILLA	0	0	1	2	7	9	11	13	13	12
HOUSTON	0	0	1	1	5	7	8	10	10	9
TRAPPER CREEK	2	2	7	9	45	62	70	88	85	76
TALKEETNA	2	2	6	7	36	49	55	70	68	63
OTHER	3	3	10	12	53	71	80	100	97	91

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL IMPACT AREA 3	253	181	138	176	242	297	313	287	191	74
ANCHORAGE REGION	259	195	157	191	252	300	315	289	205	101
ANCHORAGE	49	2	-27	1	52	89	99	79	15	-63
MAT-SU	229	215	206	212	220	230	233	227	210	189
KENAI-COOK INLET	-17	-20	-21	-20	-18	-16	-16	-15	-19	-23
SEWARD	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	-9	-17	-21	-18	-13	-7	-6	-6	-16	-29
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	1	1	1	1	1	2	2	2	1	0
MAT-SU COMMUNITIES										
PALMER	9	8	8	8	9	9	9	9	8	8
WASILLA	11	10	10	10	11	11	11	11	10	9
HOUSTON	9	8	8	8	8	9	9	8	8	8
TRAPPER CREEK	62	57	53	56	60	64	65	63	56	47
TALKEETNA	56	53	51	52	54	56	56	55	52	47
OTHER	82	78	75	77	79	82	82	81	76	70

(30103

(a) Calculated by applying a ratio of .86 school-age children per accompanied immigrant worker to the number of accompanied immigrants; these data assume that 95 percent of immigrant workers are accompanied.

TABLE 5.25: TOTAL PRIMARY SCHOOL-AGE CHILDREN ACCOMPANYING INMIGRANT WORKERS INTO IMPACT AREA 3: ON-SITE CONSTRUCTION, INDIRECT, AND INDUCED (a)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL IMPACT AREA 3	24	23	87	110	155	216	243	304	289	231	137	98	75	95	131	161	169	155	104	40
ANCHORAGE REGION	20	20	75	95	148	207	233	292	275	223	140	106	85	104	137	163	171	157	111	55
ANCHORAGE	15	15	58	74	68	99	111	138	126	88	26	0	-15	0	27	47	53	42	8	-34
MAT-SU	4	4	14	17	83	113	127	159	154	143	125	117	113	116	120	125	127	124	115	103
KENAI-COOK INLET	1	1	3	3	-3	-4	-4	-5	-4	-6	-9	-11	-11	-11	-10	-9	-9	-8	-10	-13
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	3	3	12	14	6	7	8	10	11	5	-5	-9	-12	-10	-7	-4	-3	-3	-9	-16
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	1	1	1	1	1	2	2	1	1	0	0	0	1	1	1	1	1	0
MAT-SU COMMUNITIES																				
PALMER	0	0	1	1	3	4	5	6	6	5	5	5	4	5	5	5	5	5	5	4
WASILLA	0	0	1	1	4	5	6	7	7	7	6	6	6	6	6	6	6	6	6	5
HOUSTON	0	0	0	1	3	4	4	6	5	5	5	5	4	4	5	5	5	5	4	4
TRAPPER CREEK	1	1	4	5	24	34	38	48	46	41	34	31	29	31	33	35	36	34	31	26
TALKEETNA	1	1	3	4	20	27	30	38	37	34	31	29	28	28	29	30	31	30	28	26
OTHER	2	2	5	7	29	39	44	55	53	50	45	43	41	42	43	45	45	44	41	38

(30)04

(a) Calculated by applying a ratio of .47 primary school-age children per accompanied worker to the number of accompanied inmigrants; these data assume 95 percent of inmigrant workers are accompanied.

TABLE 5.26: TOTAL SECONDARY SCHOOL-AGE CHILDREN ACCOMPANYING INMIGRANT WORKERS INTO IMPACT AREA 3: ON-SITE CONSTRUCTION, INDIRECT, AND INDUCED (a)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL IMPACT AREA 3	20	20	74	93	131	183	206	258	244	195	116	83	63	80	111	136	143	131	87	34
ANCHORAGE REGION	17	17	63	80	125	175	197	247	232	189	118	89	71	87	115	138	144	132	93	46
ANCHORAGE	13	13	49	63	59	85	95	119	108	76	23	1	-12	1	24	41	46	37	7	-28
MAT-SU	3	3	12	14	69	94	106	133	129	119	104	97	94	96	100	104	106	103	95	86
KENAI-COOK INLET	1	1	2	3	-2	-3	-3	-4	-4	-5	-8	-9	-9	-9	-8	-7	-7	-7	-9	-10
SEWARD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAIRBANKS	3	3	10	12	5	6	7	9	10	4	-4	-7	-10	-8	-6	-3	-2	-3	-7	-13
SE FAIRBANKS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALDEZ-CHITINA-WHITTIER	0	0	0	1	1	1	1	2	1	1	1	0	0	0	1	1	1	1	1	0
MAT-SU COMMUNITIES																				
PALMER	0	0	0	1	3	4	4	5	5	5	4	4	4	4	4	4	4	4	4	3
WASILLA	0	0	1	1	3	4	5	6	6	6	5	5	5	5	5	5	5	5	5	4
HOUSTON	0	0	0	1	2	3	4	5	5	4	4	4	4	4	4	4	4	4	4	3
TRAPPER CREEK	1	1	3	4	20	28	32	40	39	35	28	26	24	25	27	29	30	29	26	22
TALKEETNA	1	1	3	3	17	22	25	32	31	29	25	24	23	24	24	25	26	25	23	21
OTHER	1	1	4	5	24	32	36	46	44	42	37	35	34	35	36	37	37	37	34	32

(30105

(a) Calculated by applying a ratio of .39 secondary school-age children per accompanied worker to the number of accompanied inmigrants; these data assume 95 percent of inmigrant workers are accompanied.

TABLE 5.27: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON MATANUSKA-SUSITNA BOROUGH

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	22,285	42,964	44,076[a]	1,112[a]	2.6[a]	66,338	67,204[a]	866[a]	1.3[a]
Employment[b]	N.A.	4,002	6,914	10,842	3,928	56.8	9,505	11,554	2,049	21.6
Housing Demand (no. of units)	8,582	6,810	14,417	14,791	374	2.6	24,670	24,992	322	1.3
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Solid Waste Disposal (acres per year)	617	2.5	6.7	6.9	0.2	2.5	13.6	13.8	0.2	1.3
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	20	20	38	40-42	2-4	5.3	60	61	1	1.7
Education (primary students)	3,136	2,388	5,406	5,565	159	2.9	8,884	9,011	127	1.4
(secondary students)	3,380	2,141	4,605	4,738	133	2.9	7,568	7,674	106	1.4
Hospital Beds	23	20	60	61	1	1.7	109	110	1	0.9
Community Parks (acres)[c]	0	-	80	82	2	2.4	133	135	2	1.5

N.A. - Not Applicable

(a) Population increase refers to population influx in Mat-Su Borough communities, and does not include population residing only at work camp/village.
(b) By place of employment.
(c) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE 5.28: SUMMARIZED FISCAL IMPACTS OF THE PROJECT ON THE MAT-SU BOROUGH

General Fund:

REVENUES ($000)	Property Taxes	School Debt Service Reimburesment	Municipal Assistance	Federal Revenue Sharing	Misc. Revenues	General Fund Total Revenues	Service Area Fund Total Revenues	Land Management Fund Total Rev.$	Total Bonded Indebtedness
1981 Current	5,719	3,635	1,900	535	328	12,117	1,190	944	67,019
1990 Baseline Forecast	8,395	8,761	3,663	1,031	1,511	23,361	2,547	1,821	95,389
1990 Forecast W. Project	8,807	8,987	3,758	1,057	1,358	23,967	3,263	1,868	97,857
Impact of Project	412	226	95	26	-153	606	716	47	2,468
% Change	4.91	6.22	2.59	2.52	-10.13	2.59	28.11	2.58	2.59
1999 Baseline Forecast	11,949	13,527	5,656	1,592	3,347	36,071	3,623	2,811	135,769
1999 Forecast W. Project	12,379	13,703	5,730	1,613	3,117	36,542	4,584	2,848	137,540
Impact of Project	430	176	74	21	-230	471	961	37	1,771
% Change	3.60	1.3	1.31	1.32	-6.87	1.31	26.52	1.32	1.30

EXPENDITURES ($000)	Areawide Admin.	Ambulance	Sanitary Landfill	Library	Fire Service	Parks & Rec.	Land Mgmt. Program	Road Maint. & Repair	Total Expenses
1981 Current	11,151	688	357	713	780	1,114	1,114	797	16,714
1990 Baseline Forecast	21,019	1,353	722	1,375	1,578	2,148	2,148	1,880	32,223
1990 Forecast W. Project	21,611	1,388	740	1,410	1,620	2,204	2,204	1,880	33,057
Impact of Project	592	35	18	35	42	56	56	0	834
% Change	2.82	2.82	2.49	2.55	2.66	2.61	2.61	0	2.59
1999 Baseline Forecast	30,876	2,110	1,114	2,123	2,462	3,317	3,317	4,434	49,753
1999 Forecast W. Project	31,337	2,138	1,129	2,151	2,494	3,360	3,360	4,434	50,403
Impact of Project	461	28	15	28	32	43	43	0	650
% Change	1.49	1.33	1.35	1.32	1.30	1.30	1.30	0	1.31

Forecasts in 1981 $.

Selected years from forecasts prepared by Frank Orth & Associates, Inc.

TABLE 5.29: SUMMARIZED FISCAL IMPACTS OF THE PROJECT ON THE MAT-SU BOROUGH SCHOOL DISTRICT

REVENUES ($000)[1]	State Foundation Program Revenue	State Trans. Revenue	Total State Revenues	Local Property Taxes	Federal Revenues	Total Revenues
1981 Current	15,030	2,106	17,136	5,362	1,404	23,901
1990 Baseline Forecast	33,758	4,505	38,263	7,631	3,003	48,897
1990 Forecast W. Project	34,746	4,637	39,383	7,828	3,091	50,105
Impact of Project	988	132	1,120	197	88	1,208
% Change	2.93	2.93	2.93	2.58	2.93	2.47
1999 Baseline Forecast	55,478	7,403	62,881	10,861	4,936	78,678
1999 Forecast W. Project	56,260	7,508	63,768	11,003	5,005	79,634
Impact of Project	782	105	887	142	69	956
% Change	1.41	1.42	1.41	1.32	1.40	1.22

EXPENDITURES ($000)	Regular Instruction	Vocational Instruction	Special Education	Support Services	Operations and Maintenance	Pupil Trans-portation	Other[2]	Total Expends
1981 Current	8,726	1,058	1,587	4,760	5,024	2,115	3,173	26,442
1990 Baseline Forecast	17,819	1,188	5,940	10,691	10,691	5,940	7,127	59,395
1990 Forecast W. Project	18,340	1,223	6,113	11,004	11,004	6,113	7,336	61,134
Impact of Project	521	35	173	313	313	173	209	1,739
% Change	2.92	2.95	2.91	2.93	2.93	2.91	2.93	2.93
1999 Baseline Forecast	29,283	1,952	9,761	17,570	17,570	9,761	11,713	97,610
1999 Forecast W. Project	29,696	1,980	9,899	17,818	17,818	9,899	11,878	98,986
Impact of Project	413	28	138	248	248	138	165	1,376
% Change	1.4	1.43	1.41	1.41	1.41	1.41	1.41	1.41

1. Revenues do not include State Reimbursement for School Debt Service Payments. See General Fund Table 5.28.

2. This category includes some capital improvements.

Forecasts in 1981 $.

Selected years from forecasts prepared by Frank Orth & Associates, Inc.

TABLE 5.30: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE CITY OF PALMER

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	2,567	4,525	4,567	42	0.9	6,167	6,200	33	0.5
Employment[a]	N.A.	-[b]	-[b]	-[b]	27	-[b]	-[b]	-[b]	13	-[b]
Housing Demand (no. of units)	872	783	1,551	1,563	12	0.8	2,299	2,311	12	0.5
Water (gallons per day)	1,368,000	300,000	608,000	614,000	6,000	1.0	917,650	922,626	4,976	0.5
Sewage Treatment (gallons per day)	500,000	300,000	543,000	548,000	5,000	0.9	740,040	744,053	4,013	0.5
Police	8	8	8	8	0	0	9	9	0	0.0
Education (primary students)	800[c]	685[c]	569	580	11	1.9	826	830	4	0.5
(secondary students)	1,400[c]	951[c]	485	490	5	1.0	704	708	4	0.6
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond exactly to city limits. 1981 enrollment may include a service area that extends beyond city boundaries, whereas projections for 1990 and 1999 refer only to school children living in Palmer

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE 5.31: SUMMARIZED FISCAL IMPACTS OF THE PROJECT ON PALMER

REVENUES ($000)	Property Taxes	State Sales Tax	Total Local Revenues	Intergovt. Revenue	Service Charges	Misc. Revenue	Total General Fund Revenue	Total Water Fund Revenue	Total Sewer Fund Revenue	Capital Project Fund Revenues
1981 Current	256	329	585	417	336	333	1,671	249	108	2,258
1990 Baseline Forecast	452	423	875	625	610	390	2,500	440	190	3,982
1990 Forecast W. Project	457	427	884	631	617	394	2,526	443	192	4,018
Impact of Project	5	4	9	6	7	4	26	3	2	30
% Change	1.11	0.95	1.0	.9	1.15	1.03	1.04	0.68	1.04	0.75
1999 Baseline Forecast	616	576	1,192	851	832	531	3,406	599	259	5,426
1999 Forecast W. Project	620	580	1,200	857	837	534	3,428	602	261	5,456
Impact of Project	4	4	8	6	5	3	22	3	2	30
% Change	0.65	0.70	0.67	0.71	0.6	0.56	0.65	0.50	0.77	0.55

EXPENDITURES ($000)	Admin.	Police	Fire	Ambulance	Parks and Recreation	Health	Library	Public Works	Water Supply	Sewer	Total Expend.	Total Bonded Indebtedness
1981 Current	487	487	128	47	59	79	84	641	205	103	2,320	2,692
1990 Baseline Forecast	860	886	237	90	104	140	149	1,188	362	181	4,197	3,832
1990 Forecast W. Project	868	894	240	91	105	142	151	1,199	365	183	4,238	3,832
Impact of Project	8	8	3	1	1	2	2	11	3	2	38	0
% Change	0.93	0.90	1.27	1.11	0.96	1.43	1.34	0.93	0.83	1.1	0.91	0
1999 Baseline Forecast	1,171	1,207	327	124	142	191	204	1,619	493	246	5,724	5,453
1999 Forecast W. Project	1,178	1,213	329	125	143	192	205	1,628	496	248	5,757	5,453
Impact of Project	7	6	2	1	1	1	1	9	3	2	21	0
% Change	0.60	0.50	0.61	0.81	0.70	0.52	0.50	0.56	0.51	0.61	0.37	0

Forecasts in 1981 $.

Selected years from forecasts prepared by Frank Orth & Associates, Inc.

TABLE 5.32: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON WASILLA

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	2,168	4,157	4,207	50	1.2	7,969	8,010	41	0.5
Employment[a]	N.A.	-[b]	-[b]	-[b]	27	-[b]	-[b]	-[b]	13	-[b]
Housing Demand (no. of units)	718	670	1,404	1,421	17	1.2	2,965	2,980	15	0.5
Water (gallons per day)	864,000	-[b]	559,000	565,000	6,000	1.1	1,185,787	1,191,861	6,074	0.5
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education										
(primary students)	1,170	959[c]	523	530	7	1.3	1,067	1,073	6	0.6
(secondary students)	1,800-[c]	1,068[c]	446	452	6	1.3	909	914	5	0.6
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond to city limits. 1981 enrollment may include a service area that extends beyond city boundaries, whereas projections for 1990 and 1999 refer only to school children living in Wasilla.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE 5.33: SUMMARIZED FISCAL IMPACTS OF THE PROJECT ON WASILLA

REVENUES ($000)	Intergovt. Transfer	State Shared Taxes	Federal & State Revenue Sharing	Licenses Fines & Mics.	Total General Fund Revenues	Capital Project Fund Revenues	Library Fund Revenues
1981 Current	26	314	195	22	557	3,533	102
1990 Baseline Forecast	49	603	374	41	1,067	6,776	195
1990 Forecast W. Project	50	610	379	42	1,081	6,858	198
Impact of Project	1	7	5	1	14	82	3
% Change	2.04	1.16	1.34	2.,44	1.22	1.21	1.54
1999 Baseline Forecast	95	1,156	717	79	2,047	12,989	374
1999 Forecast W. Project	96	1,161	721	80	2,058	13,056	376
Impact of Project	1	5	4	1	11	67	2
% Change	1.05	0.43	0.56	1.27	0.54	0.52	0.53

EXPENDITURES ($000)	Parks & Recreation	Library	Fire Service	Local Government Administration	Road Maint. & Repair	Total O + M	Capital Project Expends.
1981 Current	47	102	74	264	191	679	3,794
1990 Baseline Forecast	91	195	148	507	366	1,308	7,275
1990 Forecast W. Project	93	198	150	513	370	1,324	7,362
Impact of Project	2	3	2	6	4	16	87
% Change	2.20	1.54	1.35	1.18	1.09	1.22	1.20
1999 Baseline Forecast	175	375	287	972	701	2,511	13,946
1999 Forecast W. Project	176	376	289	977	705	2,523	14,017
Impact of Project	1	1	2	5	4	12	71
% Change	0.57	0.27	0.70	0.51	0.57	0.48	0.51

Forecasts in 1981 $.

Selected years from forecasts prepared by Frank Orth & Associates, Inc.

TABLE 5.34: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSTON

Socioeconomic Variable	Present Conditions		Watana Construction Peak				Devil Canyon Peak			
	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	Percent Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	Percent Increase Over Baseline Forecast
Population	N.A.	600	1,415	1,453	38	2.7	3,335	3,367	32	1.0
Employment[a]	N.A.	-[b]	-[b]	-[b]	15	-[b]	-[b]	-[b]	7	-[b]
Housing Demand (no. of units)	229	207	508	522	14	2.8	1,249	1,261	12	1.0
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary students)	0[c]	0[c]	178	184	6	3.4	447	451	4	0.9
(secondary students)	0[c]	0[c]	152	156	4	2.6	380	384	4	1.1
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond to city limits. Children in Houston currently attend schools outside of the city. A secondary school initially accommodating 300 students is planned.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE 5.35: SUMMARIZED FISCAL IMPACTS OF THE PROJECT ON HOUSTON AND TALKEETNA

Houston	Total Estimated Grant Funding	Total Expenditures	Local Govt. Admin.	Fire Service	Parks & Recreation	Road Maintenance	Solid Waste
1981 Current	436,800	68,700	32,400	10,200	5,400	19,800	900
1990 Baseline Forecast	1,030,120	165,556	76,410	25,258	12,735	49,030	2,123
1990 Forecast w/Project	1,058,117	170,054	78,487	25,944	13,081	50,362	2,180
Impact of Project	27,997	4,499	2,077	686	346	1,332	57
% Change	2.72	2.72	2.72	2.72	2.72	2.72	2.68
1999 Baseline Forecast	2,427,880	394,230	180,090	60,130	30,015	118,993	5,003
1999 Forecast w/Project	2,451,094	398,000	181,812	60,705	30,302	120,131	5,050
Impact of Project	23,214	3,770	1,722	575	287	1,138	47
% Change	0.96	0.96	0.96	0.96	0.96	0.96	0.94

Talkeetna	Property Taxes Paid to Mat-Su Borough	State General Revenues for Fire Service	State Shared Revenues for Road Repairs	Total Revenues to Borough from Talkeetna Service Areas
1981 Current	20,742	4,800	45,820	71,362
1990 Baseline Forecast	48,615	7,500	98,215	154,330
1990 Forecast w/Project	61,401	9,473	98,215	169,089
Impact of Project	12,786	1,973	0	14,759
% Change	26.30	26.31	0	9.56
1999 Baseline Forecast	88,649	11,722	254,713	355,084
1999 Forecast w/Project	100,560	13,298	254,713	368,571
Impact of Project	11,911	1,576	0	13,487
% Change	13.44	13.44	0	3.8

Forecasts in 1981 $.

Selected years from forecasts prepared by Frank Orth & Associates, Inc.

TABLE 5.36: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON TRAPPER CREEK

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/ Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	225	320	661	341	106.6	474	710	236	49.8
Employment [a]	N.A.	- [b]	- [b]	- [b]	66	- [b]	- [b]	- [b]	31	- [b]
Housing Demand (no. of units)	69	68	107	221	114	106.5	169	261	92	54.4
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary students)	30 [c]	40 [d]	78	128-148	50-70	64.1	116	151-171	35-55	30.1
(secondary students)	0 [d]	0 [d]	34	74	40	117.6	52	82	30	57.7
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) Planned capacity of 150
(d) School service areas do not correspond exactly to community delineations. The Trapper Creek elementary school serves a wide area outside of the community. Secondary school-age children from Trapper Creek attend Susitna Valley High School.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE 5.37: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON TALKEETNA

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/ Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	N.A.	640	1,000	1,263	263	26.3	1,563	1,773	210	13.4
Employment (a)	N.A.	- (b)	- (b)	- (b)	71	- (b)	- (b)	- (b)	34	- (b)
Housing Demand (no. of units)	196	194	334	421	87	26.0	581	658	77	13.3
Water (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Sewage Treatment (gallons per day)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Police	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Education (primary students)	120 (d)	73 (d)	126	164	38	30.2	209	240	31	14.8
(secondary students)	0 (d)	0 (d)	107	138	31	29.0	178	204	26	14.6
Hospital Beds	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

N.A. - Not Applicable
(a) By place of employment
(b) Data not available
(c) School service areas do not correspond exactly to community delineations. Secondary school-age children attend Susitna Valley High School.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE 5.38: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON IMPACT AREA 3[a]

Socioeconomic Variable	1980 Amount	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: Percent Increase Over Baseline Forecast	Devil Canyon Peak: 1999 Baseline Forecast	Devil Canyon Peak: 1999 Forecast With Project	Devil Canyon Peak: Impact of Project	Devil Canyon Peak: Percent Increase Over Baseline Forecast
Population	284,166	397,999	400,323	2,324	0.6	473,191	474,419	1,228	0.3
Employment	114,112[b]	200,112	206,477	6,365	3.2	232,311	235,668	3,357	1.4
Households	96,899	138,938	139,794	856	0.6	171,895	172,384	489	0.3

(a) Includes the following census divisions: Anchorage, Kenai Peninsula, Mat-Su Borough, Fairbanks-North Star Borough, S.E. Fairbanks and Valdez-Chitina-Whittier.

(b) Average employment during the first nine months of 1980.

Source: Forecasts by Frank Orth & Associates, Inc.

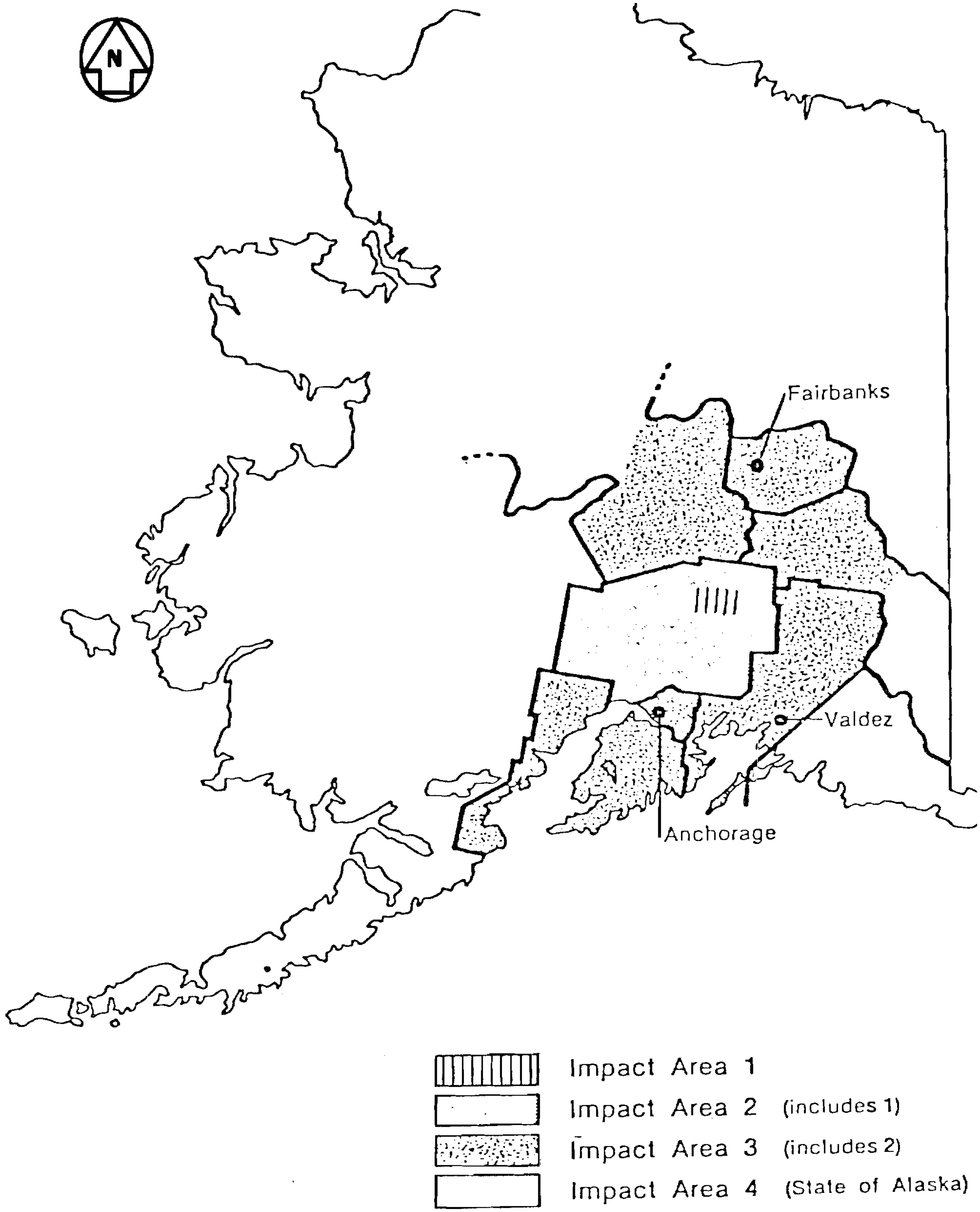
TABLE 5.39: SUMMARIZED FISCAL IMPACTS OF THE PROJECT ON ANCHORAGE AND FAIRBANKS

REVENUES ($000)	Police	Fire	Ambulance	Parks and Recreation	Library	Health Care	Transportation	Sewage Service	Solid Waste Disposal	Water Supply	Total Expend-tures
1981 Current	26,732	17,472	3,320	9,784	3,669	4,368	14,676	15,899	3,669	21,665	121,254
1990 Baseline Forecast	35,304	23,523	4,469	12,546	4,705	5,769	18,818	20,998	4,846	28,613	159,590
1990 Forecast W. Project	35,484	23,642	4,492	12,609	4,728	5,798	18,914	21,105	4,870	28,758	160,400
Impact of Project	180	119	23	63	23	29	96	107	24	145	810
% Change	0.51	0.51	0.51	0.50	0.49	0.50	0.51	0.51	0.50	0.51	0.51
1999 Baseline Forecast	39,044	26,275	4,992	13,875	5,203	6,427	20,812	23,222	5,359	31,644	176,853
1999 Forecast W. Project	39,111	26,320	5,001	13,898	5,212	6,438	20,847	23,262	5,368	31,698	177,156
Impact of Project	67	45	9	23	9	11	35	40	9	54	303
% Change	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

EXPENDITURES ($000)	Parks and Recreation	Police	Fire Service	Health Care	Public Works	Sewer Service	Electric Utilities	Water Supply	Total Expenditures
1981 Current	796	3,069	3,228	727	2,319	2,501	2,154	1,887	16,681
1990 Baseline Forecast	1,037	4,120	4,418	977	3,173	3,357	2,891	2,533	22,505
1990 Forecast W. Project	1,046	4,156	4,456	985	3,201	3,386	2,916	2,555	22,702
Impact of Project	9	36	38	8	28	29	25	22	198
% Change	0.88	0.87	0.86	0.82	0.88	0.86	0.86	0.87	0.88
1999 Baseline Forecast	1,209	4,805	5,204	1,173	3,701	3,915	3,372	2,954	26,333
1999 Forecast W. Project	1,220	4,847	5,249	1,183	3,733	3,949	3,401	2,980	26,564
Impact of Project	11	42	45	10	32	34	29	26	231
% Change	0.91	0.87	0.86	0.85	0.86	0.87	0.86	0.88	0.88

Forecasts in 1981 $.

Selected years from forecasts prepared by Frank Orth & Associates, Inc.

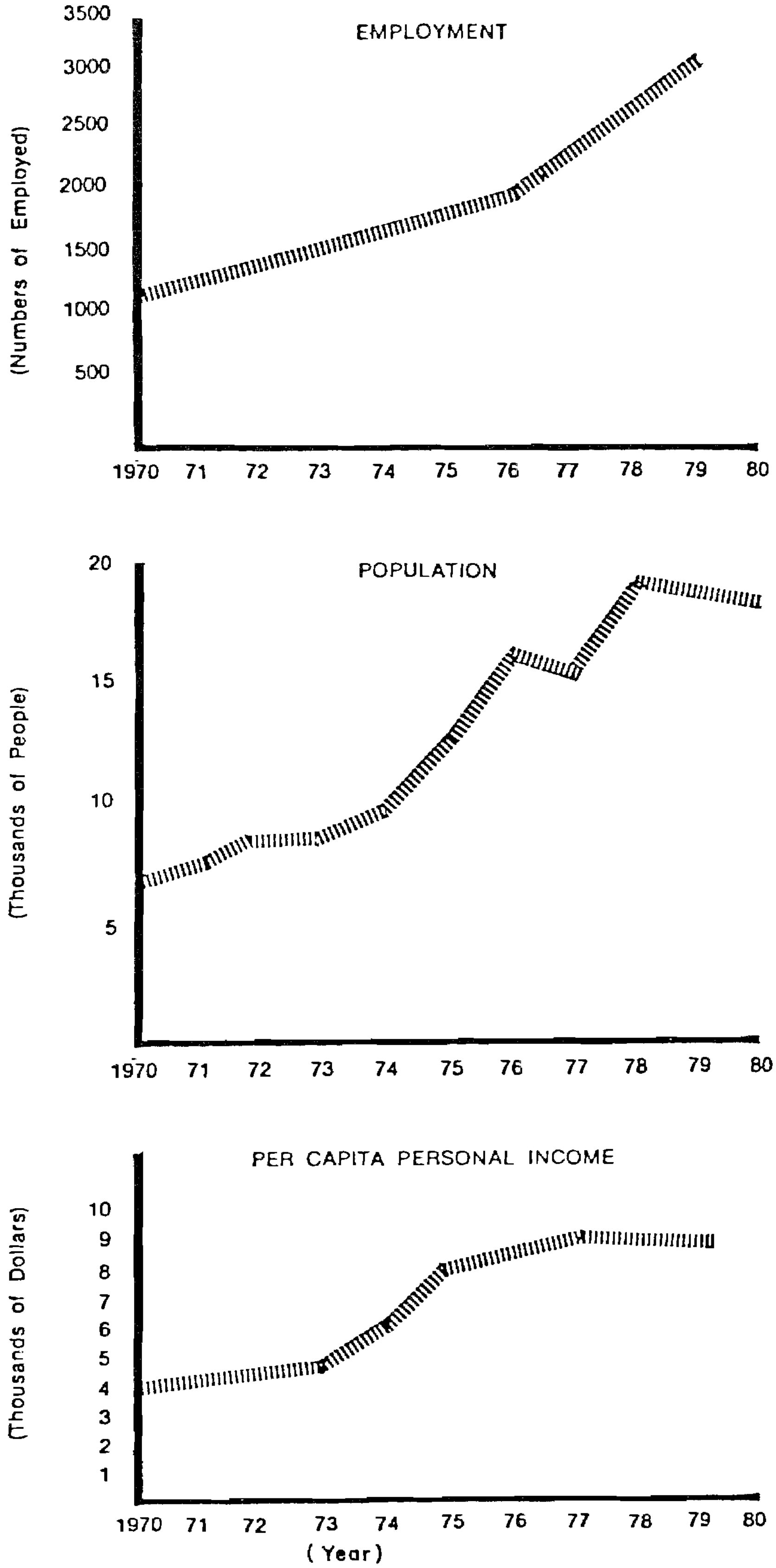


SOCIOECONOMIC IMPACT AREAS

FIGURE 5.1

ACRES

PREPARED BY TES / FRANK ORTH & ASSOCIATES, INC.

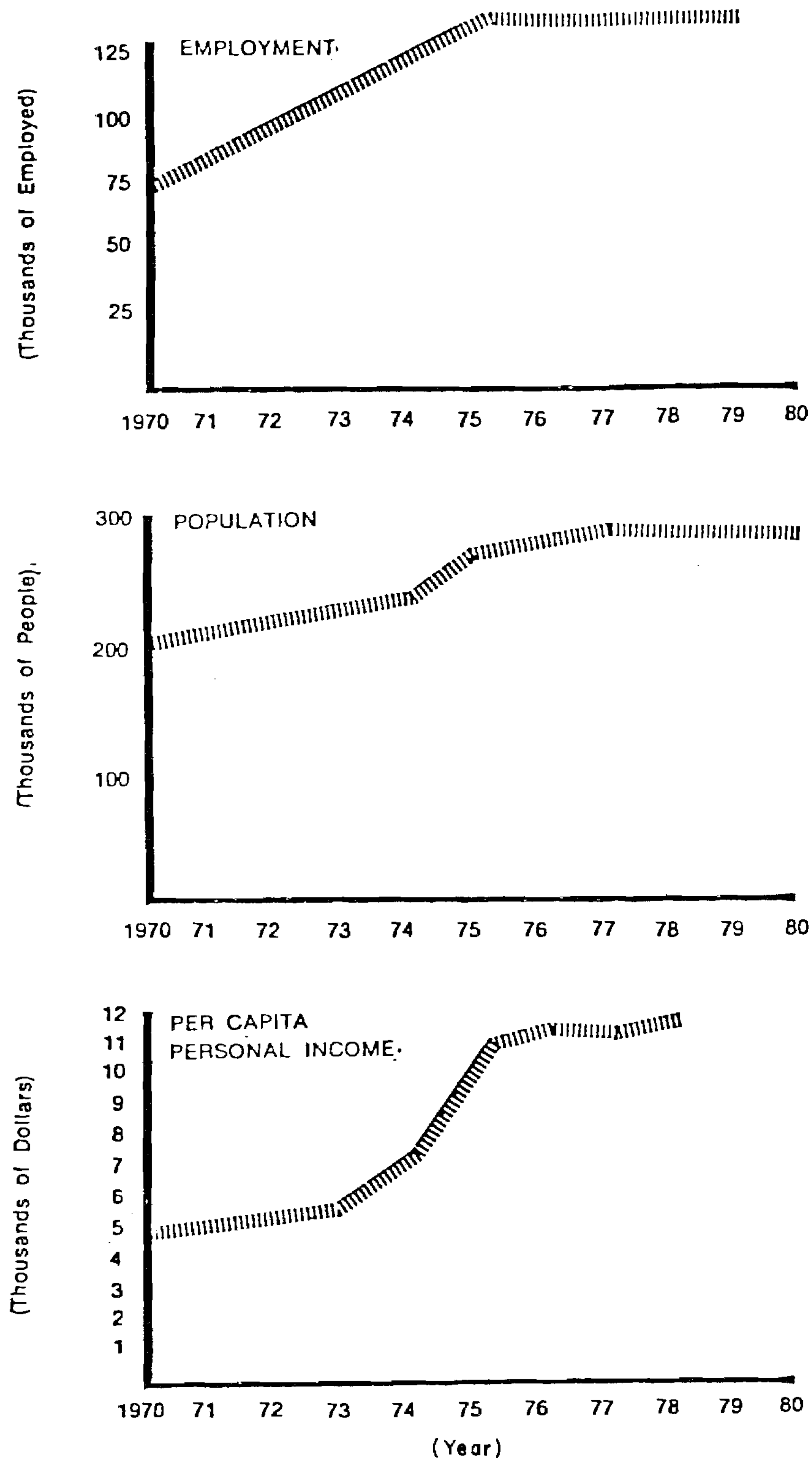


EMPLOYMENT POPULATION AND PER CAPITA PERSONAL INCOME IN THE MATANUSKA - SUSITNA BOROUGH 1970 - 1980

ACRES

FIGURE 5.2

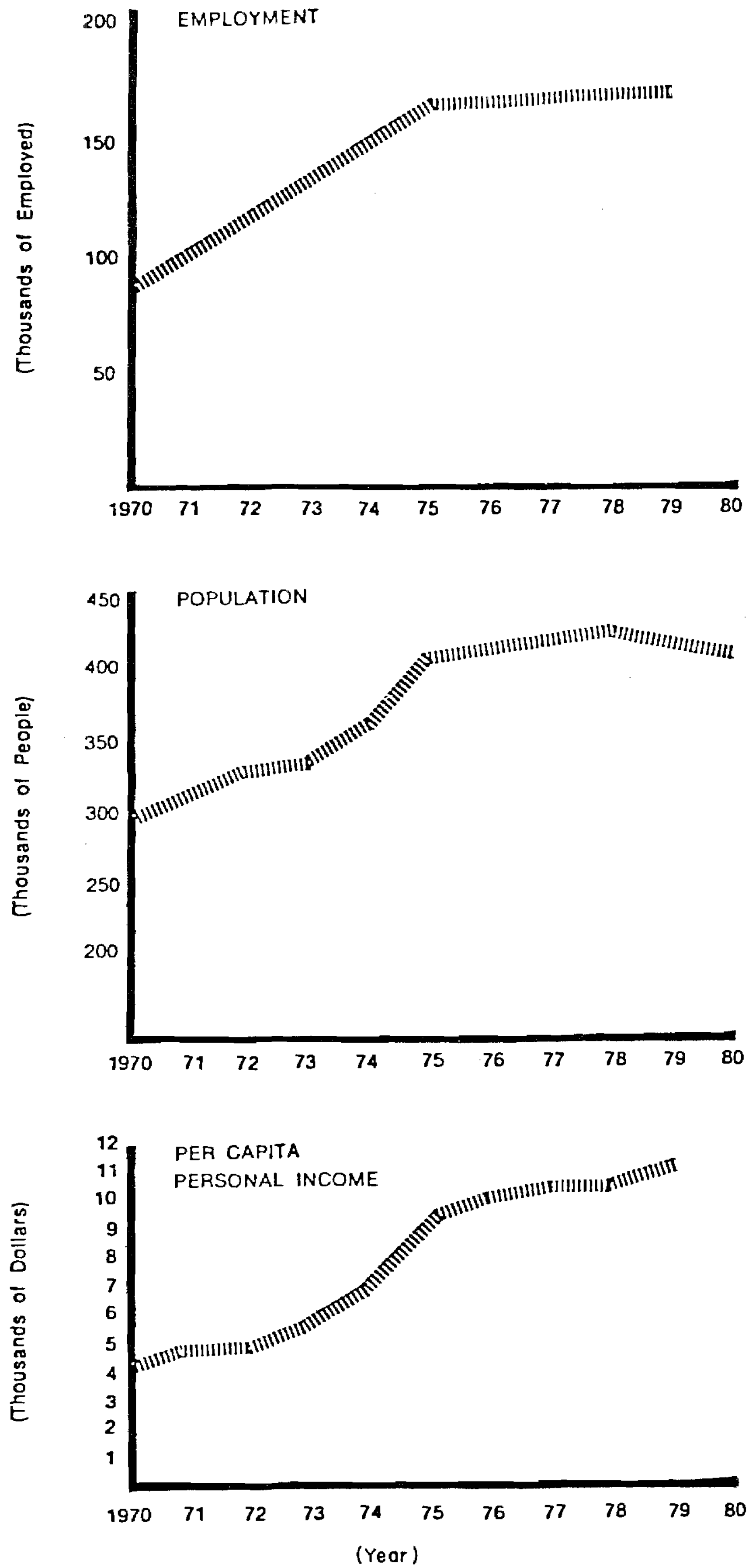
PREPARED BY TES/ORTH & ASSOCIATES, INC.



EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE RAILBELT REGION

FIGURE 5.3

PREPARED BY TES/FRANK ORTH & ASSOCIATES, INC.

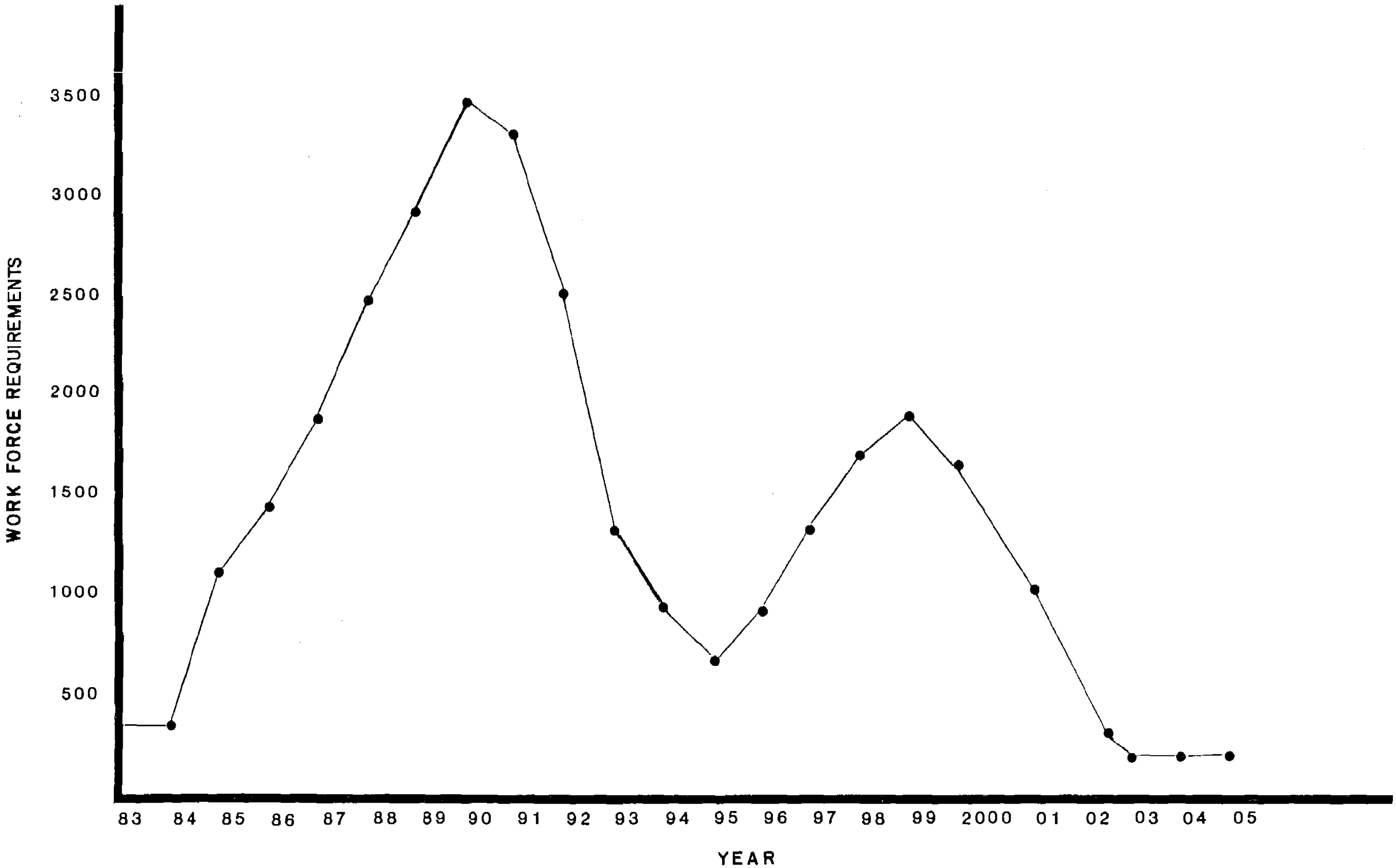


EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE STATE OF ALASKA, 1970-1980

FIGURE 5.4

ACRES

PREPARED BY TES/FRANK ORTH & ASSOCIATES, INC.



ON-SITE CONSTRUCTION AND OPERATIONS WORK FORCE REQUIREMENTS

FIGURE 5.5

PREPARED BY TES/FRANK ORTH & ASSOCIATES, INC

6 - GEOLOGY AND SOILS

This section presents a general description of the geology and soils present in the project area. More detailed information is available in the Sustina Hydroelectric Project, 1980-81 Geotechnical Report, February 1982.

6.1 - General Geology and Soils

The area of study is located within the Coastal Trough Province of south-central Alaska, with a drainage of approximately 6,000 square miles. The Susitna River is glacier-fed, with headwaters on the southern slope of the Alaska Range. From its preglacial channel in the Alaska Range, the Susitna River passes first through a broad, glaciated, intermontane valley of knob and kettle, and braided channel topography. Swinging westward along the edge of the Copper River lowlands, it enters the deep V-shaped valleys of the proposed damsites, winding through the Talkeetna Mountains until it emerges into a broad, glacial valley leading to Cook Inlet.

Virtually all topography within 16 kilometers of the project damsites consists of scoured bedrock knobs and ridges, glacial sediments and alluvium.

Soils of the Susitna Basin are typical of those found in cold, wet climates. These soils have developed from glacial till and outwash. In low-lying and poorly drained areas of forests and also above the tree line, soils are acidic, saturated, and high in organic matter. Well-drained soils of the forest zone are acidic and relatively infertile, the result of constant leaching caused by high precipitation. Sands and gravels along streams are the few neutral to alkaline soils in the region. Volcanic ash outfalls have affected the entire region, with soils in the lower basin and the west containing the most ash.

The Watana damsite is located in a relatively broad, U-shaped valley rising in steps, with the steep lower portion breaking into somewhat flatter slopes and becoming much gentler near the higher elevations. Access to the lower sections is limited because of vertical rock outcrops. Gravel bars, which can be quite wide, are exposed in the riverbed during low water flows.

At the Devil Canyon site, the river enters a very narrow gorge about two miles in length with steep walls up to 600 feet high. The valley is generally asymmetrical in shape, with the north abutment sloping at about 45° and the south abutment steeper at about 60°. The south abutment displays overhanging cliffs and detached blocks of rock. The north abutment is somewhat less rugged in the upper half, but the lower portion is very steep. Access at river level is very limited, but narrow benches are accessible at low water levels. The canyon itself is approximately 1,000 feet wide at the proposed dam crest elevation.

6.2 - Devil Canyon Reservoir

The topography in and around the Devil Canyon site and reservoir is bedrock-controlled. Overburden is thin to absent, except in the upper reaches of the proposed reservoir where alluvial deposits cover the valley floor.

(a) Bedrock Geology

A large intrusive plutonic body, composed predominantly of biotite granodiorite with local areas of quartz diorite and diorite, underlies most of the reservoir and adjacent slopes. The rock is light gray to pink, medium grained, and composed of quartz, felspar, biotite, and hornblende. The most common mafic mineral is biotite. Where weathered, the rock has a light yellow-gray to pinkish yellow-gray color, except where it is highly oxidized and iron stained. The granodiorite is generally massive, competent, and hard with the exception of the rock exposed on the upland north of the Susitna River where the biotite granodiorite has been badly decomposed as a result of mechanical weathering.

The other principal rock types in the reservoir area are the argillite and graywackes, which are exposed at the Devil Canyon damsite. The argillite has been intruded by the massive granodiorite, and as a result, large isolated roof pendants of the argillite and graywacke are found locally throughout the reservoir and surrounding areas. The argillite and graywacke varies to a phyllite of low metamorphic grade, with possible isolated schist outcrops.

The rock has been isoclinally folded into steeply dipping structures which generally strike northeast-southwest. The contact between the argillite and the biotite granodiorite crosses the Susitna River just upstream from the Devil Canyon damsite. The contract is nonconformable and is characterized by an aphanitic texture with a wide, chilled zone. The trend of the contact is roughly northeast-southwest where it crosses the river. Several large outcrops of the argillite completely surrounded by the biotite granodiorite are found within the Devil Creek area.

(b) Slope Stability and Erosion

The Devil Canyon reservoir will be entirely confined within the walls of the present river valley. This reservoir will be characterized by a narrow, deep water body that will be subject to only minimal seasonal drawdown. Much of the topography of this reservoir is bedrock-controlled. In the vicinity of Devil Creek, downstream from the damsite, the slopes of the reservoir and its shoreline consist primarily of bedrock which, in some areas, has a thin veneer of colluvium or till. Upstream from Devil Canyon, the slopes of the reservoir comprise increasing amounts of unconsolidated materials, especially on the south abutment. These materials are principally basal till and coarse-grained floodplain and alluvial fan deposits.

Current and previous slope failures in this area of the Susitna River, as defined by photogrammetry and limited field reconnaissance, are skin and bimodal flows in soil and block slides and rotational slides in rock. The basal tills are the primary materials susceptible to mass movement. On the south abutment and south of the damsite, there is a possibility of sporadic permafrost, but it is generally thought to be minimal. Upstream from this area, the basal till is nearly continuously frozen as evidenced by field information along the access road corridors and in Borrow Area "H."

Downstream from the Devil Creek area, instability is largely reserved to small rock falls. Beaching will be the primary process activity upon the shoreline in this area. Although this area is mapped as a basal till, it is coarser grained than that which is found in the Watana Reservoir, and therefore, it is more susceptible to beaching.

In areas where the shoreline is in contact with steep bedrock cliffs, the fluctuation of the reservoir will contribute to rock falls. Fluctuation of the reservoir and, therefore, the ground water table, accompanied by seasonal freezing and thawing, will encourage frost wedging as an erosive agent to accelerate degradation of the slope and beaching. These rock falls will be limited in extent and will in no way have the capacity to produce a large wave which could affect dam stability. In Devil Creek, a potential small block slide may occur after the reservoir filling.

Beyond Devil Creek, beaching will also be the common erosive agent up to approximately river mile 180. Present slope instability above reservoir normal pool level will continue to occur with primary beaching occurring at the shoreline. At river mile 175, there is a possibility that a large old landslide on the south abutment could become mobile and slide into the river valley. This landslide has a large ,accurate back scarp which has become completely vegetated since its last movement. This landslide, which has a volume of approximately 3.4 million cubic yards, has the potential for further sliding after impoundment because of thawing and/or changes in the ground water regime. However, the maximum pool elevation extends only to the toe of this slide. Therefore, it is unlikely that a large catastrophic slide could result from normal reservoir impoundment.

(c) Summary

The meandering of the river valley makes the potential of a wave induced by a massive landslide that could affect the dam stability very remote.

In general, the following conclusions can be drawn about the slope conditions of the Devil Canyon reservoir after impounding:

- Minimal drawdown of the reservoir is conducive to stable slope conditions;

- The lack of unconsolidated materials along the lower slopes of the reservoir and the existence of stable bedrock conditions are indicative of stable slope conditions after reservoir impounding;

- A large old landslide in the upper reservoir has the potential for instability; and

- The probability of a landslide-induced wave in the reservoir overtopping the dam is remote.

6.3 - Watana Reservoir

The Watana reservoir area is generally characterized by a variety of rock and soil types. The lower section of the Watana reservoir and adjacent slopes are predominantly covered by a veneer of glacial till and lacustrine deposits.

(a) Surficial Deposits

Two main types of till have been identified in the area: ablation and basal tills. The basal till is predominantly over-consolidated, has a fine grain matrix (more silt and clay), and a low permeability. The ablation till has less fines and a somewhat higher permeability. Lacustrine deposits consist primarily of poorly graded fine sands and silts with lesser amounts of gravel and clay that exhibit a crude stratification.

On the south side of the Susitna River, the Fog Lake area is characteristic of a fluted ground moraine surface. Upstream in the Watana Creek area, glaciolacustrine material forms a broad, flat plain which mantles the underlying glacial till and the semi-consolidated Tertiary sediments. Significant alluvial deposits exist in the river valley and consist of reworked outwash and alluvium. Glaciation of the area was accompanied by the filling in of the Susitna River valley. Subsequent modification by alluvial processes during deglaciation resulted in the formation of floodplain terraces. Ice disintegration features such as kames and eskers are adjacent to the river valley.

Permafrost exists in the area, as evidenced by ground ice, non-sorted polygons, stone nets, and slumping of the glacial till overlying permafrost. Numerous slumps have been identified in the Watana reservoir area, especially in sediments comprising basal till. Additional details regarding this subject will be addressed in subsequent sections. In addition, numerous areas of frozen alluvium and interstitial ice crystals have been observed in out-crops and drill hole samples.

(b) Bedrock Geology

The Watana damsite is underlain by a diorite pluton. Approximately three miles upstream from the Watana damsite, a nonconformable contact between argillite and the dioritic pluton crosses the Susitna River. An approximate location of this contact has also been delineated on Fog Creek, four miles to the south of the damsite. Just downstream from the confluence of Watana Creek and the Susitna River, the bedrock consists of semi- consolidated, Tertiary, sedimentary rocks (Smith 1974) and volcanics of Triassic age. These Triassic volcanics consist of metavolcaniclastic rocks and marble (Csejtey et al. 1980). Just upstream from Watana Creek to Jay Creek, the rock is a metavolcanogenic sequence dominantly composed of metamorphosed flows and tuffs of basaltic to andesitic composition. From Jay Creek to just downstream from the Oshetna River, the reservoir is underlain by a metamorphic terrain of amphibolite and minor amounts of greenschist and folidated diorite. To the east of the Oshetna River, glacial deposits are predominant.

The main structural feature of the Watana reservoir is the Talkeetna thrust fault which trends northeast-southwest (Csejtey et al. 1980). This thrust fault crosses the Susitna River approximately eight miles upstream from the Watana damsite. The dip of this fault is uncertain, as Csejtey and others (Csejtey, Foster, and Nokleberg 1980) have interpreted it to have a southeast dip, while Turner and Smith (Turner and Smith 1974) suggest a northwest dip. At the southwest end of the fault, unfaulted Tertiary volcanics overlie the fault (Csejtey, Foster, and Nokleberg 1980). A general discussion of regional geology is presented in Volume 1, Section 7 of this report.

(c) Slope Stability and Erosion

The geology of the slopes underlying and adjacent to the reservoir consists of unconsolidated material. As a generalization, the distribution of permafrost is nearly continuous in the basal till and is scattered to continuous in the lacustrine deposits. The distribution of permafrost has been delineated primarily on the flatter slopes, generally below the 2,300-foot contour. Other areas, including inclined slopes, may be underlain by permafrost which, when thawed, could result in slope instability. Current or previous slope instability on the slopes above the Susitna River, as defined by aerial photographic interpretation and limited field reconnaissance, indicates that the types of mass movement consist primarily of solifluction, skin flows, bimodal flows, and small rotational slides. These types of erosion occur predominantly in basal till or in areas where the basal till is overlain by lacustrine deposits. In addition, solifluction which originated in the basal till has proceeded downslope over some of the floodplain terraces.

Three major factors that will contribute significantly to potential slope instability in the Watana reservoir are the change in the ground water regime, the large seasonal fluctuation of the reservoir level (estimated at 140 feet), and the thawing of permafrost. The two processes affecting the shoreline of the reservoirs are beaching and slope stability. Models of shoreline conditions were developed and applied to select reaches of the reservoir shoreline and evaluated for conditions at or near normal pool levels. It should be noted that the slope stability of the Watana reservoir was evaluated for the "worst" case which considered the maximum and minimum pool levels for slope instability. In cases where sliding will occur, it will not be uncommon for some flows or possibly beaching to occur over the same reach.

The filling of the reservoir to the normal pool level is estimated to take approximately three years. Because of the rate of impoundment, the potential for slope instability occurring during flooding of the reservoir will be minimal and confined to shallow surface flows and possibly some sliding. These slopes will be more susceptible to slope instability after impoundment when thawing of the permafrost soils will occur and the ground water regime has reestablished itself in the frozen soils.

Assuming that the current contours will remain unchanged, the north abutment will have the potential for beaching near the damsite, except for possibly some small flows and slides adjacent to Deadman Creek. On the south abutment, thawing of the frozen basal tills will result in numerous skin and bimodal flows, and there will be a potential for small rotational sliding to occur primarily opposite Deadman Creek.

On the south abutment, between the Watana damsite and Vee Canyon, the shoreline of the reservoirs is susceptible to a high potential for flows and shallow rotational slides. In contrast to the north abutment, the shoreline is almost exclusively in contact with frozen basal tills, overburden is relatively thick, and steeper slopes are present. Thermal erosion, resulting in the erosion and thawing of the ice-rich, fine grained soil solids, will be the key factor influencing their stability. On the north abutment and on both abutments upstream from Vee Canyon, the geological and topographic conditions are more variable and therefore have a potential for varying slope conditions. In the Watana Creek drainage area, there is a thick sequence of lacustrine material overlying the basal till. Unlike the till, it appears that the lacustrine material is largely unfrozen. In addition, slope instability may occur as a result of potential liquefaction of the lacustrine material during earthquakes. Overall, the north abutment in contrast with the south abutment does not have the constant steep slopes, and the slopes are slightly better drained, which may be indicative of less continuous permafrost and/or slightly coarse material at the surface with a deeper active layer.

In general, the potential for beaching is higher because the seasonal drawdown zone will be in contact with a thin vaneer of colluvium over bedrock and, in a number of areas, low slopes. In the Oshetna-Goose Creek areas, there is a thick sequence of lacustrine material. Permafrost appears to be nearly continuous in this area based on the presence of unsorted polygonal ground and potential thermokarst activity around some of the many small ponds (thaw lakes/kettles). The reservoir will be confined primarily within the floodplain, and therefore little modification of the slopes is expected. Where the slopes are steep, there could be some thermal niche erosion resulting in small rotational slides.

The potential for a large blockslide occurring and generating a wave with the likelihood of overtopping the dam is very remote. For this condition to occur, a very high, steep slope with a potentially unstable block of large volume would need to exist adjacent to the reservoir. In approximately the first 16 miles upstream from the dam, the shoreline will be in contact with the low slopes of the broad, U-shaped valley. Between 16 and 30 miles upstream from the dam, no potentially large landslides were observed. Beyond 30 miles upstream, the reservoir begins to meander and narrows; therefore, any wave induced in this area by a large landslide would, in all likelihood, dissipate prior to reaching the dam.

(d) Summary

In general, the following conclusions can be drawn about the slope conditions of the Watana reservoir after impoundment:

- The principal factors influencing slope instability are the large seasonal drawdown of the reservoir and the thawing of permafrost soils. Other factors include the change in the ground water regime, the steepness of the slopes, coarseness of the material, thermal toe erosion, and the fetch available to generate wave action;

- The potential for beaching will occur primarily on the north abutment of the reservoir;

- A large portion of the reservoir slopes are susceptible to shallow slides, mainly skin and bimodal flows and shallow rotational slides;

- The potential for a large blockside that might generate a wave that could overtop the dam is remote; and

- The period in which restabilization of the slopes adjacent to the reservoir will occur is largely unknown.

In general, most of the reservoir slopes will be totally submerged. Areas where the filling is above the break in slope will exhibit fewer stability problems than those in which the reservoir is at an intermediate or low level. Flow slides induced by thawing permafrost can be expected to occur over very flat-lying surfaces.

6.4 - Mitigation Measures

The primary method of mitigating impacts to soils will be through standard stabilization, reclamation, and revegetation techniques.

All temporary access roads will be graded, recontoured and seeded following abandonment. Areas near streams or rivers where erosion may occur will be rip-rapped during the construction period and re-sealed when construction is complete. Borrown area will be excavated only if necessary and will either be regraded and seeded with appropriate species or, if excavation is deep enough, converted to ponds.

To insure success of restoration efforts, a comprehensive restoration and revegetation plan will be decycled and implemented to prevent soil erosion. This plan will include the use of terrain (if necessary) mulch (hay and straw) mulch anchored with a light asphalt tack and mats in area of high erosion potential. Seeding mixtures will be developed to provide the most rapid recovery possible and inlcude species adapted to all soil and light (shad, sun, etc.) conditions present at the site. Seed mixtures may be applied using the hydroseeding techniques which includes a mixture of fertilizer, lime and seeds. Restoration procedures will be monitored to insure their efficiency. Any areas showing erosion or where restoration is not effective will be restored with modified plans.

Rock excavated and not utilized in construction will be used as backfill in borrow areas or disposed of in areas which will be inundated by the reservoir.

6.5 - Conclusions

Some amount of slope stability will be generated in the Watana and Devil Canyon reservoirs as the result of reservoir filling. These areas will be primarily in locations where the water level will be at an intermediate level relative to the valley depth.

Slope failure will be more common in the Watana reservoir because of the existence of permafrost soil throughout the reservoir. The Devil Canyon reservoir is generally in more stable rock, and the relatively thin overburden is unfrozen in the reach of the river upstream from the dam.

Although skin flows, minor slides, and beaching will be common in parts of the reservoirs, they will present only a visual concern and pose no threat to the project. Many areas in which sliding does occur will stabilize into beaches with a steep backslope.

Tree root systems left from reservoir clearing will tend to hold shallow surface slides and, in cases where permafrost exists, may have a stabilizing influence, since the mat will hold the soil in place until excess pore pressure has dissipated.

7 - REPORT ON RECREATIONAL RESOURCES

7.1 - Recreational Lands Designations

Currently, there are no areas within or near the proposed project boundary that are included or designated for inclusion in the National Wild and Scenic Rivers System, the National Trails System, or a wilderness area under the Wilderness Act.

The Susitna River was among several rivers recommended for detailed study as possible additions to the National Wild and Scenic Rivers System in 1978 under Sec. 204 (e) of the Federal Land Policy and Management Act of 1976. The allowed three-year study period ended November 1981 without Congressional action to include the river in this system. Currently, it is not under consideration for inclusion under any program.

7.2 - Existing and Proposed Recreation Facilities

(a) Existing Recreation Facilities - Project Area

(i) Facilities

Presently, there are no publicly developed recreation facilities within the vicinity of the project, and the only privately owned facilities of this nature are three lodges. Access to these lodges is primarily by air, and they are used chiefly for fishing, hunting, boating, hiking, and skiing. The first, Stephan Lake Lodge, is located south of the Susitna River at Stephan Lake and is the largest of the three. It is comprised of ten structures with additional outlying cabins and offers its predominantly European clientele a variety of services on a year-round basis. High Lake Lodge has eleven structures and is located north of the proposed Devil Canyon dam site at High Lake. The clientele at present is strictly seasonal and restricted to project personnel who use the facility as an auxiliary study camp. Tsusena Lake Lodge, with three structures, is north of the proposed Watana dam site at Tsusena Lake. Clientele is restricted to family, friends, and associates of the lodge owners.

In addition to the lodges, there are also numerous private cabins in the project area utilized by individual owners. These are used primarily on a seasonal basis for hunting, fishing, trapping, and other recreational activities (Refer to Section 9.1).

(ii) Activities

Various types of recreational activities take place in the upper Susitna River basin that are not necessarily associated with formally developed facilities. The greatest concentration of use is found at lakes within the basin that are accessible by float plane (Refer to Section 9.1). These recreational activities are primarily characterized by low-volume use associated with hunting, fishing, camping, hiking, and boating. Some rafting and kayaking takes place on the Susitna and Tyone rivers and Prairie Creek.

Various trails for dog sleds, ORVs (off-road-vehicles), and snow-machines are present throughout the basin. Their use is primarily for subsistence, recreation, or mineral exploration activities.

(b) Existing Recreation Facilities - Adjacent Areas

Most of the existing recreational facilities adjacent to the project area serve the two urban centers of Anchorage and Fairbanks and, secondarily, the population along the Parks Highway that connects the two. The majority of the state's population lives in these areas.

While there are few formally developed recreational facilities within the immediate vicinity of the project, many such facilities exist in the region. These areas and facilities are described in Table 7.1. The primary attraction in the region is the Denali National Park and Preserve. With 2.3 million ha (5.7 million a), it is the largest and most popular recreational attraction in the region. Facilities include several lodges, visitor centers, gas station, bus service, campgrounds, interpretive services, and trail system.

North of the project area, the Bureau of Land Management maintains the 1.8 million ha (4.4 million a) Denali Planning Block that encompasses most of the Denali Highway and contains within its boundaries the Tangle Lakes Archeological District. More archeological sites lie within this district than in any other known area of comparable size in the American subarctic. It is of major archeological significance, with sites dating back 12,000 to 15,000 years ago. The Bureau also maintains small campground and picnic areas along the Denali Highway, with boat launches and canoe trails at Tangle Lakes.

Denali State Park is comprised of about 170,430 ha (421,120 a) and is located west of the project area. The park offers a major campground at Byers Lake, where camping, picnicking, canoeing, and a trail system are available.

Well south of Denali State Park and located approximately 110 km (70 mi) from Anchorage is Nancy Lake State Recreation Area. Comprised of 9180 ha (22,680 a), with more than 130 lakes and ponds, this area offers camping, picnicking, fishing, canoeing, and boating. Canoeing occurs through the chain of lakes that make up the 13 km (8 mi) Lynx Lake Loop, and on the Little Susitna River downstream from the Parks Highway. Overland trails available in the area are used in summer for hiking and in winter for skiing and snowmachining.

Similar facilities exist at Chugach State Park, approximately 16 km (10 mi) from Anchorage. This park covers about 200,000 ha (494,000 a) with camping, picnicking, hiking, hunting, canoeing, and fishing facilities. Summer- and winter-use trails are also provided. Developed campgrounds exist at Eklutna Lake, Eagle River, Peters Creek, and Bird Creek, all within park boundaries.

Lake Louise, with adjoining Susitna Lake, is a popular fishing, boating, and hunting area located southeast of the project area. The Lake Louise area is primarily in private ownership, although there is also a state-maintained Lake Louise wayside. As the source of the Tyone River, an upper Susitna River tributary, the lake receives occasional use from river floaters who make the trip from Lake Louise to the Susitna River.

Privately owned and operated facilities in adjacent areas provide the public with somewhat different services. Lodges, cabins, restaurants, airstrips and flying services, guiding services, whitewater rafting trips, and campgrounds are the types of services and facilities provided by private enterprises.

(c) Proposed Recreation Facilities

The following plan for recreation development is tentative. It is subject to approval by the Power Authority and review by other agencies and will likely undergo some modification and refinement. Furthermore, the results of a planned public participation survey, which will influence the development plans, are not yet available.

(i) Immediate Development

Recreational facilities to be provided within the project area reflect opportunity types that will be available to the public. The proposed opportunity settings are shown in Figure 7.1, and a description of the management program and activities to be emphasized is provided in Table 7.2. The recreational opportunity settings proposed include semi-modern, semi-primitive, and primitive. The primary emphasis will be on day-use with overnight facilities provided near the two dam sites and road-oriented recreation at the alpine lakes.

The two proposed reservoirs and the dams themselves as well as scenic lakes within the project area will be prime attractions. Along with the trails and portages to these lakes, various waterfalls in the area will offer additional opportunities not available at the reservoirs.

Figure 7.2 and Table 7.3 indicate recreational facilities proposed for development within three years of commencement of project operation. The greatest concentration of use will be near the Devil Canyon and Watana dam sites where there will be access to the reservoirs. Recreation facilities to be provided in the first three years include developed auto campgrounds (designed to accommodate various types of vehicle users and allowing for future expansion), picnic grounds, boat launches, and parking areas. Emphasis will be on rustic facilities with a minimum level of services and a maximum of natural aesthetic features.

Recreational development at Devil Canyon reservoir is limited by the reservoir's narrow gorge and steep canyon walls. While several side canyons may offer some degree of protection from wind, providing sheltered moorages for boats, the steep-sloped banks are not suitable for any type of development. Farther up the impoundment, however, there are slopes more appropriate for development of recreational facilities.

The Devil Canyon dam will serve as a focal point for recreational activities in the lower sections of Devil Canyon reservoir. A mix of day-use and overnight facilities will be available to visitors interested in both water-based and land-oriented activities ranging from boating and picnicking to hiking and camping. Day-use facilities available at the dam site will include picnic and rest areas with orientation and interpretive information and a scenic overlook of the reservoir.

Boat ramps with parking areas will be located at Cheechako Canyon (east of Devil Canyon dam) and downstream of Watana dam at Tsusena Creek. Overnight camping will also be available near Cheechako Canyon with a minimally developed auto-oriented campground. Locating the campground at Cheechako Canyon instead of directly at Devil Canyon makes it accessible to all types of visitors while removing it from the operation and maintenance activities of the dam. The topography and natural vegetation along the canyon also present a pleasant and secluded atmosphere for visitors. A trailhead from a parking area near the campground will lead to a series of waterfalls along Cheechako Creek with a short loop trail designed specifically for the physically handicapped. To minimize conflict with non-motorized day-use of the canyon, lower Cheechako Canyon, above the boat ramp, would be designated as a no-wake zone, that is, boat speed is so regulated as not to produce any wake.

Boating access at Tsusena Creek on the upper Devil Canyon reservoir will provide for dispersion of some of the reservoir's recreational use, while allowing immediate access to the upper portion of the reservoir from a launch area. Overnight camping facilities located north of this boat access point will be similar to, but slightly smaller than, those at the Cheechako Canyon campground. All developed sites will have conveniently located comfort stations that are serviced on a regular basis.

Watana reservoir will probably receive low-volume, dispersed use, mostly for boating, hunting, and sightseeing activities. Access to the reservoir will be via a boat ramp and parking area at Deadman Creek.

Both Watana and Devil Canyon reservoirs may have hazards caused by wind, wakes from passing boats, depth and temperature of the water, steep banks, and fluctuating water levels. For public safety and the encouragement of boating courtesy, boat patrols will be necessary.

Boat launching, docking, and mooring facilities in both reservoirs will need to be designed to accommodate the changes in water level. On a daily basis, these changes will be insignificant. From June to September, however, the average water level of Devil Canyon reservoir will rise 15 m (50 ft) and that of Watana will rise 9 m (30 ft). When the reservoirs are not full, the aesthetics of the exposed drawdown zone (Section 8.2) could reduce the attractiveness of water-based recreation.

Other project area developments will be in the semi-primitive opportunity setting along the access road corridor. Scenic viewpoints, pull-outs at trail-heads, and access at Indian River, where spawning salmon can be viewed during the summer months, are the facilities planned for the road system. Waste containers will be placed at the Indian River access point and at trailhead pull-outs; waste disposal for these containers will be scheduled. All other scenic viewpoints, for both short-term viewing and for photography, will not have waste containers.

Between Devil Canyon and Watana dam sites, a mix of low-speed, auto-oriented sightseeing, with scenic overlooks and trails to accessible lakes and waterfalls within the area, will provide a view of the alpine tundra. To protect the sensitive resource base and to maintain a semi-primitive recreational opportunity, no facilities are to be provided except overlooks and trails. Dispersed camping will be permitted, however, with enforcement of "pack-in, pack-out" policy. This will involve periodic inspection of the more popular camping areas to assess impact, communicate with visitors, and enforce policies.

To avoid further conflict and interference with existing private lodge operations at High Lake, this area will not be developed for recreation. Primitive portages to other alpine lakes in the area will be cleared of brush and the wet areas stabilized, but will not have developed trails. Some regulations will be developed to manage specific aspects of visitors' use of the area. For example, no off-road-vehicle use will be permitted in the project area; enforcement of this prohibition will be a normal part of the patrolling effort. Visitors will also be informed of rules on handling food within the project area to reduce their encounters with bears. These rules will apply as well to the backcountry and dispersed use areas along the reservoirs.

(ii) Long Range Development

After the first three years of project operation, long-term development will focus on the expansion of the campgrounds at Cheechako Canyon and Tsusena Creek and on the additions of two boat-in campgrounds along the Watana reservoir, and a boat-in picnic area at Devil Canyon reservoir (Figure 7.3). Boaters coming down the Susitna River from the Denali Highway and down the Tyone River from Lake Louise and Lake Susitna will be accommodated at a proposed camping area near the confluence of the two rivers. Delay in the development of these boat-in facilities is necessary until the shoreline effects are evaluated.

The semi-primitive opportunity settings will be maintained for the reservoirs. Any plans for additional facilities will have to incorporate trends in usage and public demand and be compatible with resource capability to support such usage. The option of providing commercial services such as service stations, lodging, boat rentals, campsites, or other facilities will be considered if such developments are shown to be both economically feasible and suitable for the opportunity setting. If this option is desirable it could be pursued under a concession contract.

7.3 - Plan for Public Access

(a) Shoreline Buffer Zone

Low-density, dispersed use of back country areas and reservoir shorelines will minimize damage to areas resulting from overuse or concentrated use. Monitoring of recreational use will be necessary, particularly in areas of greatest use.

The shoreline buffer zone allows for public access at both reservoirs while protecting the scenic, cultural, and other environmental values of their shorelines. To protect and enhance these values, proposed recreation facilities will be designed and located to have the least impact on the landscape. Developments at the dam sites will be located away from the reservoirs and are intended to blend into the landscape, to be of rustic design, and to be situated among vegetation with higher absorption factors. Recreation development at the dam sites will also be concentrated near areas of prior development for construction of the dams.

The shoreline buffer zone will constitute 61 m (200 feet) horizontal distance from the full-pool level of the reservoirs. [The proposed full-pool level at Devil Canyon is 444 m elevation (1455 ft.); at Watana, 666 m (2185 ft.)]. A 61-meter buffer zone will also be provided around planned recreation sites.

(b) Access Route Plan and Policy

Access from the Parks Highway to the impoundments and recreation facilities will be provided by a gravel road, which falls within the semi-modern classification of the opportunity spectrum (cf. Section 9.2; also see Figure 7.1). The road will connect with the Parks Highway at Hurricane and be constructed to Gold Creek. From Gold Creek to Devil Canyon dam, it will follow the south side of the Susitna River. It will cross Devil Canyon and be routed on the north side of the river to the Watana dam site (Acres 1981).

An orientation and information sign on the Parks Highway, at the entrance to the project road, will inform visitors of the opportunities and restrictions in the project area. This display and other signs along the road will be of simple and rustic design. Scenic viewpoints, pull-outs at trailheads, and access at Indian River are facilities planned to be served by the road system.

During construction, use of the access road will be restricted to construction personnel and to the transport of project materials and supplies. After construction, access will be allowed; however, ORV use could be prohibited. ORV use, particularly in the alpine zone, would destroy the opportunities that the recreation plan and other mitigation plans are designed to protect. Road patrols will monitor the area, and a visitor check-point, perhaps at the Devil Canyon dam, could be established.

(c) Relationship of Access to Recreation Plan

Access has a significant role in the planning of recreation facilities. The location and types of opportunities and facilities available to the public are determined primarily by the access route that is developed, the traffic for which the route is designed (and maintained), and the access policy.

It is anticipated that most road-oriented use will involve driving for pleasure and access for short hikes, photography, and fishing. Lands adjacent to the road will offer visitors a different opportunity, a chance to participate in dispersed, backcountry activities such as hiking, canoeing, and camping in an alpine-tundra environment. To protect both this unique opportunity in the semi-primitive portion of the opportunity spectrum and the environmental settings in which they occur, it will be necessary to zone the road corridor against all types of ORV use, and to enforce this restriction (as discussed in the previous section). Recreational use of lands other than project lands will need to comply with the policies established by the land-owners or management agencies. Cooperative agreements may be required where such lands border either the access corridor or recreation facilities on the reservoirs.

7.4 - Estimates of Existing and Future Recreational Use

(a) Regional Use

There are no comprehensive statistics for the amount of recreational use the project vicinity in the upper Susitna basin receives on a yearly basis. The type of use, however, primarily involves dispersed, low-volume activities, such as hunting, fishing, and boating. The predominant mode of travel to the area is by private aircraft. Lack of ready access combined with low-volume activity make accurate data collecting difficult and expensive.

Traffic counts for the Denali and Parks highways provide some indication not only of the amount of use these highways receive during the summer months but also the time of year when the majority of recreational use occurs within the region. Traffic counts taken by the Alaska Department of Transportation and Public Facilities from 1973 to 1978 are shown on Table 7.4 with the average daily traffic count for the entire length of the Denali Highway and for the East Fork Maintenance Station (Mile A185) along the Parks Highway. This station is approximately 32 km (20 m) north of the intersection of the proposed project area access road and the Parks Highway. Table 7.4 shows the average daily traffic count for both highways from mid-May to October (this coincides with the time the Denali Highway is open to the public) and the annual average daily traffic count for the Parks Highway.

Results of the 1975 outdoor recreation study for the Denali Highway area indicated that for the 75-day season from 1 July - 13 September 1975, approximately 6,400 recreation groups (average size 3.2 persons) used the Denali Highway area for a total of 20,500 recreation visits (Johnson 1975). The study determined that 90% of highway travelers interviewed (1,088 respondents) cited recreation as the primary purpose of their trip. The majority of the respondents (82%) were Alaska residents, with 35% from Anchorage and 27% from Fairbanks.

A summary of visitor counts taken by the Alaska Division of Parks for state recreation areas adjacent to the Parks Highway is shown in Table 7.5. These figures were compiled from data collected for the summers of 1979 and 1980.

(b) The Participation Survey

The major objective of the participation survey is to determine a gross estimate of recreation participation rates. Knowledge of these rates can then be used to estimate the cost effectiveness of proposed recreational facilities and the unit cost of recreational services. The number of people that a recreational facility will ultimately be designed to accommodate can also be determined from the results of the survey, when they are available.

(c) Recreational Use Resulting from Increased Access

It is obvious that recreational use of the area will increase dramatically when road access is available. A quantitative estimate, however, is not possible without the results of the participation survey, which are not available at this time.

7.5 - Schedule and Cost of Recreation Facility Development

Like the details of the proposed recreation plan, the following schedule and costs are tentative. They are subject to Power Authority approval, and will require review by other agencies.

(a) Short Term

The majority of the proposed site developments are scheduled for completion during the first three years of project operation. Since most of the cost of development is road-related, however, some site preparation could take place at the time of road construction at little extra cost. In addition, once the type and location of opportunities to be offered to the public have been established, it is important to stabilize these opportunities at that level. Failing to do so early will permit the original opportunities to be changed or lost as additional developments are introduced. The results of such an alteration will be to displace the established clientele, replacing them with a group seeking a higher level of development.

Short-term costs for recreational facility development, exclusive of road construction costs, are estimated in 1981 dollars to be $2,215,317. A summary of these costs, with the subtotal for each opportunity setting and recreation site, is shown in Table 7.6.

The estimated cost of parking areas varies with the type of area designed. Parking areas located at boat launchings have 3.1 m x 12.2 m (10 feet X 40 feet) spaces; in all other areas they will be 3.1 m x 9.1 m (10 feet x 30 feet). The estimated cost of scenic overlooks and pull-outs is based on an average size of 1,300 m^2 (14,000 sq. ft) per pull out. Actual costs will depend upon actual site conditions, distance to nearest material site, and other factors. Cost estimates are subject to modification once detailed site planning and construction drawings are completed.

(b) Long Term

Proposed site developments scheduled for completion after the first three years (long-term development) include the boat-in picnic ground at Devil Canyon reservoir, two boat-in campgrounds at Watana reservoir, and the expansion of the two campgrounds at Cheechako Canyon and Tsusena Creek.

Long-term costs for recreational facility developments, exclusive of road construction costs, are estimated in 1981 dollars at $1,050,585. A summary of these costs with the subtotal for each opportunity setting and recreation site is shown in Table 7.7. The total for both phases, in 1981 dollars, is $3,265,902.

Estimated operating costs are shown in Table 7.8 and were developed by determining normal agency operations, developing a list of possible cost categories, and soliciting 1981 costs for these items. The projected total operating cost in 1981 dollars would be $405,939 for the first year and $290,280 per year after that.

TABLE 7.1: REGIONAL RECREATIONAL FACILITIES

Site Development	Location[a]	Managing Agency	Area	Accommodations
WITHIN PROJECT AREA				
High Lake Lodge and airstrip	5 kilometers (3 miles) N.E. of Devil Canyon damsite at High Lake	Private	45 hectares (111 acres)	8 units
Stephan Lake Lodge and airstrip	16 km (10 miles) S.W. of Watana damsite at Stephan Lake	Private	17 hectares (42 acres)	24 units
Tsusena Lake Lodge and airstrip	16 km (10 miles) N.W. of Watana damsite at Tsusena Lake	Private	20 hectares (49 acres)	8 units
OUTSIDE PROJECT AREA				
Denali National Park and Preserve	Parks Highway, Mile 237.7	National Park Service	2,306,790 (5.7 m. acres)	228 units
Brushkana River Campground	Denali Highway, Mile 105	Bureau of Land Management	19 hectares (47 acres)	17 campsites
Tangle Lakes Campgrounds and Boat Launch	Denali Highway, Mile 21.5	Bureau of Land Management	16 hectares (47 acres)	13 campsites
Upper Tangle Lakes Campground and Boat Launch	Denali Highway, Mile 21.7	Bureau of Land Management	10 hectares (25 acres)	7 campsites

a. Locations of site developments taken from the 1980 Milepost.

Site Development	Location[a]	Managing Agency	Area	Accommodations
Chugach State Park	East of Anchorage	Alaska Division of Parks	200,327 hectares (495,000 acres)	Unknown
Denali State Park	Parks Highway, Mile 132 to 169	Alaska Division of Parks	170,427 hectares (421,120 acres)	Unknown
Tokositna	Parks Highway, West of Mile 135	Alaska Division of Parks	17,095 hectares (43,240 acres)	Undeveloped
Byers Lake Rest Area	Parks Highway, Mile 147.2	Alaska Division of Parks	Unknown	Unknown
Byers Lake Wayside	Parks Highway, Mile 147	Alaska Division of Parks	Unknown	61 campsites 15 picnic sites
Nancy Lake Recreation Area	Parks Highway, Mile. 67.2	Alaska Division of Parks	9,181 hectares (22,685 acres)	136 campsites
Nancy Lake Wayside	Parks Highway, Mile 66.6	Alaska Division of Parks	14 hectares (35 acres)	30 campsites 30 picnic sites
South Rolly Lake Campground	Parks Highway, Mile 67	Alaska Division of Parks	Unknown	106 campsites 20 picnic sites
Big Lake, South and East Waysides	Parks Highway, Mile 52.3	Alaska Division of Parks	14 hectares (35 acres)	28 campsites 8 picnic sites
Lake Louise Recreation Area	Glenn Highway, Mile 157	Alaska Division of Parks	35 hectares (90 acres)	Unknown
Lake Louise Wayside	Glenn Highway, West of Glennallen	Alaska Division of Parks	20 hectares (50 acres)	6 campsites

TABLE 7.1 (Page 3 of 6)

Site Development	Location(a)	Managing Agency	Area	Accommodations
Tolsona Creek Wayside	Glenn Highway, Mile 172.5	Alaska Division of Parks	243 hectares (600 acres)	5 campsites
Willow Creek Recreation Area	Parks Highway, Mile 71.2	Alaska Division of Parks	97 hectares (240 acres)	Unknown
Willow Creek Wayside	Parks Highway, Mile 71.2	Alaska Division of Parks	36 hectares (90 acres)	17 campsites
Sourdough Creek Campground	Richardson Highway, Mile 147.4	Alaska Division of Parks	65 hectares (160 acres)	20 campsites
East Fork Rest Area	Parks Highway, Mile 185.7	Alaska Division of Parks	Unknown	Unknown
Clearwater Creek camping area	Denali Highway, Mile 55.9	Bureau of Land Management	8 hectares (20 acres)	No development
Black Rapids picnic area	Richardson Highway, Mile 225.4	Alaska Department of Transportation	Unknown	Unknown
Paxson Lake Wayside,	Richardson Highway, Mile 179.4	Bureau of Land Management	1.6 hectares (4 acres)	4 campsites
Paxson Lake Campground and Boat Launch	Richardson Highway, Mile 175	Bureau of Land Management	16 hectares (40 acres)	20 campsites
Little Nelchina Wayside	Glenn Highway, Mile 137.4	Alaska Division of Parks	9 hectares (22 acres)	6 campsites

TABLE 7.1 (Page 4 of 6)

Site Development	Location[a]	Managing Agency	Area	Accommodations
Matanuska Glacier Wayside	Glenn Highway, Mile 101	Alaska Division of Parks	94 hectares (231 acres)	6 campsites
Long Lake Recreation Area	Glenn Highway, Mile 85	Alaska Division of Parks	194 hectares (480 acres)	Unknown
Long Lake Wayside	Glenn Highway, East of Palmer	Alaska Division of Parks	151 hectares (372 acres)	8 campsites
Bonnie Lake Recreation Area	Glenn Highway, Mile 82.5	Alaska Division of Parks	52 hectares (129 acres)	Unknown
Bonnie Lake Wayside	Glenn Highway, Northeast of Palmer	Alaska Division of Parks	13 hectares (31 acres)	8 campsites
King Mountain Wayside	Glenn Highway, Mile 76.1	Alaska Division of Parks	8 hectares (20 acres)	22 campsites 2 picnic sites
Moose Creek Wayside	Glenn Highway, Mile 54.7	Alaska Division of Parks	16 hectares (40 acres)	8 campsites
Finger Lake Wayside	Parks Highway, North of Wasilla	Alaska Division of Parks	19 hectares (47 acres)	14 campsites
Rocky Lake Wayside	Parks Highway, Mile 52.3	Alaska Division of Parks	19 hectares (48 acres)	10 campsites
Mirror Lake Wayside	Glenn Highway, Mile 23.5	Alaska Division of Parks	36 hectares (90 acres)	30 campsites
Peters Creek Wayside	Glenn Highway, Mile 21.5	Alaska Division of Parks	21 hectares (52 acres)	32 campsites

TABLE 7.1 (Page 5 of 6)

Site Development	Location[a]	Managing Agency	Area	Accommodations
Dry Creek Recreation Area	Richardson Highway, Mile 117.5	Alaska Division of Parks	151 hectares (372 acres)	Unknown
Dry Creek Wayside	Richardson Highway, Northeast of Glennallen	Alaska Division of Parks	52 hectares (128 acres)	58 campsites 4 picnic sites
Houston Campground	Parks Highway, Mile 57.3	Community of Houston	32 hectares (80 acres)	42 campsites
Knik Wayside	Approx. 64 km (40 miles) North of Anchorage	Unknown	16 hectares (40 acres)	Unknown
Talkeetna Riverside Boat Launch	Talkeetna	U.S. Coast Guard	0.8 hectares (2 acres)	Unknown
Independence Mine Historic Area	Hatcher Pass Road	Alaska Division of Parks	110 hectares (271 acres)	Undeveloped
Adventures Unlimited Lodge & Cafe	Denali Highway, Mile 100	Private[b]	Unknown	Unknown
Gracious House cabins, cafe, guide services	Denali Highway, Mile 82	Private	Unknown	Unknown
Summit Lake Lodge - motel, restaurant, airstrip, guide service	Richardson Highway, Mile 195	Private	Unknown	Unknown
McKinley KOA	Parks Highway, Mile 248	Private	Unknown	70 campsites

b. This list is not an all inclusive list of privately-run facilities, but only a representation of most types of recreational opportunities offered by the private sector.

TABLE 7.1 (Page 6 of 6)

Site Development	Location[a]	Managing Agency	Area	Accommodations
McKinley Village Motel, Restaurant	Parks Highway, Mile 231.1	Private	Unknown	Unknown
North Face Lodge	Mt. McKinley Park Road	Private	Unknown	15 campsites
Grizzly Bear Camper Park campground, raft trips	Parks Highway, Mile 231.1	Private	Unknown	Unknown
Chulitna River Lodge & Cafe cabins, fly-in fishing, glacier trips, raft trips	Parks Highway, Mile 156.2	Private	Unknown	Unknown
Montana Creek Lodge campground, cabins	Parks Highway, Mile 96.5	Private	Unknown	Unknown
Carlo Creek Lodge	Parks Highway, Mile 223.9	Private	Unknown	Unknown
Mt. McKinley View Lodge	Parks Highway, Mile 134.5	Private	Unknown	Unknown
Mt. McKinley View Ldoge	Parks Highway, Mile 325.8	Private	Unknown	Unknown

TABLE 7.2: DESCRIPTION OF OPPORTUNITY SETTINGS

(Keyed to Figure 7.1)

Recreation Opportunity	Opportunity Setting	Activity Emphasis	Management Program
Semi-modern	A	Day-use; auto sightseeing; photography	Pull-out and area information sign at Parks Highway intersection. Also a series of scenic pull-outs at Indian River, Susitna River, and over-look at Susitna canyon. The assumption is that the road will be gravel.
Semi-modern	B	Day-use; auto sightseeing; photography	A series of scenic overlooks and pull-outs in the alpine zone along the road connecting the two dams. Portages and trailheads to alpine lakes and waterfalls in the area with limited parking areas. Overnight use will be permitted along the road.
Semi-primitive	C	Day-and over-night use; boating; sight-seeing; hiking; at Devil Canyon reservoir	Boat launch, picnic grounds and parking area near Cheechako Creek Primitive, auto-oriented campground and trail at Cheekchako Creek with no-wake zone management of the canyon to separate motorized and non-motorized boating. At Tsusena Creek there will be a boat launch with parking area and gravel road access. A primitive, auto-oriented picnic ground will be located nearby. Long-term development will provide for a boat-in picnic ground.
Semi-primitive	D	Day- and over-night-use; boat-ing; sightseeing; hunting; and fishing at Watana reservoir	Gravel road access from Watana dam area to Deadman Cove. A boat launch, campgrounds and parking are scheduled for Watana reservoir. Two small, boat-in campgrounds near shoreline of Watana reservoir.
Semi-primitive	E	Day- and over-night-use; hiking; canoe-ing; fishing; photography; hunting	Trails and portages from the road will lead to the more accessible lakes and waterfalls on Devil, Cheechako, and Tsusena creeks. Emphasis will be on dispersed, low-density use with camping permitted and 'pack-in, pack-out' policy enforced. Primitive portages will not have developed trails. All ORV use will be prohibited.
Primitive	F	Day- and over-night-use; hiking; back-packing, sight-seeing, and hunting	No ORV use; pack-in, pack-out policy.

TABLE 7.3: DESCRIPTION OF PROPOSED RECREATION SITES AND FACILITIES

(Keyed to Figures 7.2 and 7.3)

Opportunity Setting	Site Number	Site Description
A	1[a]	Pull-out with area information sign
	2[a]	Pull-out and parking area with access to Indian River
	3[a]	Scenic pull-out and viewing point above the Susitna River
	4[a]	Scenic pull-out, with small parking area, for waterfalls near the road
	5[a]	Scenic pull-out and viewing point; large, rustic project entrance sign before reaching site 4
	6[a]	Scenic pull-out and small parking area below the Devil Canyon dam near the bridge over the canyon
B	1[a]	Scenic pull-out with panoramic view of reservoir; trailhead and parking area with developed trail to observation point
	2[a]	Trailhead and developed portage to Dawn Lake; primitive portage to other lakes (brushed trails only); parking area limited to five vehicles
	3[a]	Trailhead and developed portage to Mermaid Lake; parking area limited to five vehicles
	4[a]	Pull-out with parking area and trailhead to Devil Creek Falls; parking area limited to five vehicles
	5[a]	Scenic pull-out overlooking Swimming Bear Lake
	6[a]	Scenic pull-out
	7[a]	Scenic pull-out and access to Tsusena Creek; parking area limited to five vehicles
	8[a]	Pull-out and trailhead for short trail to overlook of Tsusena Creek Canyon and Tsusena Falls
C	1[a]	Boat launch and parking area with picnic grounds and parking nearby; trailhead for Cheechako Canyon Trail with short loop for physically handicapped
	2[a]	Primitive, auto-oriented campground (100 units, 60 units to be developed for first 3 years) and a secondary trailhead to Cheechako Canyon

a. Handicapped accessible.

TABLE 7.3 (Continued)

Opportunity Setting	Site Number	Site Description
	3	Primitive, boat-in picnic ground (10 units, long-term development)
	4[a]	Simple boat launch, and picnic and parking area at Tsusena Creek and gravel access road
D	1[a]	Boat launch, and parking area, with primitive auto campground (60 units, 30 units to be developed the first three years) with a gravel road; primary access point for Watana reservoir
	2	Primitive boat-in campground at Watana cove (10 units long-term development)
	3	Primitive boat-in campground at Jay Creek (10 units long-term development)
	4	Camping area for Susitna and Tyone River floaters (to be developed in agreement with BLM)
E	1	Trail to observation point north of Devil Canyon (see B-1)
	2	Develop portage to alpine lakes and primitive portages to more distant lakes (see B-2)
	3	Develop portage to alpine lakes (see B-3)
	4	Develop trail to Devil Creek Falls (see B-4)
	5	Develop trail to Tsusena Creek Falls (see B-7)
	6[a]	Develop trail to Cheechako Creek Falls (see C-1, C-2)
F		No developed facilities

TABLE 7.4: DAILY TRAFFIC COUNT FOR THE DENALI AND PARKS HIGHWAY

	1973	1974	1975	1976	1977	1978
Denali Highway[a]	36	53	103	66	72	58
Parks Highway[a]	551	588	721	619	739	735
Parks Highway[b]	334	387	516	452	481	468

a. Average daily traffic count, from mid-May to October
b. Annual average daily traffic count

TABLE 7.5: VISITOR COUNTS FOR STATE RECREATION AREAS ADJACENT TO PARKS HIGHWAY

Location	Summer - 1979[a]	Summer - 1980[b]
1. Byers Lake Wayside	10,238	13,327
2. Denali State Park (excluding Byers Lake Wayside)	N.A.[c]	1,337
3. Nancy Lake Wayside	10,487	10,035
4. Nancy Lake Recreation Area (excluding Nancy Lake Wayside)	8,976	8,179
5. Big Lake - East Wayside	15,075	14,776
6. Big Lake - South Wayside	17,883	11,887

a. Total for the months of July, August, and September 1979.
b. Total for the months of May, June, July, and September 1980.
c. Not Available.

TABLE 7.6: CAPITAL IMPROVEMENT COSTS - PHASE 1

Opportunity Setting	Site Number	Total Cost[a] (Excluding Roadwork)
A	1	$ 1,216
	2	2,329
	3	336
	4	1,779
	5	1,264
	6	480
	Subtotal	$ 7,404
B	1	$ 564
	2	886
	3	886
	4	336
	5	336
	6	336
	7	336
	8	886
	Subtotal	$ 4,566
C	1	$ 128,705
	2	1,083,282
	4	128,705
	Subtotal	$1,340,692
D	1	$ 728,081
	Subtotal	$ 728,081
E	1	$ 23,482
	2	4,548
	3	4,548
	4	31,811
	5	8,443
	6	61,742
	Subtotal	$ 134,574
	Grand Total	$2,215,317

a. Total cost without the cost of roads, pull-outs and parking lots

Source: Alaska Department of Natural Resources, Division of Parks, Estimated Facility Costs, January 1981; U.S. Department of the Interior, Forest Service, RIM Cost Figures For Selected Facilities and Chugach Cost Data Guide for Engineering and Road Construction, 1981; Bob's Services Unlimited, Anchorage; and various local building supply dealers.

TABLE 7.7: CAPITAL IMPROVEMENT COSTS - PHASE 2

Opportunity Setting	Site Number		Total Cost[a] (Excluding Roadwork)
A	1-6		$ -0-
		Subtotal	$ -0-
B	1-8		$ -0-
		Subtotal	$ -0-
C	1		$ -0-
	2		583,748
	3		50,365
		Subtotal	$ 634,113
D	1		$ 350,232
	2		33,120
	3		33,120
	4		-0-
		Subtotal	$ 416,472
E			$ -0-
		Subtotal	$ -0-
		Grand Total	$1,050,585

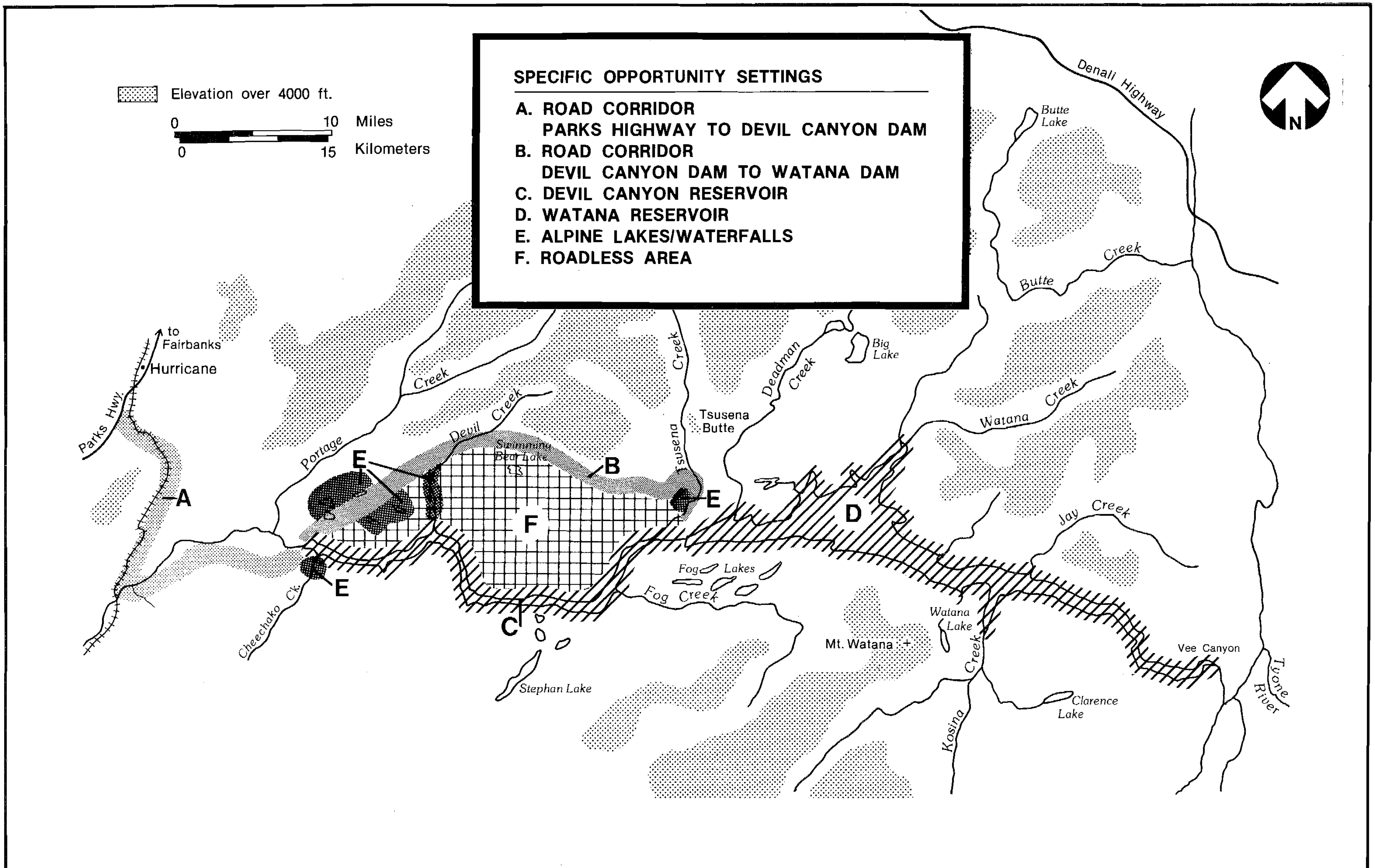
a. Total cost without the cost of roads, pull-outs and parking lots

TABLE 7.8: ESTIMATED ANNUAL OPERATING COST

- Projected First Year Operational Costs -
(Estimated in 1981 dollars)

1.	Personnel		$ 145,140
	1 Park Ranger III - permanent, 3 months		
	1 Park Ranger II - permanent, 12 months		
	1 Park Ranger I - part-time, 6 months		
	1 Park Tech. II - permanent, 12 months		
	2 Park Tech. I - part-time, 6 months		
	1 Main. Worker - part-time, 6 months		
	1 Clerk/Typist - part-time, 6 months		
2.	Travel Expenditures		7,257
3.	Contractual Services		72,570
4.	Commodities		12,095
5.	Equipment		
	Shop Maint. Equip., Tools & Supplies	$19,579	
	2 Boats with Equip., Tools & Supplies	38,134	
	4 Pick-up Trucks with Equip., Tools & Supplies	34,936	
	Office Equip., Tools & Supplies	8,571	101,220[a]
		Subtotal	$ 338,282
		20% Contingency Factor	67,657
		Total	$ 405,939

a. Projected equipment costs for successive years would be less by approximately $4,838. Total operating cost would be estimated at $241,900 with a 20% contingency factor for a total of $290,280.

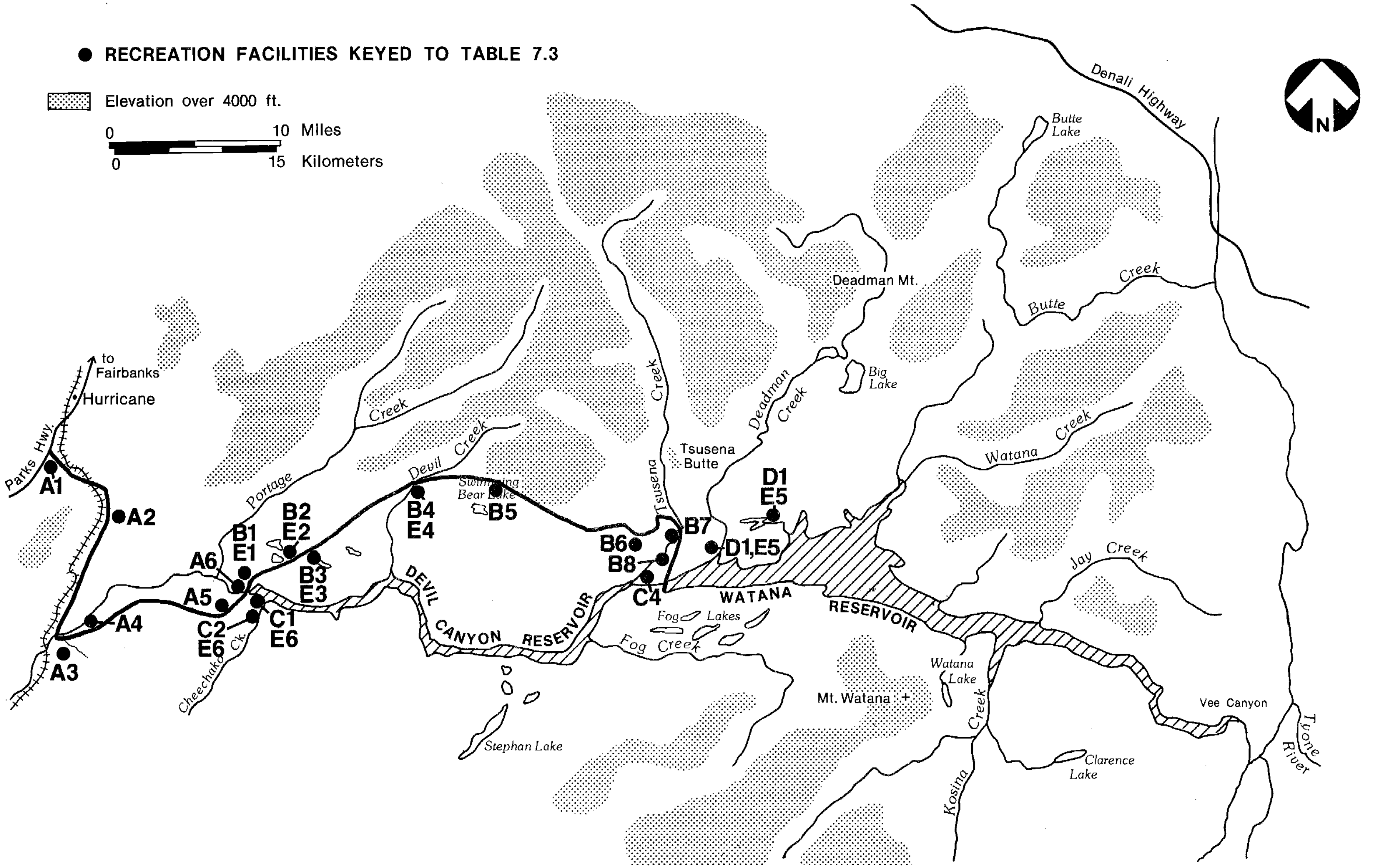


RECREATIONAL OPPORTUNITY SETTING FOR THE SUSITNA AREA

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 7.1

ACRES

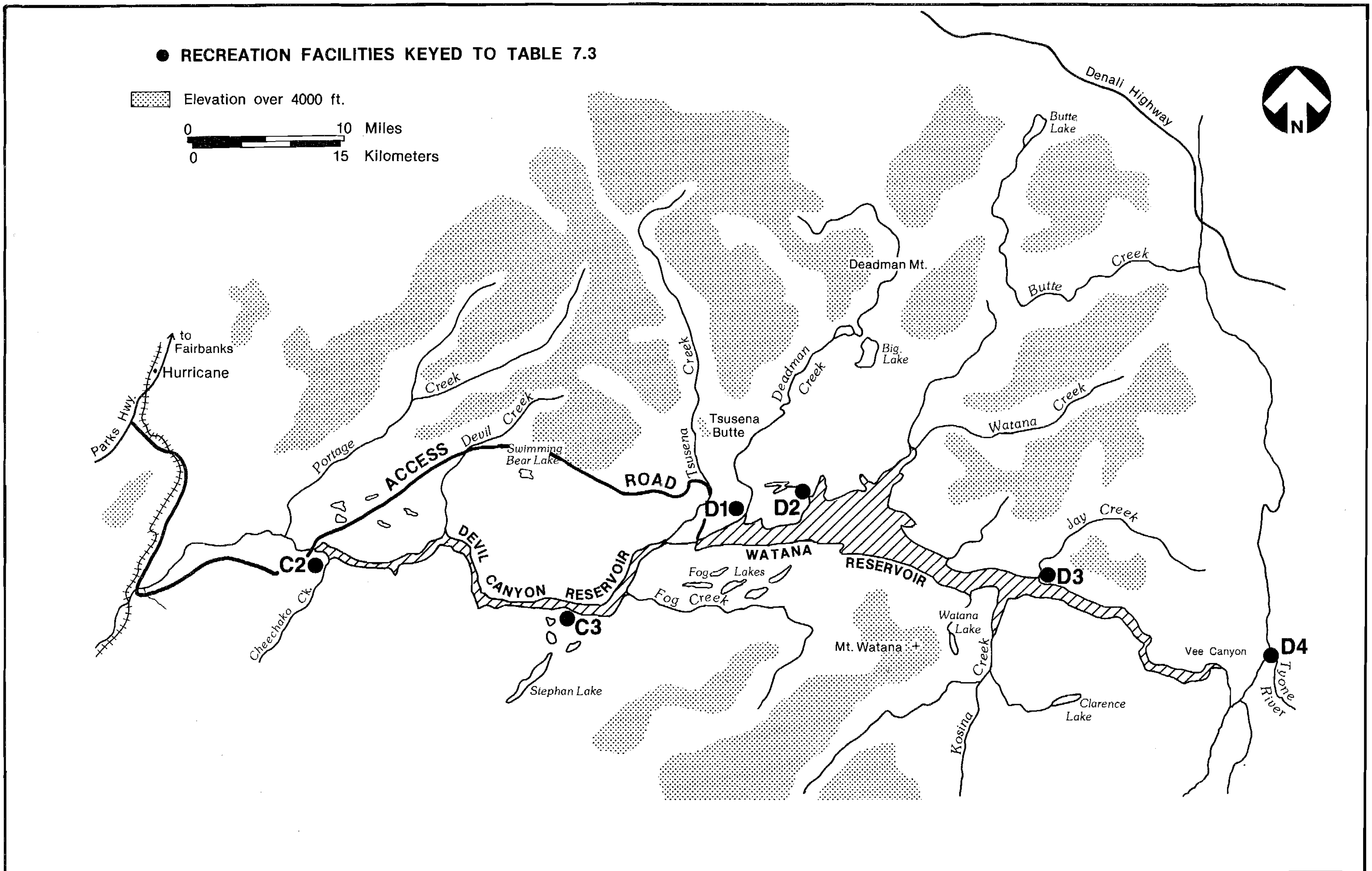


RECREATION FACILITIES -- IMMEDIATE DEVELOPMENT

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 7.2

ACRES



RECREATION FACILITIES -- LONG-TERM DEVELOPMENT

PREPARED BY TES / UNIVERSITY OF ALASKA

FIGURE 7.3

8 - REPORT ON AESTHETIC RESOURCES

8.1 - Aesthetic Character of Lands and Water to be Affected

The upper Susitna River basin comprises a diverse landscape, largely roadless and relatively uninhabited. The combination of these factors creates a natural region in which, depending upon a viewer's location in the basin, a variety of visual groupings exists free from the imprints of man. In contrast to other areas in Alaska, the aesthetic resources of the project area are generally not seen as outstanding (with the one exception of Devil Canyon itself). Because the area is a wilderness region positioned between the two major population centers of Fairbanks and Anchorage, however, the aesthetic resources of the upper Susitna basin are an important consideration when evaluating the impact of the proposed hydroelectric project. Photographs of the vicinities of the two proposed dam sites are presented in Figure 1.2.

The upper Susitna basin contains a variety of aesthetically distinct landscapes. This diversity arises from a mix of vegetation, water, and topographical features which display many combinations of form, line, color, and texture. These combinations are enhanced by both sub-elements and ephemeral qualities, including atmospheric conditions; observer distance, angle, and position; illumination; the presence of wildlife; and natural scents and sounds.

The landforms of the area are defined by three major elements: the deeply incised Susitna River valley and its tributaries, the northern Talkeetna and Chulitna Mountains, and the northern Talkeetna plateau. The area's features, textures, and relief are dominated by the plateau's northeast trending; rounded, low mountains; and generally rolling highlands. These areas of rolling terrain slope to meet adjacent landforms that are moderately rugged, higher, and more mountainous. Other landforms in the east reflect the influence of the adjoining Copper River basin. These are characterized by lower mountains and hills widely spaced on the plateau and by flat terrain interspersed with numerous ponds.

Vegetation is diverse and varies with elevation. Dense spruce-hardwood forests blanket the lower drainages and slopes, while large meadows of tundra cover higher elevations. A variety of shrub types occur between the two biomes, adding texture and color to the setting. This diversity of vegetation enhances edge effect found in the more scenic visual groupings.

Color also enhances the scenic composite, particularly in autumn, when the leaves of deciduous trees turn gold or orange and create a vivid contrast to the dominant dark spruce green. Also, in the autumn the tundra bursts into a brief period of color, especially striking when viewed against a high lake and mountainous backdrop.

The V-shaped valleys of the Susitna River and its tributaries are visually prominent as they cut a distinct swath of green through a predominantly tundra landscape. The deeply cut canyon of the Susitna River is particularly striking at Devil and Vee Canyons, where turbulent rapids, rock outcroppings and cliffs, and enclosed walls dominate the scene. There are numerous clear, fast-flowing mountain creeks, some of which flow over and through steep, rocky embankments to form waterfalls and flumes. Lakes in a variety of forms and settings are numerous in the basin. They range from small, irregularly shaped lakes set in woods and against a backdrop of mountain peaks; to lakes which reflect their glacial origin; to a complex of five, finger-shaped lakes (Fog Lakes) set in a black spruce and shrub wetland region.

The higher mountain peaks, including Deadman, Devil, and Watana mountains, as well as the more accessible overlooks of Tsusena and Chulitna buttes and the ridges above Vee Canyon and at Big and Swimming Bear lakes provide viewpoints that overlook the project and adjacent areas. Many of these sites allow extensive views of the central Talkeetna Mountains and the Alaska Range, often focusing on Mounts McKinley, Deborah, and Hess and on the Eldridge, West Fork, and Susitna glaciers.

Overall, the upper Susitna basin has considerable aesthetic appeal. Furthermore, certain natural features in the area have been identified as having exceptional aesthetic quality. These features, their locations, and their descriptions appear on Table 8.1 and on Figure 8.1. Other noteworthy natural features are listed in Table 8.2 and are also designated on Figure 8.1.

8.2 - Impact on Aesthetic Resources

(a) Dams and Impoundments and Associated Facilities

(i) Effects Common to Both Dams

The overall impact of the project will be the modification of existing scenic values. The two proposed dams and their associated facilities will contrast vividly with the natural landscape in material, color, and mass; as a result, the structures will tend to be visually isolated from the surrounding environment. Although the proposed dams will introduce into the landscape a significant non-natural feature, they will also attract visitors interested in viewing them. Because of their size (Watana will be the highest dam in North America) and the engineering accomplishment that they will represent, the dams will be impressive structures.

The construction zones around the dam sites will necessitate topographical changes, vegetation clearing, and ground disturbance that will introduce lines and forms unrelated to the natural scene. Even after recontouring and revegetation, these zones will contrast with the surrounding landscape. In addition, the dam sites will become centers of human activity and will be highly visible in an otherwise generally still area.

The primary effects on aesthetic resources resulting from inundation by the reservoirs will be the loss of the variety and natural character of the V-shaped valley floor, rock cliffs and outcroppings, river and rapids, and confluences with tributaries. These natural features will be replaced by large lakes with drawdown zones. The created shorelines, in most areas, will lack the characteristic qualities of natural shorelines. Because of their sizes, the reservoirs will be prominent features of the landscape. While these new lakes may visually enhance the landscape by juxtaposing land and water, this advantage may be limited by bank slumping, the appearance of the exposed drawdown zone, and the possible turbidity of the water.

Prior to their inundation, the impoundment zones will be cleared of trees, thereby avoiding the visual impact of dead trees in shallow areas and floating debris in the reservoir. Although vegetation above the full-pool level will not be cleared, water table changes and melting of permafrost may kill trees along portions of the reservoir shoreline.

(ii) Watana Dam and Impoundment

Watana dam and reservoir will constitute a major impact on aesthetic resources in the basin. (The factors contributing to this impact are discussed in the previous section.).

The reservoir, at full capacity, will be surrounded by shrub communities and black spruce, with a few white spruce stands in the Vee Canyon area. The relatively steep banks will be subject to periodic drawdowns of up to 61 m, creating mud flats devoid of vegetation and susceptible to erosion. Average annual drawdowns are expected to be about 27 m, with about eight meters (vertical) of drawdown zone visible in June, diminishing to zero in September. The majority of visitors to the reservoir area are expected in the period between these two months. At the head of the reservoir and in the present Watana Creek drainage, extensive mud flats could be exposed when reservoir water levels are low. In other areas of the reservoir, because of unstable soils and melting permafrost, slumping may occur, creating steep slopes with a beach flattened out to the waterline.

The unavoidable results of creating the Watana reservoir include the inundation of native vegetation (Section 3.5, Impacts on Botanical Resources) and the loss of two significant natural features, namely, Deadman Falls and the Vee Canyon rapids. In addition, the project will cause the partial loss through inundation of Vee Canyon gorge.

(iii) Devil Canyon Dam and Impoundment

The Devil Canyon concrete dam will be an imposing structure in relation to the adjacent rolling topography. The associated facilities will also have considerable visual impact on an area now aesthetically appealing (Figure 1.2).

The impoundment will be very narrow, in comparison to the Watana reservoir, and thus will not be as prominent a feature on the landscape. The water in the reservoir is expected to be clearer than that in the Watana impoundment. The pool level will fluctuate about 20 m on an annual basis (somewhat less than Watana), and the steeper slope of the canyon will further limit the extent of the drawdown zone. In the summer months, however, when the majority of visitors are expected, the Devil Canyon impoundment will not be full; the drawdown zone in June, about 20 m (vertical), will diminish to about 5 m in September.

The Devil Canyon reservoir will unite the surrounding landscape and increase viewing opportunities, although the exposed drawdown zone will degrade its appearance. Unavoidable negative effects, however, will include the loss of the character and diversity of the river valley and the major loss of much of Devil Canyon, with its rapids, rock and spruce terraces, and enclosure. Of all the natural features in the basin, Devil Canyon is, by far, the most significant, the basin being known primarily for this gorge (Table 8.1, Figure 8.1).

(b) Borrow Areas

The locations of borrow sites for construction of the dams are shown in Figure 9.8. Borrow areas, in general, create both unnatural forms and line and color contrast and are, therefore, seen as visually disruptive in a natural setting. Negative aesthetic impacts are caused by denuding expansive areas of vegetation, changing the natural topography, perhaps creating erosion, and adding spur access roads, all of which contrast visually with the surrounding landscape. The evidence of borrow area excavation will remain visible for many years. To reduce some of the long-term effects of this excavation, the borrow areas will be recontoured to resemble natural topography, and the sites will be revegetated [Section 3.9 (b)(ii)].

Table 8.3 lists the potential impact of the borrow areas for dam construction, Areas A-L; (Area C is no longer being considered). Of these sites, the highest impact on the area's aesthetic resources will perhaps be caused by Borrow Area D, since it is located in low-absorption vegetation and is highly visible from both the reservoir and a portion of the access road. A reserve area, Quarry A, is located in a scenic region. Areas E and F will alter the appearance of the area along Tsusena Creek, and although Tsusena Falls is not within either of these borrow sites, it is likely that the setting of this exceptional natural feature (Table 8.1) will be disturbed. Borrow Area K has the potential for infringing on the series of falls on Cheechako Creek; a recreational facility has been proposed in this vicinity [Section 7.2 (c)]. Area E in the upper Devil canyon reservoir will extend above the full-pool elevation, with the result that some surface scarring and modification of topography will occur. Borrow Area I will be developed to 15 m above the existing river elevation, to a maximum elevation of 472 m (1550 ft). Therefore, lower portions of the site will be inundated by the Devil Canyon impoundment, but at the upper end, it will remain exposed. This area will be particularly visible if a proposed recreational facility is built at Tsusena Creek for boating access to the Devil Canyon reservoir. As with all the other sites, recontouring to resemble natural topography will help reduce the permanent impacts. In some cases, borrow areas will be used as disposal areas for waste material from dam construction, perhaps restoring the original topography.

(c) Access Route

The proposed access route (Figure 9.7) runs from the Parks Highway along Indian River to Gold Creek and along the south side of the river to the Devil Canyon dam site, where it crosses to the north and connects to the Watana site. This road into the presently roadless project area represents a major influence on the area's aesthetic resources. The construction of a road is a long-term linear alteration of the landscape, sharply contrasting with the natural background and interrupting the unified sweep of the surroundings. A road will also allow public access into a remote region -- a change which has potential consequences for the existing resources but also affords many people the opportunity to view these aesthetic resources.

The strong horizontal line created by right-of-way clearing and by the road itself will appear incongruous with the natural setting of the Susitna basin. Long-lasting visual effects will result, even with revegetation of the right-of-way and road construction borrow areas not within the right-of-way. While views from the road will be, for the most part, attractive, with expansive views from the road segment between the two dam sites, in most areas, the transmission line on one side of the road will detract from the scene.

Construction of the permanent access road will be facilitated by a pioneer road into the project area. The portions of this pioneer route that do not coincide with the permanent access route will be visually evident for a long time.

Table 8.3 also notes the potential effects of borrow areas (1 through 8) proposed for the access route (Figure 9.8). The highest degree of impact will occur in Area 1. Located in a scenic setting adjacent to the Indian and Susitna rivers, Area 1 will be visible from the road and the river, from the Susitna bridge crossing, and from other key viewpoints. Development of this site will be of particular concern to future residents, who are expected to settle in this vicinity as a result of state land disposal.

Area 7 is on the northern edge of Mermaid Lake, a scenic area, and is set in low-absorption shrub vegetation along the access route. Area 2, which is also set in low-absorption shrub vegetation along the access route and visible from key viewpoints, may adversely affect a waterfall. Area 8 is located in a tundra region and includes a good view of the surrounding landscape. The general discussion of the types of impact caused by excavation of borrow areas, as given in Section 8.3 (b), also applies to borrow sites for road construction.

Parking lots and staging areas associated with construction of the access road, and its subsequent utilization during dam construction, will entail clearing and grading of natural areas. This transition from essentially natural to developed land areas will result in loss of vegetation and in a reduction of aesthetic character.

Access will introduce people into previously sparsely occupied land. A recreation plan has been developed (Section 7) to control some of this use and to minimize adverse effects. Nevertheless, litter and disturbance of both vegetative cover and existing recreational sites are inevitable. Overuse of some planned road pull-outs (including roadside camping) and other facilities may occur. The results of easier access may thus be incongruous with the natural setting and may have a cumulative negative effect on the landscape. The lake shores (where accessible), reservoir perimeters, creeks, and areas of tundra cover will not be able to withstand heavy traffic pressure, which will degrade the visual quality of the setting by noticeable vegetative and shoreline disturbances. Access will also increase fire hazard; excessive burning would alter the landscape, creating texture and color contrasts.

Imposing increased activity on a nearly pristine landscape will drastically reduce the peace and solitude of the area; the reduction of both scenic quality and the potential for wilderness experience will cause some previous users to seek these amenities elsewhere. The roads and borrow areas seen from the river and reservoir will alter users' visual experience. Planned foot trails, however, will allow visitors to view the landscape in a more natural setting (refer to Section 7.2).

Where the topography is suitable for their use, off-road vehicles (ORV), if permitted, would disturb the terrain. The area traversed by the access route between the two dam sites, because of its topographical make-up and fragile vegetative cover, is extremely susceptible both to ORV use and to consequent damage. ORV use on lands of tundra and shrub cover types would lead to long-term vegetative and visual damage, degrading the original character of the land. Documented ORV use off the Denali Highway has led to severe soil disturbances, left areas denuded of vegetation, and formed gullies 6-8 m wide and up to 3 m deep (Sparrow et al. 1978). If ORV use is restricted, especially in the area between the dam sites (as discussed in Section 7.3), such degradation of the landscape can be avoided.

(d) Transmission Line

(i) Impacts Common to All Study Areas

The major impact of the transmission line will be the creation of incongruous lines across the landscape, where existing utility corridors are not present, decreasing landscape unity and interfering with scenic views by deflecting attention from natural scenes. The noticeable contrast between man-made structures and the landscape's natural elements is caused by irregular patterns: the visibility of towers, because of their height above existing vegetation and their color contrast with the surroundings; the reflection of the conductors; sizeable clearings of vegetation; unconcealed substations; and conspicuous access roads and staging areas needed for construction and maintenance purposes.

Negative impacts on the aesthetic resources will occur where the transmission line is viewed against the horizon, is routed along a ridge, appears on level terrain with unobstructed views, or crosses rivers and gorges. Every effort was made, however, to avoid such areas, both in the initial corridor (5-10 km wide) selection phase and again at the route (0.8 km wide) selection phase of the study.

Construction activities cause both short- and long-term impact on aesthetic resources. The creation of new access where none previously existed will add significantly to the potential for visual disturbance caused by the transmission line. Again, efforts were made to parallel existing utility corridors and to utilize existing access whenever appropriate. Discussions of the impact of borrow areas, roads, and construction camps appear in Sections 8.2 (b), (c), and (e).

Maintenance activities during the operational phase of the lines can also cause adverse impacts as a result of clearing or of chemical treatment of the right-of-way. Impacts will vary depending upon the timing and method of right-of-way maintenance but can be minimized through careful prescription of maintenance techniques.

(ii) Upper Basin

The major impact of the upper basin transmission line will be degradation of the basin's wilderness quality; the line will disrupt otherwise unobstructed views and will decrease the unity of the natural landscape. This impact will be experienced most severely by users of High Lake Lodge and its surrounding lands and waters. The lines will be located within 1.6 km of High Lake and, although in the background, will be incongruous with the otherwise natural setting of the lodge area. For this reason, an alternative route has been proposed, which would locate the lines beyond the viewshed of the lodge and its environs. Map M8 in Appendix E3 graphically presents both route locations.

Another impact will result from clearing vegetation from one strip 122 m (400 ft) wide between the two dams (although tall-growing vegetation exists only on a small portion of this segment) and from a second strip 213 m (700 ft) wide from Devil Canyon dam to the point of intersection with the Intertie near Gold Creek. These impacts are depicted graphically on Figures 25-36 in Appendix E3. The line, where visible near the access road and reservoirs, will impair the viewer's scenic experience. Background views of the lines from Otter Lakes and from the access road will be present. Foregound and middle-ground views will be evident particularly from High Lake (unless the alternative route is selected) and again from points along the access road.

(iii) Healy to Fairbanks and Willow to Anchorage

The Healy-to-Fairbanks route will cause aesthetic impact at the three crossings of the Parks Highway, the three river crossings, the two railroad crossings, and two areas where the line is visible from and parallels the highway or railroad. Careful placement of towers, and whenever possible, retention of vegetative screens, however, will greatly reduce the degree of impact. Furthermore, by closely paralleling the existing transmission facilities where appropriate, incremental rather than totally new impacts will result. Information on aesthetics appears on Northern Study Area Figures (1-24) in Appendix E3.

The Willow-to-Knik Arm route will cause major visual impacts near Willow. Here, the line will cross the Parks Highway and the Alaska Railroad and will be most evident to travelers on these routes. The transmission line route passing west and north of the community of Willow could affect the visual setting of this community because the line may also be apparent to residents as well as to recreators on Willow Creek. The route will likewise disturb the wilderness quality of the region and will interfere with natural views, most severely near the Iditarod Trail and the Susitna Flats Game Refuge. Between a point southwest of Willow and Knik Arm, the line will intrude upon the landscape, although by following existing trails, new roads will not need to be built along much of the transmission line right-of-way. In addition, existing recreation areas will be avoided. Because the route is removed from travel corridors, the visibility of the line in this area is low, with the exception of the Little Susitna River crossing, which will be relatively noticeable. Again, the retention of vegetative screens along the river banks could significantly reduce the degree of visual intrusion at this location. Information on visual quality for this study area is presented graphically on Figures 27-48 of Appendix E3.

For that area east of Knik Arm to the proposed substation south of Muldoon Road, visual impacts will be significant. Because of the presence and proposed proximity of existing transmission structures in this area, however, impacts will be incremental rather than totally new. To help mitigate these impacts, tower and conductor materials, spacing, and design could approximate closely that which is already present.

(e) Construction Camps and Villages

The current plan is to build temporary construction camps (single worker housing) and villages (family housing) at both Devil Canyon and Watana. The village at Devil Canyon will be removed after construction, but the Watana village is planned as a permanent town site. The construction camps and village sites will be incongruous with the existing natural landscape, and the concentrated, constant human use therein will disturb the scene. Permanent and temporary human use will introduce waste disposal sites, litter, and leisure activities potentially damaging to the environment in an area now relatively free of human imprint.

Large numbers of people will be using the construction camps and villages for considerable amounts of time; as a result of this pressure, the sites and their immediate vicinities will undergo significant changes in character. Site preparation will include clearing of vegetation, which will create long-term alterations to the sites. Human activity will create paths throughout the vicinity and, as a result of anticipated heavy use, will affect any nearby streams or lakes. The aesthetic resources in the area of the housing facilities will evidence visual alteration long after the facilities are removed and the property restored. The types of impacts associated with the town site at Watana are similar in nature, but of a lesser degree because of the few people, though longer term because of the permanency of the town.

A subjective evaluation of the visual impacts associated with the construction camps and village sites at Watana and Devil Canyon is included in Table 8.3. The sites at Watana will be quite visible because of the relatively low absorption capability of the shrub community and because the sites are within the viewsheds of portions of the access road and reservoir. On the other hand, the proximity of the sites to the dam construction site serves to concentrate the impact in a limited area.

Creation of the Devil Canyon camp and village will require the clearing of trees, giving rise to contrasts of texture, color, and line between the facility and its natural environment. Because of the higher absorption capability of the surrounding spruce-hardwood forests, however, and owing to other micro-relief factors, the Devil Canyon facilities will likely be shielded from most viewsheds. Also, no permanent town site is currently planned for Devil Canyon. Thus, while the impact on aesthetic resources will be significant, it will be lessened at the Devil Canyon site.

The sites of any temporary camps for road and transmission line construction crews are presently unknown, so specific impacts cannot be discussed. If such camps are located, built, and maintained in an environmentally sensitive manner and if the sites are later restored with the same concern, then the camps' impact will be relatively short-term.

TABLE 8.1: EXCEPTIONAL NATURAL FEATURES

Feature	Location	Description
Devil Canyon	Susitna River, west end of project area T.32N., R.1W., 1E., and T.31N., R.1E., S.M.	A steep-sided, nearly enclosed gorge, its sides alternating spruce-covered terraces and rock-bound walls, constricts the channel of the Susitna River, producing an 18 km stretch of turbulent whitewater. Two narrow falls, flowing through deeply incised crevasses, plummet a distance to the river below. Devil Canyon combines unusual geology, hydrology, and aesthetics with uncommon recreational opportunities, such as kayaking, to render it a unique natural feature in both the project area and the state of Alaska.
Vee Canyon	Susitna River, east end of project area T.30N., R.10E., Sec. 11 & 12, S.M.	Vee Canyon occupies a double hairpin bend in the deeply cut channel of the Susitna River, creating a stretch of whitewater. The canyon walls are composed of very steep rock ridges and are unusually colorful, the rock often interlayed with marble and green schist. Vee Canyon, more visible than Devil Canyon and with its walls more open, is exceptional in its scenic beauty.
Clear Valley	Approx. 6 km south of Fog Lake 2230 T.30N., R.5E., Sec. 5, 8, 17, 20, 29, 34., S.M.	Clear Valley contains unusual flat surfaces raised off the valley floor and surrounded by meandering streams; the valley's dominant feature is its visually apparent geological history. Geologically, the valley is fairly young and contains good examples of lateral moraines. Clear Valley contrasts significantly with the surrounding viewscape; the valley is unusual for its geologic features.
Deadman Falls	Near mouth of Deadman Creek T.32N., R.5E., Sec. 26., S.M.	Deadman Falls with an elevation of 521 m (1710 ft) is one of the largest and most scenic waterfalls in the project area. Deadman Creek surges over loose rocks in its incised channel, plummeting straight down over rocky slopes and outcroppings into a clear boulder-dominated pool, a pool often veiled in vapor.
Tsusena Falls	Above mouth of Tsusena Creek T.32N., R.5E., Sec. 20, S.M.	Clear and turbulent, Tsusena Creek drops nearly 60 m as it rushes over a steep, rocky cliff, creating a waterfall of considerable volume, which cascades into a large, deep, rock-enclosed pool. The view of the waterfall; creek; rock outcroppings; and dense, green vegetative cover is impressive.

TABLE 8.1 (Continued)

Feature	Location	Description
Devil Creek Falls	Above mouth of Devil Creek T.32N., R.2E., Sec. 20., S.M.	Devil Creek, constricted by a narrow opening between jagged rock walls, plunges over the steep embankment in a narrow, contained flow before fanning out and cascading to the pool below. The irregular pattern of the waterfall, against bare rock and surrounded by the densely vegetated, incised creek valley walls, creates a scene of high aesthetic appeal. Elevation 579 m (1900 ft).
Big Lake	N.E. of proposed Watana dam site T.22S., R.3W., Sec. 18, 19, 30, T.22S., R.4W, Sec. 25., F.M.	Big Lake, largest lake in the project area, is a prime example of a lake held in by a terminal moraine. Big Lake's proximity to Deadman Lake and, from Big Lake, the panoramic view of the Alaska Range and nearby Deadman Mountain combine with the lake's observable glacial origin to create an area that is noteworthy for both scenic and geologic features.
Mt. Watana Cirque Lake	East of VABM Mt. Watana T.30N., R.7E., Sec. 2., S.M.	A cirque lake high on Mount Watana provides a scenic interpretation of the area's glacial history. The cirque contains a pristine lake, simple in outline and distinguished by the natural amphitheater formed on three sides by towering scree slopes, with a scenic view of the valley from the remaining side.
Tyone River	East end of project, area confluence with Susitna River T.30W, R.12E., Sec. 9., S.M.	The slow-flowing, dark, and clear Tyone River, near its confluence with the Susitna River, is flanked on its south shore by starkly contrasting chalk-colored cliffs. These are composed of lacustrine deposits left behind by an expansive proglacial lake, one of three such lakes of significant size recorded in Alaska. This particular region of the Tyone River is exceptional for its prominent glacial remains, scenic white bluffs, and dark/clear river.

TABLE 8.2: OTHER IMPORTANT NATURAL FEATURES

Feature	Location	Description
Fog Lakes	Sections 3, 7-11, 13, 18, T31N.,R.5E., and Sections 5, 7, 8, 18, T.31N., R.6E., S.M.	Five lakes in proximity to one another; average surface area is 109 ha, with no lake smaller than 56 ha.
Stephan Lake	Sections 2, 3, 9-11, 16, 17, 20, 21, T.30N., R.3E., S.M. Between Watana and Devil Canyon dam sites on south side	The longest lake immediately adjacent to the project area, it measures 7 km in length, and is the nearest lake to the project are with a run of salmon and one of the few with relatively high recreational use.
Watana Lake	Section 6, T.30N., R.8E., S.M. Section 1, T.30N., R.7E., S.M. Section 36, T.31N., R.7E., S.M. Section 31, T.31N., R.8E., S.M. East of Mt. Watana	Mount Watana, rising directly to the west of Watana Lake, provides an aesthetically pleasing setting for the high (914 m) lake.
Swimming Bear Lake (unnamed lake)	Section 4, T.32N., R.3E., S.M. Sections 32, 33, T.33N., R.3E., S.M. 8-10 km north of VABM Devil near proposed access route	One of the highest lakes in the project area, Swimming Bear Lake (Ms. K. Oldham, pers. comm.) is a large alpine lake set in mat and cushion/sedge-grass tundra surroundings.
Deadman Mountain	Sections 6, 7, 17-20, 29-32, T.21S., R.3W., F.M. Sections 1, 2, 11-14, 23-26, 34-36, T.21S., R.4W., F.M.	Isolated Deadman Mountain, reaching a height of 1684 m, overshadows Deadman Lake and Big Lake.
Tsusena Butte and Tsusena Butte Lake	Sections 16, 20-22, 27-29, T.33N., R.5E., S.M. North of Watana dam site	A prominent butte (1341 m), Tsusena Butte rises above Tsusena Butte Lake, one of the deepest lakes in the project area (34 m). The lake is comprised of two irregularly shaped segments.

TABLE 8.2 (Continued)

Feature	Location	Description
Chulitna Butte	Sections 22, 27, T.33N., R.2W., S.M. South of Hurricane	Chulitna Butte overlooks the Alaska Railroad's past and present communities and provides an accessible viewpoint of part of the project area from the Parks Highway.
Cheechako Falls	Sections 4, 8, 9, T.31N., R.1E., S.M. First creek southeast of Devil Canyon dam site. Elevation: 510 m.	A series of five waterfalls along Cheechako Creek, set in a steep gorge. The two largest falls are approximately 8 m apart, with pools and rocky cliffs, and surrounded by thick mats of moss and other vegetation.
Mount Watana Falls	Section 33, T.31N., R.7E., S.M. On north side of Mount Watana. Elevation 1370+ m.	A waterfall flows over a deeply incised rock gorge interlaid with black and white marble; barren tundra surrounds the falls, and a mist hangs above it.
Spearpoint Falls (unnamed falls)	Section 1, T.31N., R.7E., S.M. In an easterly direction, first creek past Watana Creek and Susitna River confluence on the north side. Elevation 625+ m.	Four waterfalls occur along a relatively small creek. The largest one is below the others in a large, hollowed-out area. (Named for a spearpoint that was discovered in one of two nearby archeological sites.)
Devil's Club Falls (unnamed falls)	Section 11, T.31N., R.2W., S.M. In an easterly direction, first creek past Gold Creek and Susitna River confluence on the south side. Near Borrow Area 2 for access road. Elevation: 297+ m.	Devil's Club Falls is a scenic waterfall, easily accessible from the Susitna River below the Devil Canyon rapids. (Temporarily named for the abundance of devils club that is present all the way up to the falls).

TABLE 8.3: POTENTIAL AESTHETIC IMPACTS OF BORROW AREAS AND HOUSING SITES[a]

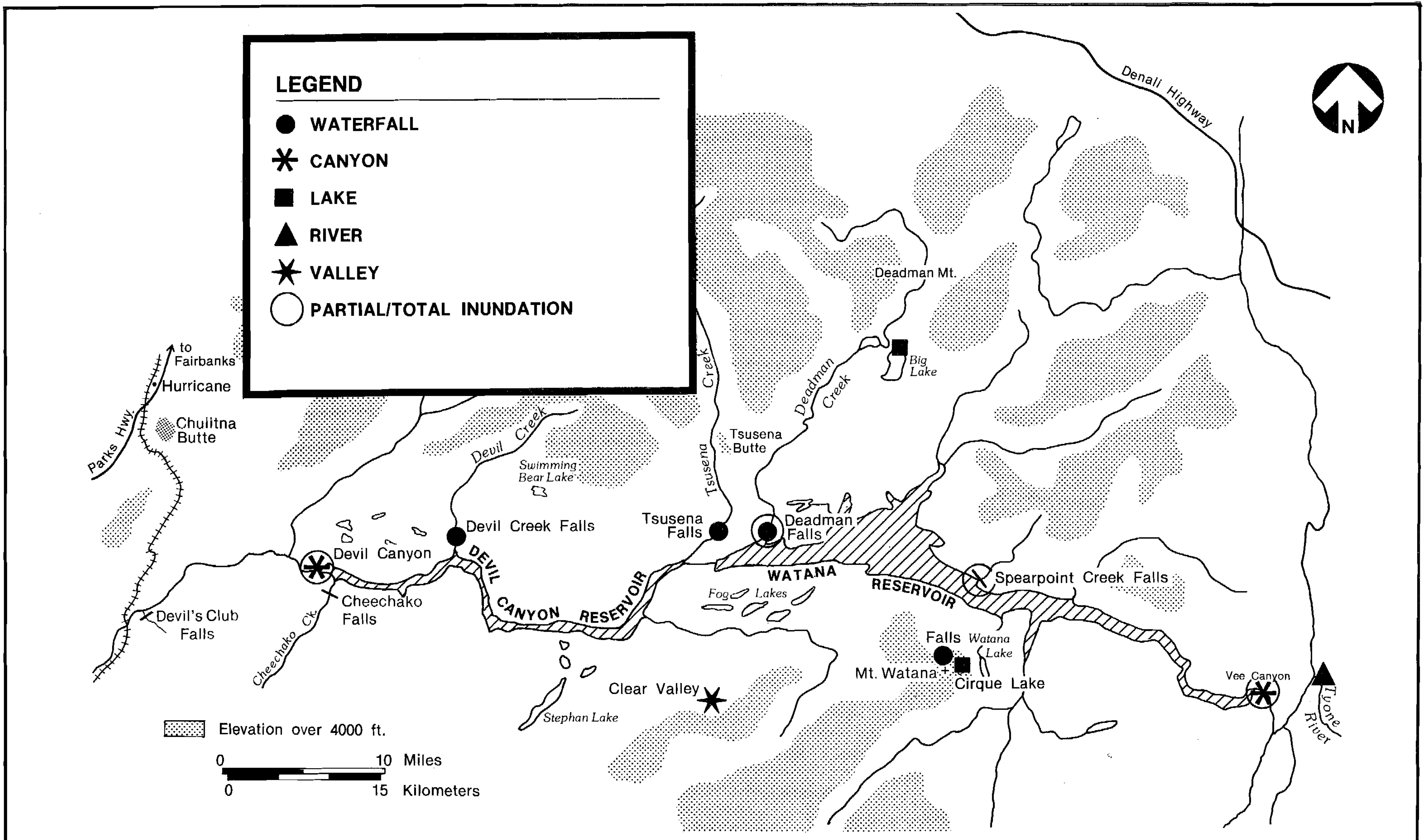
CATEGORY	DAM BORROW AREAS											ACCESS ROAD BORROW AREAS								VILLAGE SITES		CONSTRUCTION CAMPS	
	A	B[b]	D	E	F	G[b]	H	I[c]	J[b]	K	L[b]	1	2	3	4	5	6[b]	7	8	Devil Canyon	Watana	Devil Canyon	Watana
Viewshed from Access Route	3	*	5	4	5	*	0	0	*	2	*	5	5	3	4	4	*	0	4	4	5	2	5
Viewshed from Reservoir(s)	5	*	5	5	0	*	3	5	*	2	*	5[d]	5[d]	4[d]	0	0	*	0	0	0	5	2[d]	4
Vegetative Cover	5	*	4	3	4	*	4	3	*	2	*	4	3	3	3	3	*	4	5	3	5	4	5
Accessible Viewpoints	4	*	5	4	5	*	3	3	*	2	*	5	2	2	3	3	*	4	5	3	5	4	5
Visual Setting	4	*	5	5	5	*	5	3	*	5	*	5	5	3	2	3	*	5	4	2	5	4	5

a. A subjective numerical scale is used with 5 representing a great impact and 1 a small or negligible impact; 0 represents no impact at all.

b. Inundated by reservoir.

c. Most of borrow area inundated.

d. Relatively high probability would be in Susitna River viewshed below Devil Canyon dam site.



EXCEPTIONAL NATURAL FEATURES (SYMBOLS)
AND OTHER IMPORTANT NATURAL FEATURES

PREPARED BY TES/UNIVERSITY OF ALASKA

FIGURE 8.1

ACRES

9 - REPORT ON LAND USE

The land use analysis involved an assessment of the direct and indirect effects of the proposed Susitna hydroelectric project on land use. The analysis was designed to evaluate changes in land use that would occur with and without the project, including the effects of the proposed dams, reservoirs, access transportation system, and transmission line routes.

Three study areas (Zones 1, 2, and 3) were defined for analysis (Figure 9.1). These zones were designated according to geographic and land use relationships with the proposed project and extend to varying widths from the river between Gold Creek and the mouth of the Tyone River.

Zone 1 was designated to include those structures and land uses which would be affected by inundation. Zone 2, extending about 10 km (6 mi) from the river, is based upon the locations of lakes which characterize aggregations of land use. Zone 3, which extends approximately 20 km (12 mi) beyond Zone 2, is characterized by fewer aggregations of land use; existing structures and land use are sparse.

The methodology for the land use analysis was to assess past, present, and future land use. Present developed land uses in the Susitna project area are subtle and widely dispersed. Aerial photographs and topographic maps were used to locate cultural features such as trails, structures, and other indications of past and present land use. To aid in identifying present dispersed land use activities, an oral history technique was employed: residents in adjacent and other areas were interviewed. Determinations were made as to present patterns of human land use within the project area and the forces which created different types of land use. Aerial and ground truthing methods were utilized to verify many of the present land use patterns discerned from the oral history interviews.

Additional information was obtained from reports and interviews with federal, state, and local agency personnel concerning past, present, and possible future land use activities in the project area.

9.1 - Existing Land Use in Project Area

Historically, access has been a determinant of the types and level of land use in the upper Susitna River basin. Early access to the area for trapping was by dog teams and showshoeing. When the price for furs dropped, some trappers turned to the more lucrative occupation of acting as guides to sport hunters. Commercial bush pilots provided access to the area using lakes and tundra airstrips for landing. By the early 1970's, use of the area by private pilots during hunting seasons had somewhat reduced the need for hunting guides.

(a) General Patterns

Present land use patterns in the project area reflect the deep ties people of the area have with the land as a source of food, shelter, income, and recreation. Although land use developments are dispersed, present use and activity patterns can be discerned from analysis of known historic uses in the project area and by locating actual remnants of past activity.

Access trails provide indications of past land uses and their influence on present use patterns. Trails provided access into the project area for subsistence hunting, fishing, and trapping, and today these same routes, undoubtedly undergoing some changes, provide access to scattered cabins and to the region in general for recreational purposes.

Existing use patterns in the project area have been identified for hunting, fishing, trapping, mining, and recreation. Brief descriptions of each land use activity follow. The most intensive land use activity is concentrated along the major highways, and in the southern part of Mat-Su Borough well to the south of the project area. Except for hydroelectric power studies, most activity within the project area is related to recreation or mining and, as mentioned, is subtle and dispersed.

(i) Hunting

Hunting within the Susitna project area became popular in the 1960's. Two hunting lodges located within the Zone 2 study area, one on High Lake and the other on Stephan Lake, have catered to an international clientele. Guests at the lodges fly or hike from the lodges to small outreach camps on lakes or streams for stays of a few days at a time.

Lodges typically handle 15 to 25 guests at a time and about 40 guests per season. The increasing popularity of sport hunting in the 1960's caused an increase in the number of small cabins on many of the lakes in the project area. Both guided and non-guided hunting occur within the project area, particularly near Stephan, Fog, Clarence, Watana, Deadman, Tsusena, and Big lakes in addition to many of the area's smaller lakes. Both lodges and cabins provide the field bases for many hunters.

(ii) Fishing

Fishing in the project area occurs singly or in close association with other activities, such as hunting and trapping. Fish present in the area's lakes and streams include burbot, grayling, rainbow trout, Dolly Varden, lake trout, and whitefish. Salmon migrate up Indian River and up the Susitna as far as Portage Creek. Considerable fishing for lake trout, grayling, and salmon occurs in the Stephan Lake - Prairie Creek drainage. Salmon fishing occurs in lower Portage and Chunilna (Clear) creeks and Indian River. Fishing in Fog, Clarence, Watana, Tsusena, Deadman, Big, and High lakes appears to be associated with other activities such as hunting, summer cabin use, and mining. There is little stream fishing elsewhere in the project area.

(iii) Trapping

Trapping activity has declined over the past 30 years, although recently there has been a slight increase in trapping. Present trapping in the project area occurs mostly on the south side of the Susitna River near Stephan and Fog lakes. Some trapping also occurs near Tsusena Creek and Clarence and High lakes.

(iv) Mining

Mineral exploration and mining have been limited in the immediate project area. Typical of the mining done in the upper Susitna River basin since 1930 is a low density of claims characterized by intermittent activity. Nevertheless, mining has played a key role in the land development of the upper river region, particularly along Valdez Creek.

Placer mines working alluvial deposits for minerals are found in sites throughout Mat-Su Borough. Active mining has been more concentrated in Gold, Chunilna (Clear), and Portage creeks than in other areas of the upper Susitna basin with some other active claims around Stephan and Fog lakes, Jay Creek, and the Watana Hills east of Jay Creek. Mining at Gold Creek was active from the early 1950's through the late 1970's; most claims were gold, copper, and silver placer mines. A concentration of at least six mining claims has existed on Chunilna Creek where gold placer claims have been worked since the late 19th century. Mining has occurred in the Portage Creek area since the late 19th century, but only one claim remains active (see Section 5.7).

Coal is the major mineral resource in Mat-Su Borough. Although extensive deposits of varying quality are located in the river valley areas, no coal mining activity occurs in the project area. Most coal is mined to the south and west of the project area; much of it is used for household fuel.

(v) Hydroelectric Research

Following preliminary studies, the Bureau of Reclamation proposed in 1952 that the Susitna be considered for potential hydroelectric development. Since then, there have been many feasibility, design, and environmental studies of the proposed inundation zone and adjacent areas. Combined, these studies have probably contributed more total man-days of use in the area in the past twenty years than all other uses.

(vi) River Boating/Floating

Boating within the project area has involved research, fishing, or recreation. There is considerable summer boating on many of the lakes including Clarence, Watana, Fog, Stephan, Tsusena, High, Otter, Bear, and Dawn. Individuals and riverboat services out of Talkeetna travel up the Susitna and Talkeetna rivers. Some of the services offered include day trips to Devil Canyon; drops at camps for hunting, fishing, and photography; and canoe hauls to many tributary streams.

Raft float trips are taken from the Denali Highway on the Susitna or Tyone rivers down to either just above Vee or Devil canyons where rafters portage to below Devil Canyon and float to Talkeetna. Some canoeing and rafting takes place from just below Devil Canyon to Talkeetna. Boating below Devil Canyon is further discussed in Section 9.1 (e).

(b) Land Use Developments

Existing land use developments are associated with hunting, fishing, trapping, food or equipment storage, research, recreation, and mining. Categories covering the frequency with which structures are used are 1) no use, 2) seasonal use--past, 3) seasonal use--present, 4) seasonal use--past and present, 5) year round use--past, 6) year round use--present, 7) year round use--past and present, and 8) no use information.

Most of the developments, whether structures or discrete objects, are associated with some means of access. Unpaved roads and trails were or are presently used for access to certain points in the project area. Vehicles such as tracked vehicles (Cats), four-wheel drive vehicles, rolligons, dog sleds, and horses have been used for freighting, for transportation within the area, and for access to the project area. Airstrips on gravel bars or flat ground are commonly located in proximity to other historical artifacts such as cabins, trails, or lodges. Trails emanate primarily from existing structures and connect them with airstrips, lakes (on which a ski or float plane can be landed), fishing streams, or other structures.

Geographical zones within the project area (as designated in Figure 9.1) provide an approximate measure of development locations and types of use in proximity to the Susitna River. Both historically and currently, the sparsely distributed developments throughout the project area have been used predominantly on a seasonal basis. The majority of the land use developments or artifacts have been utilized for hunting, fishing, trapping, boating, mining, and other general recreation purposes, such as cross-country skiing or photography.

(i) Zone 1

Types of developments located in Zone 1, the inundation zone plus 61 m (200 ft), include structures, trails, and airstrips.

Ten isolated structures are located in Zone 1 on the shores of the river or on its steep banks (Table 9.1 and Figure 9.2). Historically, these structures were line cabins for trapping and structures used by transient fishermen, boaters, hunters, and for research. Of the ten structures, only three are maintained and then only used on a seasonal basis. Two others, though not actively maintained, appear to be sporadically used by transient hunters, fishermen, or boaters. The remainder are not currently used or usable.

(ii) Zone 2

The greatest number of existing land use developments and historical artifacts are located in Zone 2, the 10 km (6 mi) corridor which flanks Zone 1 on both shores of the Susitna. Zone 2 is a much smaller area than Zone 3, yet there is more evidence of use within Zone 2 than within Zone 3. Types of developments found in Zone 2 include structures, trails, roads, airstrips, and mines. General types of use associated with these artifacts consist of hunting, trapping, fishing, boating, mining, recreation, and research.

Although the primary distribution of uses throughout the project area is low in density, particularly noteworthy in Zone 2 is the occurrence of aggregations of existing developments and historical artifacts. The nuclei of these aggregations are the small lakes and lake systems located throughout Zone 2, which provide access by air. Like the single, scattered land uses in Zone 3, the aggregations of developments consist of cabins and related structures, lodges, roads, trails, and airstrips. Table 9.2 and Figure 9.2 present information on Zone 2.

(iii) Zone 3

Existing structures within Zone 3, the outlying influence zone, are located within a 20 km (12 mi) ribbon of land which flanks the lower and upper portions of the Zone 2 boundary. The 21 structures in Zone 3 have historically been associated with land uses such as hunting, fishing, trapping, mining, boating, research, and other types of recreational use. Fourteen of the 21 structures are currently used during some portion of the year.

Aggregations of use, although they exist, are much less common in Zone 3 than in Zone 2 and occur in the areas of Chunilna and Prairie creeks south of the project area. A summary of existing structures within the area is presented in Table 9.3 and Figure 9.2.

(iv) Summary of Land Use Patterns in the Project Area

The combined factors of the size of the Susitna project area, its isolation, and its location in a subarctic environment result in extremely low-density land use. The history of the project area provides information concerning the deeply rooted values of the people for whom the land is still a source of income, food, and related subsistence activities, and recreation. The development of land use has been a slow, evolutionary process involving utilization of the resource base. Many historic uses are relevant in assessing present land use patterns, and indeed many of the remnants of past uses shape present patterns. Structures verified through aerial truthing are shown by land use zones in Tables 9.1 - 9.3 and are summarized in Table 9.4. The major trail access routes into the project area, although not structures, represent substantial environmental modifications and reflect general use patterns; they are presented in Table 9.5. Figure 9.3 gives the locations and types of uses of developments where these are sufficiently clustered to be identifiable on the ground. Thus, intensity of use might refer to a series of isolated cabins lining a shoreline, as at Stephan Lake, or to several small mines clustered together, as at Chunilna Creek.

(c) Wetlands and Floodlands

Within the approximate boundaries of Zone 1, there are 12,579 ha (31,083 a) of wetlands of various types, including riverine. These are summarized in Table 3.7. In the vicinity of the proposed Watana impoundment, there are 10,913 ha (26,966 a), and in the vicinity of Devil

Canyon, there are 1,666 ha (4,117 a). The table indicates the sizes and types of wetlands in relation to the proposed impoundments, dams, and spillways; camps, villages, and airstrip; and borrow areas. Cover types (including wetland types) are shown on Figures 3.2 through 3.4. A map of wetlands alone is included in the 1980 Annual Report on Plant Ecology Studies (APA 1981).

Floodlands have been identified for the Susitna River downstream from Devil Canyon to Talkeetna. A map of vegetation types in this floodplain is included in the 1980 Annual Report on Plant Ecology Studies (APA 1981).

(d) Land Stewardship

Prior to the Alaska Act, Statehood, and the Alaska Native Claims Settlement Act, the entire Susitna drainage area was mostly federally owned. There were no agency resource management plans for the area and very little resource exploitation, except for some minimal mining and timbering. A major limiting factor to development of the area has been access. It has not been economically feasible to utilize the resource base of the area.

(i) Ownership Patterns

The Susitna River proper and immediately adjacent lands along with the bench country around Stephan and Fog lakes extending eastward to the Kosina Creek drainage have been selected by Cook Inlet Region, Inc. (CIRI) and associated Native village corporations. The State has selected land entitlements on the north side of the proposed reservoir between the remaining federal lands and the Native lands (Figure 9.4). In the areas designated for the Cook Inlet land trade, the State will select all those lands that are not selected by the Natives. Matanuska-Susitna Borough owns no lands in the project area.

Two state land disposal sites (Figure 9.4) exist near the Indian River in the westernmost part of the project area just north of the Susitna River. The Indian River Subdivision (T33N, R2W S.M.) lies near mile 168 of the Parks Highway, northwest of Chulitna Butte and contains approximately 518 ha (1,280 a) of land. The disposal area has been subdivided into roads and some 139 lots averaging about 2 ha (5 a) per lot. South of this subdivision is the Indian River remote parcel, located northeast of the confluence of the Susitna and Indian rivers. This remote parcel (T31-32N, R2W S.M.) is located just eat of and, at some places, adjacent to Denali State Park. The Indian River Remote Parcel is comprised of 2,590 ha (6,400 a). Approximately 607 ha (1,500 a) in 75 parcels is being disposed of.

These land disposals, along with scattered private parcels of land, represent the only real dedication of a given piece of land to a particular use. Table 9.6 displays various land holdings in the vicinity of the proposed project and Table 9.7 summarizes those holdings by status/ownership category.

(ii) Land Use Management

Personnel employed by responsible land managing agencies were interviewed to gain information about present and future programs. The results are summarized in Table 9.8.

One federal agency, one state agency in addition to the Alaska Power Authority, one borough, and one regional Native corporation have various management concerns in the project area. These entities are the Bureau of Land Management (U.S. Department of Interior), the Alaska Department of Natural Resources, Matanuska-Susitna Borough, and the Cook Inlet Region, Inc. and associated village groups.

Federal lands to the north of the project area are managed by the Bureau of Land Management (BLM). These lands are included in the Denali Planning Block, for which a land use plan has been approved.

Management in the Denali Unit and those areas not yet conveyed to the Natives or the State is essentially passive. Very few management activities are taking place.

BLM's main objective is to protect the natural environment of the area, with particular attention to caribou calving areas and river recreation routes. Fire control is also a current management consideration; BLM has a cooperative fire control agreement with the State of Alaska that covers the project area.

BLM is also developing regulations for the management of public easements across Native lands. Lands in the project area that have been identified for conveyance to the Natives have a total of six easements across them. These include: an access trail 15 m (50 ft) wide from the Chulitna wayside on the Alaska Railroad to public lands immediately east of Portage Creek; a state site easement and trail easements on Fog Lake No. 4; a site easement and trail easements on Stephan Lake; and an access trail running east from Gold Creek. Easements were only identified when it was shown that access to public lands was not possible from any other public land area. There are no easements immediately adjacent to the Susitna River above Gold Creek.

Finally, BLM is also developing a wildlife habitat management plan in cooperation with Alaska Department of Fish and Game (ADF&G) for the Alphabet Hills between the Tyone and Maclaren rivers (T11-12 N, R2-9 W, Copper River Meridian). This plan will involve moose habitat manipulation. As yet, however, only study plots for this project have been mapped out.

Most State lands fall under the jurisdiction of the Alaska Department of Natural Resources (DNR). As indicated, the State is disposing of 607 ha (1,500 a) of remote housing parcels and 518 ha (1280 a) in a subdivision. These disposal areas (located north and south of Chulitna) are west of the project area and in the vicinity of the proposed access route.

In the project area, the State has done only a resource assessment for those lands it is proposing to select. Planning for State lands in this area will not occur before 1983.

Matanuska-Susitna Borough is involved in three separate management efforts which affect the project area. These are the Mat-Su Borough Comprehensive Plan (1970), the Talkeetna Mountains Special Use District, and the Mat-Su Borough Coastal Management Program. The current Mat-Su Borough Comprehensive Plan (1970) contains very little discussion of the Susitna area lands. The borough has already selected more than its entitlement and is concentrating its selections in the lower Susitna basin near existing highways. Thus, it is unlikely that the borough will select any lands in the project area.

The borough, by ordinance, has created the Talkeetna Mountains Special Use District, through which the borough can exercise planning and zoning authority over all lands within the district's boundaries. The Special Use District includes the project area. The ordinance provides for multiple resource use of the district, and takes into account unique scenic values. Thus, lands within the special use district are subject to permit requirements for specified developments (roads, subdivisions, etc.).

The borough is updating its comprehensive plan and additional studies are being performed. The project area is considered a mixed use zone which would permit hydro development. Management objectives for the project area will probably not be refined until the current hydro studies are complete.

Through a cooperative arrangement with the Office of Coastal Zone Management (National Oceanic and Atmospheric Administration, U.S. Department of Commerce) and the Alaska Coastal Management Program (Division of Community Planning, Alaska Department of Community and Regional Affairs), Mat-Su Borough is preparing a Coastal Management Program. Preliminary studies were completed in May, 1981; the Susitna River through Devil Canyon was designated to be within the biophysical boundaries of the program (Figure 9.5). Program results to date provide for a preliminary determination of uses subject to the program guidelines including, specifically, hydroelectric development in Devil Canyon. The appropriateness of this use is to be reviewed as resource analysis continues in subsequent phases of the program.

The Cook Inlet Region, Inc. received conveyance of selected Native lands to hold in trust until these lands are conveyed to the appropriate villages (Chickaloon-Moose Creek, Tyonek, and Knik). Currently, no land management activities are being carried out. When the villages obtain their lands, the different village ownerships will create a checkerboard pattern. Immediate land problems and land reconveyance to villages are being handled by the Village Deficiency Management Association, a group made up of representatives from each of the concerned villages. Because of the checkerboard nature of future land ownership, any management of Native lands may be undertaken by this association.

The results of the interviews with BLM, DNR, Mat-Su Borough, and the Cook Inlet Region, Inc. are meaningful within the context of general resources management in present-day Alaska. Agencies, the Native corporations, and the private sector have been heavily involved in the selection and transfer of land ownership under the Alaska Statehood Act and the Alaska Native Claims Settlement Act. Because of the uncertain outcomes of the Alaska National Interest Lands Conservation Act (ANILCA) and the proposed Susitna hydroelectric project, little attention has been given to actual land management. Furthermore, the area has not been exploited in the past because it was not economically feasible to do so. It is still not economically feasible to mine and process what minerals exist within the project area, although improved access may improve the economics of exploitation. Discussions with land owners/managers and consideration of present market conditions indicate that without the project little change is likely to occur soon in existing land use patterns, regardless of changing landownership. Even if the State of Alaska or the Cook Inlet Region, Inc. and village corporations sell remote parcels surrounding the accessible lakes, it is unlikely that there will be any significant change until access into the area is improved.

(e) Downstream Navigation

The Susitna River, downstream of Devil Canyon, has long provided a major means of access into the region. The Susitna is navigable from its mouth in Cook Inlet to the area around Portage Creek. The Susitna River has been determined by BLM to be navigable as far upstream as Devil Canyon based upon (1) prior use by a boat for any purpose and (2) suitability as a highway of commerce since Alaska Statehood in 1959. Beyond Devil Canyon no determination of navigability has been made by BLM. The U.S. Coast Guard considers the Susitna River between Gold Creek and the Tyone River to be non-navigable due to shifting sand and gravel bars and shifting channels.

A variety of craft are used on the downstream portion (below Devil Canyon) of the Susitna, including rafts, canoes, airboats, and riverboats. In addition, floatplanes are used throughout the Susitna drainage area. Considerable boating is done along the Susitna, particularly near boat launches at Willow Creek, Talkeetna, Kashwitna Landing, and Sunshine. Boats are used for fishing during the warmer months of the year and as a means of access to hunting areas in the fall. Riverboat services, several of which are based in Talkeetna, are increasingly popular and provide trips up the Susitna and Talkeetna rivers for recreationists and others wishing to reach inland areas not otherwise easily accessible.

Most boating activity is concentrated on the Susitna and Talkeetna rivers. The Yentna River and its tributaries, the Skwentna and Kahiltna rivers, the Deshka River (Kroto Creek), and Willow and Alexander creeks all receive some use. The Yentna is used for fishing, other recreation, and as access to hunting areas. The Deshka River receives extensive use by sport fisherman during salmon runs. The Talkeetna River receives heavy use for trapping, subsistence, recreation, and mineral development purposes. Riverboats, many with jet units, utilize portions of the

Talkeetna River in the summer. From just below Devil Canyon to north of Talkeetna, the Susitna is highly regarded and utilized by rafters and kayakers. The rapids of Devil Canyon are considered world class white-water, but few kayakers have successfully negotiated the gorge.

In the winter, the Susitna River is used as an avenue of transportation by means of dogsleds and snowmobiles. These means of transportation are used for purposes such as trapping, recreation, and travel between Trapper Creek and Talkeetna.

9.2 - Land Uses With the Project

(a) Project Facilities

Figure 9.7 shows the locations of proposed project facilities in the upper Susitna basin. Locations of the dams, impoundments, access road, construction camps and villages, borrow areas, and related facilities are indicated. Brief descriptions of the major facilities are presented below, and details may be found in Volume 1 of the Feasibility Report.

(i) Watana Dam and Impoundment

The Watana dam will be a 247-meter (810 ft) high gravel filled structure with a crest length of 1,148 m (3,765 ft). The dam will be located at Susitna River kilometer 266 (mile 165), approximately three kilometers (two miles) upstream from the mouth of Tsusena Creek. It will impound just over 80 km (50 mi) of river to 666 m (2,185 ft) elevation and inundate over 16,000 ha (40,000 a).

An underground power plant with associated penstocks, tailrace, and related facilities will be constructed with 1,020 megawatts installed capacity. A spillway constructed on the north side of the dam will be capable of passing 165,000 cfs of water.

(ii) Devil Canyon Dam and Impoundment

Devil Canyon dam will be a 194-meter (635 ft) concrete thin arch dam and a rockfilled saddle dam constructed at river kilometer 216 (mile 134) in Devil Canyon. Its crest length will be 754 m (2,475 ft). The dam will impound 45 km (28 mi) of river to 444 m (1,455 ft) elevation. Approximately 3,055 ha (7,550 a) of land will be inundated.

The underground power plant will have an installed capacity of 600 megawatts. The emergency spillway for the dam on the south side of the river is designed to pass 222,000 cfs of water. A tailrace tunnel will extend more than two kilometers (1.3 mi) downstream on the north side of the river.

(iii) Access

Construction of a permanent access road will be facilitated by a pioneer road to be constructed from Gold Creek to the Watana site. For about 70% of the distance (discontinuous) between Gold Creek and Devil Canyon, this pioneer road will follow an existing bulldozer trail (used in earlier studies by the Corps of Engineers). Spurs will be built from the pioneer road to certain points on the permanent access route. A temporary low-level bridge will cross the river, with a series of switchbacks down into the canyon just above the dam site. Between the two dam sites the pioneer road will mostly follow the route of the permanent access road.

Full access for construction and operation of the dams and access to proposed project recreation facilities will be by a gravel road from the Parks Highway. There will also be a railroad yard in the vicinity of Gold Creek, with a short road connection to the main access road. The main access road will connect with the highway near Hurricane and roughly parallel the alignment of the Alaska Railroad through Chulitna Pass south to the confluence of the Indian and Susitna rivers north of Gold Creek. The road will then parallel the Susitna River on the south side to Devil Canyon. Initially, a bridge will be constructed at this point over the canyon; after construction, the Devil canyon dam will serve as a bridge. The road will extend northeasterly through the alpine lakes area north of Devil Canyon and parallel the upper Devil Creek drainage. From this point, the road will follow a generally easterly direction to the Watana dam site.

The total length of the access road from Hurricane to the Watana site will be 110 km (68 mi), aligned within a 60 m (200 ft) corridor. The roadway will be 10 m (34 ft) wide, with 2 m (5 ft) shoulders on either side.

Several pull-outs will be constructed along the access road to permit viewing of natural areas and some of the project facilities. Additionally, access to recreation sites from the road will be provided as indicated in the plan for recreation (Section 7.2).

(iv) Transmission Facilities

Maps of the proposed transmission routes are included in Appendix E3. From Watana to Devil Canyon within the 0.8 km (0.5 mi) wide route, a 122 m-wide (400 ft) transmission right-of-way will mostly parallel the access road. Two single-circuit 345,000 volt (345 kV) lines will be constructed. From Devil Canyon to the intertie near Gold Creek, a total of five single-circuit 345 kV lines will require a right-of-way about 213 m (700 ft) wide.

These lines (two to the north, three to the south) will parallel the intertie to Healy and Willow. From Healy to Fairbanks and Willow to Anchorage, the right-of-way will be approximately 122 m (400 ft) wide. Most of the towers are expected to be X-shaped structures approximately 30 m (100 ft) tall. In some places, such as near the Municipality of Anchorage, double-circuit construction may be used, thus requiring taller towers. Double circuit towers, while approximately 15 m (50 ft) taller than single circuit towers, allow a narrower right-of-way.

(v) Construction Camps and Villages

Construction camps (single worker housing), villages (family housing), and associated facilities will be located within the immediate project area: there will be one camp and village at each dam site. Construction of Watana dam is scheduled to begin in 1985, five years before the dam at Devil Canyon. Plans call for the building of a construction camp and village first at Watana. When construction phases down at the Watana site, the camp will be relocated to the Devil Canyon dam site. Part of the village at Watana will remain as a permanent town to provide housing and other community facilities for workers who will operate the dams. No such permanent village is currently planned for the Devil Canyon site.

The proposed camp and village at the Watana site will be constructed northeast of the dam site between Deadman and Tsusena creeks on what is now BLM land. Approximately 1-2 km (1 mi) will separate the construction camp from the village. Work on the village will begin about one year after construction of the camp has begun. Structures at the camp will be of factory-built, modular design, to facilitate their relocation to Devil Canyon. Permanent buildings are planned for the village facilities at Watana, since the village community will remain after the dams are built.

Facilities at the village will include family housing (for a projected 550 families), a school, gymnasium, recreation center, shopping center (food supermarket, department and specialty stores), fire station, generating station, and structures for other support activities. Facilities and services to be provided at the construction camp include modules for housing (dormitories) for about 5,000 workers, camp offices, food services, warehousing, fire and security protection, banking and postal services, hospital care, recreation, communications, and power generation.

Camp and village utilities will include a potable water supply system, sewage system, power supply and distribution system, communications, fuel storage, and a solid waste disposal system. The water supply is expected to serve an estimated peak population of 6,820 (5,070 in the camp and 1,750 in the village) including workers, families, and visitors. The water source will be from Tsusena Creek (where a small impoundment will be created) and groundwater wells. The treatment plant, also of modular design, will fulfill primary and secondary Environmental Protection Agency (EPA) requirements. Treated water will be stored in three tanks, two at the camp and one at the village. Sludge, a by-product of the treatment plant, and solid waste from the two sites, will be properly treated and disposed of in a landfill.

The facilities at the construction camp and village to be built at Devil Canyon will differ only slightly from those at Watana, though fewer workers will need to be accommodated. The camp will be situated south of Portage Creek and just west of Devil Canyon on the south side of the Susitna River. The village will be temporary, unlike the one at Watana, and will be just west of the camp.

(b) Induced Land Use Changes

Construction and operation of the dams and related facilities will cause impacts on area resources. Prior to determining the extent of alteration or disruption which land use patterns will experience, land uses were assessed in terms either of man's use of the landscape for particular purposes (many of which tend to be site-specific), or of man's dedication of a given geographical area to preserve some specified values. In some cases, these values and their protection are identified in agency management programs that apply to the area. Based on available information and agency interviews, however, it has been determined that no comprehensive management plans exist at present. The Alaska Department of Fish and Game (ADF&G) has developed species-specific objectives for the region, but it has no land management authority. Other agencies have only preliminarily addressed land management concerns (see Section 9.1). The generation of hydroelectric power will become the predominant land use in the area, and the presence of the project will be an important factor when agencies eventually develop comprehensive land management plans for the surrounding areas.

With increased access, certain land use activities are expected to become more intense than at present. In terms of displacement of existing land uses, by both the project itself and the induced land uses, the primary effects will be changes in the manner in which individuals (rather than land management agencies) are presently using the area.

Figures 9.8 and 9.9 shows points and areas in the vicinity of the project which will experience changes in land use and activity patterns. Project facilities will create immediate, direct impacts on the landscape, as shown on Figure 9.7; some of these impacts will be temporary, such as those of the construction camps and construction activity itself. Other aspects of the project will create or facilitate permanent and often subtle changes in the type, nature, and intensity of use and activity patterns. Chief among these aspects is the provision for automobile access to an area currently lacking such access [Section (iii) below]. For purposes of discussing induced changes in land use and associated activity patterns as they relate to major project components, impacts on four general land use categories were assessed:

- Land uses inherently associated with site-specific activities:

  This category includes land uses that involve some form of long-term commitment of resources (for example, structures) and the activities associated with them. These include the following: residences, commercial properties (primarily recreational), mining, agriculture, and transportation.

- Dispersed and isolated non-site-specific activities:

  This category includes activities that are generally non-continuous and do not involve a commitment of resources at any particular site. These include consumptive recreational or subsistence activities, such as hunting and fishing; riverine activities, such as boating or rafting; and dispersed activities, such as camping, hiking, and photography.

- Resource management activities and related concerns:

  This category involves consideration of present or potential future activities related to conservation or planned use of the land and resources, and includes fish and wildlife management, dispersed recreation management, off-road vehicle management, Native claims, and land values.

- Natural aesthetics:

  This category involves consideration of the natural land cover type itself as opposed to the uses of the land. Considered are the visual character of both land and water resources, ground cover (specifically vegetation), land surface integrity, and general natural character. Project impacts related to aesthetics are discussed primarily in Section 8.2.

(i) Dams and Impoundments

The emplacement of the dams and impoundments will cause the direct loss of ten structures (six by Watana, four by Devil Canyon). These structures and their uses are described in Table 9.1. Only three of the ten are actively maintained, being used on a seasonal basis, but two others are used sporadically. The remaining five are currently unused or unusable. The primary uses of the structures to be affected are hunting, fishing, boating, and trapping, as well as hydroelectric feasibility studies.

The impoundments will displace relatively low levels of riverine boating and rafting patterns of use between the upstream end of Watana reservoir and Devil Canyon. Kayaking (in which one must employ considerable technical expertise to negotiate the turbulence in Vee Canyon and world-class whitewater of Devil Canyon) will be eliminated. In place of these activities there will be reservoir boating. As discussed in the following section, some rafting and kayaking downstream of Devil Canyon may continue.

There likely will be increased hunting activity, as well as alterations to current patterns, resulting from the impoundments. The reservoirs and access to them [see also Section 9.2 (b) (iii)] will facilitate floatplane landing and boat travel and thus permit easier penetration by big game hunters into areas now rarely visited. As shown in Figures 9.8 and 9.9, an increase in moose hunting will likely occur immediately adjacent to the proposed impoundments. Increased hunting for caribou (to the extent that the permit system allows) will likely occur a relatively short distance back from the impoundments.

There is likely to be increased fishing for resident species, primarily grayling, in tributaries in the vicinity of the impoundments, as shown in Figures 9.8 and 9.9. A limited reservoir fishery may also develop (see Section 3.7). Because of the proximity of the Devil Canyon facility, salmon fishing in Portage Creek could increase. If necessary, further regulations can be implemented to prevent overfishing in this area.

At present, some trapping takes place in the upper basin. The reservoirs will cause disruption of present trapping patterns. Project impacts on trapping, fishing, hunting, and other land uses are further discussed in Section 5.7.

(ii) Downstream Effects of Dam Operations

A number of impact issues have been raised concerning the potential effects of project flows on downstream navigation. These concerns include the following: (1) whether present access for fishing, hunting, and other purposes via the Susitna and its tributaries may be affected by reduced summer flows in certain channels; (2) whether a reduction in flow could alter the stream bed morphology of the various tributaries at their confluences with the Susitna, thus hampering the ability of boats to enter the tributaries; and (3) whether access to land disposal areas which is now acomplished by boat and floatplane will be affected by reduced summer flows. In addition, concern has been expressed about the loss of kayaking and rafting opportunities, and also about potential impacts on winter use of the river.

Future navigational use is likely to increase along the Susitna River and other water courses in the Railbelt as the population in the region increases (see Section 5.2). Development and settlement of state land disposal areas below Devil Canyon will also change present navigational use. Therefore, the change in summer flow in the Talkeetna to Devil Canyon reach is a particular concern, although railroad access will continue and road access will be created by the project access road.

Review of limited aerial photographs, river cross-section data, and simulated water surface profiles in the reach between Devil Canyon and Talkeetna indicates that proposed project stream flows are likely to cause periodic navigation problems during the months of August and September. If project flows were increased in August and September, few areas would experience navigation problems.

One area of concern is the reach 1-5 km (1-3 mi) below Sherman where the main channel crosses the floodplain. The water depth at 6500 cfs is approximately 0.75 m (2.5 ft) at the cross section here, indicating the channel is navigable. However, examination of nearby areas (for which cross-sectional data are unavailable) indicates that they may not be navigable. Navigation problems may be encountered in about one year out of three in August, and in about one year out of two in September in this reach with the proposed flows. If water is stored in the spring to augment flows in August and September, navigation problems may be encountered in this reach in about one year out of ten during June.

Cross-sectional data were gathered for the main channel below Talkeetna in sloughs and side channels used for river access near Kashwitna Landing and Willow Creek, and at the upper access channel to Alexander Slough. While stage-discharge data at these sites are very limited, initial analysis indicates that operation of the dam will have no significant negative impacts on navigation on the main channel below Talkeetna or to access at Kashwitna Landing. Access channels near Willow Creek should be navigable at the proposed flows. Minor navigation problems could occur in this area during May if water is stored to augment flows in August and September.

Data are insufficient to completely define the flow required at Susitna Station in order to keep upstream access to the Alexander Slough area, but the decrease in stage will be less than .3 m (1 ft) for the proposed flows.

If rafting and kayaking downstream of Devil Canyon are still possible with project flows, the river will not be as appealing as at present due to the controlled flows. The limited daily peaking operations proposed for the Devil Canyon facility may present some boating hazards immediately below this facility. Because these hazards will be unlike the natural hazards posed by a wild river, this vicinity may be unsuitable for river floating.

Ice studies have predicted that during project operation the Susitna River below Devil Canyon dam will have open water in winter at least as far downstream as Talkeetna. This open water will preclude the present use of snowmobiles and dogsleds for transportation on this portion of the river.

(iii) Access

As indicated previously, increased access is a critical factor with respect to land uses. Road access will cause both the disruption of present land use and the inducement of future land uses. The most significant aspect of the access road relates not so much to various impacts associated with the road *per se* but rather to the concept of access itself, in any form, to the interior of the Susitna basin. The provision of a means by which the general public can easily and frequently venture inland to an area which is essentially wilderness will likely cause profound alterations in the character of the Susitna area.

Access, because it will facilitate the influx of people and activity into the basin, will affect the following: small population concentrations and isolated residences; peripheral commercial and transportation systems; resource utilization and level of recreational activity; visual and aesthetic factors; and the overall character of the area. These effects will have ramifications for management: the need for it and its extent and adequacy (for example, fish and game management, land management, etc.). Access will influence changes in land values and development, and may expedite the exploitation of the area's mineral resources.

Road access to the dam sites from the Parks Highway will likely create increased traffic and related activity along the Parks Highway and in adjacent communities. Residential and commercial use and the values of land made more accessible by the new road will probably be affected; there is likely to be increased demand for these parcels (due to an increased population and markets for commercial services), and improved access will make them more attractive to prospective buyers. The proposed route through Chulitna Pass and along Indian River will provide road access to state land disposal sites on Indian River.

There will likely be increased hunting for moose and bear along the access corridor. The zone around the access road subject to increased hunting will be much larger if off-road vehicles are permitted. In addition to the impacts of increased hunting activity in a larger area due to both the road and the impoundments, there will be disruption or displacement of the persons who currently hunt in the upper basin. Those who presently hunt in the area will either have to adjust to larger numbers of hunters or hunt in other areas. Fishing will also increase (for example, for salmon in Indian River) with potential effects on both the resource and those people who currently fish in the area.

The access road between the two dams on the north side of the Susitna will disrupt current use patterns at High Lake Lodge. Disruption might also occur to fly-in fishing and hunting around the lakes nearer to Devil Canyon. Some recently established trapping territories around the High Lake area would also be altered. In addition to increased hunting and fishing, this area will also recieve increased recreational use for hiking, backpacking, sightseeing, and other activities.

Further details on the anticipated impacts of the road (and the improved access it will provide) on natural resources and their present and potential uses are found in the following sections: 3.5(e), 3.6(e), 3.7(e), 4.4(a)(iv), 5.7, 7.3, and 8.2(c).

(iv) Transmission Facilities

Analysis of proposed transmission facilities for the Susitna project involved assessment of three study areas: 1) the northern study area, containing that segment of the line between Healy and Fairbanks; 2) the central study area, containing transmission lines from the power plants at the dams to the intertie; and 3) the southern study area, covering Willow to Anchorage.

The route analysis involved mapping of selected land use features and land ownership within a previously established 5-10 km wide (3-6 mi) corridor. In the central study area the corridor covered both sides of the river and thus was as wide as 23 km (14 mi) in some places. Land use features included existing recreation facilities; developed residential, commercial, and other uses; significant privately owned lands, including disposal areas; and the existing transportation network. These features are shown on the maps in Appendix E3 as man-made constraints.

Features were identified as constraints if there is the potential for physical conflicts between either existing or likely future land use developments (in the absence of the project) and the proposed transmission lines and towers.

- Northern Study Area

There are several moderate concentrations of land use developments along or adjacent to the proposed route between Healy and Fairbanks. Significant among these are developments at Healy, Nenana, and Ester. In Healy and Ester, there will be a direct interface between existing land uses and the proposed transmission route.

There are several large land disposal areas (on the west side of the Parks Highway) through which the route will pass. In traversing these disposal areas, the lines will closely parallel an existing transmission line.

Impacts in this study area will include the acquisition of a 122 m (400 ft) wide right-of-way and the elimination of future land development within this strip. In addition, one dwelling located off the Parks Highway approximately 6 km (4 mi) south of Browne may have to be acquired. Many potential impacts, however, were avoided during the selection of the corridor and route. Visual impacts of this route are discussed in Section 8.2.

- Central Study Area

Between the Watana and Devil Canyon dam sites, there will be significant conflicts between the proposed route, like the access route which it parallels, and the development at High Lake Lodge: the proposed route will pass just northwest of High Lake and the wilderness lodge and cabins located there. Several other alpine lakes are also located in this area, and the transmission line could potentially interfere with floatplane landings. A right-of-way 122 m (400 ft) wide will be required to accommodate transmission facilities between the dams.

Although slightly more land area would be required, locating the line well to the west of the proposed route within the alternative route alignment (identified on Figure 31 in Appendix E3) would reduce the conflict with existing uses at High Lake Lodge. The alternative route would roughly parallel the Portage Creek drainage just below the ridge to the east of the creek, and pass well to the west and north of High Lake.

The segment of the proposed route from the Devil Canyon facility to the intertie near Gold Creek will conflict little with existing uses. The lines and towers, however, will probably be visible from areas north of the Susitna River in the Indian River remote parcel disposal, Otter Lakes, and from some places on the river.

- Southern Study Area

The proposed route between Willow and Knik Arm northeast of Point MacKenzie will traverse an area that receives dispersed but increasing use. In this study area are land disposal areas and private lands, most of which the proposed route avoids. Access to these land holdings is via floatplanes, ORVs, and snow-machines. Boating occurs along the Susitna and Little Susitna rivers and Willow Creek as well as on many of the numerous small lakes. Potential conflicts between the proposed lines and private lands and boating use occur wherever the lines and towers will be visible. Floatplane flight patterns may be affected where the lines pass near lakes used for landing and taking off.

The route crosses or parallels numerous trails including the Iditarod Trail, seismic survey clearings, tractor and pioneering ORV trails, and several recreational trails farther north near Willow. Trails that receive substantial ORV use are located near Willow, Red Shirt Lake, and Knik Arm. The proposed route will likely not affect physical use of trails, although visual conflicts may occur where the lines and towers pass near various trails.

Residential use occurs in Willow, Red Shirt Lake, and on many of the small lakes mostly to the east of the route. Scattered cabins in the vicinity of Willow are close to the Alaska Railroad and Parks Highway. Red Shirt Lake has approximately 25 cabins along its shores; seven other lakes have several cabins along their shores and a few cabins are widely scattered elsewhere. The proposed route will not directly affect these existing structures, although the lines and towers may be visible in areas west of Long Lake, Red Shirt Lake, and smaller lakes where topography is not sufficient to screen them from view.

The corridor and portions of the western boundary of the route in this area are located in the northeast corner of the Susitna Flats Game Refuge. Agricultural use occurs north of the Point MacKenzie area, and agricultural clearings occur from a region just northeast of Middle Lake to the Little Susitna River south of Yohn Lake. Future agricultural land sales are proposed in the Department of Natural Resource's draft land use plan for the Willow sub-basin along with programs for protecting wildlife habitat and sportsmen's access. While land within a transmission right-of-way can still be cultivated, the towers could displace small areas of existing and potential future agricultural use, or disrupt normal patterns of agricultural development or cultivation.

Land use in the area of the existing Chugach Electric Association, Inc. Point MacKenzie-University Substation line (which will be paralleled by project lines east of Knik Arm to a new substation to be located south of Muldoon Road) is predominantly military: most of the route here lies within the Fort Richardson Military Reservation. Impacts on these lands will be limited primarily to those associated with the area's visual quality (see Section 8.2).

(v) Construction Camps and Villages

Construction camps and villages at each dam site and the permanent town at Watana will have a significant effect on present and future land use. Access to and from the camp and village sites could open up new areas in the project area to hunting, fishing, and recreation, or at least increase the activity levels in areas now rarely visited. If recreation by residents occurs to the south of the Watana dam site, conflict could arise with existing use patterns at Fog and Stephan lakes.

TABLE 9.1: ZONE 1 - EXISTING STRUCTURES (a)

Map # (b)	Structure	Location	Access (c)	Currently Maintained	Use Status
2	Boat cabin	S. bank Susitna: on tributary 4.8 km S.W. of Fog Creek/ Susitna confluence	boat, foot	Yes	Built in 1960's for Stephan Lake Lodge; currently used seasonally by Stephan boating/ hunting guests
90	Hunting lean-to	S.E. bank of Kosina/ Susitna confluence	boat, foot, floatplane	Yes	Built in late 1970's for hunting/ fishing purposes; fresh supplies indicate current use
91	Cabin	3 km N.E. of Watana/Susitna confluence	floatplane	No	Built in 1950's; used as seasonal hunting and fishing cabin; supplies indicate current use
112	Line cabin	N.E. corner of Jay/ Susitna confluence	foot, dog team, boat, floatplane	No	E. Simco's line (trapping) and and hunting cabin built in 1939; dates and game records indicate annual use
119	Trailer; work shack	N. bank of Susitna: 1.6 km W. of Deadman/ Susitna confluence	helicopter	Yes	Built in 1970's by Army Corps for Susitna study
107	Cabin	S. bank of Susitna at Devil Canyon	4WD	No	Built and used in 1950's for Bureau of Rec. study; currently not in use
6	Cabin foundations	N. shore of Susitna: W. bank of 1st tributary W. of Tsusena/Susitna confluence	foot, dog team	No	Built in 1939 by Oscar Vogel as a trapping line cabin; used until late 1950's, now collapsed; no longer used

a. Zone 1 is the impoundment zone plus a 61 m (200 ft) perimeter.
b. See Figure 9.2.
c. Almost all sites are accessible by helicopter.

TABLE 9.1 (Continued)

Map # (b)	Structure	Location	Access (c)	Currently Maintained	Use Status
120	Shack	S. bank of Susitna: 1.6 km W. of Deadman/ Susitna confluence	helicopter	No	Used and built in 1970's as a research site; since Army Corps study, has collapsed; no longer used
92	Cabin/ cache	N.W. bank of Watana/Susitna confluence	dog team, foot	No	Built in 1960's for hunting purposes; cabin collapsed; no longer in use
111	Cabin	S. bank of Susitna: 1.6 km E. of Watana/ Susitna confluence	dog team, foot	No	Built in 1945 as a trapping line/hunting cabin; used for trapping until mid 1950's, presently covered with brush; no longer used

Summary: Ten structures exist within this zone. Of these, five are currently being used on a seasonal basis for purposes of fishing, boating, hunting, and research.

(a)

TABLE 9.2: ZONE 2 - EXISTING STRUCTURES

Map #	Structure	Location	Access	Currently Maintained	Use Status
1	Cabin; meat house	Lake E. of Stephan Lake, 564 m (1850 ft) elevation	floatplane, skis	Yes	Built in 1960's and in current use for seasonal hunting, fishing, and boating
3 4	Cabin; shed Cabin	N.W. shore of Stephan Lake	airplane	Yes	Built 1960's and in current use for seasonal hunting, fishing, and boating
5	Cabin foundations	Tsusena Creek: 6 km from Tsusena/Susitna confluence	foot, dog team	No	Built in 1940's as a trap line cabin and used until late 1950's; no longer in use
7	Cabin; shed	S. shore of Fog Lake #2	floatplane	Yes	Built in 1960's and currently being used as a seasonal fishing and hunting cabin
8	Cabin;	On knob of Fog Lake #1	airplane	Yes	Built in 1960's and currently being used as a seasonal hunting and fishing cabin
9	Stephan Lodge (10 structures)	W. central shore of Stephan Lake	airplane, foot	Yes	Built in 1960's and in current use as hunting, fishing, and recreation lodge; can accommodate up to 35 guests; operates year-round
10	Cabin; shed	0.8 km S.W. of Stephan Lodge on Stephan Lake shore	airplane, foot	Yes	Built in 1960's and in current use seasonally as a hunting and fishing cabin
11	Cabin; shed	E. shore of Stephan Lake	airplane, foot	Yes	Hunting, fishing, boating, seasonal use; built in 1960's

a. Zone 2 is the 10-km perimeter around Zone 1 (impoundment zone plus 61 m).

Map #	Structure	Location	Access	Currently Maintained	Use Status
11	Cabin; shed	E. shore of Stephan Lake	airplane, foot	Yes	Hunting, fishing, boating, seasonal use; built in 1960's
12 13 14 15 40	Cabin; shed Cabin; shed Cabin; shed Cabin; shed Cabin; shed	E. shore of Stephan Lake	airplane, foot	Yes	Built in 1960's and in current seasonal use as hunting, fishing, and boating cabins
16	Cabin; shed	Mouth of Prairie Creek at Stephan Lake	airplane, foot, horse	No	Built in 1940's and used until late 1950's as a hunting, fishing, and trapping base and residence; no longer used
17 18	Cabin Cabin	W. shore of Prairie Creek	airplane, foot	Yes	Built in 1960 and 1970 respectively and currently used as a year-round residence from which hunting, fishing, and trapping occur
19	Cabin; meathouse	E. shore of Murder Lake (S. of Stephan Lake)	airplane, foot	Yes	Built in 1960's and used as a year-round residence; hunting and fishing
20 21	Cabin; shed Cabin; shed	S.E. shore of Daneka Lake	airplane, foot	Yes	Built in 1960's and currently used on a seasonal basis for hunting, fishing, and recreation by guests of Stephan Lodge
25	Mining buildings (5)	Portage Creek: 4 km. N. of Portage/ Susitna confluence	airplane, ATV, foot, dog team, horse	No	Mining records exist as far back as 1890's; mined 1920's and sporadically 1930's, then 1950-70's; currently inactive mining operations; buildings not in use

Map #	Structure	Location	Access	Currently Maintained	Use Status
26	Cabins (2)	1.6 km N. of Portage Creek mining	airplane, ATV foot, dog team	Yes	Mining; built in 1950's; used Creek seasonally
27	Cabins (2)	N.W. shore of Dawn Lake	airplane, ATV horse, dog team	Yes	Built in 1960's by owners of High Lake; used currently as a hunting cabin on a seasonal basis
28	Lodge, High Lake (9 buildings)	S. shore of High Lake	airplane, ATV horse, dog team	Yes	Built in 1960's for use as an international hunting/fishing lodge; currently in use by Acres American Susitna project on a seasonal basis
30	Cabin foundations	S. shore of High Lake	airplane, ATV horse, dog team	Yes	Building under construction as of June 1980
34	Chunilna Creek Placer (7 buildings)	Chunilna Creek	airplane, ATV, 4WD, snowmachine	Yes	Large placer mining operation in existence since 1950 and currently actively mined on a seasonal basis
42	Cabin	Portage Creek 3 km N.W. of Dawn Lake	foot, sled road, airplane, ATV	Yes	Built in 1960's and currently used on a seasonal basis for hunting and fishing
45	Cabin	1.8 km W. of Portage Creek mining	foot, airplane, ATV/4WD	Yes	Currently used on a seasonal basis for recreational purposes
46	Cabin	1.8 km W. of Portage Creek mining, on sled road	foot, airplane, ATV, 4WD	Yes	Currently used on a seasonal basis for recreational purposes
47 48 49	Cabin Cabin Cabin	Unnamed lake N. of Otter Lake	foot, airplane, ATV, 4WD	Yes	Currently used on a seasonal basis for recreational purposes

Map #	Structure	Location	Access	Currently Maintained	Use Status
50	Trailer	W. end of S. shore of unnamed lake N. of Otter Lake	foot, airplane, ATV, 4WD	No	Currently not in use; abandoned
51	Cabin	W. end of S. shore of unnamed lake N. of Otter Lake	foot, airplane, ATV, 4Wd	No	Built in late 1960's and currently used for hunting and fishing on a seasonal basis
52 53	Cabin Cabin	S. shore of unnamed lake N. of Otter Lake	foot, airplane, ATV, 4WD	Yes	Built in late 1960's and seasonally used since then for hunting and fishing
55	Cabins (3)	W. end of Bear Lake	foot, airplane, ATV, 4WD	Yes	Built in 1970's and currently used on a seasonal basis for hunting and fishing
56	Cabin	N. shore of Bear Lake	foot, airplane, ATV, 4WD	Yes	Built in 1970's and currently used on a seasonal basis for hunting and fishing
57 59	Lodge	N. shore of Bear Lake	foot, airplane, ATV, 4WD	Yes	Built in 1970's; lodge and cabin used for fishing, hunting, and skiing on a year-round basis; seasonal boating
58	Cabin foundations	E. end of Bear Lake	foot, airplane, ATV, 4WD	No	Built in 1950's for trapping purposes; no longer in use
64 65 65	Cabin Cabin Cabin	Miami Lake	rail, foot, car, airplane	Yes	Perhaps being used as recreational cabins
69	Cabin	S. shore of Swimming Bear Lake	airplane, foot, 4WD	Yes	Built in 1960's and currently used for hunting, fishing, and swimming

Map #	Structure	Location	Access	Currently Maintained	Use Status
70	Lodge	N. shore of Tsusena Lake	airplane, ATV	Yes	Built in 1958; used for commercial guided hunts until 1976; presently used on a seasonal basis for private hunting, fishing, and skiing trips
75	Cabin	6 km from Watana/ Susitna confluence	airplane, ATV	Yes	Built in the 1970's; currently used on a seasonal basis for hunting
76	Cabin	11 km east of Big Lake	airplane, ATV	Yes	Constructed in 1970's and currently used on a seasonal basis for hunting and mining
77 78	Cabin Cabin	N. end of Watana Lake	airplane, dog team, snow-machine	Yes	Built in 1950's and 1960's respectively and currently used seasonally for hunting and fishing
79 80	Cabin Cabin	E. end of Watana Lake	airplane, dog team, snow-machine	Yes	Built in 1950's and 1960's respectively and currently used seasonally for hunting and fishing
81	Cabin	E. end of Gilbert/ Kosina confluence	foot, dog team	No	Built in 1936 as a trapping line cabin; used until 1955; currently abandoned with everything intact
82	Tent frame structure	S.W. end of Clarence Lake	foot, dog team	No	Built in 1950's and used until 1960's for seasonal hunting
84	Cabins (2)	S.E. end of Clarence Lake	airplane	Yes	Built in 1950's and currently used seasonally as a hunting and fishing cabin
85	Cabin	E. end of Clarence Lake	airplane	Yes	Built in 1970's and currently used on a seasonal basis for hunting, fishing, and trapping

Map #	Structure	Location	Access	Currently Maintained	Use Status
86	Cabin	N. end of Clarence Lake	airplane	Yes	Built in 1960's and currently used on a seasonal basis for hunting, fishing and trapping
87	Cabin	On tributary 1.6 km E. of Clarence Lake	foot, dog team	No	Built in 1930 and used until 1950 for trapping, hunting, and fishing (Simco's line cabin #4); currently used seasonally as a hunting shelter
88	Cabins (2)	Gaging station: S. bank of Susitna	airplane	No	Built in 1950's for research purposes; currently not used or maintained
93	Cabin	W. of Jay/Susitna confluence	airplane	Yes	Built in 1960's and used currently on a seasonal basis for hunting and fishing
94	Cabin	Laha Lake: 2.4 km W. of Jay Creek	floatplane, airplane	Yes	Built in 1960's and used currently on a seasonal basis for fishing
95 96	Cabin Cabin	Unnamed lake: 4 km S.E. of Vee Canyon gaging station	airplane	Yes	Built in 1950's and used currently on a seasonal basis for fishing
99	Cabin	Tyone River/Susitna confluence	boat	Yes	Built in 1960's by Stephan Lodge owner as a river cabin for Stephan Lodge boating guests
103	Cabin	Jay Creek: 5 km N. of VABM Brown	ATV	Yes	Built in 1970's for hunting and currently used on a seasonal basis
105	Cabin	Coal Creek	ATV, airplane	Yes	Built in 1970's for hunting and currently used on a seasonal basis

Map #	Structure	Location	Access	Currently Maintained	Use Status
110	Cabin	N. end of Madman Lake	airplane	Yes	Built in 1960's and currently used on a seasonal basis for hunting and fishing
115	Cabin	3 km N. of Tsusena Lake	airplane	Yes	Built in 1970's and currently used as a year-round residence by a guiding outfit
116	Cabin	1.6 km W. of VABM Oshetna	airplane	Yes	Built in 1970's for hunting purposes and is currently used on a seasonal basis
112	Cabin foundations	W. bank of Portage Creek: 6 km from Portage/Susitna confluence	dog team, foot	No	Built in 1940's as a mining/ prospecting cabin; no longer in use
117	Cabin	Tyone River/Tyone Creek confluence	boat, dog team	Yes	Built in 1960's for hunting and fishing purposes and currently used on a seasonal basis
118	Cabin	17.7 km due E. of Tyone River/ Susitna confluence	boat, dog team	No	Built in 1960's for hunting and fishing purposes; no longer in use

Summary: Seventy-six structures exist within Zone 2.

TABLE 9.3: ZONE 3 - EXISTING STRUCTURES (a)

Map #	Structure	Location	Access	Currently Maintained	Use Status
22	Cabin; shed	Prairie/Talkeetna confluence	foot, dog team, boat	Yes	Built in 1960's and currently used seasonally by Stephan Lodge for purposes of fishing and hunting
23	Cabin; shed	Game Lake	airplane, foot	Yes	Built in 1940's and used since then for trophy game hunting; now a part of Stephan Lodge's series of outreach cabins used on a seasonal basis
36	Mining buildings	Chunilna Creek: 13 km S.W. of VABM Clear	airplane, ATV, 4WD, snow-machine, dog team, foot	Yes	Four buildings built in the 1920's, 1940's and 1960's and used seasonally for the purpose of mining
37	Cabin	5 km N.E. of VABM Curry	foot, dog team	No	Built in 1940's and used seasonally for trapping until early 1960's; no longer in use
38	Cabin	Grizzly Camp: 8 km E. of Daneka Lake	foot, dog team, airplane	Yes	Built by Vogel in the 1940's as a hunting cabin; currently used on a seasonal basis as a Stephan outreach cabin for purposes of hunting
39	Cabin	14 km E of Stephan Lake: 11 km s. of Fog Lake	foot, airplane	Yes	Built in 1970's; current use not known at this time
59 60 61 62 63	Cabin Cabin Cabin Cabin Cabin	Chulitna Pass: near railroad	rail, foot, car, airplane	Yes	Exact construction dates not known; currently used as year-round residences

a. Zone 3 is that zone beteen 10 km and 19 km from the impoundments.

TABLE 9.3 (Continued)

Map #	Structure	Location	Access	Currently Maintained	Use Status
72	Cabin	Deadman Lake: W. of Big Lake	airplane, ATV	Yes	Built in 1960's for fishing and hunting purposes and currently used on a seasonal basis
73 74	Cabin Cabin	Big Lake	ATV	Yes	Built in 1960's; currently used on a seasonal basis for hunting and fishing
89	Cabin	Unnamed lake 5 km S.W. of Clarence Lake (island in middle)	floatplane, boat	Yes	Exact construction date not known; currently used on a seasonal basis for fishing
98	Cabin	Oshetna River: 16 km S. of Oshetna/ Susitna confluence	dog team, foot, boat	No	Built by Simco in 1930 as a trap line cabin and used on a seasonal basis for hunting and fishing
100	Tent platform	Susitna sandbar: S. of Tyone River/ Susitna confluence	boat, helicopter	No	Built in 1970's and used currently for transient boaters
101	Cabin	0.4 km S. of Maclaren/Susitna confluence	boat	Yes	Built in 1960's and currently used for boating on a seasonal basis
106	Cabin	S. end of Coal Lake	ATV, airplane	Yes	Built in 1960's and currently used on a seasonal basis for mining and fishing
113	Cabin	Unnamed lake: 10 km W. of Murder Lake	airplane	No	Built in 1960's for hunting purposes; no longer in use
114	Cabin	11 km N.E. of VABM Disappointment	airplane	Yes	Built in 1970's for hunting use and currently used for seasonal hunting purposes

Summary: There are twenty-one locations in Zone 3 with existing structures.

TABLE 9.4: USE INFORMATION FOR EXISTING STRUCTURES IN THE UPPER SUSITNA RIVER BASIN

	Zone 1	Zone 2	Zone 3
PRESENT CONDITION OF STRUCTURE			
Remains of structured foundations only (no use)	1	5	-
Badly weathered; partial structure remains - use no longer possible	2	-	1
Structure intact; not currently maintained			
- seasonal use - past & present	2	2	2
- no current seasonal use	2	7	1
Structure intact; maintained with seasonal use - past & present	3	49	12
Structure intact; maintained with year-round use	-	9	3
Structure intact; maintained; no current use information	-	4	3
USE TYPES			
Hunting, fishing, trapping	3	7	1
Hunting, fishing	2	43	3
Hunting only	1	7	2
Fishing only	-	1	-
Boating	1	21	-
Skiing	-	6	-
Mining	-	4	1
Research/exploration	3	2	-
ACCESS			
Air:			
Airstrip	3	26	6
Floats/skis	2	34	6
ATV	1	20	5
4WD	1	16	1
Boat	3	3	1
Foot, dog team	6	37	9
Snowmachine	-	6	1
Horse	-	4	-
Rail	-	1	2
Car	-	1	2

TABLE 9.5: MAJOR TRAILS IN THE UPPER SUSITNA RIVER BASIN

Type	Beginning	Middle	End	Years Used
Cat, ORV	Gold Creek		Devil Canyon	1950's-present
Cat, ORV	Gold Creek	Ridge top west of VABM Clear	Confluence of John & Chunilna creeks	1961-present
Packhorse	Sherman		Confluence of John & Chunilna creeks	1948
Cat	Alaska Railroad, mile 232		Chunilna Creek	1957-present
Foot	Curry		Cabin 3 km east of VABM Dead	1926
Packhorse, foot	Talkeetna	North of Disappointment Creek	Stephan Lake	1948
Packhorse, old sled road	Chunilna	Portage Creek	Lake west of High Lake	1920's-present
ATV	Denali Highway	Butte Lake	Tsusena Lake	1950's-present

TABLE 9.6: PARCELS BY LAND STATUS/OWNERSHIP CATEGORY [(a)]

USGS Talkeetna Mountains Quad	Land Status/ Ownership Category	Location [(b)]	Areas Hectares	Areas Acres
C-1	Federal D-1	T29N,R12E SM	1,295	3,200
	Regional Selection	T29N,R10-12E SM	9,324	23,040
		T29-31N,R12E SM	4,921	12,160
		T30&31N,R11E SM	4,921	12,160
	State Selection Suspended	T29-31N,R10&11E SM	11,655	28,800
C-2	Regional Selection	T29-30N,R8-10E SM	20,979	51,840
	State Selection Suspended	T29-31N,R8-10E SM	35,094	86,719
	Private (Clarence Lake)	T30N,R9E SM Sections 19, 20, 21	5	12
C-3	Regional Selection	T29&30N,R5-8E SM	33,152	81,920
	Village Selection	T31N,R5E SM	404	998
	State Selection Suspended	T30-31N,R5-8E SM	22,921	56,639
	Private (Watana Lake)	T31N,R7E SM Sections 25 & 36	6	15
C-4	Regional Selection	T29&30N,R2-5E SM	33,152	81,280
	Village Selection	T30&31N,R2-5E SM	15,410	38,079
	State Selection Suspended	T30N,R3-5E SM	7,381	18,239
	Private (Stephan Lake)	T30N,R3E SM Sections 9, 16, 17, 20, 21	17	42
C-5	Regional Selection	T29&30N,R1W,1&2E SM	32,893	81,280
	Village Selection	T30&31N,R2E SM	1,942	4,799
	State Selection Suspended	T30&31N,R1W,1&2E SM	20,461	50,560
	Private	T29N,R2E SM Section 15	2	5
C-6	State Patented or TA'd	T31N,R2W SM	2,331	5,760
	Regional Selection	T29&30,R1&2W SM	12,302	30,399
	Native Group Selection	T30N,R2W SM	1,554	3,840
	State Selection Suspended	T29-31N,R1&2W SM	9,712	23,999
	Private (north of Chunilna Creek)	T30N,R2W SM Sections 23, 26	163	403
	(south of Gold Creek)	T31N,R2W SM Sections 29, 30	34	84
	Mining Claims	T29N,R2W SM Sections 2, 3, 10, 11, 15, 16	Unknown	

a. Status and ownership are subject to change through administrative and court proceedings.
b. Seward Meridian
c. TA'd - tentatively approved
d. Fairbanks Meridian
Source: Compiled from various sources, including Land Status Maps prepared by CIRI/H&N 1980 and 1981; Alaska Department of Natural Resouces, State Land Disposal Brochures 1979, 1980, 1981; U.S. Department of Interior, Bureau of Land Management Records, 1982.

USGS Talkeetna Mountains Quad	Land Status/ Ownership Category	Location	Areas Hectares	Acres
		(d)		
D-6	Federal (Railroad Withdrawal)	T22S,R11W FM		
		Sections 22, 23,		
		26, 27, 33, 34	803	1,984
		T33N, R2W SM		257
		Sections 15 - 17	104	180
	(near Chulitna)	T32N,R2W SM		25,600
		Sections 1, 2, 11	73	10,240
	Denali State Park	T31-33N,R2W SM	10,360	479
	State Selection	T32&33N,R2W SM	4,144	5,120
		T32&33N,R2W		
		Sections 6 & 31	194	479
		T22S,R11W FM	2,072	5,120
	State Patented or TA'd	T31N,R2W SM	3,885	9,600
		T22S,R10W FM	1,295	3,200
	Village Selection	T31&32N,R1W SM	3,108	7,680
	State Selection Suspended	T31N,R1W SM	907	2,241
		T33N,R1W SM	1,554	3,840
	Private (Indian River Remote)	T31&32N,R2W SM		
		Sections 2-4, 9, 10,		
		13, 24,25-27, 33-36	2,590	6,400
	(Indian River Sub Div.)	T33N,R2W SM	518	1,280
	(near Chulitna)	T32N,R2W SM		
		Sections 1, 2, 11, 12	150	371
	(near Gold Creek)	T31N,R2W SM		
		Sections 17, 19-21, 29,		
		30	388	959
	(Pass Creek)	T33N,R2W SM (sec. 27)	1	2
	(Summit Lake)	T33N,R2W SM (sec. 34)	2	5
	(Chulitna Pass)	T33N,R2W SM (sec. 35)	1	2
	(near Alaska RR)	T31N,R2W SM (sec. 9)	1	2
D-5	State Selection	T32&33N,R1W,1&2E SM	24,863	61,438
	State Selection TA'd	T22S,R8-10W FM	11,784	29,119
	Village Selection	T31-33N,RW,1&2E SM	8,547	21,120
	Tyonek	T31-33N,R1W,1&2E SM	3,755	9,279
	Knik	T31-32N,R1W,1&2E SM	7,252	17,920
	Chickaloon	T31&32N,R1W,1&2E SM	1,424	3,519
	State Selection Suspended	T31-33N,R1W,1&2E SM	13,079	32,319
	Private (High Lake)	T32N,R2E SM (sec. 20)	45	111
	(north of Devil Canyon)	T32N,R1E SM (sec. 16)	5	12
		T23N,R1E SM (sec. 30)	3	7
		T32N,R1W SM (sec. 9)	2	5
		T32N,R1W SM (sec. 10)	5	12
		T32N,R1W SM (sec. 23)	3	7
D-4	State Selection	T32&33N,R3-5E SM	38,461	95,039
	State Selection TA'd	T22S,R5-8W FM	11,914	29,440
	Village Selection	T31&32N,R3-5E SM	7,511	18,560
	Tyonek	T31&32N,R3-5E SM	2,978	7,359
	Knik	T31&32N,R3-5E SM	5,050	12,479

USGS Talkeetna Mountains Quad	Land Status/ Ownership Category	Location	Areas Hectares	Acres
	Chickaloon	T31N,R3E SM	78	193
	State Selection Suspended	T31N,R3E SM	4,921	12,160
	Private (Tsusena Butte Area)	T33N,R5E SM		
		Section 16, 21	20	49
D-3	State Selection	T32&33N,R5-7E SM	33,411	82,560
	State Patented or TA'd	T32N,R8E SM	1,295	3,200
		T33N,R8E SM	842	2,081
		T22S,R2-4W FM	8,806	21,760
		T22S,R5W FM	2,331	5,760
	Native Selection	T32N,R8E SM	1,036	2,560
	Village Selection	T31&32N,R5-7E SM	7,511	18,560
	Tyonek	T32N,R5&6E SM	1,683	4,159
	Knik	T31&32N,R5&6E SM	2,460	6,079
	State Selecton Suspended	T31N,R5-8E SM	11,396	28,160
	Private (Fog Lakes Area)	T31N,R5E SM		
		Sections 13 + 24	21	52
D-2	Federal D-1	T22S,R1E FM	259	640
		T22S,R2W FM	285	704
	BLM	T22S,R1&2W,1E FM	10,101	24,960
	State Patented or TA'd	T32N,R8E SM	1,813	4,480
		T22S,R2W FM	1,424	3,519
	Native Selection	T32&33N,R8-10E SM	39,109	96,640
	Village Selection	T31N,R8-10E SM	17,353	42,880
D-1	Federal D-1	T22S,R1-3E FM	7,770	19,200
		T33N,R11&12E SM	10,101	24,960
	Regional Selection	T22S,R1E FM	259	640
		T31&32N,R12E SM	13,727	33,920
		T32&33N,R10-12E SM	19,435	48,000
	Village Selection	T31N,R10-11E SM	7,252	17,920
	Fish & Wildlife Service	T33,R11E SM (sec. 20)	Unknown	
	State Selection Suspended	T31N,R10E SM	62	153

USGS Healy Quad	Land Status/ Ownership Category	Location	Areas Hectares	Acres
A-1	Federal D-1	T22S,R1&2E FM	2,460	6,079
	Regional Selection	T22S,R1&2E FM	1,554	3,840
	Historic Site (cemetery)	T22S,R1E FM (sec. 1+2)	Unknown	
A-2	Federal D-1	T22S,R1&2W,1E FM	5,309	13,119
	State Patented or TA'd	T22S,R1&2W,1E FM		
		Section 19-21, 28-33	2,331	5,760
		T22S,R2W FM	52	128
	Regional Selection	T22S,R1&2W,1E FM	5,698	14,080
	Private	T22S,R2W FM (sec. 3)	2	5
A-3	Federal D-1	T22S,R2-4W FM	9,842	24,320
	State Patented or TA'd	T22S,R2-4W FM	388	959
	Regional Selection	T22S,R5W FM	2,409	5,953
A-4	State Patented or TA'd	T22S,R5-7W FM		
		Sections 19-36	4,662	11,520
	Regional Selection	T22S,R5-7W FM		
		Sections 1-18	4,662	11,520
A-5	State Patented or TA'd	T22S,R8-10W FM		
		Sections 19-36	4,662	11,520
	Regional Selection	T22S,R8-10W FM		
		Sections 1-18	4,662	11,520
A-6	Federal RR. Wdl.	T22S,R11W FM	932	2,303
	State Selection	T22S,R11W FM	4,014	9,919
	State Patented or TA'd	T22S,R10W FM	1,295	3,200
		T22S,R12&13W FM	6,475	16,000
	Private	T22S,R11W FM (sec. 1)	13	32

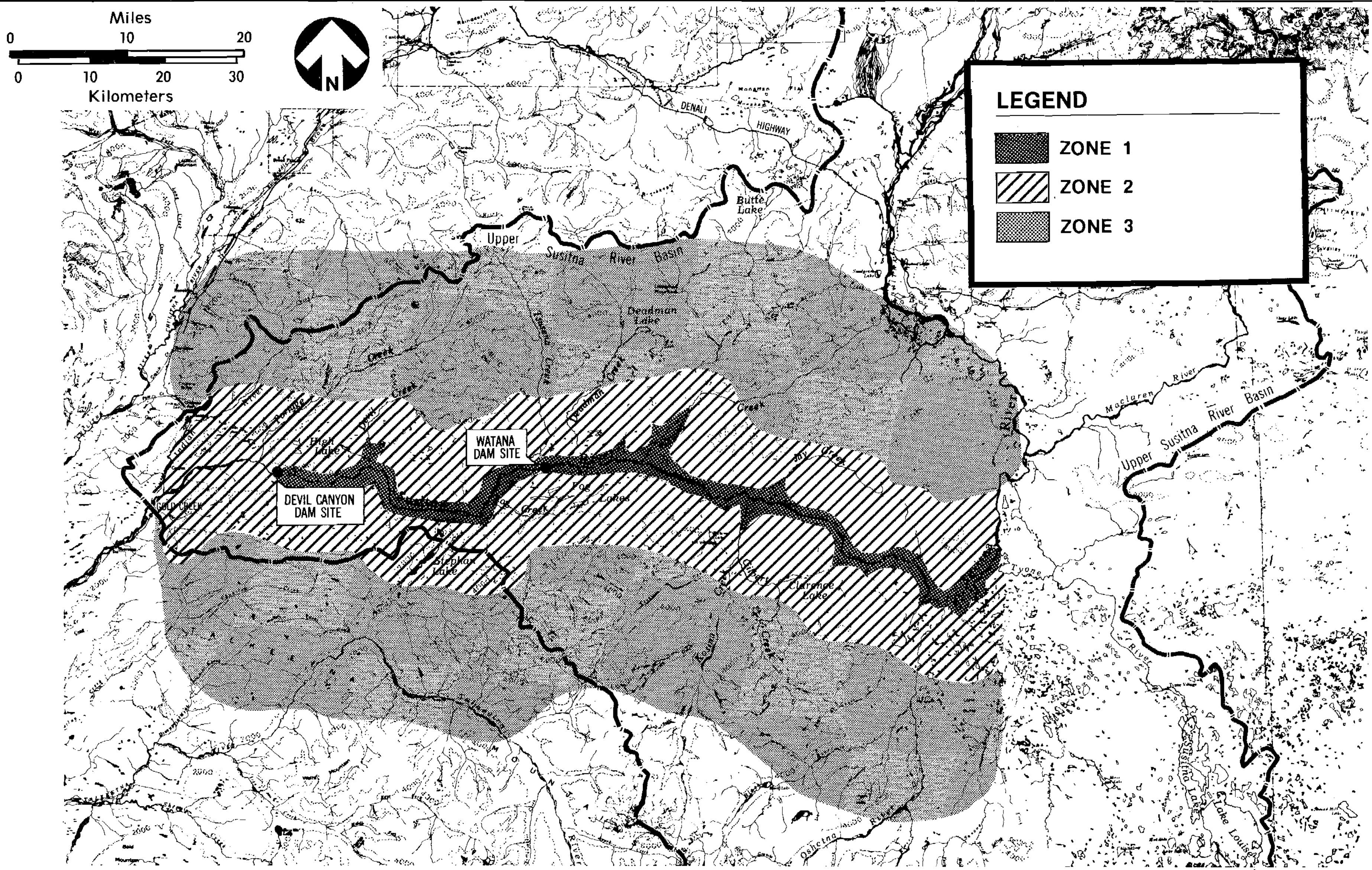
TABLE 9.7: SUMMARY OF LAND STATUS/OWNERSHIP IN PROJECT AREA[(a)]

Land Status/Ownership Category	Total Area Hectares	Acres
Federal D-1	37,321	92,222
Federal Railroad Withdrawal	1,912	4,725
Bureau of Land Management	10,101	24,960
State Selection	107,159	264,796
State Patented or Tentatively Approved (TA'd)	67,585	167,006
State Selection Suspended	139,143	343,830
Denali State Park (within study area)	10,360	25,500
Regional Selection	204,040	504,194
Native Group Selection	41,699	103,040
Village Selection	69,038	170,597
Tyonek	8,416	20,796
Knik	14,762	36,378
Chickaloon	1,502	3,712
Private	3,997	9,877

a. Summarized from Table 9.6.

TABLE 9.8: SUMMARY OF PRESENT AND FUTURE LAND MANAGEMENT ACTIVITIES IN THE PROPOSED SUSITNA HYDROELECTRIC PROJECT AREA

Land Management Agency	Current Management	Future Management Direction
U.S. Department of Interior Bureau of Land Management	Protection of natural environment; no activities other than fire control and the issuing of some special use permits. Land use planning being undertaken.	Future management will be guided by Southcentral Planning Area Management Framework Plan and an easement management plan.
Alaska Department of Natural Resources	Planning for the disposal of state lands that are immediately adjacent to the west side of the project area (north and south of Chulitna).	State will select lands in project area not selected by the natives. Management planning on these lands will not begin before 1983.
Alaska Power Authority	Performing hydroelectric development feasibility studies.	Dependent upon outcome of feasibility studies.
Matanuska-Susitna Borough	Borough has no lands in the project area. Project area does fall within the borough's boundaries and is part of the borough's Talkeetna Mountain Special Use District. Project area is a "mixed use" zone.	By Ordinance No. 79-35 creating the Talkeetna Mountains Special Use District, the borough can exercise planning and zoning authority over private lands within its boundaries; will commence further activities when hydro studies are completed.
Matanuska-Susitna Borough (in affiliation with the Federal Office of Coastal Zone Management and the Alaska Coastal Management Program)	Currently has designated the Susitna River to and including Devil Canyon as part of a biophysical area for the Coastal Zone Management Program.	Continuing CZM studies will determine any additional management direction.
Cook Inlet Region, Inc. and several villages	None; lands currently being transferred to individual villages.	Management planning not yet underway.

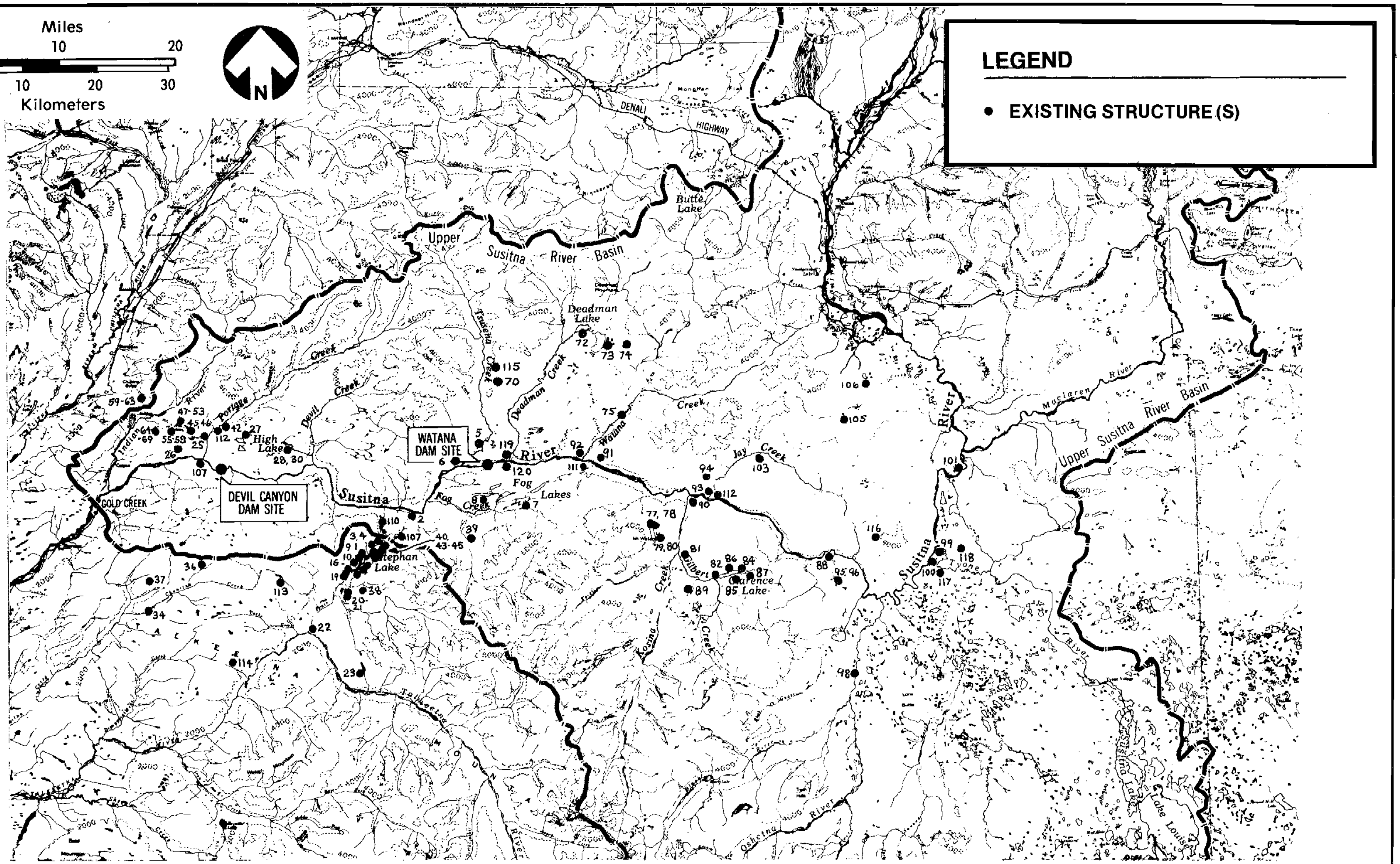


STUDY AREAS FOR LAND USE ANALYSIS

PREPARED BY TES

FIGURE 9.1

ACRES

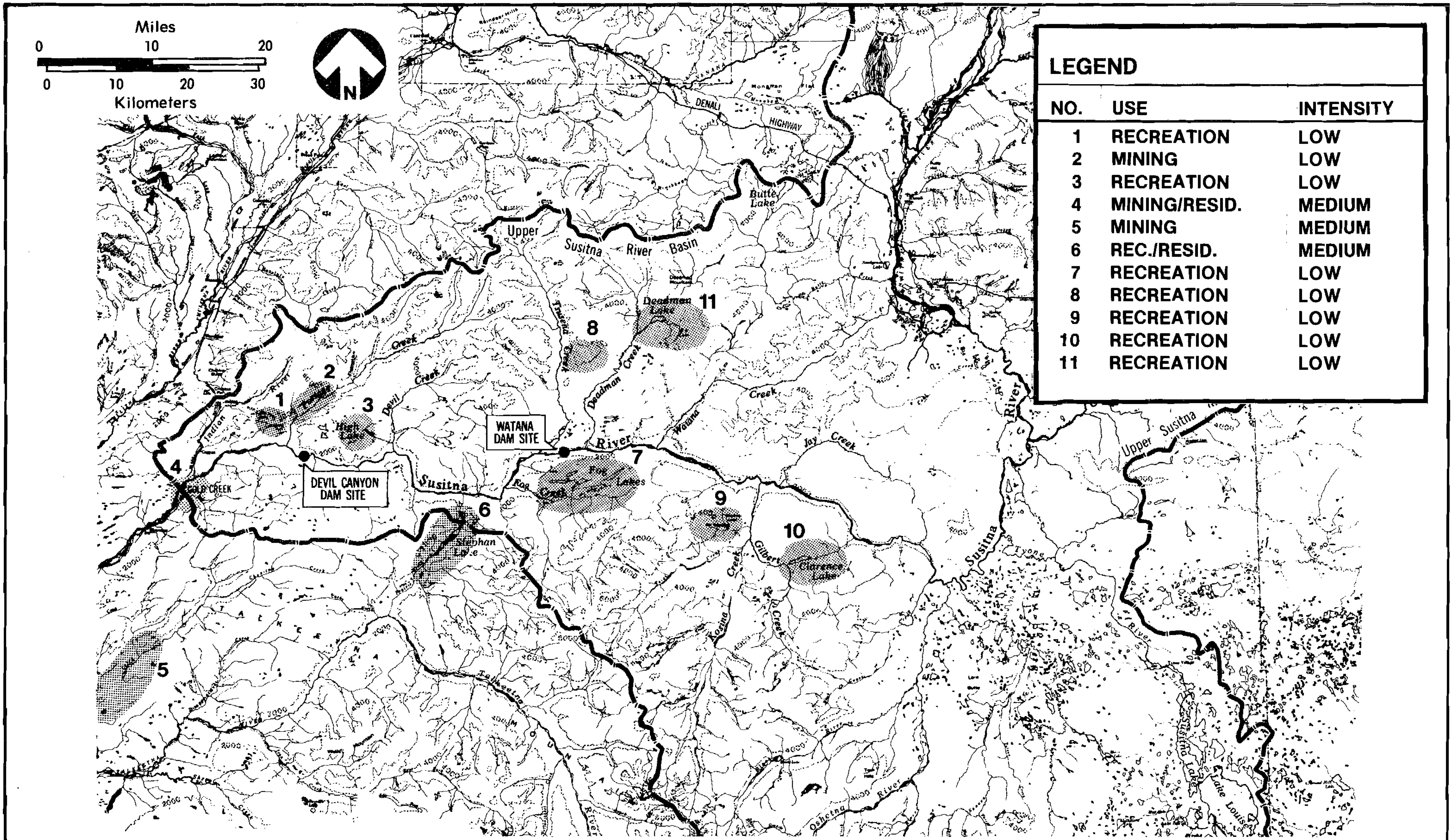


EXISTING STRUCTURES

PREPARED BY TES

FIGURE 9.2

ACRES

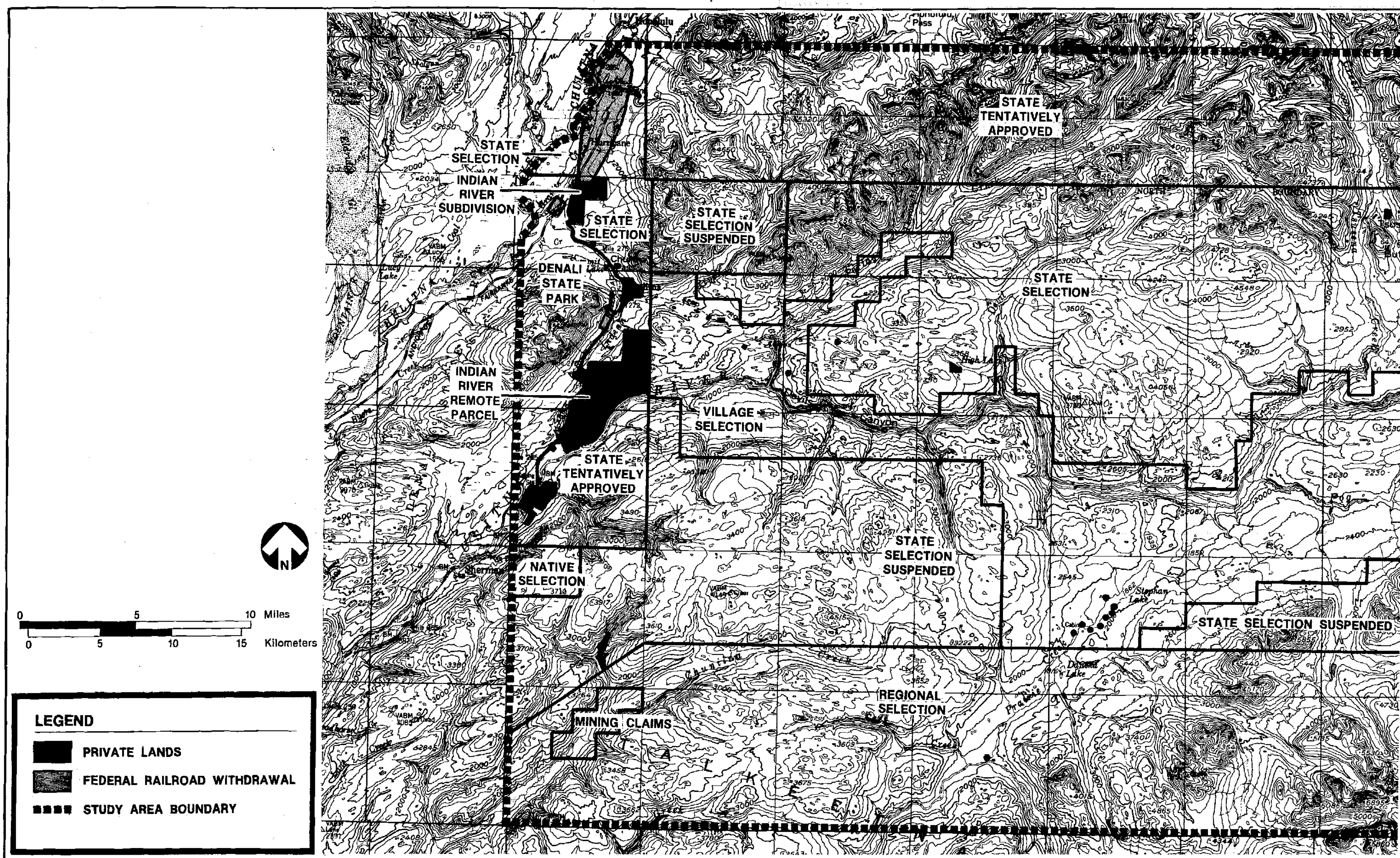


LAND USE AGGREGATIONS:
RECREATION, MINING, RESIDENTIAL

PREPARED BY TES

ACRES

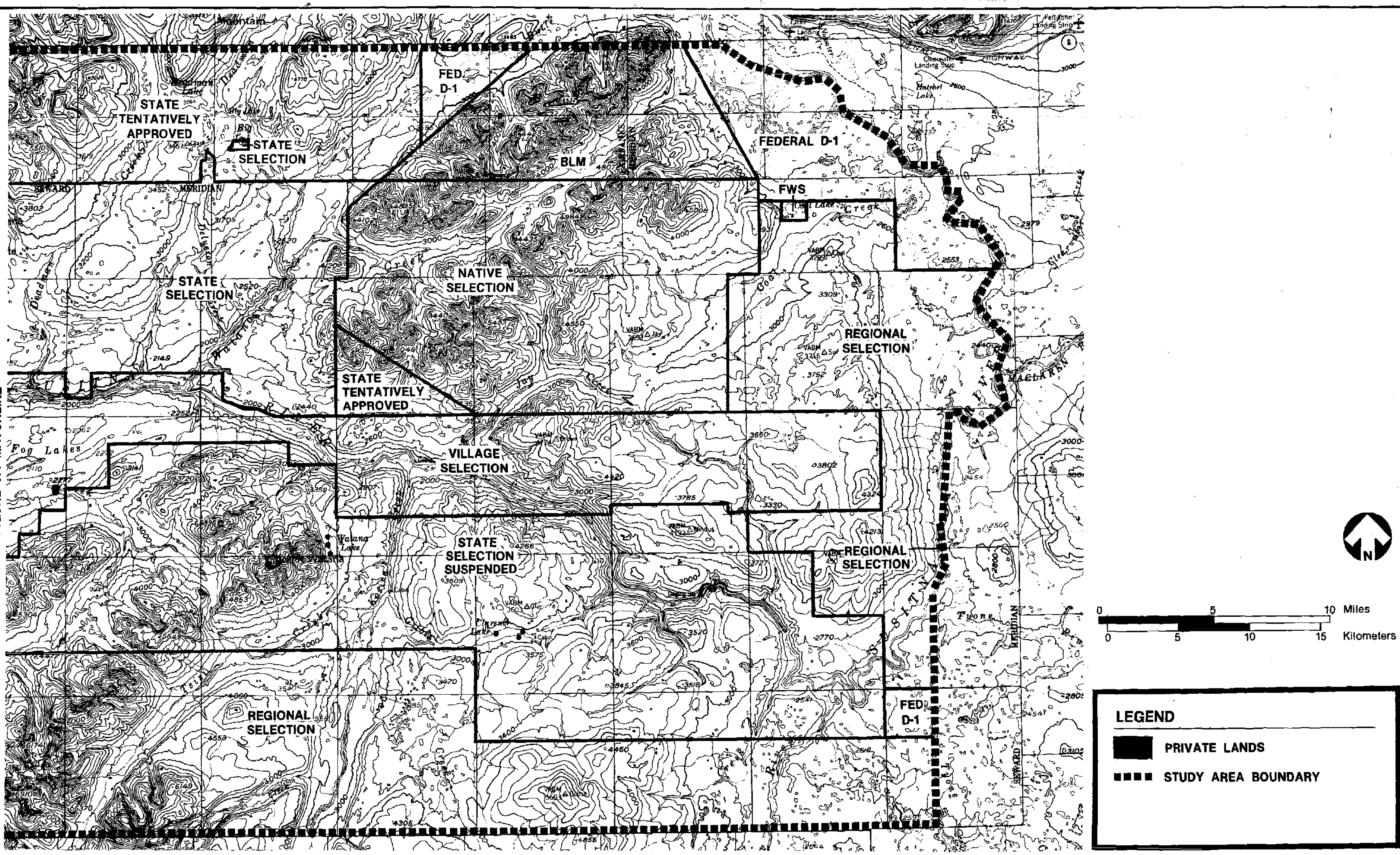
FIGURE 9.3



LAND OWNERSHIP / STEWARDSHIP, DEVIL CANYON PORTION

PREPARED BY TES

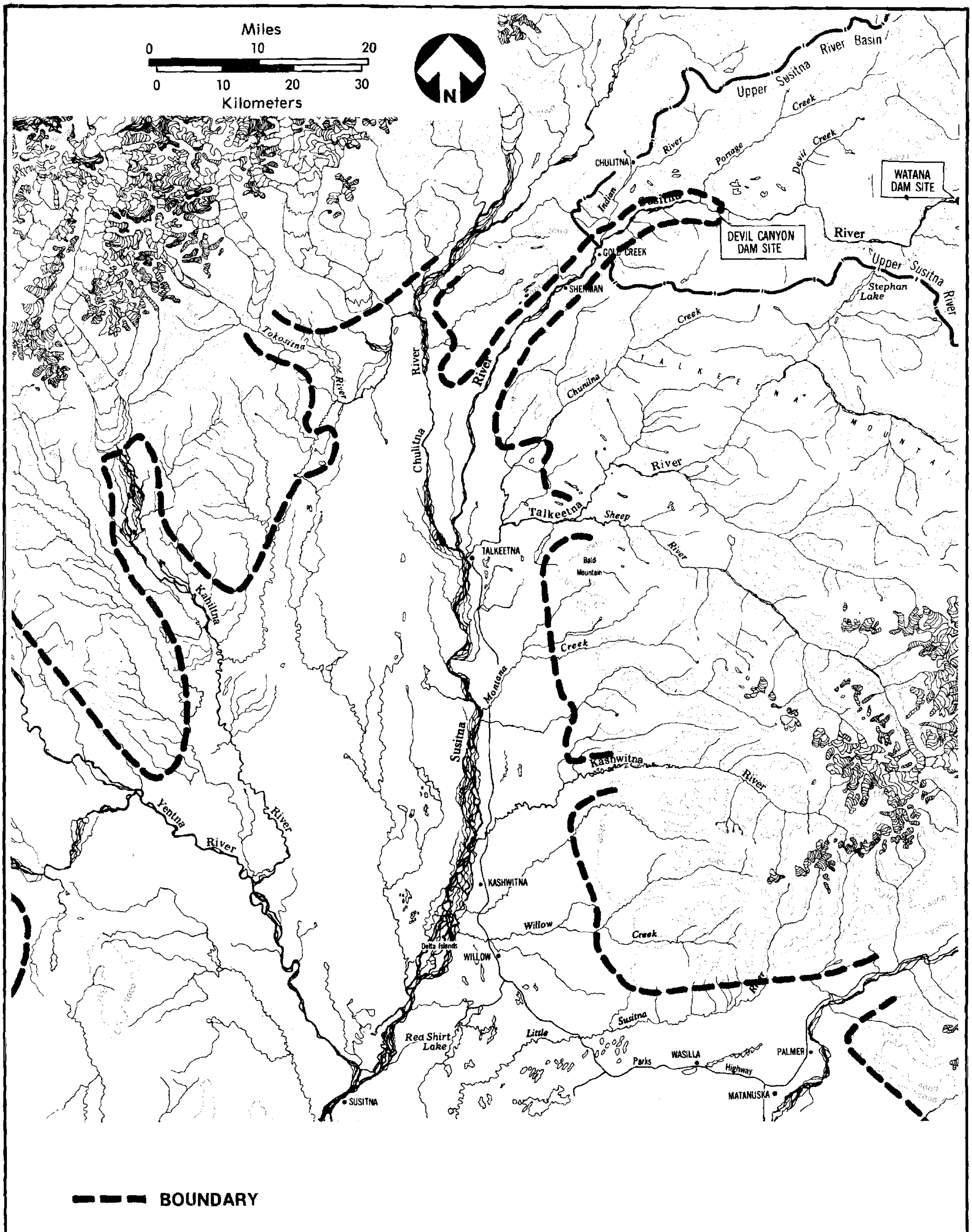
FIGURE 9.4



LAND OWNERSHIP/STEWARDSHIP, WATANA PORTION

PREPARED BY TES

FIGURE 9.5

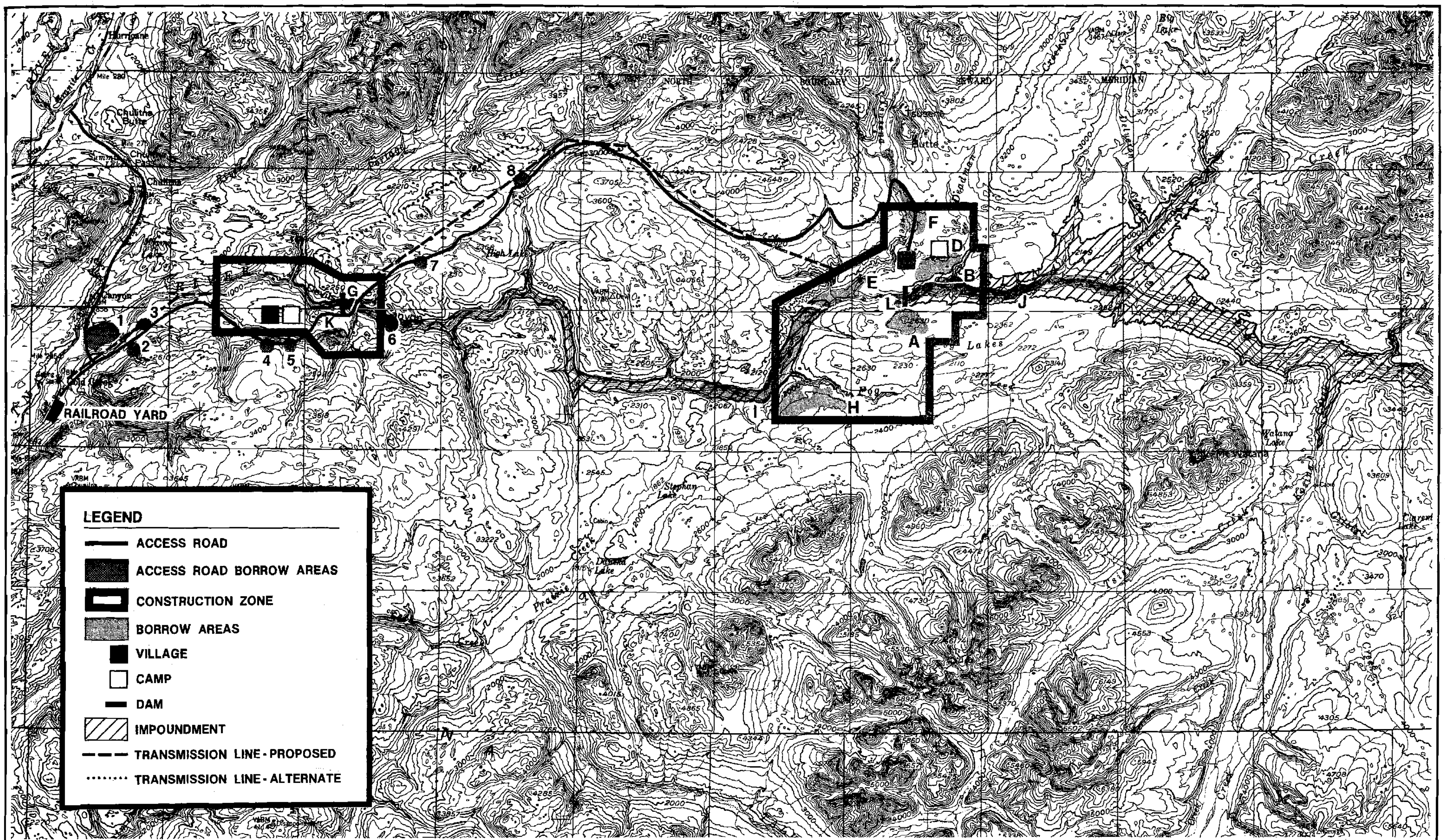


BIOPHYSICAL COASTAL BOUNDARY
MATANUSKA - SUSITNA BOROUGH
COASTAL MANAGEMENT PROGRAM

PREPARED BY TES

ACRES

FIGURE 9.6

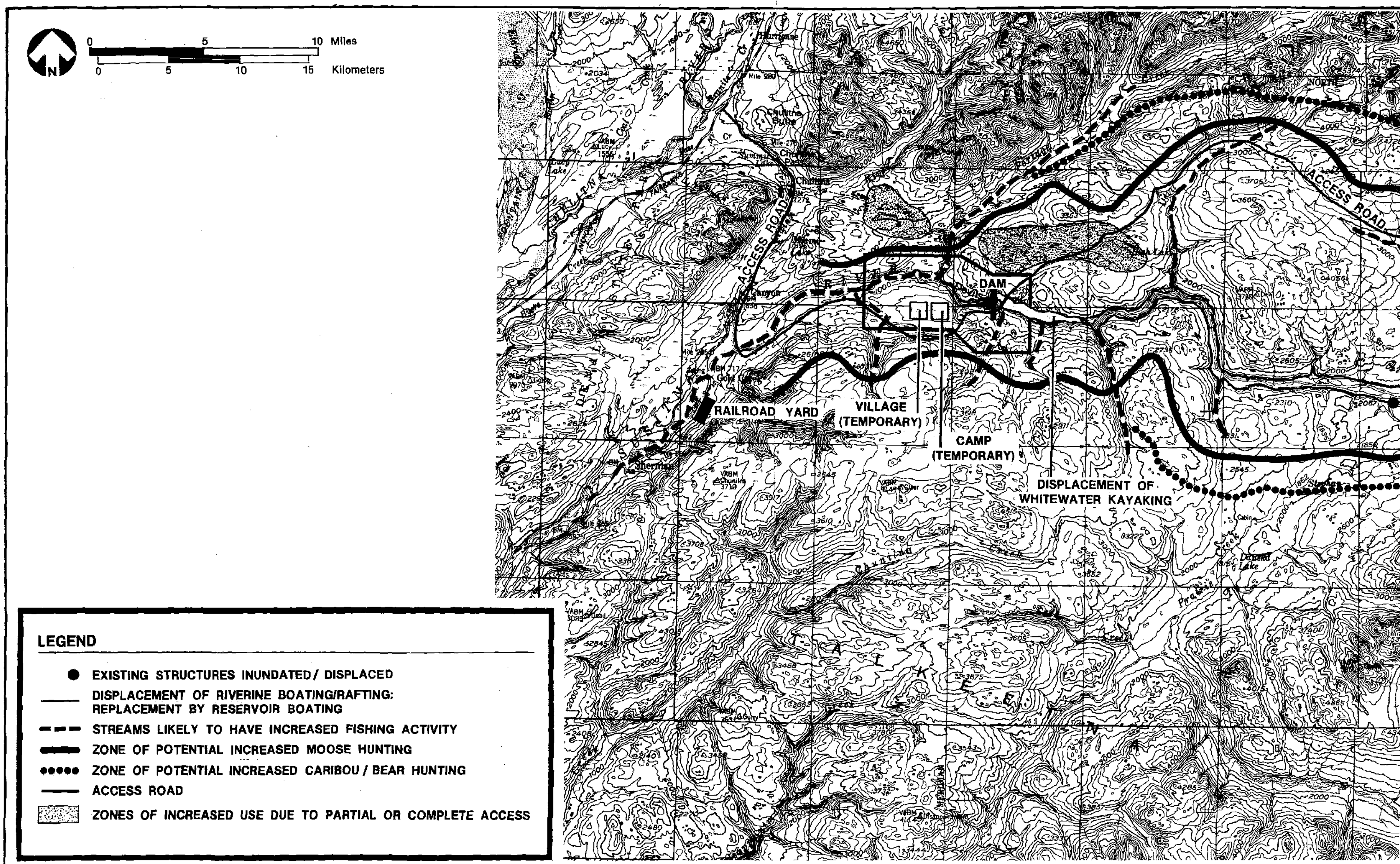


PROJECT FACILITIES

PREPARED BY TES

FIGURE 9.7

ACRES

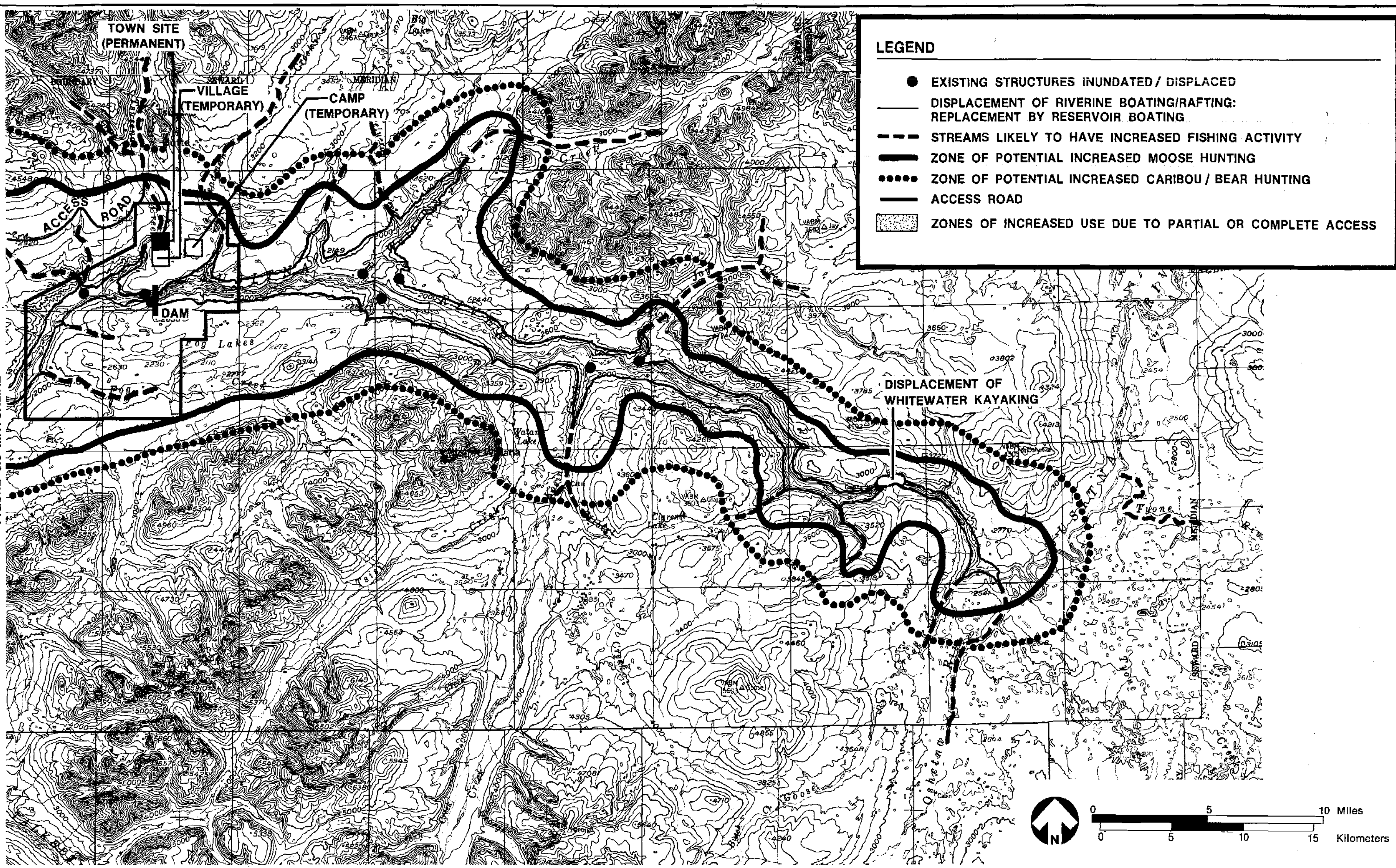


INDUCED LAND USE ACTIVITIES, DEVIL CANYON PORTION

PREPARED BY TES

FIGURE 9.8

ACRES



INDUCED LAND USE ACTIVITIES, WATANA PORTION

PREPARED BY TES

FIGURE 9.9

ACRES

10 - ALTERNATIVES TO THE SUSITNA PROJECT

This section presents the results of assessments of the environmental impacts of alternatives to the proposed Susitna Hydroelectric Project. Included in this assessment is a consideration of alternative hydroelectric generating sites outside the upper Susitna basin and alternative sites within the basin. An environmental analysis of these alternative sites is described.

An environmental assessment of two alternative methods of generation, coal-fired thermal and tidal, is also presented. Finally, a comparison of hydroelectric, thermal and tidal alternatives is presented in terms of differential environmental impact.

10.1 - Non-Susitna Hydroelectric Alternatives

The analysis of alternative sites for non-Susitna hydropower development followed the plan formulation and selection methodology discussed in Section 1.4 of Volume I. The material presented in this section is an expansion of that appearing in Section 6 of Volume I and contains additional environmental information.

Step 1 in the plan formulation and selection process was to define the overall objective of the exercise. For Step 2 of the process, all feasible sites were identified for inclusion in the subsequent screening process. The screening process (Step 3) eliminated those sites that did not meet the screening criteria and yielded candidates which could be refined to include in the formulation of Railbelt generation plans (Step 4).

Details of each of the above planning steps are given below and presented in Figure 10.1. The objective of the process was to determine the optimum Railbelt generation plan which incorporates the proposed non-Susitna hydroelectric alternatives.

(a) Screening of Candidate Sites

As discussed in Section 4, Volume 1, numerous studies of hydroelectric potential in Alaska have been undertaken. A significant amount of the identified potential is located in the Railbelt region. Review of the above studies and in particular the various published inventories of potential sites identified a total of 91 potential sites (Table 10.1). All of these sites are technically feasible and, under Step 2 of the planning process, were identified for inclusion in the subsequent screening exercise.

The screening process applied to these sites for this analysis required the application of four iterations with progressively more stringent criteria.

(i) First Iteration

As discussed in Section 6, Volume 1, the first screen or iteration determined which sites were not economically viable and rejected these sites. The standard for economic viability in this iteration was defined as energy production cost less than 50 mills per kWh, based on economic parameters. This value for energy production cost was considered to be a reasonable upper limit consistent with Susitna Basin alternatives for this phase of the selection process.

As a result of this screen, 26 sites were eliminated from the planning process (Table 10.1). The remaining 65 sites were subjected to a second iteration of screening which included additional criteria on environmental acceptability.

(ii) Second Iteration

The inclusion of environmental criteria into the planning process required a significant data survey to obtain information on the location of existing and published sources of environmental data. A detailed review of this data and the sources used are presented in Appendix C of the Development Selection Report.

The basic data collected identified two levels of detail of environmental screening. The purpose of the first level of screening was to eliminate those sites which were least acceptable from an environmental standpoint. Rejection of sites occurred if:

- They would cause significant impacts within the boundaries of an existing National Park, Wild and Scenic River, National Wilderness Area, or a proclaimed National Monument area;
- Or they were located on a river in which:
  - Anadromous fish are known to exist;
  - The annual passage of fish at the site exceeds 50,000; and
  - Upstream from the site, a confluence with a tributary occurs in which a major spawning or fishing area is located.

The definition of the above exclusion criteria was made only after a review of the possible impacts of hydropower development on the natural environment and the effects of land issues on particular site development.

Of the 65 sites remaining after the preliminary economic screening, 19 sites were eliminated on the basis of the requirements set for the second screen. These sites appear in Table 10.1, and the reason for their rejection in Table 10.2. The location of the remaining 46 sites appears in Figure 10.2.

(iii) Third Iteration

The reduction in the number of sites to 46 allowed a reasonable reassessment of the capital and energy production costs for each of the remaining sites to be made. Adjustments were made to take into account transmission line costs necessary to link each site to the proposed Anchorage-Fairbanks intertie. This iteration resulted in the rejection of 18 sites based on judgmental elimination of the more obvious uneconomic or less environmentally acceptable sites (Table 10.1). The remaining 28 sites were subjected to a fourth iteration which entailed a more detailed numerical environmental assessment.

(iv) Fourth Iteration

To facilitate analysis, the remaining 28 sites were categorized into sizes as follows:

- Less than 25 MW: 5 sites;
- 25 MW to 100 MW: 15 sites; and
- Greater than 100 MW: 8 sites.

The fourth and final screen was performed using a detailed numerical environmental assessment which considered eight criteria chosen to represent the sensitivity of the natural and human environments at each of the sites.

The eight evaluation criteria are listed in Table 10.3. For each of the evaluation criteria, a system of sensitivity scaling was used to rate the relative sensitivity of each site. A letter (A, B, C or D) was assigned to each site for each of the eight criteria to represent this sensitivity. The scale rating system is defined in Table 10.4.

Each evaluation criterion has a definitive significance to the Alaskan environment and degree of sensitivity to impact. A discussion of each criterion, and the reference maps used to obtain information on these criteria, is presented in Appendix C2 of the Development Selection Report. A summary of the evaluation and comparison of each site on the basis of these criteria is presented in the following paragraphs.

(b) Basis of Evaluation

The criteria were initially weighted in accordance with their relative significance in comparisons. The first four criteria--big game, agricultural potential, birds, and anadromous fisherieswere chosen to represent the most significant features of the natural environment. These resources require protection and careful management because of their position in the Alaskan environment, their roles in the existing patterns of life of the state residents, and their importance in the future growth and economic independence of the state. They were viewed as more important than the following four criteria because of their quantifiable and significant position in the lives of the Alaskan people.

The remaining four criteria--wilderness; cultural, recreation and scientific features; restricted land use; and access--were chosen to represent the institutional factors to be considered in determining any future land use. These are special features which have been identified or protected by governmental laws or programs and may have varying degrees of protected status; or the criteria represent existing land status which may be subject to change by the potential developments.

Data relating to each of these criteria were compiled separately and recorded for each site, forming a data-base matrix. Then, based on these data, a system of sensitivity scaling was developed to represent the relative sensitivity of each environmental resource (by criterion) at each site. A detailed explanation of the scale rating may be found in Table 10.5.

The scale ratings for the criteria at each site were recorded in the evaluation matrix. Site evaluations of the 28 sites under consideration are given in Table 10.6. Preliminary data regarding technical factors were also recorded for each potential development. Parameters included installed capacity, development type (dam or diversion), dam height, and new land flooded by impoundment. The complete evaluation matrix may be found in Table 10.7.

In this manner, the environmental data were reduced to a form from which a relative comparison of sites could be made. The comparison was carried out by means of a ranking process.

(c) Rank Weighting and Scoring

For the purpose of evaluating the environmental criteria, the following relative weights were assigned to the criteria. A higher value indicates greater importance or sensitivity than a lower value.

Big Game	8
Agricultural Potential	7
Birds	8
Anadromous Fisheries	10
Wilderness Values	4
Cultural Values	4
Land Use	5
Access	4

The criteria weights for the first four criteria were then adjusted down, depending on related technical factors of the development scheme.

All the sites were ranked in terms of their dam heights which were assumed to be the factor having the greatest impact on anadromous fisheries.

Sites were also ranked in terms of their new reservoir area, or the amount of new land flooded, which was considered to be the one factor with greatest impact on agriculture, bird habitat, and big game habitat. The same adjustments were made for the big game, agricultural potentials, and bird habitat weights based on this flooded area impact (see Table 10.8).

The scale indicators were also given a weighted value as follows:

- B = 5
- C = 3
- D = 1

To compute the ranking score, the scale weights were multiplied by the adjusted criteria weights for each criteria and the resulting products were added.

Two scores were then computed. The total score is the sum of all eight criteria. The partial score is the sum of the first four criteria only, which gives an indication of the relative importance of the existing natural resources in comparison to the total score.

(d) Evaluation Results

The evaluation of sites took place in the following manner: sites were first divided into three groups in terms of their capacity.

Based on the economics, the best sites were chosen and environmentally evaluated as described above. Table 10.9 lists the number of sites evaluated in each of the capacity groups in ascending order according to their total scores for each of the groups. The partial score was also compared. The sites were then grouped as better, acceptable, questionable, or unacceptable, based on the scores.

The partial and total scores for each of the sites, grouped according to capacity, appear in Table 10.10.

Sixteen sites were chosen for further consideration. Three constraints were used to identify these 16 sites. First, the most economical sites which had passed the environmental screening were chosen. Second, sites with a very good environmental impact rating which had passed the economic screening were chosen. And finally, a representative number of sites in each capacity group were to be chosen (Table 10.11).

From the list of 16 sites, 10 were selected for detailed development and cost estimates required as input to the generation planning. The ten sites chosen are underlined in Table 10.1.

Further discussion of the basis of selection of these 10 sites is presented in Appendix C2 of the Development Selection Report.

(e) Plan Formulation and Evaluation

Steps 4 and 5 in the planning process was the formulation of the preferred sites identified in Step 3 into Railbelt generation scenarios. To adequately formulate these scenarios, the engineering, energy, and environmental aspects of the ten short-listed sites were further refined (Step 4).

This resulted in formulation of the ten sites into five development plans incorporating various combinations of these sites as input to the Step 5 evaluations. The five development plans are given in Table 10.12.

The essential objective of Step 5 was established as the derivation of the optimum plan for the future Railbelt generation, incorporating non-Susitna hydro generation as well as required thermal generation. The methodology used in the evaluation of alternative generation scenarios for the Railbelt is discussed in detail in Section 8 of Volume I. The criterion on which the preferred plan was finally selected in these activities was least present-worth cost based on economic parameters established in Section 8, Volume I.

The selected potential non-Susitna hydro developments (Table 10.13) were ranked in terms of their economic cost of energy. These developments were then introduced into the all-thermal generating scenario in groups of two or three. The most economic schemes were introduced first followed by the less economic schemes.

On the basis of these evaluations, the most viable alternative to the Susitna project was found to be the development of the Chakachamna, Keetna, and Snow sites for hydroelectric power, supplemented with a thermal generating facility. The potential environmental impacts of hydroelectric development at these sites are discussed below; discussion of the environmental effects of thermal development is in Section 10.4.

10.2 - Environmental Assessment of Selected Alternative Sites

The analysis of alternative development scenarios outside the upper Susitna Basin showed Chakachamna, Snow and Keetna hydroelectric sites offer the most suitable schemes for development. Because maximum total power production from these three sites would be only 650 MW, additional thermal and tidal development would also be required. The potential environmental impacts of hydroelectric development at these three sites are discussed below; coal-fired thermal and tidal power are discussed in Sections 10.4 and 10.5.

The Chakachanmna area has been studied previously for hydroelectric development and is currently under study by the Power Authority. As such, fairly detailed information is available. Keetna and Snow, however, have not been intensively studied and information is limited primarily to non-specific inventory data and resource maps.

(a) Description of Chakachamna Site

Chakachamna Lake is located in the Alaska range approximately 80 miles west of Anchorage. The lake is drained by the Chakachatna River which runs southeasterly out of the lake and eventually into Cook Inlet. Three primary methods have been explored as a way to produce power at the site; one via construction of a dam on the Chakachatna River, one via diversion of water from the lake utilizing a tunnel into the MacArthur River, and one via diversion down the Chakachatna Valley. Transmission lines would run from the site to a location near the Chugach Electric Association (CEA) Beluga power plant and would then parallel existing lines to a submarine crossing of Knik Arm and then to a terminal on the eastern shore (Bechtel Civil and Minerals, Inc., 1981).

(i) Topography and Geology

Chakachamna Lake is located in a deep valley of the Alaska range surrounded by glaciers and high mountains. From an elevation of approximately 1200, land elevation drops fairly rapidly to sea level within 40 miles. In lower elevations, drainage is poor with numerous wetlands present.

Lake Chakachamna was formed by the Barrier Glacier and associated morainal deposits descending from the south side of Mount Spurr. The area is underlain by semi-consolidated volcanic debris of late Tertiary or Quaternary age and, closer to Cook Inlet, by alluvial and tidal sand, silt, and gravel of Holocene age (Cook Inlet Region, Inc, and Placer

Amex, Inc., 1981). Past movement by glaciers has resulted in scattered boulders and glacially scattered till. Chakachamna Lake, the south side of the Chakachatna River Valley, and the MacArthur River Canyon are bordered by granitic bedrock. The north side of the Chakachatna River Valley is bordered by volcanic bedrock.

(ii) Surface Hydrology

Chakachamna Lake is approximately 13 miles in length and is 1.5 to 3.0 miles wide. Inflow to the lake is primarily glacial in origin and consists of the Nagishlamina and Chilligan Rivers entering from the north (U.S. Fish and Wildlife Service 1962).

The Chakachatna River originates at the outlet of Chakachamna Lake and flows easterly approximately 15 miles through a canyon and then through lowland areas to Cook Inlet. Mean annual discharge at its origin is 3645 cfs with a range from 441 cfs in April to 12,000 cfs in July; average annual stream flow at the reservoir site is estimated at 2.5 million acre feet (Bechtel Civil and Minerals, Inc., 1981). The total length is 36 miles and the total drainage area is 1,620 square miles.

The MacArthur River originates from the MacArthur glacier and is also fed by the Blockade glacier. The river is later joined by waters from Noaukta Slough, which carry water from the Chakachatna River. The MacArthur River continues to the confluence with the Chakachatna and then empties into Trading Bay.

(iii) Terrestrial Ecology

Vegetation in the project area varies with elevation and moisture conditions. The major community types present include spruce forest, bogs, and willow thickets. Dominant species present include paper birch, black cottonwood, alder, bog blueberry, and willow (Bechtel Civil and Minerals, Inc., 1981).

Big game species utilizing the area include moose, caribou, black bear, and grizzly bear. Other species present include wolverine, mink, and various small mammals (Bechtel Civil and Minerals, Inc., 1981).

Birds present in the area are typical for the area of Alaska, with peak numbers and species occurring during the spring and fall migration periods. Goldeneyes were observed nesting in the area in 1960 with other waterfowl species present during migration, including redheads, greenwinged teal and mallards; bald eagles and trumpeter swans are known to nest in the area primarily near Cook Inlet (Bechtel Civil and Minerals, Inc., 1981).

(iv) Aquatic Ecology

The water of the tributaries to Chakachamna Lake, the lake itself and the Chakachatna and MacArthur Rivers provide a variety of water temperatures, water quality and substrate, resulting in various types of aquatic habitats.

Chakachamna Lake contains populations of lake trout, Dolly Varden, whitefish and sculpins (U.S. Fish and Wildlife Service, 1962). More importantly, sockeye salmon migrate up the Chakachatna River and spawn within Chakachamna Lake. Although the lake is not heavily utilized by sport fishermen, these spawning salmon contribute to the commercial fisheries of Cook Inlet.

The Chakachatna River is utilized by a wider variety of fish species. The upper reaches are characterized by boulders and swift currents and do not appear to be a spawning area. This reach is utilized by the anadramous fish that spawn in Chakachamna Lake (Bechtel Civil and Minerals, Inc., 1981). Sockeye salmon, chum salmon and pink salmon spawn in the river while chinook and coho salmon and Dolly Varden are known to occur.

The MacArthur River supports a fishery similar to that of the Chakachatna (Alaska Power Administration 1980). Dolly Varden are present with chinook, coho, pink, sockeye, and chum salmon present as spawners in the side channels. Pygmy whitefish occur further downstream (Bechtel Civil and Minerals, Inc., 1981).

(v) Cultural Resources

The Alaska Heritage Resource Survey File maintained by the State Historic Preservation Office lists no sites present in the Chakachamna project area. The area has not been thorougly studied and further investigations would be necessary should the project proceed.

(vi) Socioeconomics

The Chakachamna project is located in a sparsely populated area of the Kenai Peninsula Borough. The only community in the vicinity of the project area is the native village of

Tyonek, population 239. Commercial fishing and subsistence activities are the major sources of income with some employment provided by timber harvesting, gas and oil exploration activities and government.

Housing consists primarily of prefabricated structures. One school serves grades K through 12, with a current enrollment of 146. Police protection is provided by the Alaskan State Troopers, headed by a resident constable. Fire protection is provided by the U.S. Bureau of Land Management. Medical services are available in a medical center located in the village. Water is supplied from a nearby lake and wastewater disposed via septic systems.

Transportation is limited to gravel surface roads and small airstrips.

The Kenai Borough and City of Anchorage would likely contribute to the work force for the project. The work force in the Borough is 12,300, with 9.8 percent unemployed; Anchorage has a work force of 91,671, with 6.9 percent unemployment (Bechtel Civil and Minerals, Inc., 1981).

(b) Description of Snow Site

The Snow site is located on the Snow River in the Kenai Peninsula (Figure 10.2). Power development would include a dam with diversion through a tunnel approximately 7,500 to 10,000 feet in length. A transmission line would extend from the site northward for nine miles to Kenai Lake and then northwesterly for 16 miles to tie in with existing lines.

The Snow River at the proposed damsite flows in a deep narrow gorge cut into bedrock on the floor of a glacial valley. Graywacke and slate are exposed and this overburden is evident (U.S. Department of Energy 1980). The river flows west and north into the south end of the Kenai Lake. The average annual streamflow at the damsite is estimated at 510,000 to 535,000 cfs. The damsite would be fed by 105 square miles of the river's 166 square mile drainage area (U.S. Department of Energy 1980; U.S. Army Corps of Engineers).

Vegetation in the area is primarily a hemlock-spruce forest. Black bear, wolf and dall sheep are known to occur in the area, and a moose concentration area is present (Cook Inlet Region 1981). Waterfowl utilize the area both for nesting and molting.

No anadromous fish are known to occur in the Snow River, but sockeye and coho salmon are present in the drainage. Rainbow trout and whitefish also occur in Kenai Lake.

Reports consulted listed no known cultural resource sites in the Snow area.

The Snow site is located in the Railbelt region of Alaska, as discussed in Section 5 of this volume. Socioeconomic conditions relative to the Snow site are also discussed in Section 5.

(c) Description of Keetna Site

The Keetna site is located on the Talkeetna River, approximately 70 miles north of Anchorage (Figure 10.2). Power development would include a dam with a diversion tunnel.

The Talkeetna River, with headwaters in the Talkeetna mountains, flows southwesterly to its confluence with the Susitna River. The damsite has a drainage area of 1,260 square miles; stream flow records indicate discharge at the site to be 1,690,000 acre feet (U.S. Department of Energy 1980).

Vegetation on the lower elevations of the valley are primarily upland spruce-hardwood forest. The upper elevations have little vegetation. Black bear and brown bear are present and the area is a known moose concentration area. A caribou winter range is nearby.

Four species of anadramous fish are present in the area (chinook, sockeye, coho, and chum salmon). The chinook salmon is known to spawn in tributaries upstream of the proposed site.

Reports consulted listed no known cultural resources at the site.

(d) Environmental Impacts of Selected Alternatives

Most environmental impacts at the Chakachamna, Snow and Keetna sites would be those that typically occur with hydroelectric development. Vegetation and wildlife habitat would be lost, resulting in a reduction in carrying capacity and wildlife populations at the site. Based on the availability of habitat in surrounding areas, this would likely not be a major impact. Reductions in fish populations (as discussed below) would reduce the food source for bears, eagles, and other fish-eating wildlife; this could affect local populations. Creation of a reservoir at the Snow and Keetna sites would provide a different habitat type and benefit such species groups as waterfowl and furbearers.

Any archaeological or historic sites in the reservoir areas would be flooded. On-ground surveys, salvage operations and protection of areas outside the reservoir but within the construction area, would mitigate most of these potential impacts.

The Keetna reservoir would inundate two scenic areas; Sentinel Rock and Granite Gorge.

Socioeconomic impacts would be similar at each site. It is expected there would be an increase in population in the towns near the site and associated increase in demand for housing, schools and other services. Because all three sites are located within 100 miles of Anchorage, it is expected much of the labor force would be drawn from this area where an adequate work force is present. Construction camps would likely be erected to house workers, thereby reducing demand on surrounding towns. Socioeconomic impacts for the Chakachamna site would be similar to those described in Section 10.3 for thermal development but of lesser magnitude.

The greatest potential impact of these developments is to the fisheries resources, particularly at the Chakachamna site. Creation of the reservoir at the Keetna and Snow sites would flood river areas, thereby reducing this type of habitat. At the Keetna site, spawning areas may be affected and upstream migration of the anadromous salmon also curtailed, unless fish ladders are constructed and adequate downstream flows maintained. At this time, the detailed studies necessary to determine adequate flows for power generation and fishery maintenance have not been conducted.

Power development at the Chakachamna site has the potential to negatively impact anadromous fish. This impact would result from decreased flowing or dewatering from the upper portions of the Chakachatna River, removal of access to Chakachamna Lake, alterations in water quality, loss of downstream migrating fingerlings, loss of spawning habitat, decrease in the food base. All of these impacts, if large enough, could impact the commercial fisheries of Cook Inlet; the magnitude of these impacts would depend upon the design and operating scheme to produce power.

If a dam was constructed on Chakachatna River, Chakachamna Lake and its tributary streams would be inaccessible to anadromous fish. Unless fish ladders were constructed, this would eliminate the anadromous fish populations in Chakachamna Lake. In addition, losses of downstream migrating fingerlings would occur unless an effective design in the dam's construction could be developed to allow them to pass safely downstream.

If diversion into the MacArthur River via tunnels is used, increased flows could result in changes in water quality and temperature, perhaps affecting the ability of anadromous fish to migrate upstream to the spawning areas. For maximum power production, no water would be released into the upper reaches of the Chakachatna River, thereby eliminating the anadromous fish populations in the lake and lake tributaries. If fishery flows were maintained, this severe impact would not occur, provided fish passage facilities were provided at the lake outlet.

If lake water is diverted into the Chakachatna River, there will be no impact to the MacArthur River ecosystem. Above the powerhouse and below the lake, impacts to the fishery will depend on the level of flows maintained and the installation of fish passage facilities. Again, if maximum flows are utilized for power production, anadromous fish populations in the lake and tributaries would also be lost. If flows were maintained in the Chakachatna River and fish passage facilities were provided, impacts would be substantially reduced.

10.3 - Upper Susitna Basin Hydroelectric Alternatives

A second feature of the alternatives analysis involved the consideration of alternative sites within the Upper Susitna Basin. This process involved consideration of technical, economical, environmental, and social aspects.

This section describes the environmental consideration involved in the selection of Devil Canyon/Watana sites as the preferred sites within the Upper Susitna Basin and also presents a brief comparison of the environmental impacts associated with alternatives that proved economically feasible. This section concentrates on the environmental aspects of the selection process. Details of the technical and economic aspects of this evaluation are discussed in Section 8 of Volume I, and also in Section 8 of the Development Selection Report.

The objectives of the selection process were to determine the optimum Susitna Basin Development Plan and to conduct a preliminary environmental assessment of the alternatives in order to compare those judged economically feasible. The selection process followed the Generic Plan Formulation and Selection Methodology described in Section 1.4 of Volume I. Damsites were identified following the objectives described above. These sites were then screened and assessed through a sequential "narrowing down" process to arrive at a recommended plan (Figure 10.4).

(a) Damsite Selection

In the previous Susitna Basin studies discussed in Section 4 (Volume I), 12 damsites were identified in the upper portion of the basin, i.e., upstream from Gold Creek (see Figure 10.5). These sites are listed below:

- Gold Creek
- Olson (alternative name: Susitna II)
- Devil Canyon
- High Devil Canyon (alternative name: Susitna I)

- Devil Creek
- Watana
- Susitna III
- Vee
- Maclaren
- Denali
- Butte Creek
- Tyone

Longitudinal profiles of the Susitna River and probable typical reservoir levels associated with the selected sites were prepared to depict which sites were mutually exclusive, i.e., those which cannot be developed jointly since the downstream site would inundate the upstream site. All relevant data concerning dam type, capital cost, power, and energy output were asssembled as discussed in Section 8 of Volume 1. Results appear in Table 10.14.

(b) Site Screening

The objective of this screening exercise was to eliminate sites which would obviously not feature in the initial stages of a Susitna Basin development plan and which, therefore, do not require any further study at this stage. Three basic screening criteria are used; these include environmental, alternative sites, and energy contribution.

(i) Environmental Screening Criteria

The potential impact on the environment of a reservoir located at each of the sites was assessed and catagorized as being relatively unacceptable, significant, or moderate.

- Unacceptable Sites

Sites in this category are classified as unacceptable because either their impact on the environment would be extremely severe or there are obviously better alternatives available. Under the current circumstances, it is expected that it would not be possible to obtain the necessary agency approval, permits, and licenses to develop these sites.

The Gold Creek and Olson sites both fall into this category. As salmon are known to migrate up Portage Creek, a development at either of these sites would obstruct this migration and inundate spawning grounds. Available information indicates that salmon do not migrate through Devil Canyon to the river reaches beyond because of the steep fall and high flow velocities.

Development of the mid-reaches of the Tyone River would result in the inundation of sensitive big game and waterfowl areas, provide access to a large expanse of wilderness area, and contribute only a small amount of storage and energy to any Susitna development. Since more acceptable alternatives are obviously available, the Tyone site is also considered unacceptable.

- Sites With Significant Impact

  Between Devil Canyon and the Oshetna River, the Susitna River is confined to a relatively steep river valley. Upstream from the Oshetna River the surrounding topography flattens, and any development in this area has the potential of flooding large areas even for relatively low dams. Since the Denali Highway is relatively close by, this area is not as isolated as the Upper Tyone River Basin. It is still very sensitive in terms of potential impact on big game and waterfowl. The sites at Butte Creek, Denali, Maclaren, and, to a lesser extent, Vee fit into this category.

- Sites With Moderate Impact

  Sites between Devil Canyon and the Oshetna River have a lower potential environmental impact. These sites include the Devil Canyon, High Devil Canyon, Devil Creek, Watana and Susitna sites, and, to a lesser extent, the Vee site.

(ii) Alternative Sites

Sites which are close to each other and can be regarded as alternative dam locations can be treated as one site for project definition study purposes. The two sites which fall into this category are Devil Creek, which can be regarded as an alternative to the High Devil Canyon site, and Butte Creek, which is an alternative to the Denali site.

(iii) Energy Contribution

The total Susitna Basin potential has been assessed at 6,700 GWh. As discussed in Section 5, Volume I, additional future energy requirements for the period 1982 to 2010 are forecast to range from 2,400 to 13,500 GWh. It was therefore decided to limit the minimum size of any power development in the Susitna Basin to an average annual energy production in the range of 500 to 1,000 GWh. The upstream sites such as Maclaren, Denali, Butte Creek, and Tyone do not meet this minimum energy generation criterion.

(iv) Screening Process

The screening process involved eliminating all sites falling in the unacceptable environmental impact and alternative site categories. Those failing to meet the energy contribution criteria were also eliminated unless they had some potential for upstream regulation. The results of this process are as follows:

- The unacceptable site environmental category eliminated the Gold Creek, Olson, and Tyone sites.

- The alternative sites category eliminated the Devil Creek and Butte Creek sites.

- No additional sites were eliminated for failing to meet the energy contribution criteria. The remaining sites upstream from Vee, i.e., Maclaren and Denali, were retained to insure that further study be directed toward determining the need and viability of providing flow regulation in the headwaters of the Susitna.

(c) Formulation of Susitna Basin Development Plans

In order to obtain a more uniform and reliable data base for studying the seven sites remaining, it was necessary to develop engineering layouts for these sites and re-evaluate the costs. In addition, it was also necessary to study staged developments at several of the larger dams. The results of these are described in Sections 8, 10, and 11 of Volume I. These layouts were then used to assess the sites and plans from an environmental perspective.

The results of the site-screening exercise described in Section (10.3(a)) above indicate that the Susitna Basin Development Plan should incorporate a combination of several major dams and powerhouses located at one or more of the following sites:

- Devil Canyon,
- High Devil Canyon,
- Watana,
- Susitna III,
- Vee.

In addition, the following two sites should be considered as candidates for supplementary upstream flow regulation:

- MacLaren,
- Denali.

To establish very quickly the likely optimum combination of dams, a computer screening model was used to directly identify the types of plans that are most economic. Results of these runs indicate that the Devil Canyon/Watana or the High Devil Canyon/Vee combinations are the most economic. In addition to these two basic development plans, a tunnel scheme, which provides potential environmental advantages by replacing the Devil Canyon dam with a long power tunnel, and a development plan involving the two most economic damsites, High Devil Canyon and Watana, were also introduced. These studies are described in more detail in Section 8 of Volume 1 and in Table 10.15.

These studies resulted in three basic plans involving dam combinations and one dam/tunnel combination. There were Plan 1 which involved the Watana-Devil Canyon sites; Plan 2, the High Devil Canyon-Vee sites; Plan 3, the Watana-tunnel concept; and Plan 4, Watana-High Devil Canyon sites.

(i) Plan 1

Three subplans were developed:

- Subplan 1.1: Stage 1 involves constructing Watana Dam to its full height and installing 800 MW. Stage 2 involves constructing Devil Canyon Dam and installing 600 MW.

- Subplan 1.2: For this subplan, construction of the Watana dam is staged from a crest elevation of 2,060 feet to 2,225 feet. The powerhouse is also staged from 400 MW to 800 MW. As for Subplan 1.1, the final stage involves Devil Canyon with an installed capacity of 600 MW.

- Subplan 1.3: This subplan is similar to Subplan 1.2 except that only the powerhouse and not the dam at Watana is staged.

(ii) Plan 2

Three subplans were also developed under Plan 2:

- Subplan 2.1: This subplan involves constructing the High Devil Canyon Dam first with an installed capacity of 800 MW. The second stage involves constructing the Vee Dam with an installed capacity of 400 MW.

- Subplan 2.2: For this subplan, the construction of High Devil Canyon Dam is staged from a crest elevation of 1,630 to 1,775 feet. The installed capacity is also staged from 400 to 800 MW. As for Subplan 2.1, Vee follows with 400 MW of installed capacity.

- Subplan 2.3: This subplan is similar to Subplan 2.2 except that only the powerhouse and not the dam at High Devil Canyon is staged.

(iii) Plan 3

This plan involves a long power tunnel to replace the Devil Canyon dam in the Watana/Devil Canyon development plan. The tunnel alternative could develop similar head as the Devil Canyon dam development and would avoid some environmental impacts by avoiding inundating Devil Canyon. Because of low winter flows in the river, a tunnel alternative was considered only as a second stage to the Watana development.

Following studies described in Section 8 of Volume I, a plan involving a tunnel to develop the Devil Canyon dam head and a 245-foot-high re-regulation dam and reservoir was selected with the capacity to regulate diurnal fluctuations caused by the peaking operation at Watana. The plan involves two subplans.

- Subplan 3.1: This subplan involves initial construction of Watana and installation of 800 MW of capacity. The next stage involves the construction of the downstream re-regulation dam to a crest elevation of 1,500 feet and a 15-mile-long tunnel. A total of 300 MW would be installed at the end of the tunnel and a further 30 MW at the re-regulation dam. An additional 50 MW of capacity would be installed at the Watana powerhouse to facilitate peaking operations.

- Subplan 3.2: This subplan is essentially the same as Subplan 3.1 except that construction of the initial 800 MW powerhouse at Watana is staged.

(iv) Plan 4

This single plan was developed to evaluate the development of the two most economic damsites, Watana and High Devil Canyon, jointly. Stage 1 involves constructing Watana to its full height with an installed capacity of 400 MW. Stage 2 involves increasing the capacity at Watana to 800 MW. Stage 3 involves constructing High Devil Canyon to a crest elevation of 1470 so that the reservoir extends to just downstream from Watana. In order to develop the full head between Watana and Portage Creek, an additional smaller dam would be added downstream from High Devil Canyon. This dam would be located just upstream from Portage Creek so as not to interfere with the anadromous fisheries, and it would have a crest elevation of 1030 and an installed capacity of 150 MW. For purposes of these studies, this site is referred to as the Portage Creek site.

(d) Plan Evaluation Process

The overall objective of this step in the evaluation process was to select the preferred basin development plan. A preliminary evaluation of plans was initially undertaken to determine broad comparisons of the available alternatives. This was followed by appropriate adjustments to the plans and a more detailed evaluation and comparison.

Table 10.14 lists pertinent details such as capital costs and energy yields associated with the selected plans. The cost information was obtained from the engineering layout studies described in Sections 9 and 10. The energy yield information was developed using a multi-reservoir computer model.

A more detailed description of the model appears in Section 8 of Volume I.

In the process of evaluating the schemes, it became apparent that there would be environmental problems associated with allowing daily peaking operations from the most downstream reservoir in each of the plans described above. In order to avoid these potential problems while still maintaining operational flexibility to peak on a daily basis, re-regulation facilities were incorporated in the four basic plans. These facilities incorporate both structural measures, such as re-regulation dams, and modified operational procedures under a series of form modified plans, E1 through E4.

(i) E1 Plans

For Subplans 1.1 to 1.3, a low, temporary re-regulation dam is constructed downstream from Watana during the stage in which the generating capacity is increased to 800 MW. This dam would re-regulate the outflows from Watana and allow daily peaking operations. It has been assumed that it would be possible to incorporate this dam with the diversion works at the Devil Canyon site, and an allowance of $100 million has been made to cover any additional costs associated with this approach.

In the final stage, only 400 MW of capacity is added to the dam at Devil Canyon instead of the original 600 MW. Reservoir operating rules are changed so that Devil Canyon dam acts as the re-regulation dam for Watana.

(ii) E2 Plans

For Subplans 2.1 to 2.3, a permanent re-regulation dam is located downstream from the High Devil Canyon site, while at the same time, the generating capacity is increased to 800 MW. An allowance of $140 million has been made to cover the costs of such a dam.

An additional Subplan E2.4 was established. This plan is similar to E2.3 except that the re-regulation dam is utilized for power production. The damsite is located at the Portage Creek site with a crest level set to utilize the full head. A 150 MW powerhouse is installed. As this dam is to serve as a re-regulating facility, it is constructed at the same time as the capacity of High Devil Canyon is increased to 800 MW, i.e., during Stage 2.

(iii) E3 Plan

The Watana tunnel development plan already incorporates an adequate degree of re-regulation, and the E3.1 Plan is, therefore, identical to the 3.1 Plan.

(iv) E4 Plans

The E4.1 Plan incorporates a re-regulation dam downstream from Watana during Stage 2. As for the E1 Plans, it has been assumed that it would be possible to incorporate this dam as part of the diversion arrangements at the High Devil Canyon site, and an allowance of $100 million has been made to cover the costs. The energy and cost information for these plans is presented in Section 8.

These evaluations basically reinforce the results of the screening model; for a total energy production capability of up to approximately 4,000 GWh, Plan E2 (High Devil Canyon) provides the most economic energy while for capabilities in the range of 6,000 GWh, Plan E1 (Watana-Devil Canyon) is the most economic.

(e) Comparison of Plans

The evaluation and comparison of the various basin development plans described above, was undertaken in a series of steps.

In the first step, for determining the optimum staging concept associated with each basic plan (i.e., the optimum subplan) economic criteria only are used and the least-cost staging concept is adopted. For assessing which plan is the most appropriate, a more detailed evaluation process incorporating economic, environmental, social, and energy contribution aspects is taken into account.

Economic evaluation of the Susitna Basin development plans was conducted via a computer simulation planning model (OGP5) of the entire generating system. This model and the results are described in Section 8 of Volume I.

As outlined in the generic methodology (Section 1.4 and Appendix A), the final evaluation of the development plans is to be undertaken by a perceived comparison process on the basis of appropriate criteria. The following criteria are used to evaluate the shortlisted basin development plans. They generally contain the requirements of the generic process with the exception that an additional criterion, energy contribution, is added. The objective of including this criterion is to insure that full consideration is given to the total basin energy potential that is developed by the various plans.

(i) Economic Criteria

The parameter used is the total present-worth cost of the total Railbelt generating system for the period 1980 to 2040 listed and discussed in Section 8.

(ii) Environmental Criteria

A qualitative assessment of the environmental impact on the ecological, cultural, and aesthetic resources is undertaken for each plan. Emphasis is placed on identifying major concerns so that these could be combined with the other evaluation attributes in an overall assessment of the plan.

(iii) Social Criteria

This attribute includes determination of the potential non-renewable resource displacement, the impact on the state and local economy, and the risks and consequences of major structural failures caused by seismic events. Impacts on the economy refer to the effects of an investment plan on economic variables.

(iv) Energy Contribution

The parameter used is the total amount of energy produced from the specific development plan. An assessment of the energy development foregone is also undertaken. This energy loss is inherent to the plan and cannot easily be recovered by subsequent staged developments.

Economic and technical comparisons are discussed in Section 8 of Volume I; environmental, social, and summary comparisons appear in Tables 10.15 through 10.18.

(f) Results of Evaluation Process

The various attributes outlined above have been determined for each plan. Some of the attributes are quantitative while others are qualitative. Overall evaluation is based on a comparison of similar types of attributes for each plan. In cases where the attributes associated with one plan all indicate equality or superiority with respect to another plan, the decision as to the best plan is clear cut. In other cases where some attributes indicate superiority and others inferiority, these differences are highlighted and trade-off decisions are made to determine the preferred development plan. In cases where these trade-offs have had to be made, they are relatively convincing and the decision-making process can, therefore, be regarded as fairly robust. In addition, these trade-offs are clearly identified so the reader can independently address the judgment decisions made.

The overall evaluation process is conducted in a series of steps. At each step, only a pair of plans is evaluated. The superior plan is then passed on to the next step for evaluation against an alternative plan.

(g) Devil Canyon Dam Versus Tunnel

The first step in the process involves the evaluation of the Watana-Devil Canyon dam plan (E1.3) and the Watana tunnel plan (E3.1). As Watana is common to both plans, the evaluation is based on a comparison of the Devil Canyon dam and tunnel schemes.

In order to assist in the evaluation in terms of economic criteria, additional information was obtained by analyzing the results of the OGP5 computer runs. This information, presented in Section 8, illustrates the breakdown of the total system present-worth cost in terms of capital investment, fuel, and operation and maintenance costs.

(i) Economic Comparison

From an economic point of view, the Devil Canyon dam scheme is superior. On a present worth basis, the tunnel scheme is $680 million or about 12 percent more expensive than the dam scheme. For a low-demand growth rate, this cost difference would be reduced slightly to $610 million. Even if the tunnel scheme costs are halved, the total cost difference would still amount to $380 million. Consideration of the sensitivity of the basic economic evaluation to potential changes in capital cost estimate, the period of economic analysis, the discount rate, fuel costs, fuel cost escalation, and economic plant lives do not change the basic economic superiority of the dam scheme over the tunnel scheme.

(ii) Environmental Comparison

The environmental comparison of the two schemes is summarized in Table 10.16. Overall, the tunnel scheme is judged to be superior because:

- It offers the potential for enhancing anadromous fish populations downstream from the re-regulation dam because of the more uniform flow distribution that will be achieved in this reach;

- It inundates 13 miles less of resident fisheries habitat in river and major tributaries;

- It has a lower impact on wildlife habitat because of the smaller inundation of habitat by the re-regulation dam;

- It has a lower potential for inundating archaeological sites because of the smaller reservoir involved;

- It would preserve much of the characteristics of the Devil Canyon gorge, which is considered to be an aesthetic and recreational resource.

(iii) Social Comparison

Table 10.17 summarizes the evaluation in terms of the social criteria of the two schemes. In terms of impact on state and local economics and risks resulting from seismic exposure, the two schemes are rated equally. However, the dam scheme has, because of its higher energy yield, more potential for displacing nonrenewable energy resources, and, therefore, scores a slight overall plus in terms of the social evaluation criteria.

(iv) Energy Comparison

The results show that the dam scheme has a greater potential for energy production and develops a larger portion of the basin's potential. The dam scheme is, therefore, judged to be superior from the energy contribution standpoint.

(v) Overall Comparison

The overall evaluation of the two schemes is summarized in Table 10.18. The estimated cost saving of $680 million in favor of the dam scheme is considered to outweigh the reduction in the overall environmental impact of the tunnel scheme. The dam scheme is, therefore, judged to be superior overall.

(h) Watana-Devil Canyon Versus High Devil Canyon-Vee

The second step in the development selection process involves an evaluation of the Watana-Devil Canyon (E1.3) and the High Devil Canyon-Vee (E2.3) development plans.

(i) Economic Comparison

In terms of the economic criteria, the Watana-Devil Canyon plan is less costly by $520 million. As for the dam-tunnel evaluation discussed above, the sensitivity of this decision to potential changes in the various parameters considered (i.e., load forecast, discount rates, etc.) does not change the basic superiority of the Watana-Devil Canyon Plan.

(ii) Environmental Comparison

The evaluation in terms of the environmental criteria is summarized in Table 10.19. In assessing these plans, a reach-by-reach comparison is made for the section of the Susitna River between Portage Creek and the Tyone River. The Watana-Devil Canyon scheme would create more potential environmental impacts in the Watana Creek area. However, it is judged that the potential environmental impacts which would occur in the upper reaches of the river with a High Devil Canyon-Vee development are more severe in comparison overall.

From a fisheries perspective, both schemes would have a similar effect on the downstream anadromous fisheries, although the High Devil Canyon-Vee scheme would produce a slightly greater impact on the resident fisheries in the Upper Susitna Basin.

The High Devil Canyon-Vee scheme would inundate approximately 14 percent (15 miles) more critical, winter, river-bottom moose habitat than the Watana-Devil Canyon scheme. The High Devil Canyon-Vee scheme would inundate a large area upstream from the Vee site utilized by three subpopulation of moose that range in the northeast section of the basin. The Watana-Devil Canyon scheme would avoid the potential impacts on moose in the upper section of the river; however, a larger percentage of the Watana Creek basin would inundated.

The condition of the subpopulation of moose utilizing this Watana Creek Basin and the quality of the habitat appears to be decreasing. Habitat manipulation measures could be implemented in this area to improve the moose habitat.

Nevertheless, it is considered that the upstream moose habitat losses associated with the High Devil Canyon-Vee scheme would probably be greater than the Watana Creek losses associated with the Watana-Devil Canyon scheme.

A major factor to be considered in comparing the two development plans is the potential effects on caribou in the region. It is judged that the increased length of river flooded, especially upstream from the Vee damsite, would result in the High Devil Canyon-Vee plan creating a greater potential diversion of the Nelchina herd's range. In addition, a larger area of caribou range would be directly inundated by the Vee reservoir.

The area flooded by the Vee reservoir is also considered important to some key furbearers, particularly red fox. In a comparison of this area with the Watana Creek area that would be inundated with the Watana-Devil Canyon scheme, the area upstream from Vee is judged to be more important for furbearers.

As previously mentioned, the area between Devil Canyon and the Oshetna River on the Susitna River is confined to a relatively steep river valley. Along these valley slopes are habitats important to birds and black bears. Since the Watana reservoir would flood the river section between the Watana damsite and the Oshetna River to a higher elevation than would the High Devil Canyon reservoir (2200 as compared to 1750), the High Devil Canyon-Vee plan would retain the integrity of more of this river valley slope habitat.

From the archaeological studies done to date, there tends to be an increase in site intensity as one progresses towards the northeast section of the Upper Susitna Basin. The High Devil Canyon-Vee plan would result in more extensive inundation and increased access to the northeasterly section of the basin. This plan is judged to have a greater potential for directly or indirectly affecting archaeological sites.

Because of the wilderness nature of the Upper Susitna Basin, the creation of increased access associated with project development could have a significant influence on future uses and management of the area. The High Devil Canyon-Vee plan would involve the construction of a dam at the Vee site and the creation of a reservoir in the more northeasterly section of the basin. This plan would thus create inherent access to more wilderness than would the Watana-Devil Canyon scheme. As it is easier to extend access than to limit it, inherent access requirements are detrimental, and the Watana-Devil Canyon scheme is judged to be more acceptable in this regard.

Except for the increased loss of river valley, bird, and black bear habitat, the Watana-Devil Canyon development plan is judged to be more environmentally acceptable than the High Devil Canyon-Vee plan. Although the Watana-Devil Canyon plan is considered to be the more environmentally compatible Upper Susitna development plan, the actual degree of acceptability is a question being addressed as part of ongoing studies.

(iii) Energy Comparison

The evaluation of the two plans in terms of energy contribution criteria shows the Watana-Devil Canyon scheme to be superior because of its higher energy potential and the fact that it develops a higher proportion of the basin's potential.

Table 10.17 summarizes the evaluation in terms of the social criteria. As in the case of the dam versus tunnel comparison, the Watana-Devil Canyon plan is judged to have a slight advantage over the High Devil Canyon-Vee plan because of its greater potential for displacing nonrenewable resources.

(iv) Overall Comparison

The overall evaluation is summarized in Table 10.20 and indicates that the Watana-Devil Canyon plans are generally superior to all the other evaluation criteria.

(i) Preferred Susitna Basin Development Plan

Comparisons of the Watana-Devil Canyon plan with the Watana tunnel plan and the High Devil Canyon-Vee plans are judged to favor the Watana-Devil Canyon plan in each case.

The Watana-Devil Canyon plan is therefore selected as the preferred Susitna Basin development plan, as a basis for continuation of more detailed design optimization and environmental studies.

10.4 - Coal-Fired Generation Alternative

Previous studies have indicated that alternative generating resources available to supply power to the Railbelt region include use of the Beluga coal fields. The economic and technical feasibility of developing this resource and of the selection process utilized to conclude the economic feasibility of Beluga coal, is discussed in Section 6 of Volume I.

Information presented in this section was extracted from previous reports prepared in conjunction with studies of developing the Beluga coal fields (Commerce and Economic Development 1980; Cook Inlet Region 1981). Because specifics of plant design and location are not available, the existing environment is described for the general area and impacts are discussed in generic terms only.

For purposes of this evaluation, an electrical generating plant with total capacity of 400 MW was assumed. Coal would be strip-mined from the Beluga fields, transported to the plants, and burned to produce electricity. Treatment of waste streams, including air, water, and solid waste, would occur at the site. Approximately 1.5 million tons of coal per year would be burned. A construction camp would be built near the site, and a permanent village maintained for mining personnel and plant operators.

(a) Existing Environmental Condition

The Beluga coal fields are located approximately 50 to 60 miles southwest of Anchorage on the western side of Cook Inlet. The coal fields are bordered by Cook Inlet on the east and south, the Chakachatna River on the west, and the Beluga River, Beluga Lake, and Capps Glacier on the north (Commerce and Economic Development 1980).

(i) Air Quality

Air quality in the Cook Inlet and Beluga coal field area can be described as good. The Cook Inlet Air Quality Control Region is designated as a Class II Attainment area for all criteria pollutants. The Tuxedni National Wildlife Refuge approximately 80 miles southwest of the project area is Class I Attainment area for all criteria pollutants.

(ii) Topography, Geology, and Soils

The topography of the western shore of Cook Inlet is dominated by high glaciated mountains dropping rapidly to a glacial moraine/outwash plateau which slopes gently to the sea. The outwash/moraine deposits begin at an elevation of approximately 2500 and drop to tidewater in 30 to 50 miles (Cook Inlet Region 1981).

The major geologic feature of the area is the Nikolai moraine which lies in contact with sedimentary Tertiary rocks (Commerce and Economic Development 1980). Most coals occur in the Tyonek Formation of the Tertiary Kenai Group (Battelle Northwest 1978). The area is geologically young with higher upland elevations consisting of slightly to moderately modified glacial moraines and associated drifts.

The lowland areas are mantled with glacial deposits and overlaid by silt loam.

Soils are variable in the area. Generally, soils in the southern portion of the area are sandy but poorly drained, and soils in the west are well drained and dark, formed in fine volcanic ash and loam. Soils in the east and northern areas range from poorly drained fibrous peat to well-drained loamy soils of acidic nature.

(iii) Surface Hydrology

The three major river systems in the Beluga coal field area are the Chakachatna, Beluga, and Chuitna. The Chakachatna is the largest, with headwaters in Chakachamna Lake and a 1,620-square-mile drainage area, and a length of 36 miles. The Chuitna River begins near Capps Glacier, flows 27 miles, and drains approximately 150 square miles. The Beluga River is 35 miles in length and drains 930 square miles (Commerce and Economic Development 1980).

(iv) Terrestrial Ecosystem

- Flora

Four major vegetative communities in the region are the upland spruce-hardwood forest, high brush, wet tundra, and alpine tundra.

The upland spruce-hardwood forest is centered in the southern and central portions of the Beluga area and covers 40 percent of the area (Commerce and Economic Development 1980). This forest is composed of paper birch, quaking aspen, black cottonwood, and balsam poplar (Cook Inlet Region 1981a).

The high brush community in the west central portion of the Beluga district covers 15 percent of the land area. This type occupies a wide variety of soil types and may occur as pure thickets in low-lying areas. Principal species include sitka sider, raspberry dogwood, and spirea (Commerce and Economic Development 1980; Cook Inlet Region 1981a).

The wet tundra plant community occupies 7 percent of the area in the extreme southwest portion and along the eastern boundary. The vegetative mat is dominated by sedges and cottongrass, with scattered woody and herbaceous plants. Principal species include willow, birch, labrador tea, grasses, and lichens.

The alpine tundra area occupies less than 3 percent of the land area and occurs only at the higher elevations. This community comprises primarily low mat plants, both woody and herbaceous. Principal species include birches, willows, blueberry, rhododendron, and sedges.

- Fauna

The area of the Beluga coal fields supports wildlife population typical for this area of Alaska. Big game in the areas include moose, black bear, and brown bear. Both species of bear den in the area and utilize the Selvon fishery as a food source (Cook Inlet Region 1981a). A major fall and winter concentration of moose occurs in the high brush community in the west central portion of the coal fields near the Chuitna River. They are also found throughout the area during other times of the year (Commerce and Economic Development 1980).

A high diversity of bird life is present in the area, particularly during the fall and spring migration periods. Active nesting sites of bald eagles and trumpeter swans occur on the Chuitna River and peregrine falcons occur in the area (Cook Inlet Region 1981a). The coastal areas are heavily utilized by waterfowl (Commerce and Development 1980). Harbor seals, Beluga whales, and other species of marine mammals occupy Cook Inlet near the study area.

(v) Aquatic Ecosystem

The cold, running waters of river and streams in the area support both resident and anadramous fisheries. The Chuitna River supports five species of salmon (pink, king, chum, coho, and sockeye) plus rainbow trout, Dolly Varden and round white fish (Commerce and Development 1980). Nikolai Creek, Jo's Creek, Pitt Creek, and Stedatana Creek are also known to support anadramous fish populations.

(vi) Marine Ecosystem

The Cook Inlet region just south of the Beluga coal fields is a diverse area, with both aquatic and terrestrial habitats. Intertidal and shallow subtidal habitats contain broad expanses of gravel and sand and extensive areas of mud flats. These areas show varying levels of productivity, with the mud flat areas generally at low levels (Cook Inlet Region 1981a). Dominant fauna present include pelecypods and polychaete worms. The area of gravel and sand support moderate densities of amphipods and isopods.

The Cook Inlet area is also important to commercial and sport fisheries. Four species of salmon and halibut utilize this area and are harvested on a commercial basis, as are herring, shrimp, and crabs. Commercial salmon harvested in 1980 was estimated at 20.4 million pounds with a value of $18 million. The average annual herring catch is 6.4 million pounds, worth approximately $1.3 million. The smaller halibut fisheries yield approximately 0.6 million pounds, worth $400,000, while the shellfish harvest of crab and shrimp yields 16 million pounds annually, worth $8.5 million (Cook Inlet Region 1981a).

Subsistence fishing is also conducted by local natives, particularly by those from the Tyonek area. Species harvested include clams, bottomfish, salmon, and smelt.

The diverse wetland and aquatic habitats support large numbers of birds, particularly during the migration periods. The coastal wetlands and mud flats are heavily utilized by waterfowl, cranes, and shorebirds, while the offshore waters and sea cliffs are inhabited by sea birds such as gulls, puffins, and murres.

Marine mammals present in the Cook Inlet area include seals, whales, and dolphins. Only the harbor seal and Beluga whale are known to occur in the upper Cook Inlet.

(vii) Cultural Resources

Historic sites occur within the modern town of Tyonek. Other sites nearby include Californsky's fish camp, old village sites, and cemeteries. Few archaeological sites are believed to be in the area, primarily because the violent actions of the tide would have destroyed most of the sites left by coastal-dwelling natives.

(viii) Socioeconomic Conditions

The only substantial settlement on the west coast of Cook Inlet is Tyonek, inhabited by approximately 270 Tanaina Indians. The village is typical of many small villages in Alaska, with high unemployment. Recently, government programs have somewhat alleviated this problem.

Employment on the west side of Cook Inlet is supplied by three commercial developments: the Chugach generating station, Kodiak lumber mill, and crude oil processing and transportation facilities. Commercial fishing and subsistence activities are the major sources of income.

Housing consists primarily of prefabricated structures. One school, with total enrollment of 140, serves kindergarten through the 12th grade. Police protection is provided by the Alaska State Troopers utilizing a resident constable. Fire protection is provided by the U.S. Bureau of Land Management. Medical services are available in a medical center located in the village. Water is supplied from a nearby lake and wastewater disposed of via septic systems (Commerce and Economic Development 1980; Cook Inlet Region 1981a).

Transportation facilities in the areas are limited to gravel logging roads and small airstrips.

(b) Environmental Impacts

(i) Air Quality

Coal mining and power generation will result in emissions to the atmosphere of particulate matter, nitrogen oxide, sulfur oxide, carbon monoxide, and hydrocarbons, as well as lesser amounts of other pollutants. Their impacts cannot be quantified without detailed air monitoring and modeling; however, some generalizations can be made.

Mining emissions would comprise primarily particulate matter from vehicular traffic, surface disturbance, and wind across coal piles and disturbed areas. Heavy equipment operations would also result in nitrogen oxide, carbon monoxide, hydrocarbon, and sulfur oxide emissions.

Beluga coal is characterized as sub-bituminous (6,500 - 7,500 Btu/lb) with low sulfer (0.2 percent), high moisture (25 to 28 percent) and high ash content (14 to 25 percent) (Cook Inlet Region 1981a). This sulfur and heat content is comparable to that of Powder River Basin coal in Wyoming, but the moisture content is approximately twice the Powder River value. Utilizing these figures and calculations from previous reports yields approximate daily emission rates for a 700 MW facility (U.S. Fish and Wildlife Service 1978).

SO_2	40 to 60 tons per day (no scrubber)
Fly ash	3 to 5 tons per day (with precipitators)

Exact amounts of these pollutants and of nitrogen oxides cannot be calculated without specific design criteria and details on pollution-control devices.

A Prevention of Significant Deterioration (PSD) review would be necessary prior to construction. This process would require that any emissions be within the allowable increments established in the Clear Air Act regulations. However, because the area is currently relatively free of air pollution, the emissions from coal mining and generating station operation would likely result in a noticeable degradation of existing air quality. In addition, short-term maximum concentrations could, under certain meteorological conditions, exceed the National Ambient Air Quality standards near the power plant (Battelle Northwest 1978). This would would be particularly true during periods of diversion.

(ii) <u>Topography, Geology, and Soils</u>

Coal mining and construction of the generating facilities have the potential to impact topography and soils in the area. Mining operations would unavoidably change the topography of the area, although reclamation and compliance with regulations of the Surface Mining Control and Reclamation Act would minimize these impacts. Soil erosion from mining and plant construction activities could also occur if proper precautions are not implemented.

(iii) <u>Hydrology</u>

Little is known about ground water resources in the area (Cook Inlet Region 1981a). Strip mining has the potential to degrade the water quality and interferes with ground water flows. Regulations of the Surface Mining Control and Reclamation Act and the state of Alaska would require these impacts be minimized.

Surface water could be affected from runoff from the mined area, coal storage piles, site grading, road building, and other construction activities. Plant operation would also result in polluted and heated water from electrical generation. Potential sources of contamination are acid mine drainage, treatment chemicals, dust, spoil-pile runoff, fuel spillage, ash, and industrial waste. This could impact surface water quality through changes in turbidity, rates of photosynthesis, dissolved oxygen, temperature, pH, and heavy metals.

It can be expected all point sources of discharge will meet Federal New Source Performance standards and other regulations of the Federal Water Pollution Control Act. However, because of the high water quality of the river and streams in the area, any impacts will be noticeable. In addition, because of the seasonal fluctuation of flows in the area, the impacts of sedimentation and other water quality effects may be increased (Battelle Northwest 1978).

(iv) Terrestrial Ecosystems

Surface mining will unavoidably result in the removal of vegetation and wildlife habitat. If not properly restored and revegetated, erosion would result and the habitat permanently reduced in value. The areas of the generating facility, roads, and ancillary facilities would be permanently removed as wildlife habitat.

In addition to the direct impacts to wildlife, secondary effects would also occur. These include increased hunting pressure on moose and bear because of a larger human population and greater activity. New roads will add access to the area, resulting in habitat disruption and disturbance to the animals. This reduction in habitat and other secondary effects will result in a substantial loss in carrying capacity for most wildlife species and a subsequent decline in their population levels.

(v) Aquatic and Marine Ecosystems

The impacts to aquatic and marine ecosystems would depend primarily upon the effectiveness of siltation control devices and degree of water treatment. Some aquatic habitat would be lost because of mining activities. In addition, increase sedimentation, interuption or reduction in flows, and degradation of water quality could all result in negative impacts to aquatic habitats, thereby reducing fish population in the area. The potential also exists for changes in water quality to interfere with anadromous fish runs and reproduction, thereby affecting marine resources in Cook Inlet. Impacts to other marine resources, unless water quality is severely impaired, are not expected to occur.

(vi) Cultural Resources

Potential impacts to cultural resources include disturbance of sites, destruction of artifacts, and increased access to the areas resulting in disturbances to sites previously inaccessible. A cultural resource survey would be required on all areas to be mined or built upon. If significant sites are discovered, mitigation will likely occur, utilizing either avoidance or salvage operations.

Thus, with the exception of the disturbance of areas outside the project site but not currently accessible, impacts to cultural resources should be mitigatable.

(vii) Socioeconomic Conditions

There are many impacts which affect socioeconomic factors in an area. These include construction camp location (if any), commuter modes, family relocation, worker need for services, amount of local labor available, and construction schedules. Thus, only generalized impacts can be predicted.

Depending upon the size of the generation facility, direct and indirect jobs will range from 400 to 1,300 (Commerce and Economic Development 1980; Cook Inlet Region 1981a). Most of these workers would likely come from the available work force in Anchorage, with some from the Kenai Peninsula and the local village of Tyonek.

If a construction camp or new village were created near the plant site, local population would increase by several thousand. This would require construction of new roads, sewage and water systems, and other infrastructures necessary to support these workers and their families. Some of these services would be supplied by the Kenai Peninsula Borough, but most would likely be supplied either by the state of Alaska or the company building and operating the generating facility. Thus, financial impacts to the borough should be small (Cook Inlet Region 1981a). However, because the Beluga coal fields are only 75 miles from Anchorage, it is not likely a large, permanent village would be required, since most workers would prefer to live in the construction camp and leave their families in the Anchorage area.

The generating facility could add substantially to tax revenues in the Kenai-Soldotna area. This revenue would likely expand government services in the area and thereby create additional employment opportunities.

Finally, there would likely be impacts to the village of Tyonek. The large generation facility would result in increased contact with non-native people and their way of life. There could also be conflicts with subsistence hunting and fishing activities and a potential, through sport hunting, to reduce the resource bases utilized by the natives. These increased contacts with non-natives could result in the continued erosion of native customs and cultural values.

Employment opportunities would be available for Tyonek village residents. In addition, native business could likely increase to supply goods or services to the construction workers and construction site. Thus, the project would result in positive economic benefits to the village.

In summary, socioeconomic impacts to the area of plant development would not be great, primarily because of the proximity of the site to the greater Anchorage area. This area would supply most of the labor force and absorb most of the impacts from development of goods and services to supply the site. Population levels at the site would increase, with the magnitude dependent on the nature of the construction camp; however, it is likely there would not be more relocation of families to the site. Positive economic benefits would occur to the native village of Tyonek, but potential negative impacts to the cultural values also exist.

10.5 - Tidal Power Alternatives

The Cook Inlet area has long been recognized as having some of the highest tidal ranges in the world, with mean tide ranges of more than 30 feet at Sunrise on Turnagain Arm, 26 feet at Anchorage, and decreasing towards the lower reaches of Cook Inlet to 15 feet or so near Seldovia. Information concerning feasibility of tidal power generation and environmental impacts were gathered mainly from current studies being conducted for the Office of the Governor, State of Alaska (Acres American Incorporated 1981a). Initial studies of Cook Inlet tidal power development (Acres American Incorporated 1981b) have concluded that generation from tide fluctuation is technically feasible, and numerous conceptual schemes ranging in estimated capacity of 50 MW to 25,900 MW have been developed.

(a) Preferred Tidal Schemes

Studies conducted for the Governor's office (Acres American Incorporated 1981a) have indicated three sites are best suited for tidal power development. This analysis, based on capacity, energy generation and costs, considered sixteen sites and chose the following (Figure 10.6):

(i) Rainbow - This site crossed Turnagain Arm from a point near the mouth of Rainbow Creek to a point approximately two miles east of Resurrection Creek.

(ii) Point MacKenzie/Point Woronzof - This site crosses Knik Arm near Anchorage.

(iii) Eagle Bay/Goose Bay - This site crosses Knik Arm at the narrowing of the channel along Eagle and Goose bays.

Tidal power generation basically involves impounding water at high tide level and converting the head difference between the corresponding basin and the ebbing tide. Present technology allows for extension of this energy by low-head hydraulic turbines to generate electricity. A tidal power generation project, therefore, would involve construction of dams, sluice ways, powerhouses, and transmission lines (Acres American Incorporated 1981a).

(b) Environmental Considerations

Environmental assessments of the preferred Cook Inlet tidal development involve consideration of physical and biological characteristics anticipated impacts, and short- and long-term effects.

(i) Physical Characteristics

Several major characteristics of Cook Inlet are relevant to an understanding of the processes and the potential for change in the estuarine environment. These are the tidal regime, hydrology, sediment load, and climate.

The mean tide range in Knik and Turnagain Arms is 25 to 30 feet. This extreme tidal variation, combined with shallow water depths, results in a high velocity current, turbulence, and high levels of suspended sediments. Thus, suspended sediment load is also affected by the high concentration of silts and sediments present in glacial runoff that enters Cook Inlet.

Runoff from glaciers also affects the salinity concentration in Cook Inlet. In the summer months, when freshwater flows are high, salt concentrations drop and suspended load increases. In the winter, as streamflows diminish, salinity concentration increases.

(ii) Biological Characteristics

Cook Inlet is an estuary where freshwater and saltwater environments meet. These areas are usually highly productive partly because of high nutrient levels.

In Knik and Turnagain Arms, high turbidity and limited light penetration result in low biological productivity. Resident and shell-fishery populations are present only in low numbers; however, anadromous fish do use the turbid water for passage between the lower inlet and the natural streams. Five species of salmon are found in the tributaries to the Knik and Turnagain Arms. Comparatively, the

Knik Arm tributaries appear to sustain a more significant anadromous fishery than Turnagain Arm. The important salmon rivers in Turnagain Arm are Chickaloon River, Bird Creek, Indian Creek, Portage Creek, Resurrection Creek, and Six Mile Creek. Of these, the largest salmon runs have been identified in the Chickaloon River. In Knik Arm, the most important salmon tributary is the Little Susitna River. Other important streams are Fish Creek, Wasilla Creek, Cottonwood Creek, Knik River and Matanuska River.

Intertidal areas, mud flats, and lowlands are extensive in the Cook Inlet area partially because of the wide tidal fluctuations. Mud flats are broad expanses with little vegetation. Above these areas are marshland habitats, supporting grasses, emergents, submergents, and shrub vegetation. In terms of biological productivity, these coastal marshes are the most important areas within Cook Inlet. They provide important nesting and staging habitat for hundreds of thousands of shorebirds and waterfowl during the spring and fall migrations. This results in extensive recreational hunting opportunities for Alaska's most heavily populated area. During the years from 1971 to 1976, approximately 30 percent of the state duck harvest occurred in Cook Inlet.

Five coastal marshes in Cook Inlet are protected as state game refuges; four of these are in proximity to proposed tidal power development sites. They are Potter Point, located just south of Anchorage at the mouth of Turnagain Arm; Palmer Hayflats, in the upper reaches of Knik Arm; Goose Bay, on Knik Arm ten miles north of Anchorage; and Susitna Flats, to the west of Point MacKenzie at the mouth of the Susitna and Little Susitna rivers. Other important marshlands not protected as refuges are Eagle River Flats, across Knik Arm from Goose Bay, and Chickaloon Flats, across Turnagain Arm from Potter Point.

Although Cook Inlet is not an important habitat area for marine mammals, a few species do occasionally migrate to the area. Beluga whales are known to occur in the water offshore from Anchorage.

The endangered Arctic peregrine falcon is known to nest in the upper Cook Inlet region and to utilize coastal areas during the migration periods. Bald eagles, not classified as endangered in Alaska, also are present in the region. No endangered waterfowl species have been verified in Cook Inlet, although habitat for the Aleutian Canadian goose may occur in the southern reaches of the Inlet.

(iii) Anticipated Impacts

The construction and operation of a tidal power plant in either Knik or Turnagain Arm will affect the physical processes of Cook Inlet and cause changes that may directly or indirectly influence the natural environment. These impacts can be divided into short-term and long-term effects.

(iv) Short-Term Effects

Short-term effects are those associated with construction activities and include:

- Site development and construction;
- Site access and traffic;
- Operation of equipment;
- Dredging and dredged material disposal; and
- Development of construction material sources.

These short-term activities will affect, for the most part, only the environment in the vicinity of the site and will extend for the construction period. Some permanent changes will occur in the environment, such as placement of permanent facilities, but the effects will be site-specific. It should be noted that many of the negative impacts normally associated with construction can be eliminated by proper wastewater facilities, erosion control methods, and other mitigating measures.

- Dredge and Fill

The activities associated with dredging and filling may cause the most significant construction effect, because of the quantities of materials being moved and the necessary use of remote sites for dredged material disposal and acquisition of construction materials.

The Eagle Bay and Rainbow sites will both require dredging of 30 million cubic yards of sediments from the inlet bottom. Most of this will not be suitable as construction material and will need to be transported from the site for disposal. Acceptable sites for marine dumping can be found downstream where the Inlet broadens, but care must be taken to avoid commercial fisheries located in the Fire Island vicinity. The dredged material itself is not polluted or chemically contaminated. The physical constituents of the dredged material are likely to be similar to the bottom sediments found further downstream. Disposal of dredged material may temporarily disturb bottom organisms, but habitats would soon be re-established. Careful planning in the timing and choice of disposal sites can insure minimal impacts.

Because little of the dredged material at either the Eagle Bay or Rainbow sites would be suitable as construction material, upwards of seven million cubic yards of fill material must be procured from offsite sources. This would cause disturbance of upland habitats resulting from the activities of excavation and transport. Unavoidable impact of these activities may be reduced by avoiding development in sensitive environments.

The Point MacKenzie site is most attractive from the standpoint of dredge/fill operations. Less than one quarter of the dredging required for either Rainbow or Eagle Bay will be necessary for Point MacKenzie. Additionally, a substantial portion of the material removed will be rock, gravel, and sand that may be appropriate for dam construction. This further diminishes the volumes required for acquisition and disposal.

- Site Access and Traffic

Establishing access to the site by land and by sea and providing for the high volume of traffic that will occur during the construction period will affect the environment. Roads and marine docking facilities will be constructed. Marine traffic for construction purposes, delivery of equipment, and dredging operations will occur in areas where little or no shipping or boating of any type has occurred. Access roads will be established in previously undeveloped areas.

To minimize these impacts, land routes can be chosen to avoid sensitive areas such as waterfowl habitat, and the high volumes of traffic can be limited to construction periods. Marine traffic is not likely to affect the few resident species nor block the mobile anadromous species as they migrate up and downstream. The marshlands, waterfowl habitats, and upland game reserves would be most affected by development, noise, and traffic activities.

- Site Development and Construction

The preparation of the site for construction, as well as the activities associated with construction, will have its greatest impacts on the site itself. Alterations of topography and existing habitats will occur. The presence of large, noise-producing equipment and human activity will be disruptive to habitats.

Site development can be conducted in a manner that will minimize impacts. Minimization of land use, implementation of plans for erosion control and landscaping, and development of permanently useful facilities such as dry docks will aid in reducing impacts.

More site-specific details must be reviewed to determine the full scope of negative impacts versus the potential for enhancement.

Noise factors are potentially most significant at the Eagle Bay site, which is located only a few miles upstream from Goose Bay State Game Refuge. The noise levels have the potential to disrupt waterfowl, but habituation can be expected.

The marine construction activities will affect the aquatic environment. Dredging, fill placement, dry dock construction, caisson construction, and installation will occur in the water. There are few resident species to be disturbed, but migration of anadromous fish may be affected. It is likely that measures to insure fish passage will be required during all stages of construction, and this should reduce these impacts.

(v) Long-Term Effects

Certain aspects of plant operation may alter the physical regime of the estuary. These will be discussed in terms of their environmental implications:

- the altered tidal regime and estuarine hydrology; and
- the alteration of hydraulic characteristics: currents/ velocities, erosion/sedimentation.

Additionally, the following long-term impacts will be considered:

- impacts added by the causeway alternative.

- Effects of an Altered Tidal Regime

The process of capturing the tide in a basin behind the barrier and regulating the flows through it has two important consequences. First, the mean tide level in the newly formed basin will be raised by several feet. Second, the mean tide range will be substantially decreased. Mean high tide levels will probably be slightly lower and mean low tide levels will be higher than what presently exist.

The result of these changes can be conceptualized as follows. The extent of the mud flats will likely be somewhat diminished. The lowest reaches of the mud flats will remain totally submerged, since the tide will never reach its previous low levels. At the upper limits of the mud flats, marshland vegetation may encroach seaward. As the frequency of inundations decreases at the edges of the marshland, marsh grasses will grow on the former edges of the mud flats. This will result in shifts in locating mud flats and possible changes in acreages.

Other changes may alter the distribution of plant types on the lands affected by the tides. A net increase in the mean water level may alter the water table and hence runoff and other hydrologic characteristics of adjacent marshlands. Also significant is the effect of altered salinities that may occur as tidal waters are stored in the basin. There is some potential that intrusion of saltwater may have harmful effects on the ground water table. It should be noted that the Cook Inlet marshlands are high stress environments, characterized by large seasonal variation of salines. Therefore, changes in seasonal variation of salinities will probably not be detrimental to marshland vegetation, however, further investigation of these effects is necessary.

Other hydrologic characteristics could be affected, such as backwater and flooding. The raised water table could affect lowland drainage and vegetation. It appears at this time that, although the potential for alteration is great, it is also possible that only slight changes in populations will occur that will not greatly alter the nature of the environment as a habitat for waterfowl, shorebirds, and furbearing species.

The tidal regime may also be altered downstream from the barrier. However, the impoundment of a portion of high tide water behind the barrier will not greatly alter existing water levels or tidal fluctuation downstream. Possible effects caused by resonance of tidal waves will have to be studied in detail, but it appears likely that the effects of the barrier will have much greater potential for impact upstream from the dam.

- Hydraulic Characteristics of the Basin

Regulation of flow in the basin will affect hydraulics local to the dam itself, as well as having more widespread impacts. Existing current patterns and velocities throughout the basin would be altered. The most noticeable change will occur near the dam where the concentration of flow velocities through turbines and sluiceways would alter local flow patterns. These local high velocities will be dissipated with increasing distance from the dam. The decreased tidal range may result in an overall decrease in turbulence and mixing, although the tide range will still be substantial in relation to the depth of water so that the regime of total mixing may not be altered.

The effect of siltation on the environment and on the operation of the tidal power plant cannot be fully assessed. Investigations of sedimentation in the Bay of Fundy, La Rance and other construction reported that siltation caused by construction within the tidal flow is a function of (1) the degree of flow reduction caused by construction, (2) the availability of appropriate sized sediment in the water, and (3) the combined supply of material to the site.

Knowledge of the origin of sediments and the existing transport mechanism is necessary to analysis of the latter.

Sedimentation and erosion processes may be affected in the silt-laden estuary. The mud flats and bottom conditions of the Arms are highly mobile. Changes can result from a net increase or a net decrease in velocities and from redistribution of wave energy on the shoreline. These will have the greatest potential for harmful impacts to the natural environment on the shorelines of marshlands, where erosion of the outlying mud flats could result in eventual erosion of the marshland and loss of habitat. It is possible, however, that a net decrease in energy in the basin (lower tide range, decreased mixing, decreased tide range) will result in higher sedimentation rates. If this is the case, it may cause decreased storage in the basin, and correspondingly, a buildup of mud flats and an extension of marshlands.

The effects of sedimentation may also be significant downstream from a barrier in Cook Inlet. Observation of recently constructed causeways at Windsor, Nova Scotia, and on the Petitcodiac estuary in New Brunswick reveals the development of large, mid-channel mud flats seawards of the barrier caused by local flow reductions. This could result in a reduction of sediments which are normally deposited further downstream in the estuary. Effects on navigation may be significant in the Knik Arm where shoaling is already a problem in the approaches to Anchorage harbor.

Another factor related to sediment load in the Inlet waters is that of penetration of light as required for biological productivity. At present, high turbidities limit light penetration. This may be the limiting factor for growth of the aquatic food chains. It is possible that along with a decrease in sediment load, an increase in food production could result in a habitat more amenable to aquatic species.

- Causeway Development

The addition of a causeway to the tidal power project would not create any additional impacts to the upstream and shoreline environment. The most significant impacts would result from development of a permanent road through previously undeveloped areas and from the residential and commercial growth that would occur because of the new access. Other impacts to the Inlet include increased traffic noise across the causeway and increased human access to the wetlands for recreational purposes.

(c) Effects on Biological Resources

Construction and operation of a tidal power facility has the potential to affect anadromous fish in Cook Inlet. Because of the commercial and recreational importance of this resource, specific mitigation techniques would have to be developed to minimize these impacts.

Anadromous fish return to their natural streams to spawn. The mechanism by which they locate these streams is not fully understood, but it is believed the fish respond to changes in water chemistry. Thus, although it is unlikely retiming of tides will affect the hydrology and physical or chemical composition of water upstream from the reach of tidal fluctuations, the changes in sediment load and salinity of water below the power facilities could potentially affect the migration.

The largest salmon runs in Turnagain Arm occur in the Chickaloon River. Since the river is located approximately 10 miles downstream from the Rainbow site, migration should not be directly affected. In the Knik Arm area, the most important salmon tributary is the Little Susitna River, which is 10 miles downstream from the Point MacKenzie site; impacts there also should not be great. However, in both cases, it should be noted that as fish appproach their natal streams, they may wander as far as 10 miles past the mouth before turning back to the ultimate goal. In this manner, the Point MacKenzie and Rainbow sites could conceivably affect migration to the Little Susitna and Chickaloon River, respectively, although the damsites appear to be the limits of the interaction zone.

(i) Wetlands and Waterfowl Habitat

There are three primary mechanisms by which the tidal plant would directly cause impacts to marshlands: (1) interaction along the shores of the impounded basin; (2) interaction with the construction site, noise, activity, and equipment; and (3) interaction with an altered flow regime downstream from the dam.

Of these three primary impacts, the potentially most significant would be the effects of the altered tidal regime on the stability and productivity of the marshland ecosystems within the impoundment basin. Altered sedimentation patterns could result in eroded shorelines. A raised water table could result in a more saline ground water table. Altered surface hydrology may affect filtering and transport of nutrients and organics within the marsh. A loss of marsh area and a loss of vegetation types required for support of bird populations can be envisioned, thus diminishing productivity and resulting in degradation of the waterfowl habitat.

Alternatively, sedimentation may result in an enlargement of marshlands. Effects of changes in hydrology, inundations, and nutrient supplies could produce an environment more attractive to waterfowl and other species. Somewhere between the best case and the worst case lie any number of variations where, for example, vegetation or land areas may be altered but have little impact on bird populations. The conclusion, at this point, is that the interactions between hydrology, hydraulics, and the wetland ecosystem must be better understood in order to predict effects with more reliability. This should be the main focus of future environmental studies.

The second impact of a tidal power plant on marshlands would occur if the site is located in or near a marsh. None of the proposed sites is located in marshlands. A few may be close enough that effects of construction, especially noise, should be investigated.

Finally, operation of the tidal project may affect the hydraulics of the inlet downstream from the dam. These effects should be studied in greater detail for their impacts on coastal marshlands. Later phases of engineering studies should include modeling the effects of the dam on downstream hydraulics and water levels to determine ecological impacts.

(ii) Marine Mammals

Construction of tidal-generating facilities could affect the movement of marine mammals in the area. Care must be taken in design of intake structures and dam approaches to prevent harm to these animals in the event of their interaction with the structure. Other mammals may also be involved, and their movements may extend to the other damsites. This question should be more thoroughly investigated in later studies, including potential effects on marine mammal food sources.

(d) Other Effects

(i) Water Quality

Present water quality is characterized by extremely high turbidity, relatively high dissolved oxygen content, variable salinity and nutrient concentrations, and low levels of primary biological productivity. Several activities associated with the tidal project may affect water quality. These include the excavation and construction of the dam, increased ship traffic, and operation of marine equipment, as well as the regulation of flows to and from the basin.

Dredging, excavation, and placement of materials for dam construction in the submarine and intertidal environments may temporarily increase suspended sediment concentrations near the dam. Given the existing turbulence and turbidity of the water, this should not be a problem. Additionally, the introduction of new materials (sand, rock, gravel) from other sources may result in leaching of some chemical constituents not normally found in the waters. The possibility of serious chemical problems is very small.

The presence of construction equipment, tugs, barges and human activity indicates an increased possibility for such accidents as oil spills, fires, dumping of debris, and disposal of untreated sewage into the water. Adherence to health and safety plans and control of construction areas can minimize most undesirable effects.

The presence of the dam and the resultant flow patterns may act as a physical barrier which limits exchange of salt, nutrients, sediments, etc., between the freshwater inflows and the saltwater influence from the ocean. Although the total flow of water may be reduced by the dam, large volumes of water will still be exchanged. A well-mixed basin would result, although local flow patterns and water quality may be affected.

It appears that, though there are many potentials for impact to water quality, the associated risks are low.

(ii) Climatology

Short- and long-term changes in the climate of the region may occur as a result of tidal power development. Changes in ice formation, for example, could alter air temperatures in the basin vicinity. The potential changes caused by such effects should be investigated in later phases.

(iii) Rare and Endangered Species

It is not anticipated that tidal power development would affect the endangered peregrine falcon.

(e) Socioeconomic Assessment

The socioeconomic issues of a tidal development would be similar to those of other capital intensive developments, particularly to those of a large hydropower project. The investment period, characterized by very high levels of activity and expenditure, would be followed by a long operational period during which these levels would become quite low. Annual costs of operation consist mainly of capital charges. The costs of maintenance and replacement would be quite small compared to these capital charges, and the other costs of operating the facility would be negligible.

A tidal project presents, however, certain aspects and options that are very different from more conventional power modes and which may yield distinctly different social and economic results. The following examples will illustrate the characteristics in the tidal power development that may make it unique from the socioeconomic viewpoint:

- Storage and generation will take place in the sea. Consequently, very few, if any, relocations of people will be required and very little reallocation of land and water resources.

- One of the more likely construction options will be the floating in of hugh prefabricated caissons and sinking them on location as components of the structure. If this method is adopted, a significant amount of the work may be done off the site.

- Depending upon final design and the site selected for development, a tidal project in the Cook Inlet will require from 30 to 60 turbine-generating units. Such a large number may be sufficient to justify establishment of a local industry for their manufacture and overhaul.

- Tidal power will be generated in surges lasting from 4 to 6 hours followed by interruptions of approximately 8-1/2 to 6-1/2 hours duration (adding up to lunar cycle of 12 hours and 25 minutes). Energy-intensive industries that could work on the rhythm of power availability might find the general region of tidal power plants to be an attractive location.

(f) Impact on Adjacent Land Uses

The major impacts from tidal development in the Cook Inlet would occur in the Greater Anchorage Area Borough located in the south-central portion of Alaska at the head of Cook Inlet on a roughly triangular area of land between the two estuarine drainages, Knik and Turnagain Arms.

The areas within the boundaries of the municipality of Anchorage suitable for urban development are to the west of Chugach State Park, south and east including Alyeska-Girdwood, and north and east to Eagle River-Birchwood. Potential changes in land use would be to convert these areas into industrial use as businesses are attracted by availability of power.

(g) Materials Origin Supply Study

The raw materials, intermediate goods, and equipment required for a tidal project can be grouped into three main categories:

(i) Raw Materials

These materials include aggregate, rock, cement, and lumber. It is expected that aggregate and rock can be supplied locally. The final aggregate (sand) will be transported from the Palmer area. The coarse aggregate for concrete will be crushed in the rock quarry areas near the selected sites as follows:

- Rainbow: North and south side of Turnagain Arm--5-mile haul
- Point MacKenzie: North side of Turnagain area near Rainbow site--30-mile haul
- Eagle Bay: Mount Magnificant--15-mile haul

A very primary estimate of direct labor required for the production of these items indicates that about 300 to 400 jobs may be involved during the construction period.

(ii) Steel Products

These include reinforcement and fabricated gates. It is likely that these supplies would be from sources outside Alaska.

(iii) Generating Equipment

This includes hydroelectric and electrical equipment, such as the turbines, generators, transformers, and switchgear. This equipment would be supplied from North America or Europe depending on market conditions.

(h) Labor Supply and Limitations

A preliminary estimate indicates that the direct, onsite, labor requirements for the three sites considered would be approximately as follows:

Site	Rainbow	Eagle Bay	Point MacKenzie
Average man-years per year:			
Over 7.5 years	1,875		
10.5 years		2,000	
11.5 years			2,500
Peak demand man-years per year:	2,000	2,200	2,750

The peak labor requirements for any site development are not much higher than the average requirement, and it is likely that careful scheduling of the work will make it possible to arrange for a relatively steady level of employment throughout the construction period.

For each of the sites, the total demand amounts to less than 3 percent of the total labor force and about 50 percent of the construction labor force in the impact region (Anchorage-Matsu) as of March 1981. It seems likely, therefore, that a large part of the labor that would be required during the 1990s could be recruited in the surrounding region.

In 1980, the unemployment rate was about 8 percent in Anchorage-Matsu region immediately around and north of the project sites, 12 percent in the Gulf Coast region and 10 percent in the state of

Alaska. It is possible the rate of employment would be lower during the 1990s than at present, but it seems unlikely it will have become very low. Most probably, sufficient labor will be available in the region around the project sites and construction of one of the projects would likely offer a welcome contribution to reduction of unemployment in the area during the years of construction.

Supplementary labor requirements, in addition to the direct onsite requirements, are of two types. The first consists of labor employed in the production of supplies, such as cement, concrete, lumber, aggregate, steel products, turbines, generators, and other electrical products. Parts of these activities will not be located in the impact region, or even in the state of Alaska. A preliminary estimate indicated that possibly up to 300 or 400 additional jobs in the production of raw materials could be created in the Anchorage region during the construction period if in-state manufacturing facilities are developed.

Another type of supplementary labor requirement consists of additional jobs to supply the demand for services by the labor employed onsite and in supply activities.

(i) Community Impact

Direct, onsite employment would reach, in the peak years, about 2,000 to 2,750. The impact region would be the municipality of Anchorage. A socioeconomic study by the Bureau of Land Management indicates that population growth in Anchorage was responsive to the growth in economic activities: Kenai oil, Prudhoe Lease, and Trans-Alaska pipeline construction. The population of the municipality of Anchorage was estimated in that study at 195,654 as of July 1, 1979. It is likely that Anchorage could supply labor and services of sufficient variety to accommodate a project of this size.

The temporary construction activities may provide opportunities to strengthen the local infrastructure and provide lasting benefits. Transport facilities, for example, would have to be improved to facilitate construction. For site access, new roads or upgrading of existing roads would have to be done except at Eagle Point. Adjustments near the military airport would be necessary at Point MacKenzie. A viaduct off the highway over existing railroad tracks (north side) would be built at Rainbow as well as a road to the storage and work area along the shore (north side). Whenever possible, expansion of the transport facilities as required for construction should take into account opportunities to create lasting beneficial effects, but at the same time should not necessarily interfere with existing communities. It will be desirable, if and when a decision is made to build one of the projects, to initiate joint planning with municipal authorities early as possible to minimize the unavoidable strains on the communities and to maximize the benefits that can be obtained from the temporary increase in activity in the area.

(j) Impacts of a Causeway

As discussed earlier, construction of a tidal power project at any site considered in this study could be planned to provide a causeway. At Rainbow, a crossing of Turnagain Arm could be built as an integrated part of the tidal power project, and, therefore, its costs would be reduced. Turnagain Arm Crossing between the Anchorage area and the Kenai Peninsula has been considered in various studies over the past 30 years. It has been recognized that a major improvement such as a crossing of Turnagain Arm would have a great impact on the area which it serves or through which it passes.

Tourism plays a major role in the regional economics of the Anchorage-Kenai area. The opening up of territory heretofore unserved by a highway becomes of major importance.

Alaska with its almost unlimited scenary has likewise unlimited potential for recreation. Good transportation makes realization of these potentials possible as well as being one of the basic ingredients of commerce and industry. The improvement of the basic network of transportation within the Anchorage-Kenai area will produce favorable results with all of these activities.

A crossing of Turnagain Arm would bring the city of Kenai, the center of a rapidly growing petroleum industry, to the existing highway system. The 1968 study by the Alaska Department of Highways indicated that the distance between the city of Kenai and Anchorage through the crossing would be 94 miles by way of a low-level highway, whereas the distance over existing roads is 154 miles over mountain roads with long grades and passes subject to heavy snowfall.

The construction of a tidal power project at either site, Point MacKenzie or Eagle Bay, could also be planned jointly with a Knik Arm crossing. A causeway crossing joining the two sides of Knik Arm near Anchorage would provide civil benefits as well as defense benefits. The 1972 study by the state of Alaska Department of Highways indicated that the crossing will allow future economic development of the west side of Knik Arm, which would certainly add to the potential of the metropolitan area of Anchorage (State of Alaska 1982). It would shorten the Anchorage-Fairbanks highway and also would provide the necessary access for a new international airport on the west side of the arm. Such a facility presents an interesting stimulus for the future economic development of the west side of Knik Arm. In addition, the causeway crossing would provide means for development access of lands north of Knik Arm. The geographic position of Anchorage, being presently surrounded by water, mountains, and military facilities, makes the development of the lands north and west of Knik Arm very desirable. A crossing of Knik Arm would give access to the Beluga area and the Alaska Peninsula with its mineral and recreation potentials.

(k) Summary

In summary, a large number of potential impacts are associated with any construction project of this magnitude. Certain short-term and local effects cannot be eliminated--such as dredging, construction activities, traffic, noise, and installation of permanent facilities. In addition, some widespread changes in the natural regime would result from operation of the plant; namely, changes in tidal fluctuations, water levels, and sedimentation patterns. All of these changes will affect the natural environment. Further engineering and environmental studies should identify in greater detail the impact of change on the resources of Cook Inlet. Indeed, the environment may prove resilient enough to assimilate long-term changes without a net deleterious effect on resources. Enhancement potentials also exist. The State must weigh the importance of any impact on these resources against the need for growth and development.

10.6 - Comparison of Alternatives

The economic and energy aspects of each of the alternatives under consideration are discussed in Chapters 6 and 8 of Volume I. The general comparison of the environmental impacts associated with the selected alternatives are presented below. These selected alternatives are:

- Susitna/Devil Canyon Hydroelectric Sites;
- High Devil Canyon/Vee Hydroelectric Site;
- Devil Canyon Tunnel (replaces Devil Canyon only);
- Chakachanma, Keetna, and Snow Hydroelectric Sites;
- Thermal Power Development with Beluga Coal; and
- Tidal Power Development.

The environmental impacts of these alternatives have been discussed in previous sections of this chapter and in Volume I. In this section, therefore, only the major environmental impacts and the comparisons are mentioned. For more detailed discussion, the reader is referred to other sections of this chapter and to Volume I.

In this section, the Susitna/Devil Canyon proposal is compared to others. However, because the eventual installed capacity of these two dams is 1620 MW, construction of only one of the alternates would not produce the same power. For instances; the proposed Chakachamna, Keetna, and Snow sites would together have an installed capacity of only

650 MW, requiring thermal power to also be developed to meet power demands. Therefore, these developments together may have more additive impacts than development of the single Susitna/Devil Canyon complex. This should be considered when comparing the differential impacts discussed below.

(a) Air Quality

Impacts to air quality at the tidal power development site and all hydroelectric sites would occur only during the construction period. These impacts, resulting from construction vehicle exhaust emission and fugitive dust, would be minor.

Thermal power development utilizing Beluga coal would result, in addition to fugitive dust and construction vehicle emission, in substantial amounts of sulfur dioxide, fly ash, and nitrogen oxides emitted to the atmosphere. Coal mining activities would also result in additional fugitive dust and mining equipment emissions, primarily of particulate matter, hydrocarbons and nitrous oxides. Although a PSD review would require emissions be within allowable increments established by the Clean Air Act regulations, the relatively pristine air quality would be noticeably degraded.

Thus, in comparison to the other alternatives, Beluga coal development will result in much greater negative impacts to air quality; tidal and hydroelectric development would have only minor effects.

(b) Topography, Geology, and Soils

Development of tidal power or hydroelectric power would result in minor impacts to topography, geology, and soils. These impacts would occur due to construction of access roads and transmission lines, and utilization of borrow areas. Degree of impact would not differ appreciably between the various hydroelectric or tidal power alternatives and could be mitigated through restoration and revegetation efforts.

Power generation utilizing Beluga coal would result in impacts over a much larger area. Surface mining of the coal to fuel the generating station would result in surface disturbance of the topography and soils in the mined area. Reclamation efforts would reduce these impacts, but the overall impacts would be the greatest of the alternatives under consideration.

(c) Hydrology

It is difficult to predict effects of the various power development on hydrology in the project areas. Hydroelectric development at any of the sites would result in reduction in surface flows below the dams during certain times of the year. Studies for this project have indicated these changes would not impact ground water sources or ground water or surface water users downstream of the Devil Canyon site. Because all of the damsites are located in areas of very low population density, it is not expected that changes in flows would cause major impacts to water users. The primary impact associated with alteration of flows would be to aquatic ecosystems as discussed in Section (e) below.

Tidal power development would raise the mean tide level behind the tidal barrier by several feed and lower the mean tide range so that higher low tides and lower high tides occur. This may have biological ramification as discussed in Section (d) and (e) below.

Little is known about ground water resources in the vicinity of the Beluga coal fields. Strip mining has the potential to interfere with ground water flows and to degrade water quality. In addition, surface water could be affected from runoff from coal mining operations and from liquid discharges from the generating station. This would also primarily effect aquatic ecosystems as discussed in Section (e).

Thus, hydroelectric and tidal powre development will affect surface hydrology while coal powered development will affect surface and ground water hydrology and also water quality.

(d) Terrestrial Ecosystems

Impacts on terrestrial ecosystems resulting from the Susitna/Devil Canyon development are discussed in Section 3 of this report. The impacts result primarily from the flooding of approximately 48,000 acres and construction of access roads and transmission facilities. Wildlife habitat, primarily for moose and furbearers, would be inundated and caribou migration may be affected. Deciduous forest, coniferous forest, and shrub communities would be flooded.

The Vee/High Devil Canyon development would flood approximately 9,000 fewer acres. Although this is a smaller area, it is believed to be more important to wildlife. Key winter habitat utilized by three subpopulations of moose would be flooded and caribou migration routes also affected. In addition, the areas that would be flooded is of greater value to certain furbearer species, particularly red fox. Because of the distance traversed, the construction of a transmission line to the intertie from Vee/

High Devil Canyon would result in greater impacts to terrestrial ecosystem. An additional 40 miles of transmission line would be required, resulting in a minimum of 1500 more acres of land cleared.

The Devil Canyon tunnel, Keetna, and Snow sites would all result in a reduction of available wildlife habitat. The Devil Canyon tunnel scheme (including Watana development) would inundate less area than the Watana/Devil Canyon complex or the Watana/Devil Canyon/Vee complex. Depending upon the exact specification of the development scenario, Snow and Keetna together would permanently flood approximately 6,000 acres. Because the Chakachanma project involves diversion of water, land inundated and loss of habitat is expected to be minimal. Thus, overall direct terrestrial impacts from hydroelectric development outside the Upper Susitna Basin will be less than for the Watana/Devil Canyon development. However, because the amount of power produced would be substantially less, thermal development would also be required, resulting in additional impacts to terrestrial ecosystems as discussed below.

Surface mining of coal for generation plan would unavoidably result in the removal of vegetation and wildlife habitat. Mitigation efforts would partially offest this loss, but the long-term mining would result in cumulative impacts. Furthermore, the areas of the generating facility, roads, and ancillary facilities would be permanently removed as wildlife habitat.

Tidal power development would also involve disturbance of terrestrial areas. Preparation of staging sights and access roads would remove areas of habitat from use. Alteration of the tidal regime may also reduce wetland areas. Overall impacts to terrestrial ecosystems would be small.

(e) Aquatic Ecosystems

The major impacts on aquatic ecosystems resulting from the Susitna/Devil Canyon development are discussed in Chapter 3 of this volume. These impacts include reduction of downstream flows during spring, summer, and fall and possible loss of spawning habitat in the side sloughs. The chum salmon is expected to be the major species affected but mitigation efforts will likely offset any losses and insure continuance of spawning runs.

The High Devil Canyon/Vee development would inundate approximately 70 additional miles of the Susitna River. In addition, if the Olson re-regulating dam is included as part of this complex, access to Portage Creek, an important anadramous fish spawning stream, would be blocked and two miles partially inundated.

The Devil Canyon tunnel scheme would result in a smaller degree of impact to aquatic ecosystems, primarily because the number of the river miles flooded and the reservoir area created would be approximately half that of Devil Canyon reservoir.

Development at Keetna, Chakachamna, and Snow would also affect fisheries habitat, particularly at Chakachamna. Dewatering of the Chacachatna River would prevent access to Chakachamna Lake by anadramous fish, thereby eliminating spawning runs to the lake and its tributaries. Development at the Keetna site could also adversely affect upstream migration of anadramous fish.

Impacts to aquatic ecosystems from coal-fired power plants would depend upon effectiveness of siltation control devices and treatment of water discharge. Large scale mining efforts has the potential to negatively affect surface water quality over a large area.

Tidal power development could also affect migration of anadramous fish, but this is not expected to be a major impact. Possible changes in water chemistry and tidal fluctuations may change after components of the aquatic ecosystem.

(f) Cultural Resources

Potential for impacts to cultural resources is present with all development. Current studies described in Chapter 4 reveal the presence of large numbers of archaeological sites, by far, the majority of which were not discovered before these studies. Therefore, although known cultural resource sites are few at all the other development sites, it cannot be concluded that they are not present; it is likely detailed surveys would result in the discovery of these resources. Impacts to these resources are mitigatable either through avoidance or salvage operations.

Utilizing area involved as the only criteria, development at the High Devil Canyon/Vee sites and Devil Canyon/Watana sites has the highest potential for impacts and tidal power development the lowest. The other development schemes would have potentially intermediate levels of impact.

(g) Socioeconomic

Impacts on socioeconomic conditions depend primarily on the size of the project, the remoteness of the area, and condition of nearby towns. Based on this, the Watana/Devil Canyon and High Devil Canyon/Vee projects will have similar socioeconomic impacts and the tidal power development due to its size and proximity to Anchorage, the least. The use of Beluga coal would also result in substantial impacts to that area, particularly to the Tyonek Village.

(h) Summary

Comparison of the environmental impacts of the proposed Watana/Devil Canyon development with the alternatives can be summarized as follows:

(i) Hydroelectric Alternatives:

- High Devil Canyon/Vee - Similar impacts as Watana/Devil Canyon in the area of air quality, topography, geology, and soils, hydrology, cultural resources, and socioeconomics; more severe negative impacts to aquatic and terrestrial ecosystems.

- Devil Canyon Tunnel - Similar impacts as Watana/Devil Canyon in all areas except terrestrial and aquatic ecosystems. Lesser impacts to aquatic and terrestrial ecosystems. See Volume I, Chapter 8 for discussion of energy loss with this alternate.

- Chakachamna/Keetna/Snow - Fewer impacts in all areas except aquatic ecosystems due to smaller developments. Potential for severe impacts to fisheries and Chakachamna. However, low level of installed power would require supplementing with thermal increasing impacts.

(ii) Coal-fired Thermal Alternative

Greater impacts than Watana/Devil Canyon in areas of air quality, topography, geology, soils, and hydrogeology; potential for long-term negative impacts to aquatic and terrestrial ecosystems; similar levels of impacts to cultural resources and socioeconomic conditions.

(iii) Tidal Alternative

Fewer impacts than Watana/Devil Canyon in all areas, with the possible exception of anadramous fish. However, tidal power development of the same capacity of Watana/Devil Canyon (1620 MW) are not in existence anywhere in the world. Environmental impacts are not fully understood and may be greater than expected of special concern in effects of tidal regime alteration on anadramous fish. Finally, tidal power production is dependent on the tidal cycle and generation may not meet load characteristics and demands.

MAP REFERENCES

Note: File number, where present, appears to the right of the reference and is the library file number of the source at the Alaska Resources Library of the Department of the Interior, Anchorage.

File No.

List of Acronyms

ADF&G - Alaska Department of Fish and Game

AEIDC - Artic Environmental Information and Data Center (of the University of Alaska)

DOI - United States Department of Interior

FLPMA - Federal Land Policy and Management Act

JFSLUPC - Joint Federal State Land Use Planning Commission

USGS - U.S. Geological Survey

(1) "Migratory Birds: Seabirds, Raports, and Endangered Species." Resource Planning Team, JFSLUP, 1974, 1977. — FW8

(2) "Birds." — 100

(3) "Musk-Oxen and Caribou" adapted from data provided by ADF&G and from the University of Alaska, AEIDC. — 99

(4) "Large Mammals" adapted from information prepared by ADF&G and the University of Alaska, AEIDC. — 88

(5) Cultivatable Soils, Soil Conservation Service, Exploratory Survey Resource Planning Team, JFSLUPC, 1973.

(6) "Vegetation of Alaska", Data compiled by Spetzman of USGS, 1963. Overlay prepared directly from Spetzman's map by Resource Planning Team, JFSLUPC, 1972.

(7) "Selected Primitive Areas in Alaska for Consideration for Wilderness Designation", JFSLUPC, 1977.

(8) "Bear Denning and Goat Range", Resource Planning Team, JFSLUPC, 1974. — FW6

(9) "Dall Sheep, Deer and Moose Concentrations", Resource Planning Team, JFSLUPC, 1974. — FW67

MAP REFERENCES (Cont'd)

		File No.
(10)	"Distribution of Caribou Heards in Alaska", Resource Planning Team, ALUPC, 1974.	FW5
(11)	"Scenic, Natural and Primitive Values", Resource Planning Team, JFSLUPC, 1974.	PR16
(12)	"Recreation, Cultural and Scientific Features", Resource Planning Team, JFLUPC, 1974.	PR17
(13)	"Nationally Significant Cultural Features (Known and Known Potential)", JFSLVPC Alaska Division of Parks and National Park Service, 1977.	
(14)	Alaska Map E (USGS) and USGS Quad Maps (Scale 1:250,000.	
(15)	Administration National Monument Proclamation and FLPMA Withdrawals, 1980.	
(16)	"Alaska" Illustrated Land Status Subject to Verification Department of the Interior, Bureau of Land Management, 1974.	
(17)	Generalized State Land Activity - current to 9/30/79.	32-1
(18)	"Fisheries" JFSLUPC.	FW9
(19)	"Marine Mammals and Fish", Adapted from data prepared by the U.S. Fish and Wildlife Service and University of Alaska, Arctic Environmental Information and Data Center.	97
(20)	"Proposed Ecological Reserve System for Alaska" by: University of Alaska, Arctic Environmental Information and Data Center, 1977.	
(21)	State of Alaska "Game refuges, Critical Habitat Areas and Sanctuaries" prepared by ADF&G, Habitat Protection Section, Office of Projects Review.	
(22)	"Agricultural and Range Resources, Alaska Resources Inventory, South Central Region" prepared by the Joint Federal State Land Use Planning Commission.	
(23)	Alaska Map E showing "Alaska National Interest Lands Conservation Act, December 2, 1980, PL 96-487".	

TABLE 10.1: SUMMARY OF RESULTS OF SCREENING PROCESS

Site[1]	Elimination Iteration 1	2	3	4	Site[1]	Elimination Iteration 1	2	3	4	Site[1]	Elimination Iteration 1	2	3	4	Site[1]	Elimination Iteration 1	2	3	4
Allison Creek					Fox	*				Lowe				*	Talachulitna River	*			
Beluga Lower			*		Gakona		*			Lower Chulitna				*	Talkeetnna R. -Sheep	*			
Beluga Upper				*	Gerstle			*		Lucy	*				Talkeetna - 2				
Big Delta	*				Granite Gorge			*		McClure Bay			*		Tanana River			*	
Bradley Lake				*	Grant Lake			*		McKinley River		*			Tazlina				*
Bremmer R. -Salmon	*				Greenstone			*		McLaren River	*				Tebay Lake		*		
Bremmer R. -S.F.	*				Gulkana River			*		Million Dollar		*			Teklanika		*		
Browne					Hanagita		*			Moose Horn	*				Tiekel River	*			
Bruskasna					Healy		*			Nellie Juan River	*				Tokichitna				*
Cache					Hicks					Nellie Juan R. -Upper				*	Totatlanika	*			
Canyon Creek	*				Jack River	*				Ohio			*		Tustumena				*
Caribou Creek	*				Johnson				*	Power Creek		*			Vachon Island		*		
Carlo		*			Junction Island		*			Power Creek - 1	*				Whiskers				*
Cathedral Bluffs				*	Kanhshna River			*		Ramport		*			Wood Canyon		*		
Chakachamna					Kasilof River		*			Sanford		*			Yanert - 2		*		
Chulitna E.F.	*				Keetna					Sheep Creek			*		Yentna			*	
Chulitna Hurrican			*		Kenai Lake				*	Sheep Creek - 1	*								
Chulitna W.F.	*				Kenai Lower			*		Silver Lake				*					
Cleave		*			Killey River	*				Skwentna				*					
Coal			*		King Mtn	*				Snow									
Coffee				*	Klutina				*	Solomon Gulch			*						
Crescent Lake			*		Kotsina	*				Stelters Ranch	*								
Crescent Lake - 2		*			Lake Creek Lower		*			Strandline Lake									
Deadman Creek	*				Lake Creek Upper				*	Summit Lake	*								
Eagle River	*				Lane				*	Talachulitna			*						

Notes:

(1) Final site selection underlined.

* Site eliminated from further consideration.

TABLE 10.2: SITES ELIMINATED IN SECOND ITERATION

Site	Criterion
Carlo Yanert - 2	Denali National Park, National Park Wilderness
Healy Lake Creek Upper McKinley River Teklanika	Denali National Park
Cleave Wood Canyon	Wrangell-St. Elias National Park & Preserve, National Park Wilderness, Major Fishery
Tebay Lake Hanagita	Wrangell-St. Elias National Park & Preserve, National Park Wilderness
Gakona Sanford	Wrangell-St. Elias National Park & Preserve
Cresent Lake	Lake Clark National Park
Kasilof River Million Dollar Rampart Vachon Island Junction Island Power Creek	Major Fishery
Gulkana	Wild & Scenic River

TABLE 10.3: EVALUATION CRITERIA

Evaluation Criteria	General Concerns
(1) Big Game	- Protection of wildlife resources
(2) Agricultural Potential	- Protection of existing and potential agricultural resources
(3) Waterfowl, Raptors & Endangered Species	- Protection of wildlife resources
(4) Anadromous Fisheries	- Protection of fisheries
(5) Wilderness Consideration	- Protection of wilderness and unique features
(6) Cultural, Recreation & Scientific Features	- Protection of existing and identified potential features
(7) Restricted Land Use	- Consideration of legal restriction to land use
(8) Access	- Identification of areas where the greatest change would occur

TABLE 10.4: SENSITIVITY SCALING

Scale Rating	Definition
A. EXCLUSION	The significance of one factor is great enough to exclude a site from further consideration. There is little or no possibility for mitigation of extreme adverse impacts, or development of the site is legally prohibited.
B. HIGH SENSITIVITY	1) The most sensitive components of the environmental criteria would be disturbed by development, or 2) There exists a high potential for future conflict which should be investigated in a more detailed assessment.
C. MODERATE SENSITIVITY	Areas of concern were less important than those in "B" above.
D. LOW SENSITIVITY	1) Areas of concerns are common for most or many of the sites. 2) Concerns are less important than those of "C" above. 3) The available information alone is not enough to indicate a greater significance.

TABLE 10.5: SENSITIVITY SCALING OF EVALUATION CRITERIA

Evaluation Criteria	SCALE			
	A Exclusion	B High	C Moderate	D Low
Big Game:	--	- seasonal concentration - are key range areas - calving areas	- big game present - bear denning area	- habitat or distribution area for bear
Agricultural Potential	--	- upland or lowland soils suitable for farming	- marginal farming soils	- no identified agricultural potential
Waterfowl, Raptors and Endangered Species	--	- nesting areas for: . Peregrine Falcon . Canada Goose . Trumputee Swan - year-round habitat for neritic seabirds and raptors - key migration area	- high-density waterfowl area - waterfowl migration and hunting area - waterfowl migration route - waterfowl nesting or molt area	- medium or low density waterfowl areas - waterfowl present
Anadromous Fisheries	- major anadromous fish corridor for three or more species - more than 50,000 salmon passing site	- three or more species present or spawning - identified as a major anadromous fish area	- less than three species present or spawning - identified as an important fish area	- not identified as a spawning or rearing area.
Wilderness Consideration	--	All of the following - good-to-high quality: . scenic area . natural features . primitive values - selected for wilderness consideration	Two of the following - good-to-high quality: . scenic area . natural features . primitive value - site in or close to an area selected for wilderness consideration	One or less of the following - good-to-high quality: . scenic area . natural features . primitive value
Cultural, Recreational and Scientific Features	--	- existing or proposed historic landmark - reserve proposed for the Ecological Reserve System	- Site affects one or more of the following: . boating potential . recreational potential . historic feature . historic trail . archaeological site . ecological reserve nomination . cultural feature	- site near one of the factors in B or C

TABLE 10.5 (Continued)

Evaluation Criteria	SCALE A Exclusion	B High	C Moderate	D Low
Restricted Land Use	- Significant impact to: . Existing national park . Federal lands with-drawn by National Monument Proclamations	- Impact to: . National wildlife range . State park . State game refuge, range, or wilderness preservation area	- Increase: . National forest . Proposed wild and scenic river . National resource area . Forest land withdrawn for mineral entry	- In one of the following: . State land . Native land . None of A, B, C
Access	--	- no existing roads, railroads or airports - terrain rough and access difficult - increase access to wilderness area	- existing trails - proposed roads or - existing airports - close to existing roads	- existing roads or railroads - existing power lines

TABLE 10.6: SITE EVALUATIONS

Site	Evaluation Criteria: Big Game	Agricultural Potential	Waterfowl, Raptors, Endangered Species	Anadromous Fisheries	Wilderness Consideration	Cultural, Recreational, and Scientific Features	Restricted Land Use
Allison Creek	- Black and Grizzly bear present	- None identified	- Year-round habitat for neritic seabirds and raptors - Peregrine falcon nesting area - Waterfowl present	- Spawning area for two salmon species	- High-to-good-quality scenic area	- None identified	- Near Chugach National Forest
Bradley Lake	- Black and Grizzly bear present - Moose present	- 25 to 30 percent of soil marginally suitable for farming - high quality forests	- Peregrine Falcon nesting areas	- None identified	- Good-to-high-quality scenery	- Boating area	- None identified
Browne	- Black and Grizzly bear present - Moose present - Caribou winter range	- More than 50 percent marginally suitable for farming	- Low density of waterfowl	- None	- None	- Boating potential	- None identified
Bruskasna	- Black and Grizzly bear present - Moose present - Caribou winter range	- None identified	- Low density of waterfowl - Nesting and molting area	- None	- Good-to-high-quality scenery	- Boating potential - Proposed ecological reserve site	- None identified
Chakachamna	- Black bear habitat - Moose present	- Upland spruce, hardwood forest	- Waterfowl nesting and molting area	- Two species present	- Area under wilderness consideration - Good-to-high-quality scenery - Primitive and natural features	- Boating areas	- None identified
Coffee	- Black and Grizzly bear present - Moose present	- More than 50 percent of upperland suitable for agriculture - Good forests	- Key waterfowl habitat	- Four species present, two spawning in area	- None identified	- Boating area	- None identified
Cathedral Bluffs	- Black and Grizzly bear present - Moose present - Dall sheep present - Moose concentration area	- More than 50 percent of land marginal for farming - Upland spruce-hardwood forest	- Low density of waterfowl - Nesting and molting area	- One species present	- Good scenery	- None identified	- None identified
Hicks	- Black and Grizzly bear present - Caribou present - Moose wintering area	- None identified	- Waterfowl nesting and molting area	- Far downstream from site only	- None identified	- None identified	- No present restrictions
Johnson	- Black and Grizzly bear present - Moose, caribou and bison present	- 25 to 50 percent of upland soil suitable for farming - Upland spruce-hardwood forest	- Low density of waterfowl - Nesting and molting area	- Salmon spawning area, one species present	- None identified	- Boating potential	- None identified
Keetna	- Black and Grizzly bear present - Caribou winter area - Moose fall/winter concentration area	- None identified	- None identified	- Four species present, one species spawning near site	- Good-to-high-quality primitive lands	- High boating potential	- None identified
Kenai Lake	- Black and Grizzly bear present - Dall sheep habitat - Moose fall/winter concentration area	- None identified - Coastal hemlock-sitka spruce forest	- Waterfowl nesting and molting area	- Four species present, two spawning	- High-quality scenery - Natural features	- Boating potential	- Chugach National Forest

TABLE 10.6 (Continued)

Site	Evaluation Criteria						
	Big Game	Agricultural Potential	Waterfowl, Rapters, Endangered Species	Anadromous Fisheries	Wilderness Consideration	Cultural, Recreational, and Scientific Features	Restricted Land Use
Klutina	- Black and Grizzly bear present - Caribou present - Moose fall concentration area	- 25 to 50 percent of soils marginal for farming - Climate marginal for farming upland spruce-hardwood forest	- Low-density waterfowl area - Nesting and molting area	- Two species present, one species spawn in vicinity of site	- High-quality scenery - Natural formations - Primitive lands - Selected for wilderness consideration	- Boating potential	- None identifed
Lane	- Black bear present - Moose present - Caribou present	- More than 50 percent of the soils in upperlands suitable for farming - Bottomland spruce-poplar forest	- Low-density waterfowl area - Nesting and molting area	- Five species present and spawn in site vicinity	- None identified	- Boating opportunities identified	- None identified
Lowe	- Black and Grizzly bear present - Moose present	- None identified - Coastal western hemlock-sitka spruce forest	- Peregrine Falcon nesting area	- One species present, others downstream of site	- Good-to-high-quality scenery - Area selected for wilderness consideration	- Historical feature - Proposed ecological reserve site	- Located near the border of Chugach National Forest
Lower Chulitna	- Black and Grizzly bear present - Caribou present	- More than 50 percent of the upland soils suitable for farming	- Medium-density waterfowl araa - Nesting and molting area	- Four species present, three spawning in vicinity	- Area selected for wildernesa consideration	- Boating potential	- None identified
Silver Lake	- Black and Grizzly bear present - High density of seals	- None identified - Coastal western hemlock-sitka spruce forest	- Year-round habitat for neritic seabirds and raptors	- One species present, more downstream	- Good-to-high-quality scenery - Primitive value	- Boating area potential	- Chugach National Fores
Skwentna	- Black and Grizzly bear present - Moose winter concentration area	- 50 percent of upperlands suitable for farming - Lowland spruce - hardwood forest	- Low-density waterfowl area - Nesting and molting area	- Three species present, spawning in area	- None identified	- Boating area - Historical trails	- None identified
Snow	- Black bear present - Dall sheep habitats - Moose winter concentration area	- None identified	- Nesting and molting area	- None	- None identified	- Proposed ecological reserve site	- Located in Chugach National Forest
Strandline Lake	- Moose, black bear habitat - Grizzly bear present	- 25 to 50 percent marginal farming soils - Alpine tundra	- Nesting and molting area	- None present	- Good-to-high-quality scenery - Primitive lands	- None identified	- None identified
Talkeetna 2	- Black and Grizzly bear presnt - Moose fall/winter concentration area - Caribou winter range	- None identified	- None identified	- Four species present, one species spawns at site	- Good-to-high-quality scenery - Primitive lands	- Boating potential	- None identified
Cache	- Black and Grizzly bear present - Moose winter concentration area - Caribou winter range	- None identified	- None identified	- Four species of salmon present, spawning areas identified	- Good-to-high-quality scenery - Primitive lands	- Boating potential	- None identified
Tazlina	- Black and Grizzly bear present - Moose winter range - Caribou winter range	- None identified - Lowland spruce-hardwood forest	- Medium-density waterfowl area - Nesting and molting area	- Two species present at site and upstream	- None identified	- Boating potential	- None identified
Tokichitna	- Black bear present - Moose present - Caribou present	- More than 50 percent of soila are usable for farming (in upper lands)	- Medium-density waterfowl area - Nesting and molting area	- Four species present, three species spawn in site vicinity	- Border primitive area	- Boating potential	- None identified

TABLE 10.6 (Continued)

Site	Evaluation Criteria						
	Big Game	Agricultural Potential	Waterfowl, Rapters, Endangered Species	Anadromous Fisheries	Wilderness Consideration	Cultural, Recreational, and Scientific Features	Restricted Land Use
Tustumera	- Black bear habitat - Dall sheep habitat	- None identified	- None identified	- None identified	- Selected for wilderness consideration - Good-to-high-quality scenery - Natural features - Primitive lands	- None identified	- Located in Kenai National Moose Range - Site within a designated National Wilderness area
Upper Beluga	- Moose present	- More than 50 percent of upperlands are suitable for farming - Lowland spruce-hardwood forest	- Medium density waterfowl area - Nesting and molting area	- Four species present, two species spawn in area	- None identified	- Boating area	- None identified
Upper Nellie Juan	- Grizzly bear present - Moose present - Black bear habitat	- None identified - Coastal western hemlock-sitka spurce forest	- None identified	- None identified	- Selected for wilderness consideration - High primitive, scenic, and natural features	- Boating potential	- Chugach National Forest
Whiskers	- Black and Grizzly bear present - Moose present - Caribou present	- 50 percent of upperlands suitable for farming - Bottomland spruce-poplar forest	- Low-density waterfowl area - Nesting and molting area	- Five species present, two spawn in area	- None identified	- Boating potential	- None identified
Yentna	- Black and Grizzly bear present - Moose, spring/summer/winter concentration	- 25 to 50 percent of soils in lowlands are suitable for farming - Bottomland spruce-poplar forest	- Medium-density waterfowl area - Nesting and molting area	- Five species spawn in area	- None identified	- Boating potential	- None identified

TABLE 10.7: SITE EVALUATION MATRIX

	Big Game	Agricultural Potential	Waterfowl, Reptors, Endg. Species	Anadromous Fisheries	Wilderness Consideration	Cult, Recrea, & Scientific	Restricted Land Use	Access	Installed Capacity (MW)	Scheme	Dam Height (ft)	Land Flooded (Acres)
Crescent Lake	C	D	D	B	C	C	A	B	--	Reservoir w/Diversion	<150	<5000
Chakachamna	C	D	C	C	B	C	B	C	>100	Reservoir w/Diversion	<150	<5000
Lower Beluga	C	D	C	B	D	C	D	D	<25	Reservoir and Dam	<150	<5000
Coffee	C	B	C	B	D	C	D	D	25-100	Dam and Reservoir	<150	<5000
Upper Beluga	C	B	C	B	D	C	D	D	25-100	Dam and Reservoir	150-350	5000 to 100,000
Strandline Lake	C	C	C	D	C	D	D	D	<25	Reservoir w/Diversion	<150	<5000
Bradley Lake	C	C	B	D	C	C	D	D	25-100	Reservoir w/Diversion	<150	<5000
Kasilof River	C	B	C	A	D	C	B	D	--	Reservoir w/Diversion	150-350	>100,000
Tustumena	C	D	D	D	B	D	B	B	<25	Reservoir w/Diversion	<150	<5000
Kenai Lower	C	B	C	B	C	C	B	D	25-100 M	Dam and Reservoir	<150	<5000
Kenai Lake	B	D	C	B	C	D	C	D	>100	Dam and Reservoir	>350	5000 to 100,000
Crescent Lake-2	C	D	C	C	C	C	C	D	<25	Reservoir w/Diversion	<150	<5000
Grant Lake	B	D	C	B	C	C	C	D	<25	Reservoir w/Diversion	<150	<5000
Snow	B	D	C	D	D	C	C	D	25-100	Reservoir w/Diversion	150-350	5000 to 100,000
McClure Bay	D	D	B	C	B	D	C	C	<25	Reservoir w/Diversion	<150	<5000
Upper Nellie Juan R	C	D	D	D	B	C	C		<25	Reservoir w/Diversion	<150	<5000
Allison Creek	D	D	B	C	D	D	D	D	<25	Reservoir w/Diversion	<150	<5000
Solomon Gulch	D	D	B	C	D	D	D	D	<25	Reservoir w/Diversion	<150	<5000
Lowe	C	D	B	C	C	C	D	D	25-100	Dam and Reservoir	150-350	5000 to 100,000
Silver Lake	D	D	B	C	C	C	C	C	<25	Reservoir w/Diversion	<150	<5000
Power Creek	D	D	B	A	C	C	C	C	<25	Reservoir w/Diversion	<150	<5000
Million Dollar	D	D	B	A	B	C	C	C	--	Dam and Reservoir	<150	5000 to 100,000

TABLE 10.7 (Cont'd)

	Big Game	Agricultural Potential	Waterfowl, Raptors, Endg. Species	Anadromous Fisheries	Wilderness Consideration	Cult, Recrea, & Scientific	Restricted Land Use	Access	Installed Capacity (MW)	Scheme	Dam Height (ft)	Land Flooded (Acres)
Cleave	C	D	B	B	B	C	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Wood Canyon	C	D	C	B	B	B	A	D	--	Dam and Reservoir	>350	>100,000
Tebay Lake	C	D	D	C	B	D	A	B	--	Reservoir w/Diversion	<150	<5000
Hanagita	C	D	D	D	B	D	A	B	--	Reservoir w/Diversion	<150	<5000
Klutina	B	C	C	C	B	C	D	--	25-100	--	--	--
Tazlina	B	D	C	C	D	C	C	--	>100	Dam and Reservoir	150-350	5000 to 100,000
Gakona	B	C	C	C	D	C	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Sanford	B	C	C	C	D	C	A	D	--	Dam and Reservoir	--	--
Gulkana	B	D	C	C	D	B	B	D	25-100	Reservoir w/Diversion	150-350	5000 to 100,000
Yentna	B	B	C	B	D	C	D	C	>100	Dam and Reservoir	<150	>100,000
Talachultna	B	B	C	B	D	C	D	C	25-100	Dam and Reservoir	<150	5000 to 100,000
Skwentna	B	B	C	B	D	C	D	C	25-100	Dam and Reservoir	>350	5000 to 100,000
Lake Creek Upper	C	D	C	C	C	D	A	C	--	Reservoir w/Diversion	<150	<5000
Lake Creek Lower	C	B	C	B	D	C	D	C	--	Dam and Reservoir	150-350	<5000
Lower Chulitna	C	B	C	B	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Tokichitna	C	B	C	B	C	C	D	D	>100	Dam and Reservoir	150-350	5000 to 100,000
Coal	B	D	C	C	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Ohio	B	D	C	C	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Chulitna	B	D	C	C	C	C	D	D	25-100	Dam and Reservoir	150-350	<5000
Whiskers	C	B	C	B	D	C	D	C	25-100	Dam and Reservoir	<150	<5000
Lane	C	B	C	B	D	C	D	C	>100	Dam and Reservoir	150-350	<5000
Sheep Creek	B	D	D	D	C	C	D	C	25-100	Dam and Reservoir	>350	<5000

TABLE 10.7 (Cont'd)

	Big Game	Agricultural Potential	Waterfowl, Raptors, Endg. Species	Anadromous Fisheries	Wilderness Consideration	Cult, Recrea, & Scientific	Restricted Land Use	Access	Installed Capacity (MW)	Scheme	Dam Height (ft)	Land Flooded (Acres)
Keetna	B	D	D	B	D	C	D	C	25-100	Dam and Reservoir	>350	5000 to 100,000
Granite Gorge	B	D	D	B	C	C	D	C	25-100	Reservoir w/Diversion	150-350	<5000
Talkeetna-2	B	D	D	B	C	C	D	C	25-100	Dam and Reservoir	>350	5000 to 100,000
Greenstone	B	D	D	B	C	C	D	C	25-100	Reservoir w/Diversion	150-350	<5000
Cache	B	D	D	B	C	C	D	C	25-100	Dam and Reservoir	150-350	<5000
Hicks	B	D	C	D	D	D	D	D	25-100	Dam and Reservoir	150-350	<5000
Rampart	C	B	B	A	D	C	C	--	>100	Dam and Reservoir	>350	>100,000
Vachon Island	B	B	C	A	D	C	D	C	>100	Dam and Reservoir	<150	>100,000
Junction Island	B	B	C	A	D	C	D	C	>100	Dam and Reservoir	150-350	>100,000
Kantishna River	C	B	C	B	D	C	D	C	25-100	Dam and Reservoir	<150	>100,000
McKinley River	B	D	C	D	B	C	A	--	--	Dam and Reservoir	150-350	<5000
Teklanika River	B	D	D	D	B	D	A	B		Dam and Reservoir	>350	5000 to 100,000
Browne	B	C	D	D	D	C	D	D	>100	Dam and Reservoir	150-350	5000 to 100,000
Healy	B	C	D	D	B	B	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Carlo	B	D	D	D	B	C	A	D	--	Dam and Reservoir	150-350	<5000
Yanert-2	B	D	D	D	B	C	A	D	--	Dam and Reservoir	150-350	5000 to 100,000
Bruskasna	B	D	C	D	D	B	D	D	25-100	Dam and Reservoir	150-350	5000 to 100,000
Tanana	B	B	C	B	D	C	D	D	25-100	Dam and Reservoir	<150	5000 to 100,000
Gerstle	B	B	C	C	D	C	D	C	25-100	Dam and Reservoir	<150	<5000
Johnson	C	B	C	C	D	C	D	D	>100	Dam and Reservoir	<150	5000 to 100,000
Cathedral Bluffs	B	C	C	C	D	D	D	D	>100	Dam and Reservoir	150-350	5000 to 100,000

TABLE 10.8: CRITERIA WEIGHT ADJUSTMENTS

	Initial Weight	Adjusted Weights					
		Dam Height			Reserv. Area		
		+	++	+++	+	++	+++
Big Game	8				6	7	8
Agricultural Potential	7				5	6	7
Birds	8				6	7	8
Fisheries	10	8	9	10			

TABLE 10.9: SITE CAPACITY GROUPS

Site Group	No. of Sites Evaluated	No. of Sites Accepted
≤ 25 MW	5	3
25- 100 MW	15	4 - 6
≥100 MW	8	4

TABLE 10.10: RANKING RESULTS

Site Group	Partial Score	Total Score
Sites: < 25 MW		
Strandline Lake	59	85
Nellie Juan Upper	37	96
Tustumena	37	106
Allison Creek	65	82
Silver Lake	65	111
Sites: 25 - 100 MW		
Hicks	62	79
Bruskasna	71	104
Bradley Lake	71	104
Snow	71	106
Cache	86	127
Lowe	89	122
Keetna	89	131
Talkeetna - 2	98	134
Coffee	101	126
Whiskers	101	134
Klutina	101	142
Lower Chulitiua	106	139
Beluga Upper	117	142
Talachultna River	126	159
Skwentna	136	169
Sites > 100 MW		
Chakachamna	65	134
Browne	69	94
Tazlina	89	124
Johnson	96	121
Cathedral Bluffs	101	126
Lane	106	139
Kenai Lake	112	147
Tokichitna	117	150

TABLE 10.11: SHORTLISTED SITES

Environmental Rating	Capacity		
	0 - 25 MW	25 - 100 MW	100 MW
Good	Strandline Lake* Allison Creek* Tustumena Silver Lake	Hicks* Snow* Cache* Bruskasna*	Browne* Johnson
Acceptable		Keetna*	Chakachamna*
Poor		Talkeetna-2* Lower Chulitna	Lane Tokichitna

* 10 selected sites

TABLE 10.12: ALTERNATIVE HYDRO DEVELOPMENT PLANS

Plan	Description	Installed Capacity	On-Line Date
A.1	Chakachamna	500	1993
	Keetna	100	1997
A.2	Chakachamna	500	1993
	Keetna	100	1997
	Snow	50	2002
A.3	Chakachamna	500	1993
	Keetna	100	1996
	Snow	50	1998
	Strandline	20	1998
	Allison Creek	8	1998
A.4	Chakachamna	500	1993
	Keetna	100	1996
	Snow	50	2002
	Strandline	20	2002
	Allison Creek	8	2002
A.5	Chakachamna	500	1993
	Keetna	100	1996
	Snow	50	2002
	Talkeetna - 2	50	2002
	Cache	50	2002
	Strandline	20	2002
	Allison Creek	8	2002

TABLE 10.13: OPERATING AND ECONOMIC PARAMETERS FOR SELECTED HYDROELECTRIC PLANTS

No.	Site	River	Max. Gross Head Ft.	Installed Capacity (MW)	Average Annual Energy (Gwh)	Plant Factor (%)	Capital Cost[1] ($$10^6$)	Economic Cost of Energy ($/1000 Kwh)
1	Snow	Snow	690	50	220	50	255	45
2	Bruskasna	Nenana	235	30	140	53	238	113
3	Keetna	Talkeetna	330	100	395	45	477	47
4	Cache	Talkeetna	310	50	220	51	564	100
5	Browne	Nenana	195	100	410	47	625	59
6	Talkeetna-2	Talkeetna	350	50	215	50	500	90
7	Hicks	Matanuska	275	60	245	46	529	84
8	Chakachamna	Chakachatna	945	500	1925	44	1480	30
9	Allison	Allison Creek	1270	8	33	47	54	125
10	Strandline Lake	Beluga	810	20	85	49	126	115

NOTES:
(1) Including engineering and owner's administrative costs but excluding AFDC.

TABLE 10.14: POTENTIAL HYDROELECTRIC DEVELOPMENT

Site	Dam Proposed Type	Dam Height Ft.	Upstream Regulation	Capital Cost $ million	Installed Capacity (MW)	Average Annual Energy Gwh	Economic[1] Cost of Energy $/1000 kWh	Source of Data
Gold Creek[2]	Fill	190	Yes	900	260	1,140	37	USBR 1953
Olson (Susitna II)	Concrete	160	Yes	600	200	915	31	USBR 1953 KAISER 1974 COE 1975
Devil Canyon	Concrete	675	No Yes	830 1,000	250 600	1,420 2,980	27 17	This Study "
High Devil Canyon (Susitna I)	Fill	855	No	1,500	800	3,540	21	" "
Devil Creek[2]	Fill	Approx 850	No	-	-	-	-	-
Watana	Fill	880	No	1,860	800	3,250	28	"
Susitna III	Fill	670	No	1,390	350	1,580	41	"
Vee	Fill	610	No	1,060	400	1,370	37	"
Maclaren[2]	Fill	185	No	530[3]	55	180	124	"
Denali	Fill	230	No	480[3]	60	245	81	"
Butte Creek[2]	Fill	Approx 150	No	-	40	130[4]	-	USBR 1953
Tyone[2]	Fill	Approx 60	No	-	6	22[4]	-	USBR 1953

Notes:

(1) Includes AFDC, Insurance, Amortization, and Operation & Maintenance Costs.
(2) No detailed engineering or energy studies undertaken as part of this study.
(3) Includes estimated costs of power generation facility.
(4) These are approximate estimates and serve only to represent the potential of these two damsites in perspective.

TABLE 10.15: RESULTS OF SCREENING MODEL

	Total Demand		Optimal Solution				First Suboptimal Solution				Second Suboptimal Solution			
Run	Cap. MW	Energy GWh	Site Names	Max. Water Level	Inst. Cap. MW	Total Cost $ million	Site Names	Max. Water Level	Inst. Cap. MW	Total Cost $ million	Site Names	Max. Water Level	Inst. Cap. MW	Total Cost $ million
1	400	1750	High Devil Canyon	1580	400	885	Devil Canyon	1450	400	970	Watana	1950	400	980
2	800	3500	High Devil Canyon	1750	800	1500	Watana	1900	450	1130	Watana	2200	800	1860
							Devil Canyon	1250	350	710				
							TOTAL		800	1840				
3	1200	5250	Watana	2110	700	1690	High Devil Canyon	1750	800	1500	High Devil Canyon	1750	820	1500
			Devil Canyon	1350	500	800	Vee	2350	400	1060	Susitna III	2300	380	1260
			TOTAL		1200	2490	TOTAL		1200	2560	TOTAL		1200	2760
4	1400	6150	Watana	2150	740	1770	N O S O L U T I O N				N O S O L U T I O N			
			Devil Canyon	1450	660	1000								

TABLE 10.16: ENVIRONMENTAL EVALUATION OF DEVIL CANYON DAM AND TUNNEL SCHEME

Environmental Attribute	Concerns	Appraisal (Differences in impact of two schemes)	Identification of difference	Appraisal Judgment	Scheme judged to have the least potential impact: Tunnel	DC
Ecological:						
- Downstream Fisheries and Wildlife	Effects resulting from changes in water quantity and quality.	No significant difference between schemes regarding effects downstream from Devil Canyon.	---	Not a factor in evaluation of scheme.		
		Difference in reach between Devil Canyon dam and tunnel re-regulation dam.	With the tunnel scheme controlled flows between regulation dam and downstream powerhouse offers potential for anadromous fisheries enhancement in this 11 mile reach of the river.	If fisheries enhancement opportunity can be realized the tunnel scheme offers a positive mitigation measure not available with the Devil Canyon dam scheme. This opportunity is considered moderate and favors the tunnel scheme. However, there are no current plans for such enhancement and feasibility is uncertain. Potential value is therefore not significant relative to additional cost of tunnel.	X	
Resident Fisheries:	Loss of resident fisheries habitat.	Minimal differences between schemes.	Devil Canyon dam would inundate 27 miles of the Susitna River and approximately 2 miles of Devil Creek. The tunnel scheme would inundate 16 miles of the Susitna River.	Loss of habitat with dam scheme is less than 5% of total for Susitna main stem. This reach of river is therefore not considered to be highly significant for resident fisheries and thus the difference between the schemes is minor and favors the tunnel scheme.	X	
Wildlife:	Loss of wildlife habitat.	Minimal differences between schemes.	The most sensitive wildlife habitat in this reach is upstream from the tunnel re-regulation dam where there is no significant difference between the schemes. The Devil Canyon dam scheme in addition inundates the river valley between the two damsites resulting in a moderate increase in impacts to wildlife.	Moderate wildlife populations of moose, black bear, weasel, fox, wolverine, other small mammals and songbirds and some riparian cliff habitat for ravens and raptors, in 11 miles of river, would be lost with the dam scheme. Thus, the difference in loss of wildlife habitat is considered moderate and favors the tunnel scheme.	X	
Cultural:	Inundation of archaeological sites.	Potential differences between schemes.	Due to the larger area inundated, the probability of inundating archaeological sites is increased.	Significant archeological sites, if identified, can probably be excavated. Additional costs could range from several hundreds to hundreds of thousands of dollars, but are still considerably less than the additional cost of the tunnel scheme. This concern is not considered a factor in scheme evaluation.	-	-
Land Use:	Inundation of Devil Canyon.	Significant difference between schemes.	The Devil Canyon is considered a unique resource, 80 percent of which would be inundated by the Devil Canyon dam scheme. This would result in a loss of both an aesthetic value plus the potential for white water recreation.	The aesthetic and to some extent the recreational losses associated with the development of the Devil Canyon dam is the main aspect favoring the tunnel scheme. However, current recreational uses of Devil Canyon are low due to limited access. Recreation development of the area is similar for both schemes.	X	

OVERALL EVALUATION: The tunnel scheme has overall a lower impact on the environment.

TABLE 10.17: SOCIAL EVALUATION OF SUSITNA BASIN DEVELOPMENT SCHEMES/PLANS

Social Aspect	Parameter	Tunnel Scheme	Devil Canyon Dam Scheme	High Devil Canyon/ Vee Plan	Watana/Devil Canyon Plan	Remarks
Potential non-renewable resource displacement	Million tons Beluga coal over 50 years	80	110	170	210	Devil Canyon dam scheme potential higher than tunnel scheme. Watana/ Devil Canyon plan higher than High Devil Canyon/ Vee plan.
Impact on state economy	--	All projects would have similar impacts on the state and local economy.				Essentially no difference between plans/schemes.
Impact on local economy	--					
Seismic exposure	Risk of major structural failure	All projects designed to similar levels of safety.				
	Potential impact of failure on human life.	Any dam failures would affect the same downstream population.				
Overall Evaluation	1. Devil Canyon dam superior to tunnel. 2. Watana/Devil Canyon superior to High Devil Canyon/Vee plan.					

TABLE 10.18: OVERALL EVALUATION OF TUNNEL SCHEME AND DEVIL CANYON DAM SCHEME

ATTRIBUTE	SUPERIOR PLAN
Economic	Devil Canyon Dam
Energy Contribution	Devil Canyon Dam
Environmental	Tunnel
Social	Devil Canyon Dam (Marginal)
Overall Evaluation	Devil Canyon dam scheme is superior Tradeoffs made: Economic advantage of dam scheme is judged to outweigh the reduced environmental impact associated with the tunnel scheme.

TABLE 10.19: ENVIRONMENTAL EVALUATION OF WATANA/DEVIL CANYON AND HIGH DEVIL CANYON/VEE DEVELOPMENT PLANS

Environmental Attribute	Plan Comparison	Appraisal Judgment	Plan judged to have the least potential impact HDC/V	W/DC
Ecological: 1) Fisheries	No significant difference in effects on downstream anadromous fisheries. HDC/V would inundate approximately 95 miles of the Susitna River and 28 miles of tributary streams, including the Tyone River. W/DC would inundate approximately 84 miles of the Susitna River and 24 miles of tributary streams, including Watana Creek.	Because of the avoidance of the Tyone River, lesser inundation of resident fisheries habitat, and no significant difference in the effects on anadromous fisheries, the W/DC plan is judged to have less impact.		X
2) Wildlife a) Moose	HDC/V would inundate 123 miles of critical winter river-bottom habitat. W/DC would inundate 108 miles of this river-bottom habitat. HDC/V would inundate a large area upstream from Vee utilized by three sub-populations of moose that range in the northeast section of the basin. W/DC would inundate the Watana Creek area utilized by moose. The condition of this sub-population of moose and the quality of the habitat they are using appears to be decreasing.	Because of the lower potential for direct impact on moose populations within the Susitna, the W/DC plan is judged superior.		X
b) Caribou	The increased length of river flooded, especially upstream from the Vee damsite, would result in the HDC/V plan creating a greater potential division of the Nelchina herd's range. In addition, an increase in range would be directly inundated by the Vee reservoir.	Because of the potential for a greater impact on the Nelchina caribou herd, the HDC/V scheme is considered inferior.		X
c) Furbearers	The area flooded by the Vee reservoir is considered important to some key furbearers, particularly red fox. This area is judged to be more important than the Watana Creek area that would be inundated by the W/DC plan.	Because of the lesster potential for impact on furbearers the W/DC is judged to be superior.		X
d) Birds and Bears	Forest habitat, important for birds and black bears, exists along the valley slopes. The loss of this habitat would be greater with the W/DC plan.	The HDC/V plan is judged superior.	X	
Cultural:	There is a high potential for discovery of archaeological sites in the eaterly region of the Upper Susitna Basin. The HDC/V plan has a greater potential of affecting these sites. For other reaches of the river the difference between plans is considered minimal.	The W/DC plan is judged to have a lower potential effect on archaeological sites.		X

TABLE 10.19 (Continued)

Environmental Attribute	Plan Comparison	Appraisal Judgment	Plan judged to have the least potential impact HDC/V	W/DC
Aesthetic/ Land Use				
	With either scheme, the aesthetic quality of both Devil Canyon and Vee Canyon would be impaired. The HDC/V plan would also inundate Tsusena Falls.	Both plans impact the valley aesthetics. The difference is considered minimal.	-	-
	Because of construction at Vee Dam site and the size of the Vee Reservoir, the HDC/V plan would inherently create access to more wilderness area than would the W/DC plan.	As it is easier to extend access than to limit it, inherent access requirements were considered detrimental and the W/DC plan is judged superior. The ecological sensitivity of the area opened by the HDC/V plan reinforces this judgment.		X

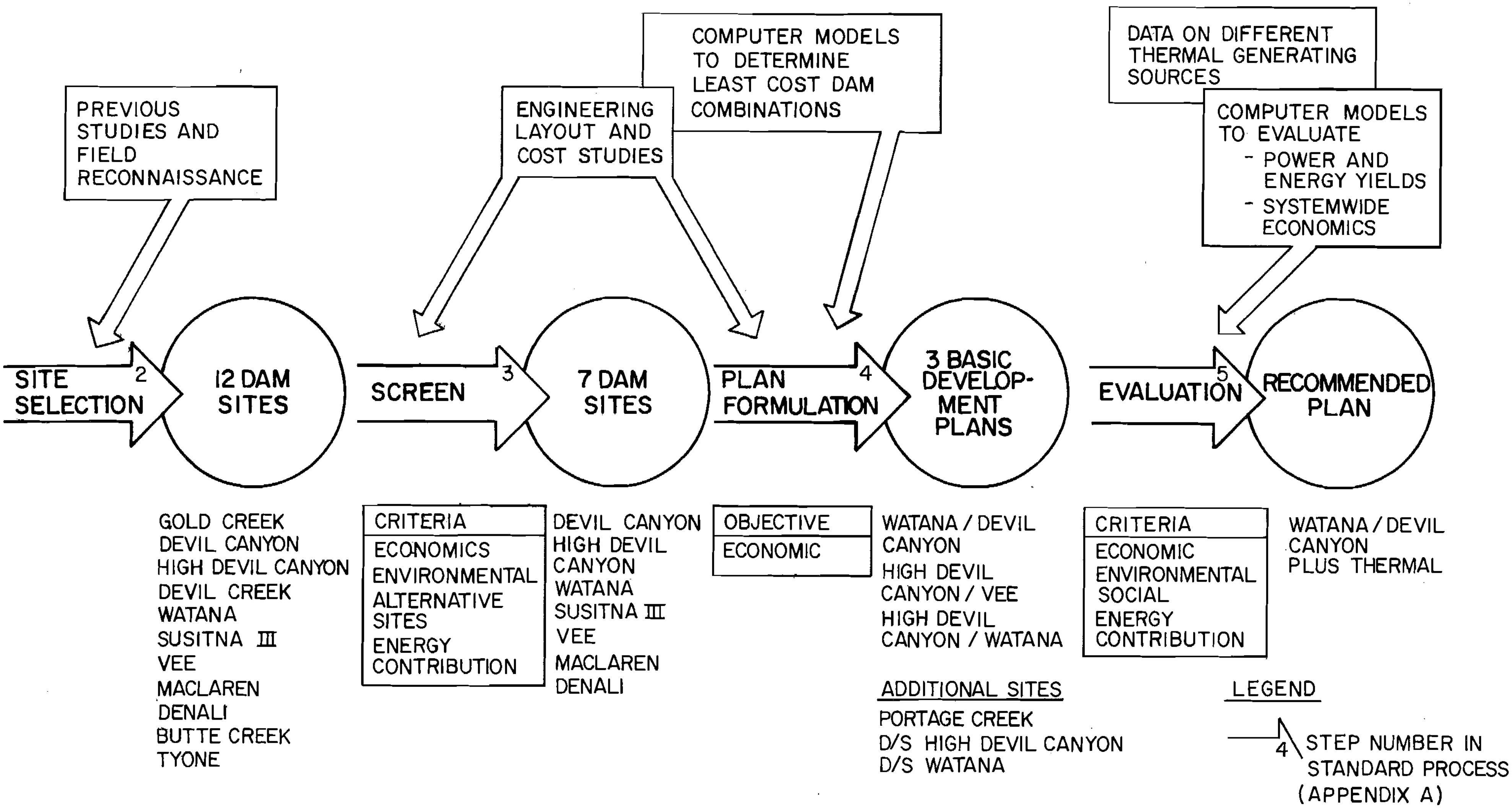
OVERALL EVALUATION: The W/DC plan is judged to be superior to the HDC/V plan. (The lower impact on birds and bears associated with HDC/V plan is considered to be outweighed by all the other impacts which favour the W/DC plan.)

Notes:

W = Watana Dam
DC = Devil Canyon Dam
HDC = High Devil Canyon Dam
V = Vee Dam

TABLE 10.20: OVERALL EVALUATION OF THE HIGH DEVIL CANYON/VEE AND WATANA/DEVIL CANYON DAM PLANS

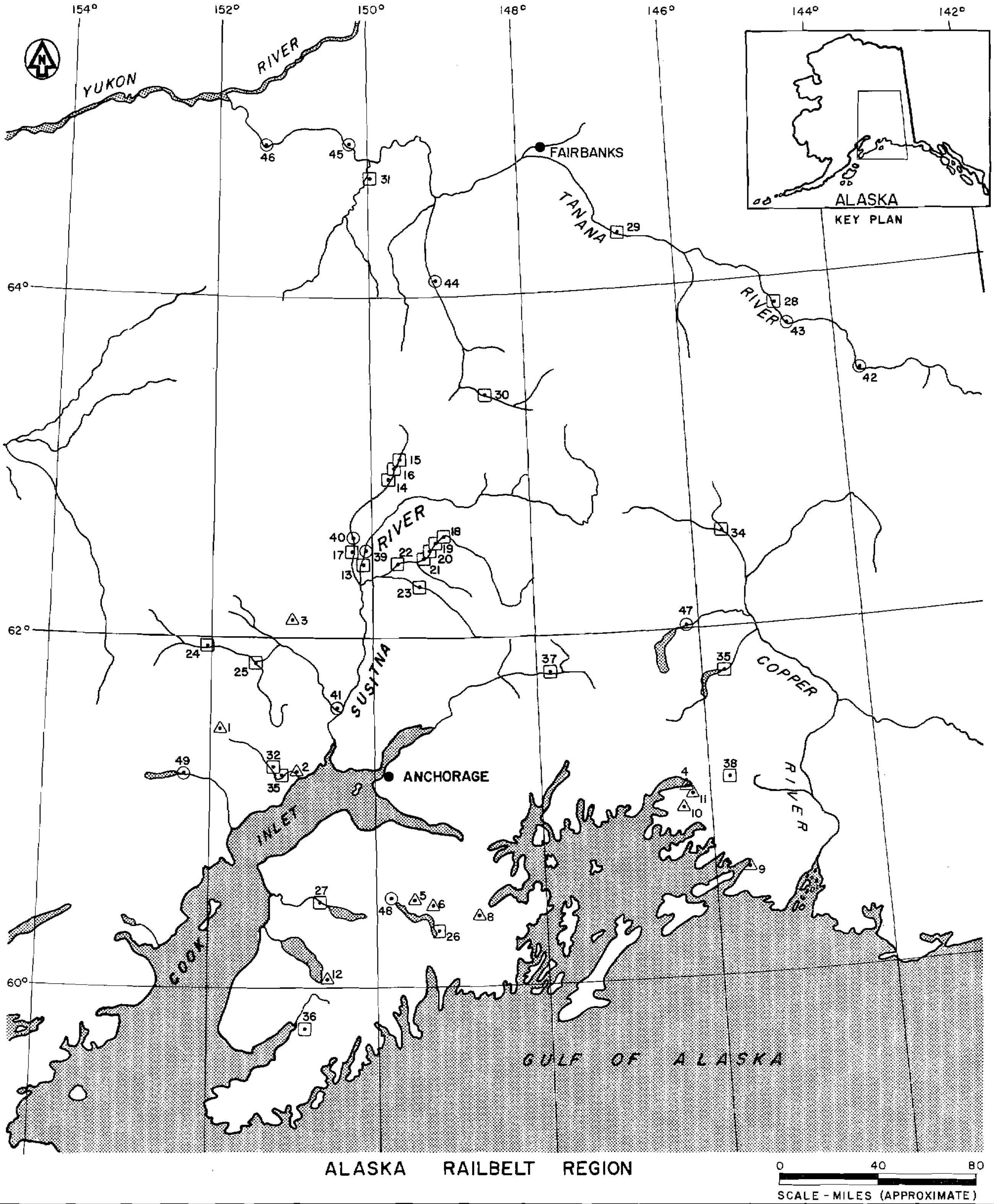
ATTRIBUTE	SUPERIOR PLAN
Economic	Watana/Devil Canyon
Energy Contribution	Watana/Devil Canyon
Environmental	Watana/Devil Canyon
Social	Watana/Devil Canyon (Marginal)
Overall Evaluation	Plan with Watana/Devil Canyon is superior Tradeoffs made: None



SUSITNA BASIN PLAN FORMULATION AND SELECTION PROCESS

ACRES

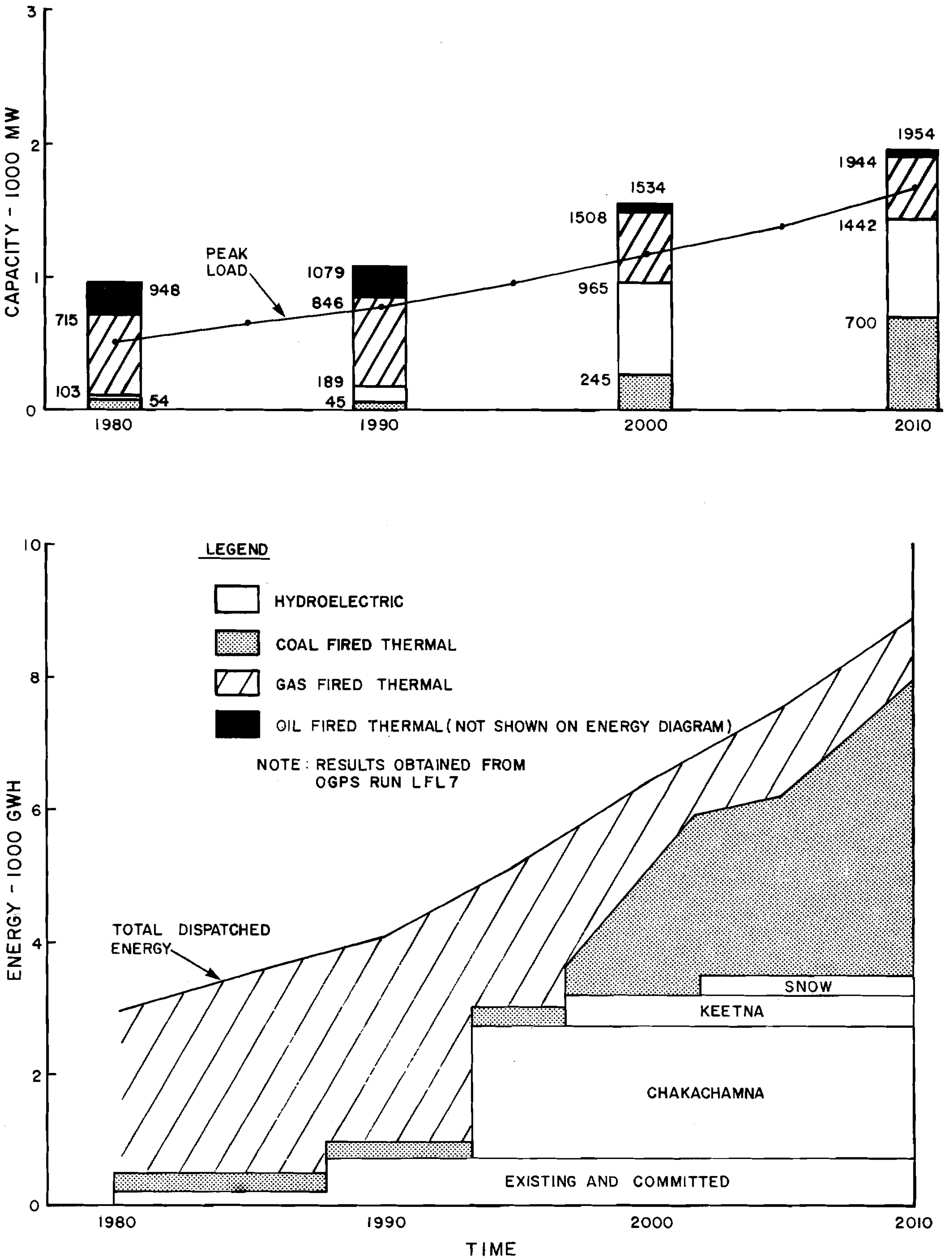
FIGURE 10.1



0 - 25 MW		25 - 100 MW				> 100 MW	
1.	STRANDLINE L.	13.	WHISKERS	26.	SNOW	39.	LANE
2.	LOWER BELUGA	14.	COAL	27.	KENAI LOWER	40.	TOKICHITNA
3.	LOWER LAKE CR.	15.	CHULITNA	28.	GERSTLE	41.	YENTNA
4.	ALLISON CR.	16.	OHIO	29.	TANANA R.	42.	CATHEDRAL BLUFFS
5.	CRESCENT LAKE 2	17.	LOWER CHULITNA	30.	BRUSKASNA	43.	JOHNSON
6.	GRANT LAKE	18.	CACHE	31.	KANTISHNA R.	44.	BROWNE
7.	McCLURE BAY	19.	GREENSTONE	32.	UPPER BELUGA	45.	JUNCTION IS.
8.	UPPER NELLIE JUAN	20.	TALKEETNA 2	33.	COFFEE	46.	VACHON IS.
9.	POWER CREEK	21.	GRANITE GORGE	34.	GULKANA R.	47.	TAZILNA
10.	SILVER LAKE	22.	KEETNA	35.	KLUTINA	48.	KENAI LAKE
11.	SOLOMON GULCH	23.	SHEEP CREEK	36.	BRADLEY LAKE	49.	CHAKACHAMNA
12.	TUSTUMENA	24.	SKWENTNA	37.	HICK'S SITE		
		25.	TALACHULITNA	38.	LOWE		

SELECTED ALTERNATIVE HYDROELECTRIC SITES

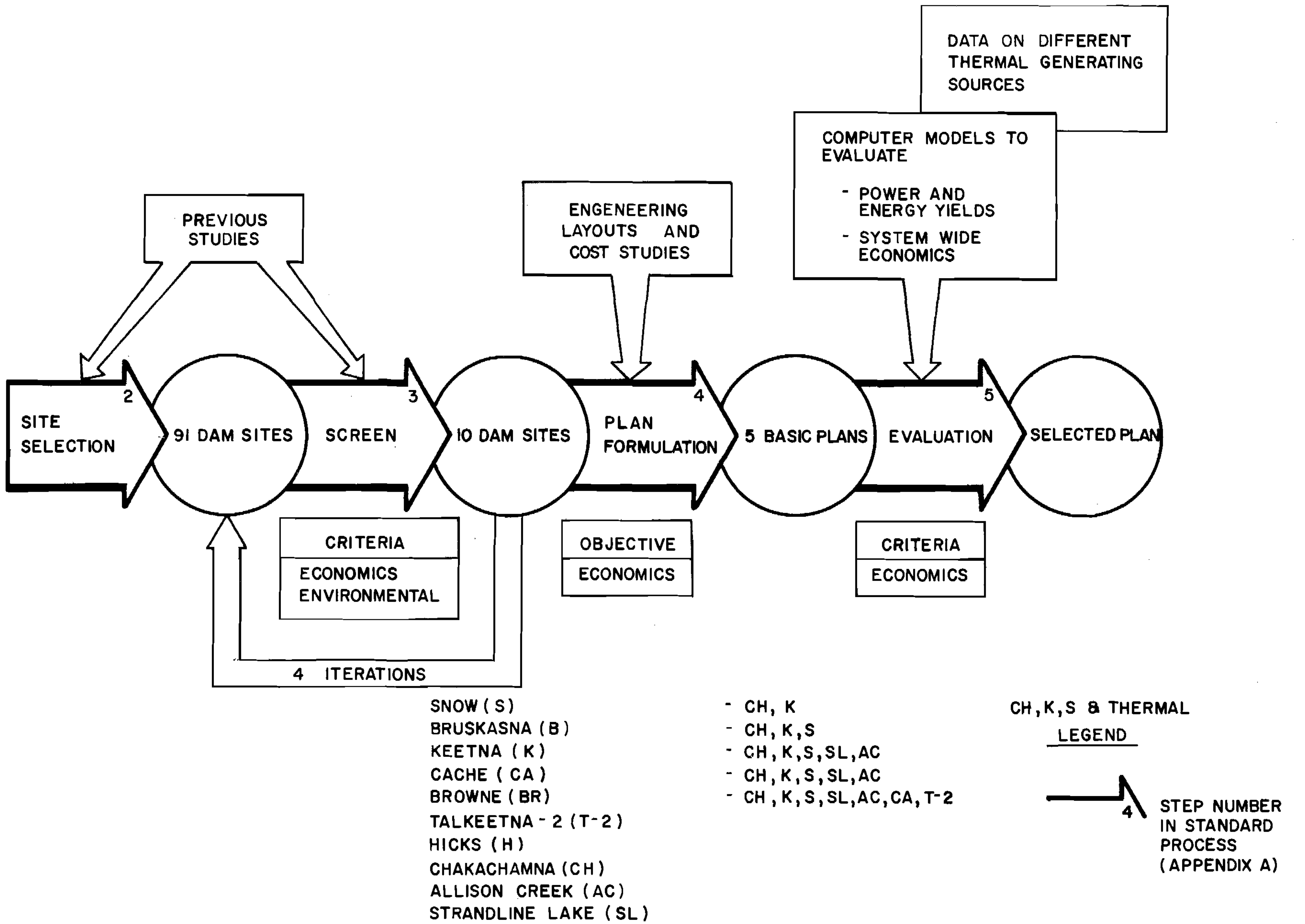
FIGURE 10.2



GENERATION SCENARIO INCORPORATING THERMAL AND ALTERNATIVE HYDROPOWER DEVELOPMENTS - MEDIUM LOAD FORECAST -

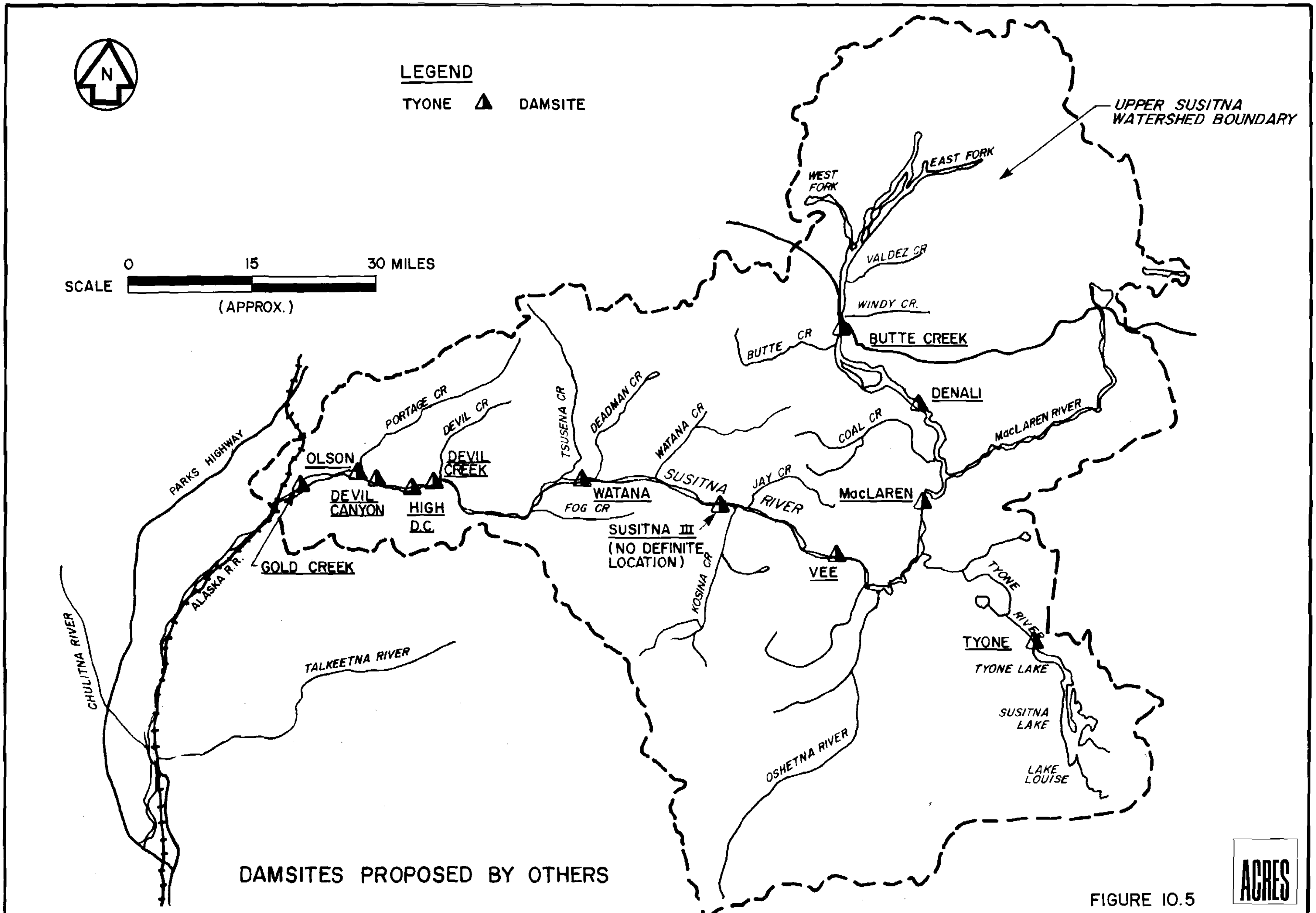
FIGURE 10.3

ACRES



FORMULATION OF PLANS INCORPORATING NON-SUSITNA HYDRO GENERATION

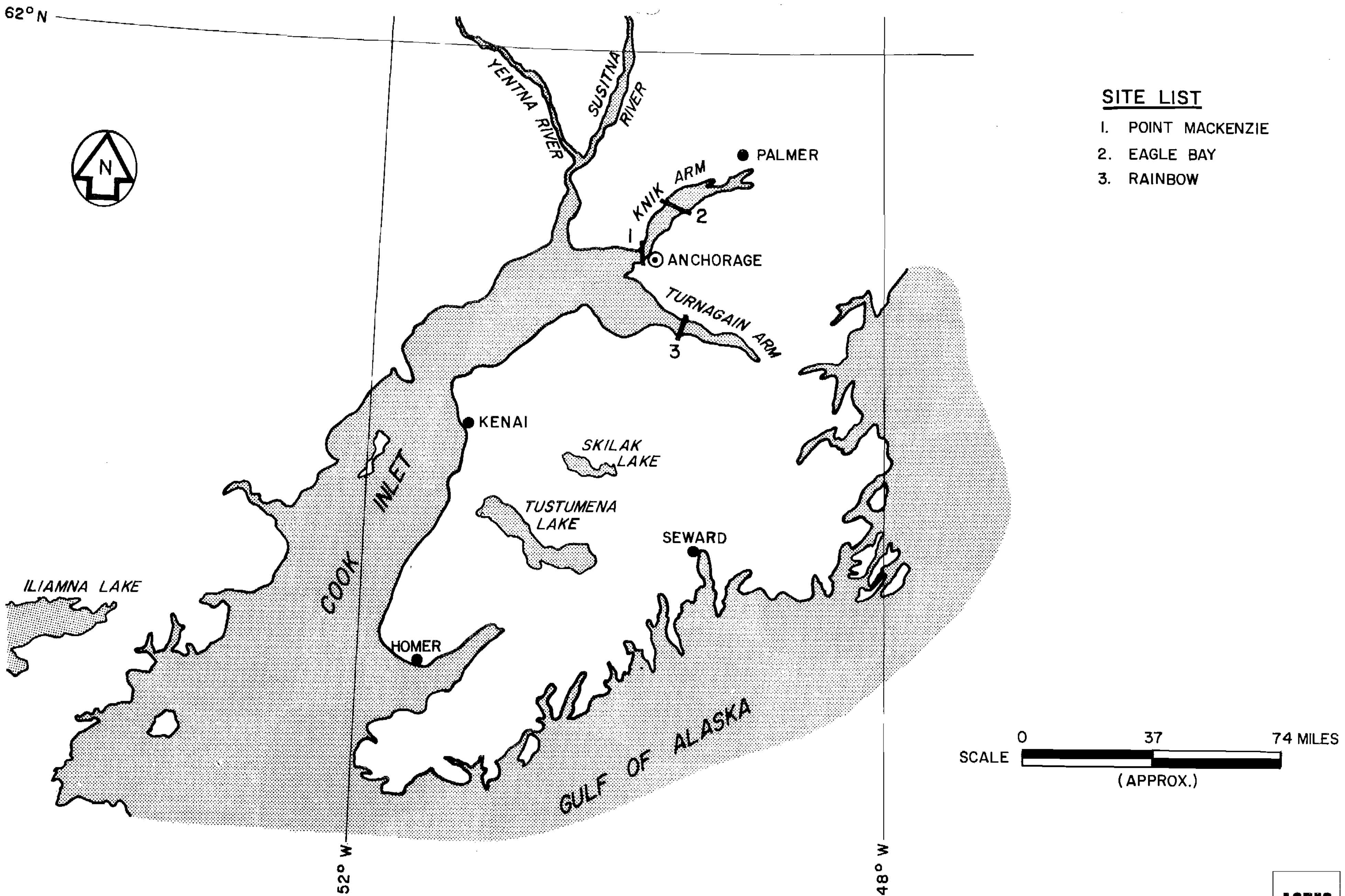
FIGURE 10.4



DAMSITES PROPOSED BY OTHERS

FIGURE 10.5

ACRES



POTENTIAL TIDAL POWER SITES

FIGURE 10.6

11 - LIST OF LITERATURE

The following is a list of literature used in the preparation of the Susitna Hydroelectric Project Environmental Studies Feasibility Report. The list is arranged by environmental report section. References which were cited in the text are denoted with an asterisk (*).

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