BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT

VOLUME 6A

EXHIBIT E

Chapter 3

FEBRUARY 1983

Prepared by:

ACRES

ALASKA POWER AUTHORITY

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FISH, WILDLIFE AND BOTANICAL RESOURCES

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

3 - FISH, WILDLIFE, AND BOTANICAL RESOURCES

1 - INTRODUCTION

This report discusses the fish, vegetation, and wildlife resources of the area that will be affected by the proposed Susitna Hydroelectric Project. Each of the major subsections (2 - Fish, 3 - Botanical Resources, and 4 - Wildlife) provides a baseline description of species and populations of the project area; an assessment of potential project impacts on this biota (assuming no mitigation); and a mitigation plan that explains how preliminary engineering design and construction planning have incorporated measures to avoid, minimize, or rectify potentially adverse effects of the project on the biological environment. In appropriate cases, resource management options to reduce or compensate for adverse impacts that cannot otherwise be mitigated are discussed.

1.1 - Baseline Descriptions

These sections describe the distributions and characteristics of biological populations and communities within the project area. The discussions are based on a thorough review of the scientific literature and emphasize documented studies conducted in preparation for the Susitna Hydroelectric Project by the Alaska Department of Fish and Game and professional consultants. They provide the most current available information through December 1982 on fish, vegetation, and wildlife of the project area.

Discussions of animals focus on vertebrate species: resident and anadromous fish, big game, furbearers, birds, and non-game (small) mammals. The plant descriptions deal with species aggregations that occur in recognizable patterns, such as vegetation communities and successional stages.

The baseline descriptions emphasize functional relationships among habitat components and animal communities. Factors that regulate species distribution and abundance receive particular attention, because knowledge of these regulating mechanisms can suggest where populations are most sensitive to potential disturbance. For example, water temperature and stream regimes are discussed as regulators of fish populations, and the role of plant communities in regulating wildlife populations is examined.

1.2 - Impact Assessments

It is expected that the distribution and abundance of fish, plant, and wildlife species in and around the area of the Susitna Hydroelectric Project will change as a result of project construction and operation.

1.2 - Impact Assessments

The impact assessments presented in this report are based, in part, on the project description presented in Exhibit A, project operations described in Exhibit B, the proposed construction schedule shown in Exhibit C, and an analysis of similar activities associated with large construction and hydroelectric projects in similar habitats. In addition, the Recreation Plan presented in Exhibit E, Chapter 7, has been reviewed as a proposed project action to determine its potential impacts on fish, vegetation, and wildlife. The impact assessments link predicted physical changes with habitat utilization to provide a qualitative statement of impacts likely to result from the Susitna Hydroelectric Project. Quantitative assessments are presented where justified by current knowledge and research techniques. Changes potentially resulting from the project are discussed with respect to specific project features and activities, assuming standard engineering design and construction practice without the incorporation of mitigation measures. Much of the discussion is based on professional judgment. Data collection and analysis programs currently underway will refine several of the impact assessments as explained in the text.

Although some project impacts, if not mitigated, will be adverse, other impacts will be innocuous and some will enhance fish or wildlife productivity. Therefore, potentially beneficial impacts are given balanced treatment with those to be mitigated. Each potential effect, together with the action responsible for it, is called an impact issue.

The identification and prioritization of impact issues have followed the procedures established by the Susitna Hydroelectric Project Fish and Wildlife Mitigation Policy (Alaska Power Authority 1982; Appendix 3.A). This policy was prepared by the Power Authority through a Fisheries Mitigation Core Group, a Wildlife Mitigation Core Group, and a Fish and Wildlife Mitigation Review Group. The core groups, consisting of professional consultants and agency representatives, developed the technical specifics of the mitigation policy. The review group, which consists entirely of state and federal agency representatives, evaluated draft stages of the mitigation policy and provided comments that were incorporated through successive revisions. The review group included representatives of the following resource agencies:

- Alaska Department of Fish and Game (ADF&G);
- Alaska Department of Natural Resources (ADNR);
- National Marine Fisheries Service (NMFS);
- U.S. Bureau of Land Management (USBLM);
- U.S. Environmental Protection Agency (USEPA); and
- U.S. Fish and Wildlife Service (USFWS).

In addition to procedures outlined in the Susitna Hydroelectric Project mitigation policy, criteria for assessing the relative importance of biological impact issues have been provided by (1) mitigation policies of the Alaska Department of Fish and Game (1982a) and the U.S. Fish and

Wildlife Service (1981); (2) letters and testimony by the Alaska Department of Fish and Game (1980, 1982b, 1983), the Alaska Department of Natural Resources (1982), the U.S. Fish and Wildlife Service (1979, 1980, 1981a, 1981b, 1982a-d, 1983), and the Susitna Hydroelectric Steering Committee (1981, 1982); and (3) discussions of impact issues in workshops (ESSA/WELUT/LGL 1982) and numerous other technical meetings involving Susitna project personnel and resource agency representatives.

All three mitigation policies imply that project impacts on the habitats of certain sensitive fish and wildlife species will be of greater concern than changes in distribution and abundance of less sensitive species. Sensitivity can be related to high human use value as well as susceptibility to change because of project impacts. The policies and comments also indicate that, for the Susitna Project area, vegetation is considered more important as a component of wildlife habitat than as a botanical resource in itself. Statewide policies and management approaches of resource agencies suggest that concern for fish and wildlife species with commercial, subsistence, and other consumptive uses is greater than for species without such value. These species are often large, sometimes numerous, and utilize a wide range of habitats, as well as having high human use value. Such characteristics often result in these species being selected for careful evaluation when their habitats are subjected to alternative uses. By avoiding or minimizing alterations to habitats utilized by these evaluation species, the impacts to other less sensitive species that utilize similar habitats can also be avoided or reduced.

The mitigation policies all agree that resource vulnerability is an important criterion for impact prioritization. Resources judged most vulnerable to potential project impacts have therefore been given highest priority in impact assessment and mitigation planning. Similarly, impact issues have been considered with regard to probability of occurrence. Where there is a high degree of confidence that an impact will actually occur, it has been ranked above impacts that are predicted to be less likely to occur. Also, the mitigation policies and agency comments indicate that impacts on animal productivity and population size through changes in habitat availability are of high concern. Behavioral responses that have the potential for producing population-level effects are also important. Adverse impacts that are longer lasting or irreversible have priority over short-term impacts.

1.3 - Mitigation Plans

Mitigation plans have been developed for identified impact issues in accordance with the sequence of steps defined by 40 CFR 1508.20, pursuant to the National Environmental Policy Act (42 USC 4321 et seq.).

1.3 - Mitigation Plans

The mitigation planning sequence includes, in priority order of implementation, the following steps:

- Avoiding the impact through project design and operation, or by not taking a certain action;
- Minimizing the impact by reducing the degree or magnitude of the action, or by changing its location;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected portion of the environment;
- Reducing or eliminating the impact over time by preservation, monitoring, and maintenance operations during the life of the action; and
- Compensating for the impact by providing replacement or substitute resources that would not otherwise be available.

This sequential strategy for mitigation option analysis and implementation is shared by all three mitigation policies applied to the project (Alaska Power Authority 1981, ADF&G 1982a, USFWS 1981). The relationships of steps within the sequence are shown in Figure E.3.1 and further compared in Table E.3.1.

The process by which mitigation will be implemented and continually refined throughout the life of the project is shown schematically in Figure E.3.2. The process involves the following steps:

- Impact issue evaluation:
  - . Identification of the nature and extent of impacts:
    - .. Populations
    - .. Subpopulations
    - .. Habitat types
    - .. Geographical areas
  - . Prioritization of impacts:
    - .. Ecological value of affected resource
    - .. Consumptive value of affected resource
    - .. Resource vulnerability
    - .. Confidence of impact prediction
    - .. Long-term vs. short-term impacts
- Option analysis procedure:
  - . Identification of practicable mitigation options:
    - .. Type of mitigation option
    - .. Sequence of implementation

1.3 - Mitigation Plans

. Evaluation of mitigation options:
.. Effectiveness of option
.. Conflicts with project objectives
.. Residual impacts

. Documentation of option analysis:
.. Impact issues
.. Mitigation options
.. Conflicts (if any) with project objectives

- Mitigation plan implementation:

. Engineering design and construction planning:
.. Participate in design development
.. Participate in preconstruction field surveys and site evaluations
.. Review designs, schedules, permit applications

. Construction and operation monitoring:
.. Review work accomplished
.. Evaluate degree of impact
.. Evaluate effectiveness of mitigation
.. Identify modifications to the mitigation plan
.. Submit regularly scheduled reports

. Mitigation plan modifications:
.. Propose modifications
.. Submit modifications for review
.. Implement and monitor approved modifications

Data from the baseline, impact, and monitoring studies will be used throughout the life of the project by the mitigation core and review groups to plan and continually refine the mitigation process in a flexible, adaptive fashion.

Mitigation measures proposed for the Susitna Hydroelectric Project may be classified within two broad categories:

- Modifications to design, construction, or operation of the project; and

- Resource management strategies.

The first type of mitigation measure is project-specific and emphasizes the avoidance, minimization, rectification, or reduction of adverse impacts, as prioritized by the Fish and Wildlife Mitigation Policy established by the Power Authority (1982) and coordinating agencies (ADF&G 1982a, USFWS 1981). As shown in Figure E.3.1, these measures must first be implemented to keep adverse impacts to the minimum consistent with project requirements. They involve adjusting or adding project features during design and planning so that mitigation becomes a built-in component of project actions.

When impacts cannot be fully avoided or rectified, reduction or compensation measures are justified. This type of mitigation can involve management of the resource itself, rather than adjustments to the project, and will require concurrence of resource management boards or agencies with jurisdiction over lands or resources within and around the project area.

Mitigation planning for the Susitna Hydroelectric Project has emphasized both approaches. The prioritized sequence of options from avoidance through compensation has been applied to each impact issue. If full mitigation can be achieved at a high priority option, lower options may not be considered. In the resulting mitigation plans, measures to avoid, minimize, or rectify potential impacts are treated in greatest detail. Specifications for facility siting and design, special mitigation facilities, construction procedures, and scheduling of project actions to mitigate adverse effects on the biota are presented. Guidelines for these specifications are summarized in Appendix 3.A.

Monitoring and maintenance of mitigation features to reduce impacts over time are recognized as an integral part of the mitigation process. The monitoring program will be developed during detailed engineering design and construction planning and will apply to fish, botanical resources, and wildlife.

Long-term management strategies for impact mitigation are discussed as potential options. The Power Authority is committed to evaluate and recommend such resource management options, and is sponsoring continuing research to define their need and application. Final agreement on measures will require interagency coordination.

2 - FISH RESOURCES OF THE SUSITNA RIVER DRAINAGE

2.1 - Overview of the Resources

2.1.1 - Description of the Study Area for Fish Resources

The study area for the Susitna Hydroelectric Project fish studies includes the Susitna River mainstem, side channels, sloughs, and mouths of major tributaries (Figure E.3.3). From the terminus of Susitna Glacier in the Alaska Mountain Range to its mouth in Cook Inlet, the Susitna River flows approximately 318 miles (530 km) and drains 19,600 square miles (50,900 km^2). The mainstem and major tributaries of the Susitna River, including the Maclaren, Chulitna, Talkeetna and Yentna Rivers, originate in glaciers and carry a heavy load of glacial flour during the ice-free months. There are many smaller, clear water tributaries that are perennially silt-free, except during floodflows, including Tyone River, Oshetna River, Portage Creek, Indian River, Kroto Creek (Deshka River) and Alexander Creek (Figures E.3.4 to E.3.6).

Streamflow is characterized by moderate to high flows between May and September and low flows from October to April. High summer discharges result from snowmelt, rainfall and glacial melt. Winter flows are almost entirely ground water inflow (see Chapter 2, Section 2.2.3). Freezeup begins in the higher regions in early October, and most of the river is ice free by late May.

Three study reaches have been defined for baseline data gathering and impact analysis based upon stream morphology, flow regime and anticipated impacts. These study reaches are: the impoundment from the Oshetna River (River Mile [RM] 236) to Devil Canyon (RM 152), Devil Canyon to Talkeetna (RM 98); and Talkeetna to Cook Inlet (RM 0).

2.1.2 - Data Collection and Analysis Methods

(a) Anadromous Adult Investigations

Methods utilized during 1981 and 1982 to enumerate adult salmon within the Susitna River drainage included side-scan sonar monitoring, fishwheel monitoring, tag and recapture estimates and ground/aerial spawning surveys.

Side-scan sonars and fishwheels were used to determine the upstream migration timing of sockeye, pink, chum, and coho salmon in the Susitna River from July through early to mid-September 1981 and 1982 at Susitna Station (RM 26), Yentna Station (Yentna RM 04), Sunshine Station (RM 80) and Talkeetna Station (RM 103) (ADF&G 1982a, Figures E.3.4 and E.3.5). The species composition of the daily catch of a nearby fishwheel was used to apportion side scan sonar counts. Fishwheels were also operated at Curry Station (RM 120), but without associated sonar counters.

2.1 - Overview of Resources

The side-scan sonar counts recorded at Susitna Station were not used for defining Susitna River salmon escapements because of suspected inaccuracy of counts caused by counter siting problems. Details of these problems are discussed in ADF&G (1983). Yentna Station (RM 04) sonar counts were considered suitable for reporting 1981 and 1982 Yentna River salmon escapements (ADF&G 1983).

A tag/recapture program was conducted to estimate numbers of the five salmon species passing upstream of Sunshine, Talkeetna and Curry Stations during 1981 and 1982 (ADF&G 1981a, 1982e). Salmon captured by fishwheels at the above sampling sites were measured, scales were removed for aging, then the fish were fitted with tags, color-coded for each site and released. Personnel surveyed all known and suspected salmon spawning tributaries (15) and sloughs (34) from RM 101.4 to 148.8 of the Susitna River at weekly intervals from late July through early October. All tagged and untagged salmon were counted. Species population estimates were then calculated from survey and fishwheel catch data at each station.

Salmon abundance within the entirety of sloughs and selected tributary index reaches was determined by the above surveys during 1981 and 1982. The tributary index reaches were within 0.5 mile (0.8 km) of the confluence with the Susitna River.

Spawning chinook salmon were counted from helicopters during 1981 and 1982 in the Indian River (RM 128.6) and Portage Creek (RM 148.8). Cheechako Creek (RM 152.5) and an unnamed creek (RM 156.8) were also surveyed in 1982. Other Susitna, Chulitna, and Talkeetna River drainage chinook salmon spawning areas were surveyed as part of an ongoing project since 1975 to determine chinook salmon escapement trends in the Cook Inlet drainage (ADF&G 1982a). The suitability of helicopter surveys as a census method for chinook salmon is discussed in Neilson and Green (1981).

Sockeye, chum, pink and coho salmon spawning activity in mainstem, side-channel, and tributary confluence locations of the lower and middle Susitna River was evaluated by a variety of techniques during 1981 and 1982 including: observation, electroshocking, drift gill netting, and egg pumping (ADF&G 1982a, 1982e). Egg pumping occurred after fish spawning activity terminated.

Adult chinook, chum, and coho salmon were fitted with internal radio transmitters at Talkeetna and Curry in 1981 and

1982. These fish were followed to evaluate directional movements, upstream migration rates, upstream migration extent, and spawning locations.

Stationary gill nets were operated near Devil Canyon at RM 150.2 at five-day intervals from late July to mid-September 1981 and 1982 to detect adult sockeye, chum, pink, and coho salmon.

The migration timing, upstream migration extent, and probable spawning areas of eulachon in the Sustina River were evaluated from mid-May through mid-June 1982 by a variety of techniques. Upstream migration timing was assessed by stationary gill nets placed at selected Susitna River estuary locations. The extent of upstream migration was determined by dip net and electrofishing. Eulachon spawning habitat was determined directly by searching for eggs in substrate samples and indirectly by evaluating the spawning condition of female smelt collected by dip net and electrofishing at suspected spawning sites.

During 1981 and 1982 the migration timing, upstream migration extent, and spawning habitat selection of Bering cisco in the Susitna River were investigated. A fishwheel used for salmon investigations was maintained through late September 1981 and 1982 to intercept cisco. Electrofishing was used to assess the upstream migration extent and spawning habitat selection by cisco, as evidenced by spawning condition of captured fish.

(b) Resident and Juvenile Anadromous Fish Investigations

Fish investigations also assessed the seasonal distribution and relative abundance of resident and juvenile anadromous fish in the Susitna River downstream from Devil Canyon (RM 152). Methods include baited minnow traps, trot (i.e., set) lines, hook and line, electrofishing, stationary and drift gill nets, and beach seines. Studies commenced in November, 1980 and are continuing. Selected tributaries and tributary confluences, sloughs, side-channel and mainstream locations from RM 10.1 to 148.8 of the Susitna River were sampled during the winter (November to April) and the open-water season (May to October). Fewer sites were sampled during the winter than during the open-water season because of sampling constraints, including the short length of daylight, and ice conditions.

Captured fish were processed and returned alive to their respective capture locations. All resident fish exceeding 8 inches (200 mm) in fork length were tagged with individually numbered tags.

2.1 - Overview of Resources

Lotic habitats at resident and juvenile anadromous fish sampling sites were described at the time of sampling to correlate seasonal fish distribution and abundance trends to selected physical/chemical lotic habitat components. Habitat variables measured included water temperature, dissolved oxygen, conductivity, turbidity, water depth, velocity and instream cover (ADF&G 1981c and 1982a).

Electrofishing was conducted during the 1982 open-water season along the Susitna River from Cook Inlet to Devil Canyon (RM 152) to tag resident fish and evaluate their seasonal distribution and movements within the Susitna River.

Individually identifiable radio transmitters of three-to-six months longevity were surgically implanted in adult rainbow trout and burbot from August through early October of 1981 and 1982 at various locations along the Susitna River downstream from Devil Canyon (RM 152). These tags were used to evaluate autumn and winter movements and overwintering locations. Conventional winter fish sampling techniques, under-ice submerged gill net sets and baited tip-ups, were used to detect non-radio-tagged burbot and rainbow trout.

A smolt trap was operated just upstream from Talkeetna at RM 103 from mid-June through early October 1982 to measure the out-migration of juvenile salmonids from the reach above Talkeetna.

Studies were conducted upstream from Devil Canyon (RM 152) to evaluate the seasonal distribution and abundance of Arctic grayling. Eight major clear-water tributaries, located between RM 173.9 and 226.9, were sampled monthly from June to September during 1981 and 1982. Arctic grayling exceeding 8 inches (200 mm) in fork length were tagged with individually numbered tags. Seasonal movements and population estimates were derived from fish recapture data. Segments of the lower one mile of the above streams were sampled for arctic grayling during 1981, whereas the entire reaches of six of the eight streams that would be inundated by the Watana impoundment were sampled during 1982.

Fish were sampled by baited minnow traps, trot lines and seine along the eight tributaries during 1981 and 1982 to detect the presence of other resident fishes. Selected physical/chemical lotic habitat data were collected along these tributaries during 1981 and 1982.

2.1 - Overview of Resources

2.1.3 - Threatened and Endangered Species

No threatened or endangered species of fish have been identified in Alaska. The USFWS (1982) does not list any fish species in Alaska as being threatened or endangered. The state of Alaska Endangered Species Act also does not list any fish species as endangered.

2.1.4 - Overview of Important Species

Fishery resources in the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvest and provide sport fishing for residents of Anchorage and the surrounding area. Anadromous species that form the base of commercial and non-commercial fisheries include five species of Pacific salmon: chinook, coho, chum, sockeye, and pink. Other anadromous species include eulachon and Bering cisco.

Important resident species found in the Susitna River drainage include arctic grayling, rainbow trout, lake trout, burbot, Dolly Varden, and round whitefish. Scientific and common names for all fish species identified from the Susitna drainage are listed in Table E.3.2.

The Susitna River is a migrational corridor, spawning area, and juvenile rearing area for five species of salmon from its point of discharge into Cook Inlet to Devil Canyon, where salmon are usually prevented from moving upstream by the water velocity at high discharge. The majority of the 1981 and 1982 Susitna River escapement of sockeye, pink, chum, and coho salmon spawned above the Yentna River confluence and below Curry Station. Sloughs between Devil Canyon and Talkeetna provide spawning habitat for pink, sockeye, and chum salmon. Juvenile chinook and coho salmon occur throughout the river below Devil Canyon, concentrating at slough and suitable mainstem habitat during winter and at tributary mouths during summer.

Rainbow trout and Dolly Varden were recorded at mouths of tributary streams. Rainbow trout do not occur upstream from Devil Canyon. Arctic grayling are the dominant species upsteam from Devil Canyon.

2.1.5 - Contribution to Commercial and Non-commercial Fishery

(a) Commercial

Figure E.3.7 shows the ADF&G upper Cook Inlet salmon harvest statistical areas. The upper and lower Cook Inlet commercial fishery harvests mixed stocks (Tables E.3.3 and E.3.4).

2.1 - Overview of Resources

With the exception of sockeye salmon, the majority of upper Cook Inlet Salmon production originates in the Susitna drainage (ADF&G 1982b). The long-term average annual catch of 2.8 million fish is worth approximately $17.9 million (ADF&G 1982b). The Susitna River is considered the most important salmon-producing system in upper Cook Inlet; however, the quantitative contribution of the Susitna River to the commercial fishery can only be estimated because of:

- The high number of intra-drainage spawning and rearing areas;

- The lack of data on other known and suspected salmon-producing systems in upper Cook Inlet;

- The lack of stock separation programs (except for sockeye salmon); and

- Overlap in migration timing of mixed stocks and species in Cook Inlet harvest areas.

Therefore, the following discussion of the contribution of the Susitna River to the upper Cook Inlet fishery as influenced by the above limitations is based upon:

- Historical sustained harvest in upper Cook Inlet;

- Escapement data from the ADF&G Susitna River tag/recapture studies for 1981 and 1982; and

- Conversion of the 1981 and 1982 escapement data past Talkeetna to an estimate of catch associated with that escapement using long-term average harvest to escapement ratios presented in Friese (1975).

Further discussion of the commercial salmon harvest is contained in Chapter 5, Section 3.7.1(b).

(i) <u>Sockeye</u>

The commercial sockeye harvest has averaged approximately 1.11 million fish annually in upper Cook Inlet over the last 28 years (Table E.3.3). The estimated 1981 and 1982 catches were 1.44 million and 3.24 million, respectively. The 1982 catch was the highest in the 29 years of record.

The estimated sockeye escapement in the reach above Talkeetna was 4800 in 1981 and 3100 in 1982 (Table E.3.5, Figure E.3.8). These represented 3.6 percent and 2.0 percent of the estimated sockeye escapement past Sunshine Station (Figure E.3.9). These escapements represent an estimated commercial catch of 14,400 in 1981 and 9300 in 1982, assuming a 3.0:1 harvest to escapement ratio (Friese 1975).

(ii) Chum

The upper Cook Inlet chum salmon catch has averaged approximately 614,000 fish annually since 1954 (Table E.3.3). The 1981 and 1982 estimated catches were 843,000 and 1,430,000, respectively. The 1982 catch of chum salmon was also the highest for the 29 years of record.

The 1981 and 1982 estimates of chum salmon escapement in the reach above Talkeetna were 20,800 and 49,100 (Table E.3.5., Figure E.3.8). These represented 7.9 percent and 11.4 percent of the estimated chum escapement past Sunshine Station (Figure E.3.9). These escapements represent an estimated commercial catch of 45,800 in 1981 and 108,000 in 1982, assuming a 2.2:1 harvest to escapement ratio (Friese 1975).

(iii) Coho Salmon

Since 1954, the upper Cook Inlet coho salmon commercial catch has averaged approximately 230,000 fish (Table E.3.3). The estimated 1981 and 1982 catches were 494,000 and 777,000, respectively, with the 1982 catch the highest during the 29 years of record.

The 1981 and 1982 estimates of coho salmon escapement in the reach above Talkeetna were 3300 and 5100 (Table E.3.5, Figure E.3.8). These represented 16.7 percent and 11.1 percent of the estimated coho escapement past Sunshine Station (Figure E.3.9). These escapements represent an estimated commercial catch of 7300 in 1981 and 11,200 in 1982, assuming a 2.2:1 harvest to escapement ratio (Friese 1975).

(iv) Pink Salmon

The upper Cook Inlet annual, average, odd-year harvest of pink salmon since 1954 is about 124,000 with a range of 12,500 to 554,000, while the average even-year harvest is approximately 1,701,000 with a range of 484,000 to 3,232,000 (Table E.3.3). The 1981 and 1982 catches were 128,000 and 789,000, respectively. The 1982 catch was the third lowest even-year catch recorded during the 29 years of record.

The estimates of pink salmon escapement in the reach above Talkeetna were about 2300 in 1981 and 73,000 in 1982 (Table E.3.5, Figure E.3.8). These represented 4.6 percent and 16.5 percent of the pink escapement past Sunshine Station (Figure E.3.9). These escapements represented an estimated commercial catch of 8700 in 1981 and 278,000 in 1982, assuming a 3.8.1 harvest to escapement ratio (Feiese 1975).

(v) Chinook

Since 1954, the commercial catch of Chinook salmon in upper Cook Inlet has averaged 19,500 (Table E.3.3). The upper Cook Inlet harvests for 1981 and 1982 were 11,500 and 20,600, respectively. Since 1964, the opening date of the commercial fishery has been June 25, and the Susitna River chinook salmon run begins in late May and peaks in mid-June. Thus, the majority of chinook have already passed through the area subject to commercial fishing. Estimates of chinook salmon escapement in the reach above Talkeetna were 10,900 in 1982 (Table E.3.5, Figure E.3.8). This represented 22.0 percent of the chinook escapement past Sunshine Station (Figure E.3.9).

(b) Non-Commercial Fishing

(i) Sport Fishing

Recent increases in population and tourism in Alaska have resulted in a growing demand for recreational fishing. Recreational fishing is now considered a significant factor in total fisheries management, especially in Cook Inlet where commercial and non--commercial user conflicts have developed (Mills 1980). The Susitna River and its major salmon and resident fish-producing tributary streams provide a multi-species sport fishery easily accessible from Anchorage and other Cook Inlet communities. In 1978, the Susitna River and its primary tributaries accounted for over 124,000 angler days of sport fishing effort, about 10 percent of the total angler days in Alaska (Mills 1980). In 1981, over 102,240 angler days were expended in the Susitna Basin, representing about 7 percent of the total angler days in Alaska (Mills 1982).

The sport fish harvests for 1978 through 1981 from the Susitna basin, based on mailing surveys to a sample of licenses, are shown in Table E.3.6 (Mills 1979, 1980, 1981, 1982).

The figures represent the sport fishing harvest throughout the Susitna basin and represent an area that is larger than that which could be affected by the proposed project (see Figures E.3.4 to E.3.6 for locations of major tributaries listed in Table E.3.6).

The 1978 and 1981 estimated catch of arctic grayling represents about 28 and 33 percent of the estimated harvest in south-central Alaska and the estimated catch of rainbow trout represented about 13 and 10 percent of the entire state harvest in 1978 and 1981, respectively. The 1978 and 1981 Susitna harvest of pink salmon represented about 39 and 13 percent of the total estimated harvest for south-central Alaska; the harvest of coho represented about 18 and 10 percent; and the harvest of chinook represented about 11 and 19 percent.

(ii) Subsistence Harvest

Although salmon form an important resource for many Susitna basin residents, subsistence fishing within the Susitna basin is an unquantified harvest. However, the Tyonek Village subsistence salmon fishery, approximately 30 miles (50 km) southeast of the mouth of the Susitna River, is supported primarily by Susitna River stocks (see Chapter 5, Section 3.7.1[d]).

2.2 - Species Biology and Habitat Utilization in the Susitna River Drainage

2.2.1 - Species Biology

(a) Salmon

(i) Chinook

A generalized periodicity chart summarizing significant chinook life stages in the Susitna River upstream from Talkeetna is illustrated in Figure E.3.10.

2.2 - Species Biology and Habitat Utilization

- Upstream Migration of Returning Adults

In the Susitna River below Talkeetna, the adult chinook salmon migration begins in late May and ends in early to mid-July. Historically, by July 1, 90 percent or more of the escapement have migrated past the Susitna Station (ADF&G 1972). Sonar counters and fishwheels installed in 1981 at stations identified in Figures E.3.4 and E.3.5 to monitor escapements for pink, chum, sockeye, and coho salmon provided incidental information regarding the timing of chinook runs. Fishwheel catches indicate that the 1981 migration ended by July 7 at the Yentna Station (ADF&G 1983). Initial sonar counts made at Sunshine Station also suggested that a significant segment of the 1981 escapement had migrated past this location prior to the June 23 sonar counter installation.

Similarly, a sizable portion of escapement had already passed the Talkeetna site before June 23, when the sonar counters became operational. Fishwheel catches and sonar counter data indicated that the migration had passed Sunshine Station by July 7 (ADF&G 1983). At Curry Station, the fishwheels clearly defined the beginning of the 1981 migration on June 16, the peak of migration on June 23, and the end of migration on July 4.

In 1982, the chinook migration at Sunshine Station began, reached a midpoint and ended June 18, June 30, and July 9, respectively (ADF&G 1983). At Talkeetna Station the 1982 chinook migration covered the period June 11 to August 5 with over 80 percent of the run passing Talkeetna from June 21 to July 12. A similar pattern was observed at Curry Station where 80 percent of the fishwheel captures were recorded from June 21 to July 12 (ADF&G 1982e). Catches at Sunshine, Talkeetna and Curry Stations peaked on June 30, July 3, and July 1, respectively.

Radio telemetry studies during June, July, and August of 1981 (ADF&G 1981b) indicated that the confluence of the Talkeetna, Chulitna, and Susitna rivers is a milling area for migrating adult chinook salmon. The four fish tagged at the Talkeetna site moved downstream and remained either at the confluence or downstream from this area for several days or weeks before moving back upstream.

This downstream movement was seen in 2 of the 12 fish that were radio tagged at the Curry site. Ten of the 12 fish tagged at the Curry Station site and three and four fish tagged at the Talkeetna site moved upstream, 11 entering one tributary and two into another. Of the three remaining fish, one moved downstream and held near Chase Creek, and two were lost because of technical difficulties with the transmitters.

- Population Estimates

Population estimates for chinook were calculated from tag/recapture data in 1982. Based on these estimates, 49,600 chinook reached Sunshine Station, 10,900 reached Talkeetna, and 11,300 reached Curry (ADF&G 1983; Table E.3.5).

- Age Composition

In 1981, four-year old individuals were dominant at Sunshine and Curry Stations, while at Talkeetna, six- and four-year olds were equally abundant. There was a higher percentage of younger fish, mainly three-year olds, at Sunshine Station than at either the Talkeetna or Curry Stations. Seven-year old fish were relatively scarce at Sunshine and Talkeetna, and none were identified from the Curry Station sample.

- Spawning Locations

Surveys of chinook salmon spawning areas were performed by helicopter; single-engine, fixed-wing aircraft; and by foot during the 1981 and 1982 investigations. Chinook appear to spawn in the tributaries rather than the mainstem of the Susitna River. Some of the more important spawning tributaries include Alexander Creek, Kroto Creek, (Deshka River), Willow Creek, Clear Creek (in the Talkeetna drainage), Chulitna River, Peters Creek, Lake Creek, Talachulitna River, Prairie Creek, Montana Creek, Indian River, and Portage Creek (Tables E.3.7 and E.3.8, Figures E.3.4 to E.3.6).

During 1982, adult chinook entered Devil Canyon and spawned at Cheechako Creek (RM 152.5) and an unnamed creek (RM 156.8). Peak spawning ground counts were 16 and 4 chinook at Cheechako Creek and the unnamed creek, respectively (ADF&G 1982e).

2.2 - Species Biology and Habitat Utilization

- Incubation and Emergence

In the Susitna River system, chinook spawn in July and early August (ADF&G 1981b). In Alaska, each female deposits from 4200 to 13,000 eggs, which incubate in the gravel through winter and hatch the following spring (Morrow 1980). The alevins generally remain in the redd until the yolk sac is absorbed and then emerge from the gravel and become free-swimming, feeding fry (Morrow 1980).

- Juvenile Behavior

The chinook fry school after emerging from the gravel but become territorial as they grow. Aquatic insect larvae, including chironomids and caddis flies as well as small crustaceans, are the major food sources for juvenile chinook salmon (ADF&G 1978). Analysis of adult chinook salmon scales shows that most Susitna River salmon remain in freshwater for one year before smolting (ADF&G 1981b).

Juvenile chinook salmon were captured throughout the study area from Alexander Creek (RM 10.1) upstream to Portage Creek (RM 148.8). Collection techniques and data summaries for juvenile collections are detailed in ADF&G (1981d). Populations varied in abundance and distribution by river habitat type and seasonal period.

During winter, most juveniles were captured at mainstem and slough sites. All juvenile chinook salmon captured at the mainstem and slough sites are believed to have migrated from associated streams, since no chinook salmon spawning has been recorded in the mainstem or sloughs. The migration to mainstem and slough sites during late fall is apparently the result of icing and lowered flow in tributaries (ADF&G 1981d).

During summer, juvenile chinook were also captured throughout the study area below Devil Canyon from Portage Creek to Alexander Creek. The reach between Devil Canyon and Talkeetna accounted for 34 percent of the total captures, and the remainder were captured between Talkeetna and Cook Inlet (ADF&G 1981b). Tributary mouths appear to provide important rearing habitat during summer months.

Clear-water sloughs supply summer rearing habitat and may be important year-round rearing habitat.

During the 1981 field program, two age groups of juvenile chinook salmon, representing brood years 1979 (1+) and 1980 (0+), were identified from scale analysis and length distribution. Age 1+ were observed between Devil Canyon and Talkeetna at 45 percent of sites surveyed during the first two weeks of June. Captures decreased and terminated in July. Age 1+ were not captured after August in the Talkeetna to Cook Inlet reach. It was concluded that the decreasing numbers of age 1+ chinook salmon were a result of smolt out-migration (ADF&G 1981d). The highest catches of juvenile chinook in 1982 smolt trap samples from Talkeetna Station was recorded between mid-June and mid-July, but the trap may have been deployed after the peak of out-migration (Table E.3.8).

Catches of age 0+ in mainstem and slough habitats increased from late June to a high in early September for the Devil Canyon to Talkeetna reach. This was interpreted as an indication that juvenile distribution expanded from tributary streams and stream mouth sites into mainstem and slough sites as summer progressed (ADF&G 1981d).

Interpretation of present and past surveys of the Susitna River and its tributaries have resulted in the following conclusions relating to abundance, distribution, and out-migration (ADF&G 1981d).

- Juvenile chinook salmon populations are not static but vary in abundance and distribution by season within the various river habitats;

- Redistribution of juvenile chinook from areas of emergence (tributaries) to more favorable habitat at the mouths of tributaries and sloughs begins as the fish reach a mobile state;

- Tributary mouths appear to provide important milling and rearing areas for juveniles during summer months;

- During late fall, tributary discharge decreases causing the juveniles to move into the mainstem and slough habitats to overwinter; and

- The majority of juvenile chinook spend one winter in freshwater before migrating to the sea. Out-migration in the reach from Devil Canyon to Talkeetna peaks prior to early June and terminates by the end of July throughout the drainage.

(ii) Sockeye

A generalized periodicity chart summarizing significant sockeye life history stages in the Susitna River upstream from Talkeetna is illustrated in Figure E.3.10.

- Upstream Migration of Returning Adults

The escapement, migrational timing, and population estimates of adult sockeye moving up the Susitna River to spawning grounds were measured in 1981 and 1982 by side-scan sonar, fishwheel catches, and tag/recapture studies. The five escapement monitoring stations were established in early June 1981 at locations identified in Figure E.3.4 to E.3.6. Operating dates, equipment used, and methodology are described in detail in ADF&G (1981b); results are reported in ADF&G (1983).

- At Susitna Station, the 1981 sockeye salmon migration extended from July 4 to July 31 (ADF&G 1983). Because July 10 and July 23, 75 percent of the escapement passed Susitna Station. Fishwheel catch per hour indicated that the peak migration occurred between July 10 and July 19. In 1982, the migration began, reached midpoint and ended July 18, July 25, and August 5, respectively (ADF&G 1983).

- At the Yentna Station, the migration began on July 10, and the run ended by July 30. Between July 12 and 23, 75 percent of the total fish escapement had passed Yentna Station. Fishwheel catches indicated that the migration peak was between July 13 and 15. In 1982, the majority of the migration passed Yenta Station between July 18 and August 6 (Figure E.3.11).

- At Sunshine Station, the 1981 migration began on approximately July 16, and ended on August 26. Between July 19 and 28, 75 percent of the sockeye migrated past this location. Based upon fishwheel catch records, the peak of the migration occurred between July 18 and 23. The majority of the 1982 sockeye migration passed Sunshine Station between July 27 and August 18 (Figure E.3.11).

- At Talkeetna Station, the 1981 migration commenced on July 23 and was completed by August 26. A majority of the total count was made between July 23 and August 6. It appeared from fishwheel catch data that the migration peak occurred between July 27 and August 1. The majority of the 1982 migration passed Talkeetna Station between July 27 and August 18.

- At Curry Station, the 1981 migration commenced on July 23, was over on August 22. In 1982, the majority of the sockeye were counted between July 27 and August 28 (ADF&G 1983).

From the sonar data, the 1981 migration chronology of sockeye salmon indicates that those fish passing Susitna Station enroute to the Yentna River made the 6.2-mile (10-km) trip in one day or less. Individuals migrating past Susitna Station toward Sunshine Station covered this distance in 1981 in an average of 8 days (6.8 miles per day, or 11 km per day), and reached Talkeetna Station in an average time of 13 days (4.6 miles per day, or 7.7 km per day). Tag/recapture data indicated that the mean travel rate between Sunshine and Talkeetna Stations and Curry Station in 1981 was between 3.0 and 4.4 miles per day (5.0 and 7.7 km per day) (Table E.3.10). In 1982, the mean travel rate was between 2.7 and 3.4 miles per day (4.5 and 5.7 km per day).

- Population Estimates

Population estimates were calculated based upon tagging operations at Sunshine, Talkeetna, and Curry Stations and upon side-scan sonar counts at Yentna Station. Sockeye estimates indicated that approximately 139,000 sockeye migrated past Yentna Station, 133,000 migrated past Sunshine, 4800 past Talkeetna, and 2800 past Curry Station in 1981. In 1982 the values were 114,000, 151,000, 3100, and

1300 past the same stations, respectively (Table E.3.5). The 95 percent confidence limits on the Petersen population estimates and components used to calculate them are discussed in ADF&G (1981b, 1983).

The Susitna River drainage escapement can be approximated by the summation of Yentna River and Sunshine Station escapement estimates. The result is an underestimate, however, because the escapement estimates do not include escapements to other tributaries downstream from RM 77. Using these estimates, the minimum sockeye escapement to the Susitna River was 272,000 in 1981 and 265,000 in 1982 (ADF&G 1983).

- Age Composition

Sockeye salmon age composition analyses in 1981 indicate that a majority of the fish sampled at each station were age 5_2, (i.e. five years old with two years in freshwater). The second most abundant age group was 4_2 followed by age 6_2. Five-year-old fish comprised approximately 86 percent of the return at Susitna and Yentna Stations, 73 percent at Sunshine and Talkeetna Stations, and 70 percent at Curry Station (ADF&G 1981a). Further age composition data are given in Table E.3.11.

- Spawning Locations

Surveys of sockeye spawning areas in 1981 and 1982 were conducted in the mainstem Susitna River between Devil Canyon and Cook Inlet from late July through September using drift gill nets, electroshocking equipment, and egg deposition pumps. Susitna River tributary streams and sloughs between Devil Canyon and the Talkeetna River confluence were surveyed on foot for spawning salmon from late July through September. The detailed methodology used is given in ADF&G (1981b and 1983). No mainstem spawning was observed for sockeye salmon. In the Devil Canyon to Talkeetna reach, adult sockeye were observed in 12 of the 33 sloughs surveyed and in Lower McKenzie Creek in 1981; while in 1982, spawning sockeye were observed in 10 of 34 sloughs and Portage Creek (Figures E.3.12 - E.3.17). Peak spawning occurred during the last week of August and the first three weeks of September. Of the locations listed, sockeye were most numerous in Sloughs 8A, 9B, 11, and 21.

- <u>Utilization of Spawning Habitat</u>

The weekly counts of spawning sockeye obtained by ADF&G in 1981 and 1982 for the sloughs upstream from Talkeetna (ADF&G 1981a and 1983) were converted to estimates of the total number of spawning sockeye in each slough. The counts were converted to estimated total numbers using the estimating technique described in Bell (1980), i.e., the counts are plotted by day, the area under the resulting curve is calculated and divided by the estimated average stream life of the spawning fish. The sockeye stream life was assumed to be 12 days, based on estimates derived for the Chakachamna system on the west side of Cook Inlet (Bechtel Civil and Minerals, Inc. 1983). The estimated numbers of spawning sockeye using each slough in 1981 and 1982 are presented in Table E.3.12. The total number of sockeye estimated to have spawned in sloughs during 1981 and 1982 was 2315 and 1402.

The 1981 and 1982 total estimates for slough spawning sockeye are 83 and 108 percent of the Peteren population estimates of sockeye passing the Curry fishwheel station in the respective years. These high percentages, combined with the lack of spawning sockeye in mainstem and tributary spawning areas, indicate that sockeye spawning is confined to sloughs upstream from Talkeetna. Over 98 percent of the sockeye spawning in sloughs in 1981 and 1982 spawned in 11 sloughs: 8A, 8B, 8C, Moose, B, 9, 9A, 9B, 11, 17, and 21 (Figures E.3.12 to E.3.17; Table E.3.12). If it is assumed that there was a 1:1.3 ratio to female sex ratio in 1981 and 1.5:1 ratio in 1982 (ADF&G 1983) and that sockeye require 72 square feet of spawning habitat per redd (Foerster 1968, Bell 1980), then the 1981 spawning sockeye used 2.2 acres (0.9 ha) and 1982 spawning sockeye used 0.9 acres (0.4 ha) of slough spawning habitat.

Scale patterns of sockeye returning to Chulitna and Talkeetna River spawning areas and of sockeye spawning in sloughs upstream from Talkeetna were examined as part of the ADF&G stock separation program. The analysis indicated that the sockeye spawning in sloughs upstream from Talkeetna in 1982 were not a separate stock, but were strays from Chulitna River and Talkeetna River stocks.

- Incubation and Emergence

Based upon information from other sockeye-producing spawning areas, mature females typically produce from 2500 to 4300 eggs (Morrow 1980). Hatching normally occurs during the period January-March. Fry remain in the gravel until emerging from April through June. In most systems, fry move into lakes or other rearing areas after emerging from the gravel and spend 1 to 3 years in freshwater before migrating to feeding grounds in the Pacific Ocean (Morrow 1980). In the Devil Canyon to Talkeetna reach, however, there are no lakes for sockeye rearing, and sockeye fry originating in the sloughs appear to leave this reach during the first summer (Table E.3.9) (ADF&G 1981d, 1982f).

- Juvenile Behavior

Results of the 1982 smolt trapping program indicate that age -0 sockeye leave the Devil Canyon to Talkeetna reach in June and July (Table E.3.9). The peak of out-migration appears to occur in the first two weeks of July. There was a gradual decline in catch rate from August through September.

(iii) Coho

A generalized periodicity chart summarizing significant coho life history stages in the Susitna River upsteam from Talkeetna is illustrated in Figure E.3.10.

- Upstream Migration of Returning Adults

The escapement, migrational timing, and population estimates of adult coho salmon migrating up the Susitna River to spawning grounds were determined from results of apportioned, side-scan sonar counts, fishwheel catches, and tag/recapture estimates (ADF&G 1981b and 1983).

2.2 - Species Biology and Habitat Utilization

The peak of the coho salmon migration into the Susitna River drainage occurs in mid-July and early August, but can extend from late June into September. Migration periods for each sampling station are summarized below.

- At the Susitna Station in 1981, the migration began on July 23 and ended August 9. Approximately 75 percent of the fish passed this station between July 23 and August 16. Fishwheel catches indicated a migration peak occurring between July 25 and July 30. During 1982, the majority of the run passed Susitna Station between July 19 and August 9 (Figure E.3.19).

- At the Yentna Station in 1981, the migration began on July 22 and ended on August 17. The major portion of the run passed this location between July 23 and August 16. The peak of migration occurred between July 23 and August 6. During the 1982 migration, the majority of the coho passed Yentna Station between July 20 and August 24.

- At the Sunshine Station, the beginning of the 1981 migration was August 1, and the run ended on August 3. Between August 4 and August 24, 75 percent of the migration run occurred. The peak migration period was between August 18 and August 25. In 1982, the majority of the coho passed Sunshine Station between August 3 and August 23 (Figure E.3.19).

- At the Talkeetna, the beginning of the 1981 migration was August 6, and September 1 was the termination. The majority of coho were counted between August 11 and September 1. The migrational peak period occurred between August 19 and August 30. In 1982, the coho passed Talkeetna Station primarily between August 5 and September 2.

- Curry Station fishwheel catches indicated that the 1981 coho migration began at this location on August 5 and ended on September 4. During 1982, the Curry fishwheels caught coho from August 2 to September 11 (ADF&G 1982e).

2.2 - Species Biology and Habitat Utilization

In 1981, the average travel time for coho salmon migrating between Susitna Station and Yentna Station was two days, a travel rate of approximately 3.1 miles (5 km) per day. In 1981, coho had a migration rate of 3.9 miles (6.5 km) per day from Susitna Station to Sunshine Station and 4.0 miles (7 km) per day between Sunshine and Talkeetna Stations. In 1982, the mean rate between Sunshine and Talkeetna was 5.3 miles (8.5 km) per day. Tag/recapture of marked coho indicated that between Talkeetna and Curry Stations the mean travel rate in 1981 was approximately 11.3 miles (18.8 km) per day, while in 1982 the mean rate was 10.0 miles (16 km) per day (Table E.3.10) (ADF&G 1983).

- Population Estimates

Population estimates derived from tagging and recapture operations at Sunshine Station, Talkeetna, and Curry stations and sonar counts at Yentna Station indicated that approximately 17,000 coho migrated past Yentna Station, 19,800 migrated past Sunshine Station, 3300 past Talkeetna Station and 1100 past Curry Station in 1981, while 34,100, 45,700, 5100, and 2400 passed the same stations in 1982 (Table E.3.5).

The Susitna River drainage estimated escapement of coho, derived by summing the Yentna Station and Sunshine Station estimates, was 36,000 in 1981 and 79,800 in 1982. This estimate does not include coho migrating to tributaries downstream from RM 77, except for the Yentna River (ADF&G 1983).

- Age Composition

The majority of individuals sampled for age analyses in 1981 were 4_2 from the 1977 brood year, followed by age 3_2 from the 1978 brood year. Less than 10 percent of the 1981 coho escapement consisted of other age groups (ADF&G 1981a).

- Spawning Locations

Surveys of spawning areas were conducted in the mainstem, sloughs, and tributaries of the Susitna

River (ADF&G 1981b). Of 12 mainstem spawning sites identified in 1981, coho salmon were the only species observed at 1 site, and at 2 other mainstem sites coho and chum salmon shared the spawning sites. In 1982, 4 of 11 mainstem spawning sites between Devil Canyon and Talkeetna contained coho, and all 4 were shared with chum salmon (Table E.3.13). Coho salmon were not observed spawning in any sloughs during 1981. In 1982, coho were observed in 3 sloughs but actually spawned in only 1, Slough 8A (Figures E.3.12 to E.3.17, ADF&G 1983). Spawning coho were observed in 8 of 15 creeks surveyed between Devil Canyon and Talkeetna in 1981 and 12 of 19 creeks surveyed in 1982 (ADF&G 1981a, 1982e). The survey data indicate that the spawning peak occurred in the second and third weeks of September.

- Incubation and Emergence

Based upon information on coho salmon life history in Alaska (Hartman 1971), each female deposits an average of 3500 eggs, which incubate in the gravel through winter. Upon emergence in March and April, fry generally occupy areas with adequate cover, low-water velocities, and moderate water temperature for optimum growth (Gray et al. 1978; Delaney and Wadman 1979; Watsjold and Engel 1978). Drifting aquatic insect larvae are the major diet items of juvenile coho salmon in spring; adult stages of these insects are major feed items during summer and fall (ADF&G 1978). Juvenile pink, chum, and sockeye salmon can also be an important supplemental food source to age 1 or older coho salmon (Roos 1960; Scott and Crossman 1973).

- Juvenile Behavior

The geographical and seasonal distribution, relative abundance, age composition, and smolt migration timing of coho salmon reared in the Susitna drainage are summarized below based on studies by ADF&G (1981d).

Juvenile coho salmon were captured throughout the study area between Alexander Creek (RM 10.1) and Slough 21 (RM 141.8) at 55 of the 99 sample sites sampled between November 1980 and October 1981. Collection techniques and data summaries for juvenile collections are detailed in ADF&G (1981d).

During the winter and spring (November-May), juvenile coho salmon most frequently occurred at tributary mouth sites between Talkeetna and Cook Inlet, and at mainstem and slough sites between Devil Canyon and Talkeetna (Table E.3.13). During June-September 1981, juvenile coho salmon occurred most frequently at tributary mouths in the Talkeetna to Cook Inlet reach (Table E.3.14).

During June-September 1981, juvenile coho salmon occurred most frequently at tributary mouths in the Talkeetna to Cook Inlet reach (Table E.3.15).

Three age groups of juvenile coho salmon as indicated by length frequency and scale analysis were collected at various habitat locations in the Devil Canyon to Cook Inlet reaches of the Susitna River from November 1980 to October 1981. These fish represented brood years 1978 (2+), 1979 (1+), and 1980 (0+). Distribution of 0+ fish progressively increased from June when they were first captured, through September. Occurrence was consistently higher at tributary mouth locations than at mainstem or slough locations throughout the summer. The frequency of occurrence in tributary mouths increased during the summer indicating that age 0 coho were moving out of the tributaries. The incidence of 1+ coho salmon in catches of all habitat locations between Devil Canyon and Talkeetna also increased from late July to September. Between Talkeetna and Cook Inlet, a similar pattern was observed. Catch rates then decreased in late September for 0+ and 1+ throughout the Devil Canyon to Cook Inlet reach (ADF&G 1981b).

Age 2+ individuals were captured during the winter sampling period, November 1980 to May 1981, but were not captured after May in the Devil Canyon to Talkeetna reach and after mid-June in the Talkeetna to Cook Inlet reach. This finding indicates that the predominate age group for smolts in the Susitna River is age 2+ and that in the Devil Canyon to Talkeetna reach the majority of smolting took place prior to June 1, 1981 and between Talkeetna to Cook Inlet by June 15. The 1982 smolt trapping program at Talkeetna further supports this finding. Peak catches of juvenile coho were recorded shortly after the trap was set in mid-June, and catches declined rapidly thereafter (Table E.3.9). If the peak outmigration occurred in early June, the trapping program caught the end of the migration.

(iv) Chum

A generalized periodicity chart summarizing significant chum life history stages in the Susitna River upstream from Talkeetna is illustrated in Figure E.3.10.

- Upstream Migration of Returning Adults

The escapement, migrational timing, and population estimates of adult chum salmon migrating up the Susitna River to spawning grounds were measured by side-scan sonar and fishwheel catches in combination with tag/recapture estimates (ADF&G 1983). Apportioned sonar counts and fishwheel catches show that the chum salmon migration began during the second week in July and ended during early September. The peak migration period in the Susitna River upstream from Talkeetna was from late July until late August.

- At Susitna Station, the 1981 migration began on July 10 and ended on August 25. Between July 15 and August 7, 75 percent of the escapement occurred. Fishwheel catches indicated that the migration peak occurred between August 3 and 7. In 1982, the majority of the chum migration passed Susitna Station between July 19 and August 10.

- The 1981 migration began at Yentna Station on July 18, and ended on August 21. A majority of the fish were counted between July 18 and August 15. Fishwheels operated at Yentna Station indicated that the migration run reached its peak July 23. In 1982, the majority of the run passed Yentna Station between July 20 and August 18 (Figure E.3.18).

- At the Sunshine Station the 1981 migration commenced on July 26, and ended on approximately August 5. Seventy-five percent of the fish were counted between July 27 and August 24. The peak of chum migration at Sunshine Station, as indicated by fishwheel catches, occurred on August 19. In 1982, the chum migration passed Sunshine Station primarily between July 29 and August 21.

- At Talkeetna Station, the beginning of the 1981 migration was approximately July 28, and the migration ended on September 4. In 1982, the chum migration passed Talkeetna Station between August 2 and August 22 (Figure E.3.18).

- Fishwheel catches at Curry Station indicated that the chum migration began around August 5, and the migration terminated on September 2. In 1982, the majority of the chum were caught between August 3 and August 26 (ADF&G 1983).

  In 1981, chum salmon averaged 4 days travel time between Susitna Station and Yentna Station, which corresponds to a travel rate of 1.6 miles (2.7 km) per day. Average travel time between Susitna Station and Sunshine Station was 10 days, a travel rate of 5.6 miles (9.3 km) per day. The migration period between Susitna Station and Talkeetna Station averaged 14 days or approximately 5.6 miles (9.3 km) per day. Chum salmon tagged at Sunshine Station in 1981 took between 2 and 9 days to reach Talkeetna Station, with a mean travel rate of 4.6 miles (7.7 km) per day (Table E.3.10). Between Talkeetna Station and Curry Station the number of travel days in 1981 ranged from 1 to 24 days with a mean travel rate of approximately 3.8 miles (6.3 km) per day. In 1982, the mean travel rate of tagged chum was 7.4 miles (12.3 km) per day between Sunshine and Talkeetna and 6.5 miles (10.9 km) per day between Talkeetna and Curry (Table E.3.10) (ADF&G 1983).

- Population Estimates

Population estimates derived from tag and recapture data at Sunshine, Talkeetna, and Curry Stations and sonar counts at Yentna Station indicated that approximately 19,800 chum migrated past Yentna Station, 263,000 migrated past Sunshine, 20,800 passed Talkeetna Station and 13,100 past Curry Station in 1981, while 27,800, 430,000, 49,100, and 29,400 passed the same stations in 1982 (Table E.3.5).

The Susitna River drainage estimated escapement of chum, derived by summing the Yentna Station and Sunshine Station estimates, was 283,000 in 1981 and 458,000 in 1982. This estimate does not include chum migrating to tributaries downstream from RM 77, except for the Yentna River (ADF&G 1983).

2.2 - Species Biology and Habitat Utilization

- Age Composition

At each sampling site, age 4 chum salmon from the 1977 brood year dominated the catch in 1981, comprising, on the average, 86 percent of the sample. Second in abundance were age 5 fish, followed by age 3 individuals (ADF&G 1981a).

- Spawning Locations

Spawning surveys conducted in the mainstem of the Susitna River from Devil Canyon to Cook Inlet revealed that 10 of 12 mainstem spawning locations identified in 1981 were occupied by chum salmon, while 10 of 11 mainstem spawning locations identified between Devil Canyon and Talkeetna in 1982 were utilized by chum salmon (Table E.3.13). Spawning surveys conducted in sloughs and tributaries between Devil Canyon and Talkeetna documented the presence of chum salmon in 20 of the 33 sloughs surveyed in 1981 and 17 of the 34 sloughs surveyed in 1982 (Figures E.3.12 to E.3.17). Spawning chum were also found within the survey reaches of 8 of 15 tributaries surveyed in 1981 and 8 of 19 tributaries surveyed in 1982 between Devil Canyon and Talkeetna. The peak spawning activity in the sloughs occurred during the last two weeks of August and the first two weeks of September. Based on the stream survey data, the peak spawning period was approximately one week earlier in streams than in slough spawning areas.

- Utilization of Spawning Habitat

The weekly counts of spawning chum salmon obtained by ADF&G in 1981 and 1982 for the sloughs upstream from Talkeetna (ADF&G 1981a and 1983) were converted to an estimate of the total number of spawning chum in each slough using the technique described for sockeye salmon. For chum, the stream life was assumed to be 10 days, based on estimates derived for the Chakachamna system (Bechtel Civil and Minerals, Inc. 1983). The estimated numbers of spawning chum using each slough in 1981 and 1982 are presented in Table E.3.12. The total number of chum estimated to have spawned in sloughs upstream from Talkeetna during 1981 and 1982 was 3526 and 3674.

The 1981 and 1982 estimates of the total number of chum spawning in sloughs upstream from Talkeetna are 27 and 12 percent of the Petersen population estimate for chum passing the Curry fishwheel station. The remainder primarily spawned in tributaries, with some also spawning in the mainstem (Figures E.3.12 to E.3.17 and Table E.3.13). Over 97 percent of the chum spawning in sloughs in 1981 and 1982 spawned in 13 sloughs: 8, 8A, 8B, 8C, Moose, A', B, 9, 9A, 9B, 11, 17, and 21. If it is assumed that the sex ratio was 1:1 (ADF&G 1983) and that chum salmon need 81 square feet (7.3 m^2) of spawning habitat per redd (Hale 1981), chum used 3.3 acres (1.3 ha) and the 1982 chum used 3.4 acres (1.4 ha) of slough spawning habitat.

- Incubation and Emergence

Based on information from other chum salmon-producing areas in Alaska, females produce an average of 3000 eggs (Hartman 1971). Limited sampling of pre-emergent chum fry conducted April 11, 1981 near Gold Creek (RM 136.8) revealed that yolk sac absorption was 95 to 100 percent complete. Following emergence, usually during April or May, chum fry remain in the river for only a short period before out-migrating. Limited beach seine sampling resulted in the capture of 1650 chum fry on June 19, 1981 in Slough 11.

- Juvenile Behavior

In 1982, a smolt trap was utilized at Talkeetna to evaluate the timing of downstream smolt migrations. The trap was monitored from June 18 through October 12. Peak catches of chum fry were recorded during the first week of sampling (Table E.3.9); thus, it is possible that out-migration peaked prior to the June 18 sampling effort.

(v) Pink

A generalized periodicity chart summarizing pink salmon life history stages in the Susitna River is illustrated in Figure E.3.10.

- Upstream Migration of Returning Adults

Pink salmon have a 2-year life cycle that results in two genetically distinct stocks occurring in each stream. The stocks are called "odd-" or "even-year" on the basis of the year in which adults spawn. In the Susitna drainage, the even year runs are numerically dominant. The escapement migrational timing and population estimates of pink salmon migrating up the Susitna River to spawning grounds was measured by side-scan sonar and tag/recapture (ADF&G 1983).

- At Susitna Station, the 1981 migration period started around July 10 and the migration terminated on August 21. Seventy-five percent of the escapement passed this station between July 15 and August 3. Fishwheel catches indicated that the migration peak occurred between July 21 and August 3. In 1982, the majority of the pink salmon passed Susitna Station between July 21 and August 5 (Figure E.3.20).

- At the Yentna Station the 1981 migration began on approximately July 10 and ended on August 24. The majority of the pink salmon passed this station between July 21 and August 6. Fishwheel catches indicated that the migration peak occurred on July 30. The 1982 pink migration primarily passed Yentna Station between July 23 and August 7.

- The 1981 migration reached Sunshine Station on approximately July 26, two weeks later than Susitna Station, and was completed on August 14. Seventy-five percent of the migration was counted between July 28 and August 9. Fishwheel catches showed the migration peak to have occurred August 1. The majority of the 1982 migration passed Sunshine Station between July 29 and August 3 (Figure E.3.20).

- The 1981 migration period at Talkeetna Station was similar to that at Sunshine Station: the migration reached Talkeetna on July 29, and ended on August 20. Seventy-five percent of the escapement passed Talkeetna Station between July 29 and August 10. Peak fishwheel catches occurred between August 1 and 10. In 1982, the majority of the pink salmon passed Talkeetna Station between August 12 and August 13.

- At Curry Station, the 1981 pink migration began on July 30 and terminated approximately August

21. Between August 4 and 19, 75 percent of the escapement passed Curry Station. In 1982, the pink salmon run passed Curry Station between August 2 and August 13 (ADF&G 1983).

The migrational rates based on sonar and fishwheel catch data indicate that pink salmon took an average of three days to reach Yentna Station from Susitna Station, a distance of approximately 6.2 miles (10 km). This represents an average travel speed of approximately 1.9 miles (3 km) per day. Between Susitna Station and Sunshine Station, the average travel time was 9 days with a travel rate of 6.2 miles (10 km) per day. Travel time between Sunshine and Talkeetna Stations averaged 2.6 miles (4.3 km) per day. Tag and recapture data on pink salmon indicate that travel time between Sunshine and Talkeetna Station in 1981 ranged from 2 to 30 days. In 1981, pink salmon averaged three days of travel time or 6.0 miles (9.9 km) per day between Talkeetna and Curry Station (Table E.3.10). In 1982, the mean travel time for tagged pink salmon was 7.4 miles (12.3 km) per day between Sunshine and Talkeetna and 10.0 miles (16.7 km) per day between Talkeetna and Curry (Table E.3.10) (ADF&G 1983).

- Population Estimates

Population estimates derived from tag and recapture data at Sunshine, Talkeetna, and Curry Stations and sonar counts at Yentna Station indicate that approximately 36,100 pink salmon migrated past Yentna Station, 49,500 pink salmon passed Sunshine Station, 2,300 passed Talkeetna Station, and 1,000 passed Curry Station in 1981, while 447,000, 443,000, 73,000, and 59,000 passed the same stations in 1982 (Table E.3.5).

The Susitna River drainage estimated escapement of pink salmon, derived by summing the Yentna Station and Sunshine Station estimates, was 85,600 in 1981 and 890,000 in 1982. This estimate does not include pink salmon migrating to tributaries downstream from RM 77, except for the Yentna River (ADF&G 1983).

- Spawning Locations

Spawning surveys revealed that few pink salmon spawn in mainstem habitats. During 1981, no mainstem spawning areas were found, while in 1982 two mainstem spawning areas were found between Devil Canyon and Talkeetna (Table E.3.12). In 1981, 3 of the 33 surveyed sloughs contained spawning pink salmon while in 1982, 10 of 34 surveyed sloughs between Devil Canyon and Talkeetna supported spawning pink salmon (Figures E.3.12 to E.3.17, ADF&G 1983). Most pink salmon spawned in tributary habitats, with 9 of the 15 tributaries surveyed in 1981 and 14 of 19 tributaries surveyed in 1982 containing spawning pink salmon (ADF&G 1981a, 1982e).

- Utilization of Spawning Habitat

The weekly counts of spawning pink salmon obtained by ADF&G in 1981 and 1982 for the sloughs upstream from Talkeetna (ADF&G 1981a and 1983) were converted to an estimate of the total number of spring pink salmon in each slough using the technique described for sockeye salmon. The stream life was assumed to be 7 days, based on estimates derived for the Chakachamna system (Bechtel Civil and Minerals, Inc. 1983). The estimated numbers of spawning pinks using each slough in 1981 and 1982 are presented in Table E.3.12. The total number of pinks estimated to have spawned in sloughs upstream from Talkeetna during 1981 and 1982 was 28 and 735.

The 1981 and 1982 estimates of the total number of pink salmon spawning in sloughs upstream from Talkeetna represent 2.8 and 1.2 percent of the Petersen population estimate for pink salmon passing the Curry fishwheel station. Most pink salmon were found to spawn in tributaries (Figures E.3.12 to E.3.17).

If it is assumed that the sex ratio was 1:1 and that pink salmon need 6.3 square feet (0.6 m^2) of spawning habitat per redd (Bell 1980), then the 1981 spawning pinks used 90 square feet (8.1 m^2) and the 1982 pinks used 2313 square feet (208.2 m^2) of slough spawning habitat.

- Incubation and Emergence

Based on general information from other pink salmon-producing areas in Alaska, female pink salmon produce an average of about 2000 eggs (Bailey 1969). Eggs hatch in mid-winter about 3 to 5 months after they are spawned, but fry remain in the gravel until April or May. Spawning and time of fry emergence are related to temperature regimes of the streams (Bailey 1969). Pink salmon fry are about 1 inch (2.5 cm) long when they emerge and migrate directly to the sea. Limited information obtained in spring 1981 for the Susitna drainage indicates that sac fry of pink salmon appeared on March 23 in Slough 11 and Indian River and yolk sac absorption for pink fry was approximately 50 percent on April 11 (ADF&G 1981d).

(b) Other Anadromous Species

(i) Bering Cisco

The Bering cisco is a coregonid (i.e., whitefish) that occurs from the Beaufort Sea to Cook Inlet. Although Bering cisco have been collected from upper Cook Inlet and the Knik Arm, the species was not known to inhabit the Susitna River drainage prior to 1980-1981 ADF&G studies. Interior and western Alaskan populations appear to contain both anadromous and freshwater resident forms. Susitna River Bering cisco appear to be anadromous (ADF&G 1981e).

Bering cisco were collected in the lower Susitna River between RM 70 and RM 98.5 in 1981 and 1982, respectively (ADF&G 1983). In 1981, the migration began in August at Susitna Station (RM 26) and on September 8 at Sunshine Station (RM 80). At Sunshine, the 1981 fishwheel catches peaked on September 21. In 1982, the migration began on August 7 at Susitna Station and on September 4 at Sunshine Station. The 1982 fishwheel catches peaked on September 27.

During 1981, spawning concentrations were identified at RM 78 - 79, 76 - 77.5 and 75. In 1982, spawning was confirmed at RM 76.8 - 77.6 and 81.2 (ADF&G 1983). It is suspected that spawning may occur throughout the reach between RM 30 and RM 100 (ADF&G 1981e). Spawning substrates were composed primarily of 1- to 3-inch (2.5- to 7.5-cm) gravel. Peak spawning occurred during the second week of October in both 1981 and 1982 (ADF&G 1983). Susitna River Bering cisco appear to occupy their spawning grounds 15 to 20 days. After spawning, these fish probably rapidly migrate downstream to sea (ADF&G 1981e).

(ii) Eulachon

The eulachon is an anadromous member of the smelt family that 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 close proximity to shore. In the northern portion of its range, eulachon spawn in May and June.

During 1982, the spawning migration appeared to be composed of two segments: an early run that started prior to May 16 and ended about May 31, and a late run that started about June 1 and ended about June 10 (ADF&G 1983). The second run was approximately 4.5 times larger in numbers than the first run. Eulachon are known to utilize the Susitna River system at least as far upstream as RM 58 in 1981 and RM 48 in 1982 (ADF&G 1982d).

In 1982, eulachon spawned in riffle areas and offshore of cut banks on unconsolidated sands and gravels. Spawning occurred at water temperatures between 37.4 to 49.1°F (3.0 to 9.5°C) (ADF&G 1983).

(c) Resident Species

(i) Dolly Varden Char

Dolly Varden char are an important sport fish and are distributed throughout Alaska where the species occupy aquatic habitats ranging from coastal streams to lakes and streams located far inland. Dolly Varden occur in Alaska in both anadromous and freshwater resident forms. However, indications are that in the Susitna drainage, Dolly Varden are not anadromous. Dolly Varden reach sexual maturity at age 4 to age 7 and normally spawn in clear-water streams during the fall.

Two Dolly Varden were taken in the Devil Canyon to Cook Inlet reaches from November, 1980 through May 1981. From June through September 1981, the catch of Dolly Varden increased. Catches of Dolly Varden peaked in June and late September; largest catches per unit effort were recorded at the mouths of tributary streams. Higher catches during late June and July coincided with peak migration periods of pink, chum, and sockeye salmon; higher catches during

September can be attributed to Dolly Varden moving into their spawning areas within clear-water tributaries and the beginning of out-migration into their wintering habitat. Sexually mature fish were found in September and October, and Dolly Varden displaying spawning behavior were observed on October 2 in Upper Indian River (ADF&G 1981e).

(ii) Rainbow Trout

Rainbow trout are one of the most valued sport fishes in North America. Susitna River sport harvest and effort levels have steadily increased over the past five years. The general life history is discussed by Morrow (1980) and Scott and Crossman (1975).

Low numbers of rainbow trout were collected throughout the winter months (November-May 1981) from RM 10 to RM 133 at seven tributary and four mainstem locations. During summer (June-September 1981), rainbow trout were captured from RM 10 to RM 148 near Portage Creek but not in the impoundment reach. Portage Creek represents one of the northernmost boundaries of the native range for rainbow trout in North America. The most consistent catches were associated with tributary mouths and sloughs between Devil Canyon and Talkeetna. Age groups 2, 4, and 5 made up a majority of the fish collected (ADF&G 1981e).

Catches peaked in late June between Devil Canyon and Talkeetna and again during the first two weeks of September throughout the drainage. The June peak was probably the result of the presence and movements of spawning fish, while the high in September probably reflected movement downstream into winter habitat (ADF&G 1981e).

(iii) Arctic Grayling

The arctic grayling is also one of the most important sport fishes of Alaska and northern Canada and contributes substantially to the sport fishery of the Susitna River and its tributaries. Grayling are generally residents of clear, cold streams and lakes (Scott and Crossman 1973).

Silt-laden glacial systems, such as the Susitna River, are believed to support relatively few grayling; however, such systems may provide essential migratory channels and over-wintering habitat (ADF&G

1981e). The arctic grayling is characterized by Reed (1964) as a migratory species. During spring breakup from April to June, adults migrate from ice-covered lakes and large rivers into clear, gravel bottomed tributaries to spawn (Morrow 1980). In Alaska, arctic grayling reach sexual maturity at age 2 to 7 years and are capable of spawning several times during their lifetime. After spawning, the adults move from the spawning areas to spend the rest of the summer feeding on aquatic and terrestrial insects taken from the aquatic drift (Vascotto 1970). A downstream migration back to overwintering areas in large rivers and deep lakes occurs in late August to mid-September (Pearse 1974).

During 1980-81 ADF&G studies, grayling were captured between Alexander Creek (RM 10.1) and the upper reaches of the impoundment area. Catches were low throughout winter months, but increased sharply in May, both below and above the impoundment area. Below the impoundment area, catches increased during the period May 1-15 and then declined at all habitat locations throughout the summer until catches again increased at tributary mouths in September. Within the impoundment area, catches were highest in June and July and declined towards the end of summer and early fall (Table E.3.16).

Changes in distribution and catch of grayling are associated with migrational movements to spawning grounds and overwintering areas that may have been initiated in response to surface water temperature (ADF&G 1981e). Below the impoundment area, high catches in May are associated with migration from the mainstem Susitna into nonglacial tributary spawning grounds. High catches in September are probably associated with migrational movements back to overwintering areas in the mainstem Susitna.

Within the impoundment area in May and June, grayling appeared to move upstream into pool-type habitat in tributaries where they had spawned. The movement may be associated with increasing water temperatures (ADF&G 1982a). As surface water temperatures began to decrease in late summer and early fall, lower numbers of fish were observed in these upper stream reaches and tagged fish were observed migrating downstream. Small-scale distribution patterns and abundance within upper stream reaches are determined primarily by streamflow and channel morphology.

2.2 - Species Biology and Habitat Utilization

Observed preferred grayling habitat characterized by high pool/riffle ratios, large, deep pools, and moderate velocities (ADF&G 1982a).

Additional distribution patterns in the impoundment reach were documented by catching, tagging and releasing 2511 grayling during 1981 (ADF&G 1981f). Many tributary fish moved into the Susitna mainstem for overwintering. Analysis indicates that there is a wide range of intertributary migration as well as movement within individual tributaries.

Grayling population estimates were calculated for the reaches of major tributaries to be inundated by the Devil Canyon and Watana impoundments (Table E.3.17). The 1982 estimates were based on tag/recapture data during July and August 1982, while the 1981 estimates were based on results from the entire summer period. There were insufficient tag returns from Watana Creek in 1981 and from Tsusena and Fog creeks in 1982 to derive estimates. The 1982 population estimate was calculated for age groups (Table E.3.18). The total grayling population in the impoundment zone was estimated to be at least 16,000 in 1982, while the population of grayling over 8 inches (20 cm) was estimated to be 9375, excluding Watana Creek in 1981 (ADF&G 1981f, 1982e). In 1982, summer density estimates ranged from 323 grayling per mile (1.6 km) in Watana Creek to 1835 grayling per mile (1.6 km) in Deadman Creek for the reaches to be inundated (Table E.3.17).

There was no evidence of spawning at any sampling locations between Devil Canyon and Cook Inlet. In the impoundment reach grayling fry were captured at the Watana Creek study area in 1981, indicating spawning in the immediate vicinity. It is thought that adult grayling from the mainstem Susitna below Devil Canyon migrate into nonglacial tributaries to spawn some time in late April or May. In the impoundment reach, spawning may occur from late April through early May under ice or during mid-May spring floods in the lower reaches of all eight tributaries sampled. Suitable spawning habitat, i.e., proper spawning gravel in pool regions, was observed in all streams studied (ADF&G 1982a). Assuming favorable spawning conditions exist, it is not likely that spawning habitat significantly limits grayling in the impoundment area (ADF&G 1982a). Availability of summer feeding areas is probably more significant in limiting the grayling population in this area.

(iv) Lake Trout

Near the Watana impoundment area, lake trout were collected in Sally Lake and Deadman Lake. Both lakes support a limited sport fishery. Of the two lakes, only Sally Lake will be inundated by the proposed Watana impoundment. All lake trout were captured within 130 feet (39.4 m) of the shoreline in less than 6 feet (1.8 m) of water. A total of 35 lake trout were captured: 32 in Sally Lake and 3 in Deadman Lake. All Deadman Lake fish were captured by hook and line, while gill nets produced the highest catches in Sally Lake. Gill nets were not used in Deadman Lake. Age group 5 dominated the catch. During mid-August, both pre- and post-spawning lake trout were captured in Sally Lake.

(v) Burbot

In Alaska, burbot are distributed in the Susitna and Copper rivers, Bristol Bay drainages, throughout the interior, and in the Arctic (McLean and Delaney 1978). Burbot mature between ages 3 and 6 in Alaska and may live a total of 15 to 20 years. Spawning generally occurs between mid-December and April in shallow water over a substrate of sand or gravel. Movements and migration of burbot are not well documented. Burbot support a limited sport fishery in the Susitna River.

During winter (November 1980 through May 1981) burbot were caught throughout the reach between Devil Canyon and Cook Inlet. The highest catch rates were recorded downstream from Talkeetna, at the mouth of Kroto Creek and Alexander Creek. Two mainstem sites upstream from Talkeetna, one 2 miles (3 km) below Portage Creek (RM 146.9) and one upstream from Lane Creek (RM 114.4) produced the highest catches of burbot in this reach (ADF&G 1981e).

During the summer of 1981, burbot catch rates for Talkeetna to Cook Inlet reach and in the impoundment reach upstream of Devil Canyon increased as summer progressed, reaching a maximum in September. In the Devil Canyon to Talkeetna reach, catches declined from early June until mid-July, then increased throughout the remainder of summer. Burbot catches during low flows were restricted to the mainstem, deeper sloughs, and side-channels in the Devil Canyon to Talkeetna reach. During high flows, burbot were captured at a greater number of locations including shallow side channels, sloughs and tributary mouths (ADF&G 1981e).

Age groups 4, 5 and 6 made up the majority of burbot caught in the impoundment zone and age groups 4, 5 and 8 made up the majority of burbot caught between Devil Canyon and Cook Inlet. Population estimates were not made in any of the reaches (ADF&G 1981e, 1981f).

Although no observations of spawning burbot were made during the 1980-81 season, collection of female burbot in early September with well-developed eggs and collection of spent burbot from November to May suggested that lower Susitna River burbot spawn between November and January. Both sexually ripe and unripe mature burbot observed from June through September indicate that nonconsecutive spawning occurs for Susitna River burbot. Location of spawning and rearing areas in the Susitna were not documented, although juvenile burbot were captured at Alexander and Kroto creeks (ADF&G 1981e).

(vi) Round Whitefish

Round whitefish are distributed across all of arctic and interior Alaska. They are normally abundant in clear-water streams with gravel-cobble substrate but can be found in large glacial rivers and lakes. Whitefish mature at age 4-7, and spawning occurs in late September through October over gravel substrate in the shallows of rivers and inshore areas of lakes (Morrow 1980). Upstream migrations are often associated with spawning.

Round whitefish were captured at four locations (all below Talkeetna) during the 1980-1981 winter studies. The fish were all captured as they moved upstream during March, April, and May. The presence of whitefish near the mouths of tributary streams in the March to May period after none had been caught in the same locations between November-February, indicates a general pattern of movement into the various tributaries in the spring (ADF&G 1981e).

During the summer, the incidence of whitefish caught in the Devil Canyon and Cook Inlet reach was higher than during the winter and peaked in June and September. The most productive sites were Anderson Creek, Sloughs 10 and 11, and Portage Creek mouth. The most prevalent age groups were ages 3, 4, and 5 (ADF&G 1981e). Round whitefish were also captured upstream of Devil Canyon during the summer. Jay and Kosina Creeks were the most productive areas for round whitefish in the impoundment reach. Age group 7 was encountered most frequently (ADF&G 1981f).

(vii) Humpback Whitefish

In Alaska, there is a complex of three closely related species of whitefish: humpback whitefish, Alaska whitefish, and lake whitefish. Because of similar appearance and overlapping distributions, the data collected on the three species have been reported under the general heading of humpback whitefish. The Alaska whitefish is not recognized by AFS/ASIH (Robins et al. 1980).

Alaska whitefish are largely stream inhabitants and undertake lengthy up- and downstream migrations to and from spawning grounds. Spawning occurs in September and October. Lake whitefish reside primarily in lakes but spawn in rivers or creeks between October and December. Humpback whitefish is apparently the only species of whitefish that can be considered anadromous, although migration habits vary widely in different systems. Spawning migrations generally begin in June with spawning in October and November (Morrow 1980).

During the 1980-81 winter, a single humpback whitefish was captured below the mouth of Montana Creek. During the summer of 1981, peak catches were made in early June and late September (ADF&G 1981e). Largest catches per unit effort were recorded at the mouth of Anderson Creek, the mouth of Portage Creek, and a slough at RM 23.8. Generally, humpback whitefish were most abundant in the Talkeetna to Cook Inlet reach. Fish collected ranged from ages 2 to 7; age 4 was the predominant age group (ADF&G 1981e).

No evidence of humpback whitefish spawning was collected at any sampling location between Devil Canyon and Cook Inlet in 1981. Inspections of dissected fish caught from mid-September to early October showed well developed gonads, but fish were not ready to spawn. Because no whitefish were caught or observed after October 7, it was speculated that spawning must occur after this date (ADF&G 1981e).

(viii) Longnose Sucker

The longnose sucker, the only representative of the sucker family found in Alaska, is ubiquitous and occurs in most of the mainland drainages. Spawning usually occurs in spring after ice out. Spawning runs (i.e., movement from lakes into inlet streams or from deep pools into shallower, gravel-bottomed stream areas) are initiated when water temperatures exceed 5°C (41°F). Longnose sucker feed almost exclusively on benthic invertebrates but will occasionally ingest live or dead fish eggs (Scott and Crossman 1973).

Longnose sucker were collected throughout the study area from Cook Inlet to the upper reaches of the impoundment area. No specimens were collected during winter sampling. During the summer of 1981, adult suckers were captured in the impoundment zone from May-September, generally near the confluence of mainstem river and the tributary streams (ADF&G 1981f). During the same period, the percentage of habitat locations where fish were collected was relatively high in June from Devil Canyon to Cook Inlet with lower catches recorded during July and August. The percentage increased again during September between Talkeetna and Cook Inlet but not between Devil Canyon and Talkeetna. Anderson Creek, Kroto Creek, Sunshine Creek, and the mainstem of the Susitna River (RM 40.6) were the most productive locations. The most prevalent ages were 4, 5 and 6.

(ix) Threespine Stickleback

Threespine stickleback generally inhabit shallow areas in bays and estuaries and in rivers not more than a hundred miles upstream from the coast. Wintering areas tend to be in deeper waters. Stickleback feed mainly on small crustaceans and insects.

Threespine stickleback were collected throughout the Devil Canyon to Cook Inlet reach of the Susitna River. Catches per unit effort in the Lower River were higher, overall, than those in the Devil Canyon to Talkeetna reach. The number of habitat locations that produced threespine stickleback was highest in June and declined steadily to September. The higher percentage in early summer indicated that fish had been involved in spring spawning movement. This activity was not observed in September (ADF&G 1982a).

(x) Cottids

All sculpin species captured in the Susitna River have been grouped under the general heading of cottids. The slimy sculpin is the most common cottid found in the Susitna, although there is a possibility that three other species may be present below the impoundment area.

Between November 1980 and October 1981, cottids were captured throughout the Devil Canyon to Cook Inlet reach of the Susitna River (ADF&G 1981e). The catch rate in the impoundment area from May to September was 0.11 per trap day (ADF&G 1981f). The percentage of sampling locations producing catches in the Lower River attained a high in late August and a low in late July. For the Devil Canyon to Talkeetna reach, there was a high in early July and a low in late September. Habitats associated with clear-water tributaries consistently produced the highest catches throughout the study area from Cook Inlet to above the proposed impoundment zone (ADF&G 1981e, 1981f).

(xi) Lamprey

The arctic lamprey, one of four lamprey species that occurs in Alaska, was observed in the Susitna River during 1981 (ADF&G 1981e). The Pacific lamprey, an anadromous species that has been reported to range into the lower Susitna River (Morrow 1980), was not observed during 1981 investigations.

Some populations of arctic lamprey are composed of both anadromous and freshwater forms. It was speculated that a portion (30 percent) of the Susitna population is anadromous based on analysis of length frequencies (ADF&G 1981e). The anadromous form is parasitic; hosts include adult salmon, trout, whitefish, ciscoes, suckers, burbot, and threespine stickleback (Heard 1966). The freshwater forms have been reported to be both parasitic and nonparasitic.

2.2 - Species Biology and Habitat Utilization

Arctic lamprey spawn during the spring in streams of low-to-moderate flow. Eggs develop into a larval stage, which spend one to four years burrowed into soft substance. After an indefinite period, adults migrate upstream to spawn.

Arctic lamprey were captured at 14 sampling sites between RM 10 and RM 101 that were surveyed from November 1980 through September 1981. During the winter surveys, the only habitat site to produce arctic lamprey was Rustic Wilderness, where one lamprey was captured. All other lamprey were collected during the summer months. Lamprey were not collected in the impoundment area (ADF&G 1981e).

The highest catch frequency was recorded during the September 1 to 15 sampling period. All lamprey taken during this period were collected at tributary sites downstream from RM 50.5. The lowest incidence of capture for this species during the summer was observed in the July 16-31, 1981 sampling period (ADF&G 1981e).

2.2.2 - Habitat Utilization

The physical parameters associated with the free-flowing characteristics of the Susitna River determine the quality of the aquatic habitat available to the fishery resources. Alteration of these physical parameters would ultimately affect associated fish populations. The complex relationship between the aquatic habitat and the physical parameters that exist is compounded by the effects of seasonal and yearly fluctuations in physical habitat components.

Most of the baseline description of the Susitna River aquatic habitat presented below is based on reports of habitat evaluation studies conducted by ADF&G during the 1980-81 field season (ADF&G 1981c, 1982a) and by results of continuing studies during the 1981-82 season. These studies have identified seasonal habitat characteristics of selected anadromous and resident species within the study area.

Species occurrence, relative abundance, and the significance of aquatic habitat to species and important life history stages are discussed below for each of the three defined study reaches: Oshetna River to Devil Canyon, Devil Canyon to Talkeetna, and Talkeetna to Cook Inlet.

2.2 - Species Biology and Habitat Utilization

The gradation of habitat types available in the Susitna River were grouped into four classes: mainstem, side channel, slough, and tributary mouth. Each of these habitat types encompass a range of physical attributes rather than a set of fixed characteristics (Trihey 1982d).

- Mainstem habitat consists of that portion of the Susitna River that conveys streamflow at all times. Both single and multiple channel reaches are included in this category. The physical characteristics of mainstem habitat in the Susitna River reflect the integration of the streamflow, sediment, and thermal regimes of the upstream basin with the topography and geology of a particular river segment. Ground water and tributary inflow are generally minor contributors to streamflow within a river segment, although tributaries provide more than half of the flow in the river downstream from Talkeetna. Total sediment load and suspended sediment concentrations are dependent upon glacial melt and rainfall or snow melt. Stream temperature responds primarily to meteorological conditions and directly influences intergravel water temperatures.

- Side-channel habitat consists of those portions of the Susitna River that normally convey streamflow only during the high flow open-water season but which become appreciably dewatered during periods of low flow. In general, shallower depths, lower velocities, and smaller streambed materials occur in side channels than occur in the mainstem. However, the streamflow, sediment, and thermal regimes of side-channel habitats respond directly to mainstem conditions. Tributary and ground water inflow may prevent side-channel habitats from becoming completely dewatered as mainstem flows receed; however, the presence of these inflows is not considered a necessary component to define side-channel habitat.

- Sloughs are overflow channels that convey glacial meltwater from the mainstem during moderate and high-flow periods and that convey clear water from local runoff and ground water during intermediate and low-flow periods. Sloughs are generally located on the downstream side of old, well-vegetated point bars. The streambed elevation in a slough is notably higher at the upstream entrance than at the mouth, and sloughs often function like small stream systems. A portion of the channel in each slough, which may vary in length from several hundred to several thousand feet, conveys water without the influence of the mainstem backwater.

  The physical characteristics of slough habitat appear to depend upon the interaction of four principal factors: the discharge of the mainstem Susitna River, surface runoff patterns from the adjacent catchment area, ground water flow contributions, and ice processes within the mainstem river system. These four principal factors interact to varying degrees during different portions of the year to provide a unique habitat type.

The amount of streamflow in the mainstem of the Susitna River influences habitat conditions in the sloughs: (1) by causing a backwater effect at the mouth of the slough which facilitates access into the slough and (2) by overtopping the upstream end of the slough at high flows, thereby flushing debris and fine sediments from the slough. Local surface runoff contributes a greater portion of the clear-water flow to the slough than the ground water upwelling during the ice-free period of the year. During winter months, ground water provides nearly all of the flow in the sloughs. The ground water upwelling in the sloughs maintains open-water conditions in the slough during the winter season.

Spring breakup combined with high flows in the mainstem river also maintains the character of the slough habitat by flushing debris and beaver dams from the sloughs, which can be barriers to upstream migrants during periods of low flow. Mainstem river winter ice processes also contribute to the maintenance of ground water upwelling in the sloughs during the winter season.

- Tributary habitat consists of the full complement of habitats that occur in the tributary streams of the Susitna River. The streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology and climatology of the tributary drainage. Therefore, physical characteristics of tributary habitat are not dependent on mainstem river conditions that exist at the tributary mouth. At the mouth of most tributaries the stage of the mainstem river causes a backwater that extends into the tributary, and the tributary flow creates a clear-water plume along the bank in the mainstem. This interaction provides another type of habitat (tributary mouth habitat) that is considered a subset of tributary habitat.

(a) Oshetna River to Devil Canyon

The impoundment reach of the Susitna River flows through a steeply cut, degrading channel. From Devil Creek (RM 162) to the downstream end of Devil Canyon (RM 150), the river forms one channel that lies in a deep valley with an average gradient of 31 ft/mile (5.9 m/km). From Oshetna River (RM 233) to Devil Creek, the river is wider and often splits into two or more channels with an average gradient of approximately 13 ft/mile (2.4 m/km). Substrates throughout the impoundment reach and mouths of tributaries generally consist of rubble, cobble, and boulders, often embedded in sand; gravels are present in some locations (ADF&G 1981c).

2.2 - Species Biology and Habitat Utilization

Because of the inaccessibility of the Devil Creek and Devil Canyon area and the apparent lack of suitable fisheries habitat, the study area was limited to that section of the Susitna River from the Oshetna River to Fog Creek (RM 177) (ADF&G 1981c). Based upon a preliminary reconnaissance of the upper Susitna River basin (ADF&G 1977), eight major tributaries were selected for fisheries studies: Fog and Tsusena creeks in the proposed Devil Canyon impoundment; and Deadman, Watana, Kosina, Jay and Goose Creeks and the Oshetna River in the Watana impoundment. For the purpose of this study, the first mile of each of these streams upstream from their confluence with the Susitna River was sampled. To assess mainstem utilization, sampling was conducted in an area 300 feet (90 m) upstream and downstream from a tributary's confluence with the Susitna River.

Overall values of the physiochemical parameters measured in the mainstem during May to September (ADF&G 1982a) include:

- Well-oxygenated water (9.0-14.1 mg/l);
- pH values near seven or slightly higher (6.8-7.9);
- Moderate conductivity values (44-248 umhos/cm);
- Water surface temperatures in the range of 1.5-12.6°C (34.7-54.7°F); and
- Low turbidity levels in the tributaries (0.3 to 19 NTU) compared to the mainstem (10 to 175 NTU).

(i) Mainstem Habitat Near the Confluence of Major Tributaries

- Species Occurrence and Relative Abundance

Although adult chinook salmon were documented for the first time at RM 156.8 in 1982, no other anadromous species were reported in the mainstem Susitna in the impoundment reach (ADF&G 1982e). This supports the current opinion that hydraulic characteristics of the Susitna River at Devil Canyon act as a barrier to upstream salmon movement during high flows (ADF&G 1982a).

Seven resident species occur in the mainstem: arctic grayling, longnose sucker, humpback whitefish, round whitefish, Dolly Varden, burbot, and slimy sculpin. The longnose sucker, round whitefish, and burbot were almost exclusively captured in the mainstem near the mouths of the tributaries. Based on tagging studies, the arctic grayling occupied mainstem locations primarily during winter.

- Significance of Habitat

The mainstem Susitna River in the impoundment reach provides primary overwintering habitat and migration routes between tributaries for arctic grayling (ADF&G 1981f).

Burbot use the mainstem immediately up or downstream from tributaries as year-round habitat. All burbot catches in the impoundment area were made in the mainstem between May and September (ADF&G 1981f). It is unlikely that tributaries would be utilized during winter months because of ice conditions.

Round whitefish and longnose suckers also use the mainstem near tributary confluences as year-round habitat. However, no specific spawning or rearing areas were identified (ADF&G 1981f).

(ii) Tributaries

- Species Occurrence and Relative Abundance

At least two resident species, arctic grayling and cottids, occur in tributaries. Other species captured near the mouths of tributaries, as discussed above under Section (i), probably also use the tributaries periodically; however, none were captured in the tributaries during the field studies.

Abundance estimates for grayling from 1982 data indicate that in excess of 16,300 grayling inhabit clear-water tributaries in the impoundment zone during the summer (Table E.3.17). Total catch of cottids was 38 in 352 trap days.

- Significance of Habitat

Tributaries are primarily utilized by grayling as spawning and rearing habitat (ADF&G 1982a). Although spawning has not been observed in the impoundment zone, suitable spawning habitat (sandy gravel) does exist in all of the tributaries sampled, and it is likely that spawning occurs in the lower reaches of these tributaries. Grayling fry were found in the lower reaches of Watana Creek, indicating that spawning had occurred nearby. Grayling that have completed spawning move upstream into areas that have pool type habitats where they remain throughout the summer. Large, deep streams with a high pool/riffle ratio and moderate streamflow velocity (below 2.0 ft [0.6 m] per sec), such as the Oshetna River and Kosina Creek, provide optimal habitat (ADF&G 1982a).

(b) Devil Canyon to Talkeetna

In the reach of the Susitna River from Devil Canyon to Talkeetna, the river channel is relatively stable and straight with some meandering and minimal braiding. Numerous islands, gravel bars, and sloughs are present. Flow alternates between a single channel and split channels configuration throughout the reach. Between Curry (RM 120) and Talkeetna the approximate gradient is 8.1 feet per mile (1.5 m/km). Typical substrate between Curry and Talkeetna is gravel, rubble, and cobble with small amounts of sand and silt. Above Curry the substrate varies from silt to bedrock. The majority of mainstem shoreline substrate is rubble and cobble whereas silt and gravel are the most common substrate in sloughs and slow water areas. Below Curry, streambank vegetation is dense spruce/hardwood forest. In addition to numerous smaller streams draining the surrounding hillsides, the principal tributaries to the Susitna River in the Devil Canyon to Talkeetna reach include Portage Creek, Indian River, Gold Creek, Fourth of July Creek, Lane Creek, and Whiskers Creek.

A breakdown of the habitat study sites in the Devil Canyon to Talkeetna reach includes 11 slough sites, 8 mainstem or side-channel sites, and 5 tributary sites. Ranges of physiochemical parameters measured for these sites from May to September 1981 are shown in ADF&G (1982a). Ranges given for tributary sites included all of the sampling sites from that particular tributary. Overall trends for physiochemical parameters measured in this reach included:

- High dissolved oxygen (8.8-12.8 mg/l);

- Moderate conductivity readings, (15-222 umhos/cm);

- pH values in the range of 6.1-7.8, slightly lower than the impoundment reach or downstream. Tributaries such as Whiskers Creek and Indian River had slightly lower pH values than mainstem or slough sites;

- Turbidity levels were generally lowest at upstream tributary sites (0.4-148 NTU). Levels were also generally lower in downstream tributary sites and sloughs when the influence of the mainstem Susitna was negligible. Levels were highest in the mainstem (23-230 NTU).

(i) Mainstem and Side Channels

The Susitna River from Devil Canyon to Talkeetna has both single and split channel configuration reaches. Single channel reaches are generally stable with non-erodible banks controlled by valley walls, bedrock or armor layer consisting of gravel/cobbles. The channel is either straight or meandering. In straight channel reaches, the thalweg often meanders across the channel. Occasional fragmentary deposits can be found in the floodplain. Split channel configurations are characterized by moderately stable channels with a gravel/cobble substrate. There are usually no more than two channels in a given reach. Channels are separated by well established vegetated islands. The main channel behaves much like a single channel at low flows with the side channels flowing only at discharges above about 20,000 cfs. Bankfull flow generally corresponds to the mean annual flood (R&M 1982c).

- Species Occurrence and Relative Abundance

. Salmon

Five species of Pacific salmon were observed in the Susitna River between Devil Canyon and Talkeetna. Studies indicate that adult salmon utilize the mainstem upstream from Talkeetna from late spring into the fall during migration and spawning periods (ADF&G 1981b). Use periods for adults of each species are:

Chinook--mid-June through July;
Sockeye--July 23 through mid-September;
Coho--July 30 through September;
Chum--July 28 through mid-September; and
Pink--July 27 through August.

Relative abundance estimates based on 1981 and 1982 escapement data and population estimates are given in Table E.3.5 for each of the salmon species that utilize this reach of the Susitna River primarily as a passage way to spawning areas.

Juvenile salmon are also present in the mainstem at various times of the year. Periods of use and relative abundance are outlined below.

Chinook--During winter, juveniles were most abundant in the mainstem. Prior to June 1 through the end of July, age 1+ juveniles were abundant as they were observed moving downstream in the mainstem.

Sockeye--In 1982 sockeye juveniles moved out of the Devil Canyon to Talkeetna reach as age 0 fish, primarily during June and July (Table E.3.9).

Coho--During winter, coho are most abundant in the mainstem. During summer they are slightly less abundant in the mainstem than at the tributary mouths. In 1982, out-migration peaked in June.

Chum--The majority of the chum juveniles migrated downstream prior to July 1 in 1982.

Pink--Studies to date have caught few pink juveniles in the mainstem.

. <u>Resident Species</u>

Resident species reported in this reach included all of the resident fish reported in the Susitna River drainage (Table E.3.2) except for lake trout. Resident fish observed throughout the year in the mainstem include burbot and longnose sucker. Other resident species were most abundant in the mainstem primarily during the late fall, winter, and early spring.

- <u>Significance of Habitat</u>

Based on existing data, the mainstem Susitna River between Devil Canyon and Talkeetna is primarily used by anadromous and resident species as a migrational corridor and overwintering area. The significance of mainstem aquatic habitat is discussed below for various species of commercial and recreational importance.

- Salmon

  The mainstem reach from Devil Canyon to Talkeetna serves as a migration corridor for a relatively small percentage of the total Susitna River salmon escapement (Table E.3.5, Figure E.3.9). During migration periods, various behavioral and distribution patterns are associated with certain characteristics of mainstem habitat, including water depth, velocity, channel configuration, and location or absence of obstructions (ADF&G 1981c).

  Generally, passage of adult salmon during migration corresponds with the summer high flow season. However, passage of adult salmon on a daily basis (measured by side-scan sonar) indicated that salmon movements decreased during periods of highest flows (40,000 cfs) and increased as flows subsided following major flow events (ADF&G 1982a).

  It is hypothesized that increased water velocities associated with peak flows discouraged passage and encouraged milling (ADF&G 1982a). Radiotelemetry investigation and gillnetting indicated that the confluence of the Talkeetna, Chulitna and Susitna Rivers is a chum, pink, coho and chinook milling area and that sockeye, chum, coho, pink, and chinook mill in the mainstem one mile below Devil Canyon.

  Chum were observed spawning at 10 sites and coho at 4 of the 11 mainstem spawning sites identified in the Devil Canyon to Talkeetna reach during 1982. Mainstem spawning appeared to be restricted by lack of suitable spawning substrate and ground water upwelling (ADF&G 1981c, 1982a).

  Juvenile chinook and coho salmon use the mainstem for overwintering. Salmon juveniles use the mainstem for out-migration.

. Resident Species

Resident species, other than burbot and longnose sucker, primarily use this mainstem area as a migration channel to spawning, rearing, and summer feeding areas in the tributaries. No mainstem spawning or rearing areas have been located. Rainbow trout and grayling overwinter in mainstem habitats.

Burbot and longnose sucker use the mainstem as year-round habitat. Burbot catches during low flows were restricted to the mainstem and deep side channels. During high flows, burbot were captured at a greater number of locations, including shallow side channels.

(ii) Slough Habitat

The clear water in the sloughs originates from local surface runoff and ground water upwelling. Ground water upwells in the slough channels throughout the year, thus keeping these areas relatively ice free in the winter. Observations indicate the Susitna River is the primary source of the water in many of the sloughs. Local runoff is a primary water source in slough habitats in the summer.

The stage in the mainstem controls the water surface elevation of the lower portion of the sloughs by forming a backwater that can extend some distance upstream into the slough[1/]. This backwater is divided into two parts-clear water and turbid water. The mainstem water creates a turbid plug at the mouth of the slough that backs up the clear water in the slough. As the stage in the mainstem drops, the size and character of the backwater changes. At summer flows of approximately 8,000 to 10,000 cfs at Gold Creek (RM 136.8), the backwater recedes. This reduces the depth of water at the entrance to the sloughs. In some cases, the slough mouth and the mainstem become separated by a gravel bar.

When high mainstem flows overtop the head end of the sloughs, the flows flush the fine sediments that accumulate in the lower portion of the sloughs. As peak flows in the mainstem subside and the stage in the mainstem drops below the head end of the slough, discharge through the slough drops and the water in the slough begins to clear.

[1/]Appendix E.2.A provides an incremental description of mainstem discharge influence on slough hydraulic conditions.

2.2 - Species Biology and Habitat Utilization

Because there is much diversity in the morphology of individual sloughs, the flows at which they are overtopped vary considerably. In general, most side-channel sloughs are overtopped at flows between 20,000 and 24,000 cfs. Other sloughs are overtopped only during flood events such as spring breakup.

In the summer, when mainstem temperatures are ranging from 8° to 12°C (46.4° to 53.6°F), intergravel temperatures in the sloughs range from 4° to 6°C (39.2° to 42.8°F). Some winter temperatures measured in the sloughs and the mainstem indicate that when mainstem temperatures range from 0.1° to 0.5°C (32.2° to 32.9°F), intergravel temperatures ranged from 2° to 4°C (35.6° to 39.2°F) (Atkinson 1982).

- Species Occurrence and Relative Abundance

. Salmon

Adults and/or juveniles of five salmon species have been observed in slough habitat between Devil Canyon and Talkeetna. Results of escapement and spawning surveys indicated that adult sockeye and chum salmon were the most numerous salmon in these sloughs during peak spawning periods (ADF&G 1981b, 1982e). In 1981, an estimated 3526 chum and 2315 sockeye spawned in sloughs in this reach, while in 1982 an estimated 3674 chum and 1402 sockeye spawned in these habitats. Pink salmon were less abundant, with an estimated 28 and 735 spawning in sloughs in 1981 and 1982. In 1982, coho were observed spawning in one of the sloughs (8A). No chinook have been observed spawning in the sloughs. Spawning counts for individual sloughs are reported in ADF&G (1981b, 1983) (Figures E.3.12 to E.3.17). Estimates of the total number of spawning salmon by slough are given in Table E.3.12.

Studies of species occurrence and relative abundance of juvenile salmon in slough habitat indicate the following information:

Compared to other habitats in this reach, juvenile chinook salmon are abundant in all sloughs during winter and relatively abundant in selected clear-water sloughs during summer.

Juvenile coho salmon are abundant at slough sites during winter and less abundant but still present at slough sites during summer.

Preliminary data indicate that chum, pink, and sockeye fry were present in slough habitat during part of the summer.

. Resident Species

All resident species reported in this reach of the Susitna drainage have been observed in slough habitat between Devil Canyon and Talkeetna except for lake trout.

Available data indicate that most species are present in slough habitats as well as the mainstem throughout winter. During summer, most adult residents are not abundant in slough habitat. Those that were relatively abundant in slough habitat during summer included burbot, longnose sucker, and rainbow trout. Previous studies indicated that juvenile whitefish, grayling, and rainbow trout were abundant in slough habitat during late summer (Friese 1975).

- Significance of Habitat

Slough habitat between Devil Canyon and Talkeetna is used by various anadromous species primarily for spawning and also for rearing and overwintering of juveniles; it is equally important for overwintering and rearing of various resident species. The significance of slough habitat is discussed below for species of commercial and recreational importance.

. Salmon

Slough habitat in this reach serves as spawning habitat for sockeye and chum salmon and less important spawning habitat for pink salmon (Table E.3.12 and Figures E.3.12 to E.3.17). In 1981 and 1982, 83 and 108 percent of the sockeye estimated to have passed Curry Station were estimated to have spawned in sloughs in this reach. For the same two years, 27 and 12 percent of the chum salmon estimated to have passed Curry Station, spawned in sloughs. Factors contributing to the salmon spawning in the sloughs in this reach are outlined below:

Clear-water base flows originating from sources such as ground water upwelling, local surface runoff, or interstitial inflow insure maintenance flows.

The presence of ground water upwelling in the sloughs oxygenates spawning substrate, keeps silt from compacting the spawning gravels, and provides a stable temperature regime that maintains incubating embryos through the winter.

Sloughs also serve as rearing and overwintering habitat for juvenile chinook and coho salmon. During summer, tributary sites appear to be more important chinook rearing habitat, although clear water sloughs also provide rearing habitat. Coho juveniles appear to use sloughs and tributary mouth sites for summer rearing. The importance of sloughs as juvenile overwintering and summer rearing habitat may be related to:

Ice-free clear-water conditions during winter compared to lowered flow and icing in coho and chinook salmon natal tributaries; and

During high summer mainstem flow, the high stage of the mainstem acts as a hydraulic control at the slough outlet, increasing the depth of water in the lower end of the slough. These clear-water areas promote benthic production, which improves the quality of the rearing habitat for juvenile salmon.

- <u>Resident Species</u>

Slough habitat between Devil Canyon and Talkeetna provides overwintering habitat for adult rainbow trout, grayling, and whitefish; year-round habitat for adult burbot and longnose sucker; and rearing habitat during late summer months for juvenile whitefish, grayling, and rainbow trout. The importance of sloughs as overwintering habitat is related to the same factors as discussed above for juvenile salmon.

(iii) Tributary Habitat

The depth of water in the mouth of tributaries between Devil Canyon and Talkeetna is sensitive to changes in mainstem flow. At high flows, the mainstem creates a backwater at the tributary moûth, thus increasing the water depth. The lineal extent of the backwater in the tributary depends on the stage in the mainstem and the gradient of the tributary. At low mainstem stages, the backwater is eliminated, resulting in shallower water and increased flow velocities at the mouth.

Small deltas are formed at the mouth of most of the tributaries. As the tributary enters the mainstem river, the change in gradient and subsequent change in flow velocity cause the tributary to drop transported materials if the velocity in the mainstem is not sufficient to carry the material downstream. As the stage in the mainstem river decreases, the tributaries become perched above the river, that is, the tributaries flow across steep deltas. Were they to remain under low mainstem flow conditions, upstream passage of adult salmon and resident fish would be inhibited or eliminated. However, based on studies computed by R&M Consultants (1982f), the tributary flows are sufficient to cut through the deltas to establish a channel at a new gradient. In 1982, the tributaries were observed to cut throught their deltas during the low flows in August. Even during the low August flows, most of the tributaries had sufficient energy to move the delta material (R&M Consultants 1982f).

- Species Occurrence and Relative Abundance

  . Salmon

  Except for sockeye salmon, the salmon species present in the Susitna drainage were observed in tributaries within the Devil Canyon to Talkeetna reach. Spawning counts for individual tributary index areas are given in ADF&G (1981b, 1982e) (Figures E.3.12 to E.3.17).

  Species occurrence and relative abundance of juvenile salmon in tributaries or at tributary mouths varied by season and by species. Results of studies to date are outlined below:

2.2 - Species Biology and Habitat Utilization

Juvenile chinook salmon are most abundant at tributary mouths during summer. Redistribution of juveniles from areas of emergence in tributaries to more favorable rearing habitat, including the mouths of tributaries, occurs throughout the summer as fish become more mobile.

Juvenile coho were slightly more abundant at tributary mouth sites than at mainstem sites during summer.

. Resident Species

All resident species except for burbot, longnose sucker, and lake trout were abundant in, and at the mouths of, clear-water tributaries during summer months. Limited information on winter distribution and abundance indicates that few resident fish overwinter in the tributaries.

- Significance of Habitat

. Salmon

Tributary habitat in this reach serves as primary spawning habitat for chinook, coho, chum, and pink salmon (ADF&G 1981b, 1983). Important spawning tributaries include Indian River (chinook, pink, chum and coho), Portage Creek (chinook, coho, pink and chum), Gash Creek (coho), Lane Creek (chinook and pink salmon), and Fourth of July Creek (chinook, pink and chum) (Figures E.3.12 to E.3.17).

Tributaries in this reach also serve as rearing and summer feeding habitat for chinook and coho. Tributary mouths also provide important milling and rearing areas for juvenile chinook and coho salmon. Occurrence of age 0+ coho was particularly high at tributary mouth sites (ADF&G 1982a).

. Resident Species

Between Devil Canyon and Talkeetna, tributaries provide spawning habitat, juvenile rearing areas, and summer feeding habitat for several resident species including rainbow trout, arctic grayling, round whitefish, and Dolly Varden (ADF&G 1981e, 1982a). In general, these fish migrate from mainstem or slough habitat to the clear-water tributaries to spawn in the spring (or early fall for Dolly Varden). Once spawning is completed, the fish move into favorable tributary habitat for rearing and summer feeding. As freezeup begins, the fish migrate from the tributaries to the mainstem or deeper pools near the mouths of tributaries.

(c) Cook Inlet to Talkeetna

Below Talkeetna, the Susitna River is moderately to extensively braided throughout most of the reach. From the inlet to Bell Island (RM 10), the river is separated into two braided channels; from Bell Island to the Yentna River (RM 27), a single meandering channel is formed. From the Yentna River to Sheep Creek (RM 70), the river is moderately to extensively braided, with forested islands and nonforested bars between the channels of the river. The river is reduced to a single channel near the Parks Highway Bridge (RM 84), and braiding becomes moderate from this point to Talkeetna. Gradients vary considerably in this reach. From Cook Inlet to RM 50, gradient is 1 ft/mile (0.2 m/km); from RM 50 to 83, it is 5.9 ft/mile (1.1 m/km); and from RM 83 to Talkeetna, the gradient is 6.9 ft/mile (1.3 m/km). Typical substrate in the reach is silt and sand with some gravel and rubble. Major tributaries include: Alexander Creek, Yentna River, Kroto Creek (Deshka River), Chulitna River, and the Talkeetna River. Flows in these tributaries are considerable. The Chulitna and Talkeetna Rivers contribute about 57 percent of the total flow below the confluence near Talkeetna (R&M 1982c).

Study sites located in this lower reach included 11 tributary mouth sites, 5 tributary sites, 8 slough sites, and 5 mainstem and side-channel sites. The ranges for physiochemical parameters in this reach are given in ADF&G (1982a). The data collected include the following:

- Tributaries, sloughs, and the mainstem all exhibited high dissolved oxygen readings (7.6-12.9 mg/l).

- Conductivity was generally low in the tributaries (19-46 umhos/cm) and moderately high in mainstem and slough sites (29-216 umhos/cm).

- pH values were in the 6.1-8.0 range, with tributaries having the lowest pH values.

2.2 - Species Biology and Habitat Utilization

- Turbidity was lowest in tributaries, particularly Caswell and Montana creeks (0.3-1.9 NTU), and highest at mainstem and slough sites (2.2-255 NTU).

(i) Mainstem and Side Channels

Braided river reaches such as the lower Susitna are characterized by two or more interconnecting channels separated by unvegetated or sparsely vegetated gravel bars. The active floodplain is wide and sparsely vegetated, and contains numerous high water channels and occasional vegetated islands. Active channels are typically wide and shallow and carry large quantities of sediment at high flows. Bars separating the channels are usually low, gravel-surfaced, and easily erodible. The lateral movement of channels within the active floodplain of a braided river that carries large quantities of bed load is expected to be high. The channels shift either by bank erosion or by channel diversion into what was previously a high-water channel. Gravel deposits may partially or fully block channels, thereby forcing flow out of the channel to develop a new channel.

Because braided river channels are wide and shallow, they are more sensitive to flow reductions than the deeper channels of a split channel system, i.e., a drop in stage could result in a substantial reduction in the width of the river and loss of large areas of flow along the margins of the channel.

Because the thalwegs of the side channels are usually at higher elevations than the main channel thalweg, they are more sensitive to fluctuating river stages. As a result, they may be completely dewatered at low flows. Side channels are not subject to as high a flow velocity as the main channels, thus the substrate is not scoured from these channels as easily. The water quality in the side channels is the same as that found in the mainstem.

- Species Occurrence and Relative Abundance

. Salmon

Adult salmon pass through this reach of the mainstem during spawning migration. Generally, the migration period extends from late May into September (specific dates are reported in Section 2.2.1[a]). The relative abundance of adult salmon in this reach is high because the entire Susitna salmon run must pass through the lower sections of the river in order to arrive at spawning grounds. Population estimates of the number of salmon that migrate to various escapement monitoring stations are given in Table E.3.5 and Figure E.3.8.

With the exception of sockeye salmon, the majority of upper Cook Inlet salmon are believed to originate in the Susitna drainage and, therefore, must migrate through portions of the reach of mainstem between Talkeetna and Cook Inlet.

Juvenile chinook salmon are relatively abundant in this reach of the mainstem during winter months. Juvenile coho are less abundant and more often associated with tributary mouth sites.

. Other Anadromous and Resident Species

Other anadromous species observed in this reach include Bering cisco and eulachon. Bering cisco are abundant in the mainstem from August to October (ADF&G 1982a). Eulachon were observed in the lower 48 miles of the reach in 1982, and lower 58 in 1981 (ADF&G 1983).

All resident species found in the Susitna drainage except for lake trout were found in this reach or the mainstem. Lamprey were observed in this reach but not in other reaches of the Susitna River (ADF&G 1981e).

- Significance of Habitat

. Salmon

The portion of the reach closest to Cook Inlet serves as a migration corridor for the entire Susitna River salmon run.

Salmon spawning habitat in the mainstem or side channels of the reach is limited and is comparable to the spawning habitat discussed for the Devil Canyon to Talkeetna reach. Of the six mainstem or side channel spawning sites identified in 1981, chum salmon occupied six and coho salmon occupied one (Table E.3.13, ADF&G 1981a). No mainstem or side-channel spawning was observed for chinook or sockeye salmon. Mainstem and side channel spawning habitat is probably restricted because of the lack of suitable spawning substrate and upwelling, which are two of the key factors determining substrate suitability for spawning.

Mainstem habitat also provides overwintering for chinook and coho juveniles, limited summer rearing habitat, and a migrating channel for smolt outmigration.

- Other Anadromous and Resident Species

The mainstem from Talkeenta to Cook Inlet serves as primary overwintering habitat and as an important migration channel. Bering cisco and eulachon are anadromous species that use the mainstem as a migratory channel from Cook Inlet to their respective spawning areas. Arctic grayling, rainbow trout, Dolly Varden, and round whitefish are resident fish that use the mainstem as a migratory channel to tributary spawning habitat and as overwintering habitat. The movement from tributaries to the mainstem for overwintering is inferred from capture data gathered during the fall and spring near tributary mouths.

Mainstem habitat in this reach provides possible spawning habitat for at least three species: Bering cisco, eulachon and burbot. Although spawning activity by Bering cisco may occur throughout the reach between RM 30 and RM 100, three spawning concentrations were identified (see Section 2.2.1(b)[i]). Bering cisco spawning substrates were composed primarily of 1- to 3-inch (2.5- to 7.5-cm) gravel.

Burbot and longnose sucker are present in the mainstem throughout the year and utilize the mainstem for overwintering, spawning, and juvenile rearing. Habitat utilization within the mainstem is probably similar to that previously discussed for the reach of mainstem between Devil Canyon to Talkeetna.

(ii) Slough Habitat

During periods of low flow, the sloughs below Talkeetna are primarily fed by tributaries and ground water upwelling and carry clear water. At high flows, the sloughs are essentially overflow channels for the mainstem, and the water in the sloughs becomes quite turbid as it assumes the characteristics of the mainstem water. Slough water clears as the mainstem stage drops and turbid water no longer enters the upstream end. Higher velocities associated with higher flows act to flush fine sediments from the sloughs. Backwaters are created at slough mouths when the river stage is high, but disappear at low flows.

- Species Occurrence and Relative Abundance

. Salmon

Chum, sockeye, and pink salmon adults were observed in sloughs in this reach of the river (ADF&G 1981b). No estimates of relative abundance were made of the salmon using the slough habitat in this reach.

Juvenile salmon occurrence and relative abundance in slough habitat is similar to that reported for the Devil Canyon to Talkeetna reach. Chinook juveniles are relatively abundant in slough habitat during winter and less abundant during summer. Juvenile coho are less abundant in slough habitat than in tributaries in this reach throughout the year (ADF&G 1981d).

. Resident Fish

Occurrence and relative abundance of adult resident species in this reach of slough habitat is similar to that discussed for the Devil Canyon to Talkeetna reach. The majority of resident species are present, and relative abundance is highest beginning in late summer and continuing throughout the winter. Adult residents that are most abundant in slough habitat during summer include burbot, longnose sucker, and rainbow trout (ADF&G 1981e).

Previous studies indicated that juvenile whitefish, grayling, and rainbow trout were abundant in the slough during late summer (Friese 1975).

- Significance of Slough Habitat

. Salmon

Based on spawning surveys upstream from Talkeetna, slough habitat in this reach probably serves as spawning habitat for chum, sockeye, and pink salmon. Factors that may contribute to the suitability of sloughs as spawning habitat are the same as previously discussed for the Devil Canyon to Talkeetna reach.

Slough habitat also serves as important rearing and overwintering habitat for juvenile chinook and coho salmon. The importance of sloughs as juvenile overwintering and rearing habitat may be related to factors discussed previously for the Devil Canyon to Talkeetna reach.

. Resident Species

The significance of slough habitat downstream from Talkeetna to resident fish is similar to that discussed for the reach between Devil Canyon to Talkeetna. Slough habitat in this reach is utilized as overwintering habitat for adult rainbow trout, grayling and whitefish; year-round habitat for adult burbot and longnose sucker; and as rearing habitat during late summer for juvenile whitefish, grayling and rainbow trout. The importance of sloughs as overwintering habitat is related to the same factors as discussed previously for juvenile salmon species in the Devil Canyon to Talkeetna reach. No spawning sites were observed in the sloughs of this reach (ADF&G 1981e).

(iii) Tributary Habitat

- Species Occurrence and Relative Abundance

. Salmon

All of the salmon species present in the Susitna drainage were observed in tributaries downstream from Talkeetna. Results of previous studies by ADF&G (1980a, 1980b) and the 1981-1982 surveys in the tributaries downstream from Talkeetna indicate that the highest level of spawning for all salmon species in this reach occurs in the tributaries.

Species occurrence and relative abundance of juvenile salmon in the tributaries or at tributary mouths varies by season and by species. Results of studies to date indicate:

Juvenile chinook salmon are most abundant at tributary mouth sites during summer; tributary sites accounted for 95 percent of all juveniles captured in this reach. During winter, juvenile chinook were less abundant in the tributaries, but were captured near tributary mouths.

Juvenile coho were relatively abundant at tributary mouth sites during both summer and winter.

. Resident Species

All resident species except for burbot, longnose sucker, and lake trout were most abundant in and at the mouths of clear-water tributaries during summer. Information on winter distribution and abundance indicates that few resident fish overwinter in tributary habitat.

- Significance of Habitat

. Salmon

Tributary habitat serves as the primary spawning habitat for all salmon species occurring in this reach.

Based on escapement counts and population estimates at monitoring stations along the mainstem, tributaries in this reach provide the majority of spawning habitat for chinook, coho, and pink salmon in the Susitna drainage.

Other Susitna River investigations have revealed that all adult salmon mill to some degree in the mainstem and that it is not uncommon to find adult salmon in the mainstem well upstream from their spawning destination (ADF&G 1974, 1975).

Tributary habitat in this reach also supports rearing and summer feeding habitat for juvenile chinook and coho salmon. Sites associated with tributary mouths appear to provide particularly important rearing areas for juvenile chinook and coho salmon. Occurrence of age 0+ coho was particularly high at tributary mouth sites during summer. In addition, tributary mouth sites in these reaches appeared to provide overwintering habitat for juvenile coho salmon.

. Other Anadromous and Resident Species

Tributary habitat in this reach, similar to the Devil Canyon to Talkeetna reach, apparently provides spawning habitat, juvenile rearing areas, and summer feeding habitat for rainbow trout, arctic grayling, round whitefish, and Dolly Varden (ADF&G 1981e). In general, these fish migrate during spring (early fall for Dolly Varden) from the mainstem or slough habitat to clear-water tributaries to spawn. Once spawning is completed, fish move into favorable tributary habitat for rearing and summer feeding. As freezeup begins, fish migrate from tributaries to the mainstem or deeper pools near the mouths of tributaries. Habitat characteristics that influence grayling distribution and abundance within tributary habitat are discussed for the impoundment reach in Section 2.2.1(c)(iii).

2.2.3 - Streams of Access Road Corridor

(a) Stream Crossings

The access road to the Watana and Devil Canyon damsites will depart from the Denali Highway and proceed south to Watana (see Plate F-32, Exhibit F). From there, the road will traverse the north side of the Susitna River to the Devil Canyon damsite. A railroad spur from Gold Creek will connect to Devil Canyon. The access road corridor, including that portion of the Denali Highway to be upgraded as part of the project, contains at least 45 streams and rivers in both the Nenana and Susitna River drainages (Tables E.3.19 to E.3.21).

2.2 - Species Biology and Habitat Utilization

The portion of the Denali Highway between Cantwell and the Watana Access Road crosses 10 streams in the Jack River and Nenana River drainages (Table E.3.18). Fish species present in Jack River or Nenana River include grayling, northern pike, burbot, whitefish and sculpin. Of these, the tributary streams would contain at least grayling and sculpin.

From the Denali Highway to Watana, the road will cross Lily Creek, Seattle Creek, and Brushkana Creek, as well as numerous unnamed streams (Table E.3.20). These streams are tributaries of the Nenana River, which supports populations of grayling, northern pike, whitefish, burbot, and slimy sculpin in this reach. Tributary streams are assumed to contain at least grayling and sculpin.

The upper reaches of Deadman Creek will also be crossed by the Watana access road. This creek is a tributary of the Susitna River and is considered important grayling habitat.

Between the Watana and Devil Canyon damsites, the access road will cross Tsusena and Devil Creeks (Table E.3.21). The streams contain grayling and may contain cottids, whitefish, longnose sucker and Dolly Varden.

The road will cross the Susitna River approximately 2 miles (3 km) below the Devil Canyon damsite. Salmon and probably grayling, whitefish, cottids and longnose sucker occur in the vicinity of the crossing. The habitat in this reach of the Susitna is considered relatively non-productive compared to reaches farther downstream.

The railroad between Devil Canyon and Gold Creek will cross Jack Long Creek and Gold Creek (Table E.3.21). Jack Long Creek contains small numbers of pink, coho, chinook, and chum salmon (Figure E.3.17). Gold Creek has been documented to contain chinook, and a few coho, and pink salmon (Figure E.3.16). Three unnamed tributaries of the Susitna River will also be crossed. These most likely do not contain fish because of their steep gradients, but they are considered important sources of clear water to Sloughs 19 and 20, which are salmon spawning areas (Figure E.3.16).

(b) Streams Adjacent to Access Corridors

In addition to crossing streams, the Watana access road will parallel some streams, particularly Deadman Creek. The fisheries resources are described in Section 2.3.1(a) above. Devil Creek will also be paralleled by the access road while the railroad between Devil Canyon and Gold Creek will parallel Jack Long Creek.

2.2 - Species Biology and Habitat Utilization

2.2.4 - Streams of the Transmission Corridor

Transmission lines will be built from Watana and Devil Canyon to Gold Creek and from there to Anchorage and Fairbanks. From Watana to Gold Creek, the transmission line route is within 1 mile (1.6 km) of the Devil Canyon access road except near the Watana Dam. At Gold Creek the transmission lines will use the same right-of-way as the Anchorage-Fairbanks Intertie, which extends from Willow to Healy.

Resources of the Intertie are described in Commonwealth et al. (1982). At least 27 major salmon streams, including Willow Creek, Kashwitna River, Talkeetna River, Chulitna River, and Indian River will be crossed by the intertie and, presumably, by the additional lines to be built in the right-of-way in conjunction with the Susitna Hydroelectric Project. The streams contain grayling, rainbow trout, Dolly Varden, and cottids in addition to salmon.

South of Willow, the transmission line will be routed between the Susitna River and the Parks Highway for much of its length. It will cross Fish Creek and the Little Susitna River as well as many unnamed streams (Table E.3.22). The Little Susitna is a productive fish stream and contains coho, pink, chinook, chum, and sockeye salmon, as well as rainbow trout, Dolly Varden, and grayling. Fish Creek is known to support chinook, sockeye, pink and coho salmon, and rainbow trout. Many of the unnamed tributaries to the Susitna River most likely provide salmon spawning habitat.

An underwater crossing wll be used to cross the Knik Arm. The transmission line will then proceed east and south to the University power substation. Knik Arm serves as a migration corridor for five species of Pacific salmon as well as other anadromous species such as Dolly Varden, Bering cisco, eulachon, and lamprey. The transmission line will skirt Otter Lake, which is stocked with rainbow trout, and will cross Fossil and Ship Creeks. Fossil Creek is not considered a fish stream. Ship Creek supports populations of pink, chum, coho, sockeye, and chinook salmon as well as Dolly Varden and rainbow trout, but because of the heavy development along its reaches, it is not considered prime fish habitat. Planned construction of a diversion wier for a power plant intake will block upstream movements of anadromous fish prior to construction of the transmission line.

North of Healy, the transmisson line will cross at least 50 creeks and rivers including the Nenana and Tanana Rivers (Table E.3.23). These are two of Alaska's major rivers and provide habitat for salmon, grayling, whitefish, suckers, burbot, cottids, northern pike, and inconnu. Panguinge Creek has been documented to contain coho salmon, Dolly Varden and grayling (Tarbox et al. 1978). The streams in the Little Goldstream vicinity are not considered to be important fisheries habitat because of their step gradients. While many of the streams go dry in the summer, some do support grayling populations near their mouths (Table E.3.23).

2.3 - Anticipated Impacts To Aquatic Habitat

Construction and operation of the proposed Susitna Hydroelectric Project would result in both beneficial and detrimental impacts on the aquatic habitat and associated fishery resources in the Susitna basin. Many of the potential adverse impacts can be avoided or minimized through design and/or operation of the project, as described in Chapter 3, Section 2.4. This section examines the potential effects of the project as proposed in Exhibit A and addresses the impacts likely to be sustained as a result of project construction, reservoir filling, and operation of Watana and Devil Canyon dams. Since the project is a staged development, impacts to the aquatic habitat are presented by project stage, phase, and river segment. The discussions focus on important anadromous and resident species.

In this section, the term "impact" refers to a change affected on a fish population or on its capability to utilize aquatic habitats, resulting from project-induced changes in the physical characteristics of the environment. Impacts refer to changes or effects that are both beneficial and detrimental to fish populations. The project may alter physical characteristics of the aquatic environment that do not affect fishery resources, and therefore, these changes are not considered to be impacts to the resources.

The description of impacts presented below is based on all available data through spring 1982 including a significant portion of the data from the summer 1982 field program. The types of impacts that have occurred at similar projects have also been considered when describing the probable impacts this project will have on the fishery resources. The discussion represents the present understanding of the physical processes, habitat relationships, and likely response of fishery resources. The quantitative estimates of impacts presented in this section will be refined as more site-specific data becomes available from ongoing field programs. Data collection and analysis programs currently planned or in progress will provide the information necessary for a more refined quantitative impact analysis and mitigation plan.

The majority of the anticipated impacts resulting from the construction and operation of the two dam development will occur during the first phase of the development, the Watana Dam. Additional impacts but of a significantly lesser magnitude would be sustained as a result of the addition of the Devil Canyon Dam. The Watana Dam will be constructed first and will alter the character of the aquatic environment downstream from RM 238, the uppermost extent of the reservoir. The magnitude of change in aquatic habitats below the damsites decreases as the distance from the damsites increases. Alteration of the character of existing aquatic environment would be most notable within the impoundment and the 53-mile (88.3 km) reach between the Devil Canyon damsite (RM 152) and Talkeetna (RM 99). Lesser changes are anticipated in the 99-mile (165-km) reach from Talkeetna to Cook Inlet (RM 0). Most of the potential impacts to aquatic habitat that arise from dam construction will be avoided through careful design and siting, and by employing good construction practices.

2.3.1 - Anticipated Impacts to Aquatic Habitat Associated with Watana Dam

(a) Construction of Watana Dam and Related Facilities

Potential impacts to aquatic habitat associated with the construction of Watana Dam and related facilities can be divided into three categories:

- Effects of permanent or temporary alterations to water bodies, i.e., dewatering, alteration of flow regime, or alteration of channels;

- Effects on water quality i.e., changes in temperature, turbidity, nutrients, and other water chemistry parameters; and

- Effects, both direct and indirect, on fish population.

Table E.3.23 summarizes a number of the individual construction activities that would occur during the construction period.

(i) Watana Dam

The period of construction considered for the proposed Watana Dam consists of those activities occurring from initial site preparation to the start of reservoir filling. The proposed dam will consist of a fill structure constructed between RM 184 and RM 185 of the Susitna River. The fill will be approximately 0.75 mile (1.3 km) wide, 0.75 (1.3 km) mile long and 885 feet (267 m) high. Over 63 million cubic yards (47,880,000 m^3) of material will be used to construct the dam.

Prior to construction of the main fill structure, access will be completed; the diversion tunnels and cofferdams will be completed and the river diverted through the tunnels; and site-clearing activities begun. Heavy equipment will be brought to the site, and construction material will be stockpiled in the project area.

The two cofferdams will surround the area of the main dam construction. One cofferdam will be built upstream from the damsite and the other downstream (see Plate F 4 in Exhibit F). The upstream cofferdam will be approximately 800 feet (242 m) long and 450 feet (136 m) wide; the downstream cofferdam will be 400 feet (121 m) long and 200 feet (60 m) wide. Water blocked by the upstream cofferdam will be diverted into two 38-foot (11.5-m) diameter concrete-lined tunnels about 4100 feet (1242 m) long. The cofferdams will be constructed during a two-year period (1985-1987) and will remain in use until reservoir filling begins.

The construction of the main dam will have a number of effects on the river and its biota. Some effects will be the direct result of construction activities, while other effects will result from alteration of the river environment during construction. Impacts will vary in duration and overall extent, some being temporary or localized while others will be permanent or more widespread.

- Alteration of Water Bodies

The greatest alteration of aquatic habitat during construction of Watana Dam will occur at the damsite and at the mouth of Tsusena Creek where Borrow Area E is located. At the construction site, the Susitna River flows through a confined valley with a surface width of approximately 400 feet (121 m). The river bottom is sand, gravel and boulders. The tributaries closest to the damsite are Deadman Creek at RM 187 and Tsusena Creek at RM 182. Burbot, sculpins, and longnose sucker probably occupy the damsite during the open water season and grayling probably overwinter here (ADF&G 1981f).

The first major phase of dam construction involves placement of the two cofferdams, thereby permanently dewatering 0.75 mile (1.3 km) of riverbed at the damsite. It is anticipated that fish normally using this stretch will move into adjacent habitats and that the effects on population size will be minimal. The dewatered area will eventually be covered by the Watana dam; thus, the effect will be a permanent, but a relatively minor loss of aquatic habitat and permanent blockage of fish movements through this reach.

Gravel mining will be an important activity associated with construction of the dam and related facilities. A large portion of the material for the main dam will be excavated from the north bank of the Susina River at the confluence of Tsusena between RM 180 and RM 182. Prior to inundation, it can be expected that some impacts to aquatic habitat will occur, such as increased erosion, removal of bank cover, ponding, dewatering, and increased ice buildup caused by ground water overflow. In the construction zone, Tsusena Creek is considered more sensitive habitat than the mainstem of the Susitna River. Anticipated impacts from gravel removal operations include increased turbidity caused by erosion and minor instream activities, introduction of small amounts of hydrocarbons from equipment operating in streams and the possibility of accidental hydrocarbon spills. These impacts will be temporary and are not expected to last beyond site operation. A long-term impact to aquatic habitat is expected at the mouth of Tsusena Creek. The volume of material to be removed will result in a large pit that will become filled with water. This pit will produce increased lentic habitat in exchange for lost riparian and upland habitat. In order to avoid impacts to the aquatic system, borrow sites will be located, planned, and mined in accordance with the recommendations in Section 2.4.3(d)(ii).

During summer flood flows, the operation of the diversion tunnels will result in increased water levels upstream from the damsite. During winter, the water will be ponded to an elevation of 1470 feet (445 m) affecting about 0.5 mile (0.8 km) of river upstream from the cofferdam. During the summer, a flood event equal to the once-in-50-year flood will cause a water level of 1536 feet (465 m), thus causing backwater effects for several miles upstream. Water velocities within the tunnels during operations will act as a barrier to upstream fish passage. Fish residing upstream from the tunnels may be entrained into the flow and transported downstream from the damsite. If river transport mechanisms move rocks and other materials into the tunnels, or if the tunnels are not smooth, fish may be damaged through abrasion while being transported downstream.

Experiments with fish transport indicate that fish are adversely affected when exposed to velocities in excess of 9.0 ft/sec (2.7 m/sec) (Taft et al. 1975). Tunnel velocities are expected to exceed 18 ft/sec (5.4 m/sec) during much of the summer (Chapter 2, Section 4.1.1[a]), but because relatively few resident fish are expected to occupy the mainstem area immediately upstream from the tunnels during the summer, little impact on populations is expected (see Section 3.3.1[e] for description of mainstem fish habitats in this reach). To avoid ice problems in the diversion tunnel during the winter, a control gate will be partially closed to create a head pond approximately 50 feet (15 m) deep. Entrance velocities into the tunnel are expected to be in excess of 20 ft/sec (6 m/sec) (Chapter 2, Section 4.1.1[a]). Grayling and other resident fish move into mainstem habitat to overwinter, and physical conditions within the head pond will provide substantial overwintering habitat. Entrance velocities of 20 ft/sec (6 m/sec) are expected to entrain fish that are overwintering in the head pond into the tunnel, probably resulting in fish mortality.

High discharge velocities at the downstream end of the tunnels will scour gravels, sands and silts from the immediate area of the tunnel outlet. The velocities will also deter fish from using the area immediately downstream from the tunnel (Bates and VanDer Walker 1964; Stone and Webster 1976).

- <u>Changes in Water Quality</u>

The primary change in water quality that is expected as a result of Watana Dam construction is increased turbidity. Increases in turbidity will vary with the type and duration of construction activity and may be of severe local consequence, but are not expected to produce a widespread detrimental effect upon aquatic habitat in the Susitna River system. Some of the first construction activities to take place will include clearing the areas, construction of access roads, stockpiling of construction materials and fuel, movement of heavy equipment, and construction of support facilities. The construction of support facilities and the access roads are discussed below.

Removal of cover vegetation may result in a number of effects. The removal of cover will increase the local run-off causing erosion, increased turbidity, and increased dissolved solids (Likens et al. 1970; Boreman et al. 1970; and Pierce et al. 1970). The removal of bank cover may also increase the exposure of fish to predators, and lead to a decrease in fish populations (Joyce, et al. 1980b). Temperatures in local areas may also increase.

The movement of fill materials and the actual process of construction of the fill dam will contribute to turbidity and siltation. During the transport, storage, and placement of the 63 million cubic yards (47,880,000 m^3) of fill material used in constructing the dam, a small percentage will be introduced to adjacent water bodies including the mainstem Susitna River through spills and erosion. A loss of one percent of 63 million cubic yards (47,880,000 m^3) represents approximately a 25 percent increase in suspended sediment in the mainstem of the Susitna River. Thus, although the impact on the mainstem may not be severe, the impact on local clear-water streams could be significant.

Operation of heavy equipment in streams also increases siltation and turbidity. The extent of the impact of siltation and turbidity is dependent upon the extent of machinery operation in the stream beds and the substrate of the streams affected. Finer substrates tend to be most affected (Burns 1970); but effects are also dependent upon streamflows in the local area. If velocities are sufficiently high, deposition of suspended silts stirred up by the machinery will not occur locally and the effects would be minor (Shaw and Maga 1943). Since velocities can be expected to vary seasonally, the potential for impacts will vary seasonally as well.

2.3 - Anticipated Impacts to Aquatic Habitat

Impacts caused by machinery-induced siltation and turbidity are expected to be more temporary in nature than those resulting from streambank clearing.

Increased turbidity generally reduces visibility and decreases the ability of sight-feeding fish to obtain food (Pentlow 1944; Hynes 1966), thus effectively reducing feeding habitat. Most fish species will avoid turbid areas and many salmonids avoid spawning in turbid waters. However, increased turbidity is anticipated to be temporary, and associated with actual clearing or gravel removal activities and runoff from rainfall events.

Siltation (sedimentation) is also associated with these activities. There is a considerable amount of literature dealing with siltation effects on fish (Burns 1970; Shaw and Maga 1943; Ward and Stanford 1979) particularly the effect on spawning and incubation. A general conclusion reached by a review of the literature (Dehoney and Mancini 1982) is that the greatest adverse impact of siltation is on immobile eggs and relatively immobile larval fish. In general, siltation can cause significant losses of incubating eggs and fry in redds, particularly by interfering with oxygen exchange. Areas of ground water upwelling flow would tend to be affected to a lesser extent than other areas because silt would tend to be prevented from settling. Only resident fish in the vicinity of Watana Dam, including Dolly Varden, arctic grayling, and round whitefish, may be affected by siltation. Entrainment of suspended materials would also affect other water quality parameters, such as dissolved oxygen, trace metals, and pH (Pierce et al. 1970), but is not expected to produce widespread detrimental effects upon aquatic habitat in the Susitna system.

The production of concrete for tunnel lining, spilling and powerhouse construction, and grouting will generate concrete batching wastewater. Peters (1978) points out that the discharge of wastewater, if untreated, can lead to detrimental effects on fish populations and habitat. A particular problem with concrete wastewater is the need to adjust its pH (10+) prior to discharge.

2.3 - Anticipated Impacts to Aquatic Habitat

Waterbodies can be contaminated during construction activities by petroleum products that enter from a variety of sources. Fuels can enter streams, lakes and wetlands from leaks in storage tanks and pipes and from vehicle accidents during transportation. Poor maintenance of vehicles can also allow small quantities of hydraulic fluid, antifreeze, and fuel to enter water bodies.

Diesel fuel will be used and will have to be stored in large quantities onsite. New and used lubricating oils will also be commonly in use. There is a great deal of literature (USEPA 1976; AFS 1979) describing deleterious effects caused by oil spills. Aromatics in diesel and gasoline are particularly toxic until evaporated. Heavier oils can coat streambeds and aquatic vegetation and interfere with production of food organisms consumed by fish (Kolpak et al. 1973). In a river as large as the Susitna, small spills are expected to dilute quickly and would likely cause harm. Spills into smaller tributaries, especially while incubating embryos are present, could impact resident populations. In the winter, it is difficult to recover petroleum product spills that flow under ice in rivers. Substantial mortality could result if toxic substances reach overwintering fish and other organisms. However, it is likely that any adverse impacts that may occur from an oil spill would be short-term.

Waste oils containing trace metals require handling as a hazardous waste under 40 CFR 261-265. Solvents, while probably present in much smaller quantities than petroleum products, are usually considerably more toxic to aquatic life. Other chemicals of concern would include antifreeze, hydraulic oil, grease, and paints. The factors that will affect the severity of the impact on fish of a spill are:

- The substance spilled;
- The quantity spilled;
- Frequency of spills in that area.
- The biota present;
- The life stages present;
- The season; and
- Mitigation and cleanup plans and preparedness.

- Other Effects on Fish Populations

Other effects that instream construction activities may have on fish populations include avoidance of the area, injury, and mortality caused by instream use of heavy equipment. Heavy equipment crossings can also cause damage to incubating eggs and preemergent fry if the crossing location passes through a spawning area.

Water will be needed for production of concrete, processing of gravel, and dust control during construction. Fish impacts may result from entrainment and impingement of juvenile fish as water is withdrawn from local water bodies. However, because low volume pumps equipped with proper intake screens will be used, it is expected that the number of fish affected will be low. The potential for dewatering fish habitat in either the summer or winter low flow period will be minimized by pumping from streams with relatively high flow.

Current construction plans do not require instream blasting. Blasting is planned for areas 500 feet (150 m) or more from streams. A review of the effects of blasting on aquatic life (Joyce et al. 1980a, Appendix G) indicates that effects from such blasting would probably not be lethal (at least with charges of less than 200 kg of TNT). The transmitted shock waves from the blasting may disturb fish and perhaps temporarily displace them from areas near blasting activity. This type of behavior is well documented for a variety of noise sources (Vanderwalker 1967; Latvaitis et al. 1977; and USEPA 1976). Secondary effects of blasting include increased turbidity and siltation caused by loosened soils and dust (see effects described above). The extent of such effects would be dependent upon the location and amount of blasting.

(ii) Construction and Operation of Watana Camp, Village and Airstrips

During peak construction activity for the Watana dam, facilities to house a maximum of 4720 people are anticipated (see Exhibit A, Section 1.13). The facilities must be located adjacent to the construction site to simplify transportation to and from the camps. Two campsites are proposed: the construction camp will be located near Deadman Creek about 2 miles from the dam, and the construction village will be within a mile of the site. Each development will occupy approximately 170 acres (68 ha). After the dam is completed, a permanent townsite will be developed that encircles a 25-acre (10-ha) lake.

The construction camp will contain the management offices, hospital, recreation hall, warehouses, communications center, and bachelor dormitories, among other facilities. It is anticipated that the camp will be dismantled at the end of Watana dam construction, to be utilized during the Devil Canyon Dam project. The construction village will be made up of 320 temporary housing units and an additional 240 lots with utilities furnished. These temporary housing units will be used primarily for workers who are accompanied by families and will also be removed when construction of Watana is complete. The permanent town will be built to house the families of employees who will form the operation and maintenance team for Watana. The town will contain a hospital, a school, gas station, fire station, store, recreation center, and offices, as well as residences. Construction of the town will not begin until the early 1990s, since it will not be needed until Watana is operational.

A 2500-foot (758-m) temporary airstrip will be built approximately 1 mile (1.6 km) from the damsite at the 2200-2300-foot (667-697-m) level. A permanent airstrip will be built about 5 miles (8 km) north of the townsite. This strip will be 6000 (1818 m) feet long.

- Alteration of Waterbodies

Alteration of waterbodies resulting from the construction of camps and related facilities will be confined to the immediate area of the development. Few adverse impacts are anticipated. Gravel or other material required for facilities construction will be mined from Borrow Site D. Project facilities will be located away from waterbodies to minimize the potential of increased sediment input to water bodies. Overburden will be stored in areas where it will not affect waterbodies.

2.3 - Anticipated Impacts to Aquatic Habitat

Operation of the camps and airstrips is not expected to result in appreciable alteration of waterbodies. The lake within the townsite may experience some continued erosion from unstabilized building pads, but this is expected to be minimal.

Water will be withdrawn from Tsusena Creek 6 miles (10 km) upstream from its confluence with the Susitna River for domestic use in the camp and construction village. An estimated 1.5 cfs will be required to meet peak demands in both the construction camp and construction village. This represents less than one percent reduction in flow during the open-water season, and little impact is expected to result from decreases of this magnitude. A reduction of approximately 8 percent is expected during the winter period. A flow reduction of this magnitude is not expected to adversely affect fish populations.

- Water Quality Changes

Changes resulting from camp construction are expected to be similar to those experienced during dam construction but much reduced in magnitude because of the relatively great distance of the camp from water bodies inhabited by fish. Turbidity and suspended sediment levels will increase in areas where erosion enters water bodies from such activities as installation of the water intake system, but such effects will be temporary.

During camp operations, the most significant impacts on water quality will result from discharge of treated wastewater into Deadman Creek, oily and silty runoff from the camps, water used for dust control, and accidental fuel spills.

Current plans call for pumping water from Tsusena Creek or a series of wells to supply the camps and town during operations. Treated sewage during dam construction will be discharged into Deadman Creek. This sewage system will serve both the camp and construction village and will be used for the permanent town after the temporary camp and village are removed. The solid waste landfill is situated between the village and the camp. Fuel will be stored within the village and the construction camp. Details of fuel storage and handling will be developed by the construction manager in accordance with accepted procedures.

The sewage treatment plant will include a biological lagoon, which will provide secondary treatment (Chapter 2, Section 4.1.1[g]). Secondary treatment will avoid many of the problems associated with primary treatment, such as decreased dissolved oxygen and increased BOD, increased metals, and bacterial counts, although it will introduce increased levels of phosphorus and nitrogen into Deadman Creek (Warren 1971). Also, if the discharge is treated with chemicals such as chlorine, residual levels may have detrimental effects upon aquatic organisms. Rainbow trout in the Sheep River in Canada were reported to avoid areas where chlorinated sewage effluents were discharged, and some fish mortality resulted (Osborne et al. 1981). Grayling, the primary species in Deadman Creek, are considered to be very sensitive to alterations in water quality (Carl et al. 1967). The effects of treated discharge into Deadman Creek and thence into the reservoir will depend upon: (1) the water chemistry of the creek and reservoir; (2) the composition of the treated sewage discharge; and (3) the dilution of the discharge within the stream.

Storm drainage and oily water runoff are expected to occur at both the camp and the village, but will be more of a concern at the camp, since this is where the vehicle maintenance areas, shops, and related facilities will be located. By providing proper drainage facilities, ponding areas, and if necessary, pump stations to pump contaminated water to the treatment facility, oily and silty water will not reach Tsusena and Deadman Creeks. The small lake within the town limits will be more susceptible than the creeks to intrusions of oily water, storm drainage, and fuel spills.

Adverse effects may also result from oily water runoff from dust control on construction roads and airstrips and from accidents involving vehicles transporting fuels. The possible frequency and severity of such occurrences cannot be predicted at this time. Runoff from the solid waste landfill is not expected to adversely impact any aquatic habitat.

- Other Effects on Fish Populations

Disruption of fish populations during camp and village construction is expected to be limited to areas of in-stream activity and would be similar to those that may occur during construction of Watana dam or access road.

Operation of the camps will result in increased access to an area previously exposed to minimal fishing pressure. The areas expected to sustain the heaviest harvest pressure would be those stretches of Deadman and Tsusena Creeks and the Susitna River that are easily accessible from the camps and the damsite. The resident fish populations are thought to be at their maximum level, i.e., they are at their carrying capacity (ADF&G 1981e). Studies to date have indicated a relatively high percentage of "older" age group fish (up to 9 years). Sportfishing will inflict heaviest impacts upon larger, older fish and would likely result in a change in the age distribution of the population (Ricker 1963).

(b) Filling Watana Reservoir

Filling of the Watana reservoir will impact aquatic habitats both up and downstream from the dam. The 9.47-million-acre-foot reservoir is expected to take approximately three summer runoff periods to fill (Table E.3.25). The length of time required to fill the Watana reservoir depends on the amount of runoff that occurs during the filling period. If low-flow years occur, filling will be extended for an additional spring runoff period. Table E.3.26 presents the flows expected at Gold Creek during reservoir filling if average flow occurs in the Susitna River. Expected flows at Gold Creek exceed minimum target flows proposed during reservoir filling in all but the second year of filling, when the target flows are provided. Winter flows (November- April) are reduced slightly in April during the first winter of filling and are unaffected from November to April in the second winter[1/].

Impacts to downstream fisheries are summarized in Table E.3.27. These habitat alterations will result in changes to all trophic levels of the aquatic community presently functioning in the area.

[1/] The effects of various mainstem flows on hydrologic characteristics of sloughs are presented in Appendix E.2.A of Chapter 2 of Exhibit E.

2.3 - Anticipated Impacts to Aquatic Habitat

During filling, downstream releases will be made through one of the diversion tunnels. The tunnels are low-level discharge structures with limited capability to control downstream water temperatures (Chapter 2, Section 4.1.2[e][i].

(i) Watana Reservoir Inundation

Filling the Watana reservoir will inundate 38,000 acres (15,200 ha). The reservoir will flood 54 miles (90 km) of Susitna River mainstem habitat and 28 miles (46.7 km) of tributary habitats that would be converted from lotic to lentic systems with accompanying changes in hydraulic characteristics, substrate, turbidity, temperature, and nutrient levels. These habitat alterations will result in changes to all trophic levels of the aquatic community presently functioning in the area. Figure E.3.21 shows the area to be inundated by the Watana reservoir.

Reservoir filling will begin in May 1991 with the spring runoff flows. The greatest changes in water surface elevation and the most significant impacts will occur during the first year (see Table E.3.25). During May of the first year, the water surface elevation of the reservoir will rise an average of 5 feet (1.5 m) per day reaching a depth of approximately 165 feet (50 m) by the end of the month (an elevation of 1625 feet, or 492 m). Increases in water surface elevation of 3 feet (0.9 m) and 4 feet (1.2 m) per day are predicted in June and July, respectively. At the end of the first year, the reservoir will encompass an area of approximately 13,000 acres (5200 ha). It is expected to have a surface elevation of 1875 feet (568 m) and depths of 425 feet (128.8 m).

- Mainstem Habitats

Impoundment of the Susitna River by Watana dam will alter the physical characteristics of mainstem habitats and consequently affect the associated fishery resources. Burbot, longnose sucker, and whitefish generally occupy mainstem habitats year-round. Arctic grayling use mainstem habitats for overwintering (ADF&G 1981f). Mainstem habitats would be eliminated by the impoundment and replaced by a reservoir environment. The expected physical characteristics of the reservoir are presented in Chapter 2, Section 4.1.1.

2.3 - Anticipated Impacts to Aquatic Habitat

At present, mainstem habitats are utilized by burbot during the open-water season. Longnose sucker and whitefish generally occupy mainstem habitats only in the vicinity of tributary mouths (ADF&G 1981f). Burbot, longnose sucker, and whitefish are found in glacial lake environments in south-central and southwestern Alaska (Bechtel Civil and Minerals, Inc. 1981; Russell 1980). Since these fish are associated with habitats similar to those that will be present in the reservoir, conditions within the reservoir during filling are not expected to adversely affect these species. Thus, these species are expected to utilize the reservoir habitats year-round after the reservoir is filled.

Whitefish and burbot spawning areas may be located in mainstem habitats near tributary mouths. These areas will be inundated during the first year of filling, eliminating their present value as spawning areas. Since the habitat in the vicinity of tributary mouths would be changing rapidly, it is unlikely that stable spawning areas (similar to those presently existing) would develop during reservoir filling. The loss of spawning habitat is expected to adversely affect burbot and whitefish production in the proposed impoundment. However, since the water surface elevation during reservoir filling remains constant from November through April, the spawning and incubation periods for both burbot and whitefish, any spawning that does take place would probably be successful.

Water depth, water quality, and food availability are critical factors associated with overwintering habitat (Bustard and Narver 1975; Tripp and McCart 1974; Tack 1980). The reservoir is expected to provide adequate depth and water quality conditions for overwintering fish. At the end of the first year of filling, water depths would exceed 400 feet. Turbidity levels of the impoundment are expected to be suitable for fish, although slightly higher than existing winter turbidity levels in the mainstem Susitna River. Particles less than 5 microns in diameter are expected to remain in suspension (Chapter 2, Section 4.1.2 [e][iii]). Studies report fish overwinter in lake habitats with suspended glacial flour levels similar to and greater than those expected for the Watana reservoir (Russell 1980; deBrugn and McCart 1974). When filled, the reservoir will have a surface area of approximately 38,000 acres (15,200 ha), which greatly increases the amount of habitat having suitable conditions for overwintering fish. The increase in overwintering habitat may have a beneficial impact on fish resources of the upper Susitna basin above the Watana dam, if lack of available overwintering habitat presently limits fish populations in the area.

Winter reservoir water temperatures may increase the quality of overwintering habitat in the upper Susitna Basin. Reservoir temperatures in the top 100 feet (30 m) are expected to be in the range of 1 to 2°C (33.8 to 35.6°F) (Chapter 2, Section 4.1.3[e][i]). Present winter water temperatures in mainstem habitats in the proposed impoundment area are near 0°C (32°F). These warmer water temperatures may benefit fish by increasing the overwinter survival rate. During the winter of 1981-1982, fish apparently sought out water with warmer temperatures in the lower Susitna River. Other investigators have reported that fish prefer warmer water areas in the winter (Umeda et al. 1981).

- Tributary Habitats

Filling the Watana reservoir will inundate portions of six tributaries (Table E.3.28): Deadman, Watana, Kosina, Jay, and Goose Creeks and the Oshetna River (Figure E.3.21). All of these tributaries support grayling populations, and grayling that depend on habitats inundated by the reservoir will be displaced and may be lost.

The initiation of reservoir filling in May 1991 coincides with grayling spawning activities. In the project area, arctic grayling spawn in the clear water tributaries during spring breakup, and the embryos take approximately 11 to 21 days to develop (Morrow 1980). Most of the spawning activity appears to take place in the lower portion of the tributaries. Spawning areas in the six streams will be inundated in May and June of the first year of filling. The water surface elevation is forecast to increase at a rate of 5 feet (1.5 m) per day during the spawning period, with increases of 3 feet (0.9 m) per day during the latter part of the incubation period.

2.3 - Anticipated Impacts to Aquatic Habitat

During the grayling spawning period, streams generally carry increased sediment loads from high spring flows and ice breakup. The sediments carried by the stream will be deposited at their confluence with the reservoir as a result of the reduced stream velocities associated with backwater conditions. The resultant sedimentation will deposit on the spawning bed, and embryos on the stream bottom will likely be covered with sediment and suffocate. Longnose sucker may spawn in tributary mouths during the spring (ADF&G 1981f), and they are expected to experience the same effects as grayling.

Arctic grayling depend on tributary habitats for summer rearing areas. Grayling are not expected to occupy reservoir habitats during the summer as they are not found in lake habitats with turbidity levels similar to those projected to occur in the reservoir (Russell 1980) (see Chapter 2, Section 4.1.2[e][iii] for projected impoundment turbidity levels). Grayling densities in tributaries are high, averaging 323-1835 fish per mile in 1982 (Table E.3.17), which indicates that available summer habitats are occupied (ADF&G 1981f, 1982e). Grayling occupying tributary habitats inundated by the reservoir will likely be lost because of lost feeding habitat. A small percentage of these grayling are expected to remain in the reservoir near tributary mouths.

Approximately 2.3 miles (3.8 km) of Deadman Creek will be inundated by the reservoir at full pool. Presently, a waterfall located about 1 mile (1.6 km) upstream from the mouth prevents upstream fish migration. The reservoir will inundate this barrier and allow fish passage to the upper Deadman Creek and Deadman Lake. Since the available limiting habitats in Deadman Creek are presently occupied by grayling, this is not expected to cause significant increases in the populations.

Dolly Varden will be only slightly affected by the inundation. Dolly Varden occupy a wide range of habitat types in south-central Alaska including glacial lakes with a wide range of water quality (Russell 1980). In the project area, Dolly Varden are residents occupying tributary habitats during the open-water season and after spawning return to the mainstem to overwinter. It is anticipated that Dolly Varden will occupy reservoir habitat year-round.

Dolly Varden spawn in the fall, the embryos incubate through the winter, and the alevins emerge in the late spring. Since the reservoir is not filling during the spawning and incubation period, any spawning areas available in the fall would not be affected before emergence.

- Lake Habitats

Sally Lake (Figure E.3.21) and several other small lakes will be inundated by the reservoir. Sally Lake has populations of lake trout and grayling that appear to be stunted (ADF&G 1981f). Since grayling populations are not usually associated with glacial lakes or turbid water, the grayling population will likely be lost. Lake trout will be able to survive in the reservoir if an adequate food base exists. Lake trout are found in glacial lakes, including Chakachamna and Kontrashibuna Lakes (Bechtel Civil and Minerals, Inc. 1981 and Russell 1980), with physical characteristics similar to those expected in the Watana reservoir.

(ii) Watana Dam to Talkeetna

Table E.3.26 presents a comparison of average monthly pre-project flows and projected monthly flows at Gold Creek during initial reservoir filling. The greatest change to the system will occur during the summer season. The filling phase of the Watana development will alter streamflows, water quality, and water temperatures downstream from Watana dam to Talkeetna (Chapter 2, Section 4.1.2). The second open-water season of filling (May 1992 through October 1992) is scheduled for minimum releases and is thus discussed below as maximum expected impact, unless otherwise noted.

- Mainstem Habitats

Mainstem habitats in this reach can be divided into two segments: from Watana Dam to RM 152 in Devil Canyon and from RM 152 to Talkeetna (RM 99). High velocities associated with natural flows through

Devil Canyon normally appear to prohibit upstream passage of fish beyond RM 152. Thus, anadromous fish are prevented from using habitats upstream from the canyon except during dry years when flows are 12,000 to 15,000 cfs or less. During 1982, one of the driest summers on record, chinook salmon ascended to RM 156.8 but were not reported upstream from that point.

During the open-water season (June through October) mainstem habitats below Devil Canyon are primarily used as a migratory corridor by adult and juvenile fish as they move to and from spawning and rearing areas that are located in other habitat types associated with the river. A few isolated salmon spawning areas have been identified in the mainstem (ADF&G 1981b, 1982e). Some juvenile salmon rear in this habitat type in low densities during most of the open-water season. Juvenile salmon from other rearing areas and resident fish move into mainstem habitats for overwintering as the river clears in late fall (ADF&G 1981d, 1981e). Several resident species, including burbot, whitefish, and longnose sucker, occupy mainstem habitats year-round (ADF&G 1981e). Upstream from Devil Canyon, mainstem habitats are used by burbot, sculpin, longnose sucker, and whitefish year-round and by arctic grayling for overwintering habitat (ADF&G 1981f).

- Altered Flow Regime

A variety of changes will occur in mainstem habitats as a result of the proposed Watana reservoir-filling schedule. Flows will be substantially reduced during the spring period. With the exception of the first year, average monthly flows in May and June will be reduced to approximately 6000 cfs from pre-project average annual flows of 13,300 and 28,100 cfs, respectively (Table E.3.26). Decreases of this magnitude will affect the physical processes in this reach, which in turn will affect fish associated with this habitat type.

Filling flows during May and June will affect the ice removal process in this reach. Presently, the natural flows increase during May, causing a mechanical breakup of the ice cover, and rapidly transport large chunks of ice and attached sediment downstream. The force to raise and fracture the ice cover is the result of rising stream flows caused by rapid snowmelt and is common to many Alaskan rivers. Under the filling schedule, mechanical breakup will tend to be less severe in the mainstem and unlikely to occur in side-channel or slough habitats. Thus, ice scouring and bank gouging would be reduced. The potential for ice jams and resultant flooding would be diminished (Chapter 2, Section 4.1.2[e][ii]).

Outmigration of salmon fry and smolts generally occurs in June, apparently on the receding limb of the high spring flows. Flows of 6000 cfs would not affect downstream migrations in mainstem habitats because sufficient depth and velocities would exist to transport fry or smolts. Predicted depths and velocities at all 65 surveyed cross-sections between Devil Canyon and Talkeetna indicate that at 6000 cfs, minimum depths would exceed 2 feet (0.6 m) (Figure E.2.10).

Flows of 6000 cfs would persist until the last week of July. Chinook salmon are passing through the system in late June and July to spawning habitats in tributary streams. These fish hold in mainstem areas to mature before moving into the tributaries (ADF&G 1981b). Many of the holding areas available at flows of 20,000 cfs would probably not be available at 6000 cfs, however, other suitable holding areas are expected to exist under the low-flow conditions resulting from filling the reservoir.

During June and July of the second and third years of filling, flow velocities in Devil Canyon are not expected to block all upstream fish passage. Chinook salmon would likely be able to pass through the canyon and utilize spawning habitat available in tributaries upstream from Devil Canyon and below Watana Dam. Telemetry studies located chinook salmon in the lower Devil Canyon reach (RM 150.4 to 151.5) in late June and early July 1982 (ADF&G 1983). In August, spawning chinook salmon were observed in the mainstem at the mouth of Cheechako Creek (RM 152.5) and in an unnamed creek (RM 156.8), both upstream from the Devil Canyon damsite. High velocities blocked migrations past RM 156.8 (ADF&G 1982d).

2.3 - Anticipated Impacts to Aquatic Habitat

According to 1982 USGS provisional streamflow data, flow levels dropped to 17,000 cfs at Gold Creek in early July, then rose to 25,000 for the remainder of the month. Since the telemetry studies located chinook salmon just downstream of Devil Canyon in late June, the salmon probably passed through the canyon in early July when the flows had dropped. High flows in 1981 prevented them from migrating past RM 151.7 (ADF&G 1981b). With the filling flow of 6000 cfs in June and July, the entire canyon is expected to be passable by chinook salmon, allowing them to enter Tsusena, Fog, and Devil Creeks (RM 178.9, 173.9, and 161.0).

Pink, chum, and coho salmon spawning areas in the mainstem are expected to be adversely affected by the flows proposed in the filling schedule. These spawning areas are generally small, isolated areas on the river margins or behind velocity barriers (ADF&G 1981a, 1983). Lateral areas are more susceptible to changes in flow. The quality of these habitats will be degraded through reduced depth and velocity; some areas may be completely dewatered.

Fall flows at Gold Creek drop rapidly under the filling schedule (Table E.3.26). Under the filling flows, the river would reach 2000 cfs in October, whereas flows of 2000 cfs do not normally occur until November. In addition, the entire ice formation process will be delayed 3 to 4 weeks later than normal, and the staging will be less than normal. Thus, the stage during filling in October would be reduced, decreasing the wetted perimeter. Spawning areas of summer and fall spawning fish, such as salmon and whitefish, are expected to be adversely affected by receding flows.

. <u>Altered Temperature Regime</u>

Since the diversion tunnels will function as low-level intakes, the thermal regime of the Susitna River from Watana Dam to Talkeetna will be altered (Chapter 2, Section 4.1.2[e][i]). Downstream water temperatures during the first open-water period of reservoir filling (May through

October) will be similar to pre-project temperatures, with some lagging. During fall, the reservoir will retain heat longer and will gradually cool to 4°C (39.2°F). Winter temperatures above Devil Canyon are expected to range from 2 to 4°C (35.6° to 39.2°F). When the water reaches RM 160, water temperatures are expected to be near 0°C (32°F) (pre-project levels).

Temperatures during the second open-water season will be substantially reduced. Water released at Watana Dam will be approximately 4°C (39.2°F). Because of the large water volume (12,000 cfs in August) and the high average water velocities (3-4 ft/sec or 0.9-1.2 m/sec), water temperatures during August are expected to be in the range of 5° to 6°C (41° to 42.8°F) at Talkeetna. At the beginning of the third year of filling, the reservoir water surface elevation is expected to be 2083 feet (631.2 m), high enough to utilize the multiple level intake structure (Figure E.2.105). This will provide sufficient control to release water near 10°C (50°F) during July, August, and early September (Figure E.2.174).

Lower water temperatures during the second season of filling may adversely affect fish populations in the reach from Watana Dam to Talkeetna. Projected water temperatures of 5° to 6°C (41° to 42.8°F) are well below normal water temperatures of 10° to 12°C (50° to 53.6°F) in August. Under natural conditions, pink salmon have been reported to migrate at 5°C (41°F) in Russia, while 7°C (44.6°F) is the lowest reported migration temperature below 50°N latitude (Bell 1983). For coho salmon, 4°C (39.2°F) is the lowest recorded temperature at migration in northern stocks, while 7°C (44.6°F) is the lowest temperature below 50°N latitude. In the Columbia River, coho movements ceased at approximately 6°C (42.8°F) (Bell 1983). In northern areas, chinook have been reported moving at 4°C (39.2°F), sockeye at 2.5° to 4°C (36.5° to 39.2°F), and chum at 1.5°C (34.7°F). These observations are not directly applicable for predicting the impacts associated with the temperature reduction during filling since they represent natural migrating temperatures. Salmon returning to the Susitna River will begin migrating in the near-normal temperature regime in the lower river and then encounter reduced temperatures at Talkeetna. These lower temperatures are expected to increase milling behavior and delay the migration into the reach upstream from Talkeetna. Portions of some stocks, particularly pink and coho, will likely not enter the reach and will select alternative spawning areas. For those adults that enter the reach, the mainstem temperatures are expected to slow the rate of migration and retard sexual maturity. These impacts will result in reduced productivity in this reach during the second year of filling. Slough and tributary temperatures will be unaffected, so adults that reach these normally-used spawning areas would resume natural spawning activity.

Lower water temperatures during the second open-water season are expected to adversely affect resident and juvenile anadromous fish that utilize mainstem and side-channel habitat. Feeding activity and growth are closely correlated with water temperature (Clarke et al. 1982). Colder water temperatures may reduce growth during the open-water season. Juvenile salmon have been found to avoid cooler water when possible (Bustard and Narver 1975). Thus, fish may avoid mainstem and side-channel habitats and move to warmer water in tributary and slough habitat.

- Side-Channel Habitats

Many of the physical changes identified for mainstem habitats would also occur in side-channel habitats. Since the side channels are generally characterized by higher streambed elevations at their upstream than the mainstem bed elevation at that location, the forecasted changes in streamflow are expected to cause greater effects in side-channel habitats. During the open-water season, side-channel habitats are used for passage by salmon and rainbow trout; for spawning by pink, chum and coho salmon; and for summer feeding areas by longnose sucker, burbot, and whitefish (ADF&G 1981b, 1981d, 1981e, and 1983). Little juvenile salmon rearing has been reported in side-channel habitats during the open-water season (ADF&G 1981e).

2.3 - Anticipated Impacts to Aquatic Habitat

As in mainstem habitats, the greatest changes would occur in the spring because of the substantial flow reductions from pre-project flows (Table E.3.26). Many side channels that normally convey water in May, June and the first three weeks of July may be dewatered under filling flows.

Decreased mainstem flows would likely result in decreased depths and velocities in some side-channel habitats and complete dewatering of others. This is expected to alter or eliminate the availability or suitability of currently used spawning habitat.

It is unlikely that new spawning areas will become available in side channels under the filling flows. Side-channel habitats with a streambed elevation at their upstream end that is low enough to convey water during the reservoir filling process are expected to have substrate that is too large for spawning. Under natural conditions these side channels are subject to peak flows that have removed most of the gravel substrates, leaving the streambed armored with large cobbles and boulders (R & M Consultants 1982c). It is unlikely that the substrate in these areas would change as a result of the project. Thus, the use of these areas by spawning fish would continue to be limited by substrate.

Reduced flows in the spring may inhibit emergence and outmigration in some side-channel spawning areas. At times, spawning areas can be substantially dewatered but the embryos can be maintained by intergravel flow that allows development to proceed. Normally, increased spring streamflow in these areas provides water for emergence and outmigration. Filling flows are not expected to be sufficient to provide streamflow in some of these areas.

Filling flows will alter the hydraulic conditions of the side channels that are not dewatered. Lower discharges will decrease velocities, depths, and wetted perimeters. This is expected to improve the quality of these areas as rearing habitat for some resident and juvenile anadromous fish. Juvenile fish are generally found in association with low velocities (ADF&G 1982, Wilson et al. 1981; and Environaid 1982). Burbot, longnose sucker and whitefish are also found in waters with a low velocity, but require greater depth.

Use of these areas by juvenile salmon may be presently limited by lack of a food source. Benthic production is limited by the high summer turbidities and scouring effects of suspended sediments. Under filling flows, turbidity would be decreased (Chapter 2, Section 4.1.2[e][iii]), allowing greater light penetration; the scouring effect of the greater pre-project flows would also be reduced (Chapter 2, Section 4.1.2 [d]). Some side channels above Talkeetna will be completely dewatered under the proposed filling flows, thus eliminating any rearing or feeding habitat normally supported by pre-project flow levels. Benthic production from these areas would also be lost. The increase in production because of greater light penetration and reduced scouring in flowing side channels is expected to be much greater than the loss expected from dewatering some of the side channels.

Stream temperatures during filling in side-channel habitats will be similar to mainstem habitats (see previous section).

- Slough Habitats

Slough habitats in the Watana Dam to Talkeetna reach have been identified as the most important spawning areas directly influenced by the Susitna River. Sockeye, chum, pink, and coho salmon have spawned in 20 of the 34 sloughs found above the confluence with the Chulitna River (see Figures E.3.12 to E.3.17). Juvenile coho and chinook have been found utilizing these areas as rearing and overwintering habitat (ADF&G 1981d). Rainbow trout, burbot, longnose sucker, and whitefish have been found in these habitats at various times of the year (ADF&G 1981e).

Sloughs in this reach of the river resemble confined side channels. In general, they function as overflow channels and convey turbid water from the mainstem at high flows. During mainstem flows of less than 20,000 cfs, clear water originates from surface runoff and ground water upwelling and flows through the slough channel into the mainstem river. (Refer to Section 2.2.2[c] of this chapter and Appendix E.2.A.)

Preliminary conclusions from a study of Slough 9 indicated that ground water upwelling, and in part, flow, in this slough is related to the stage of the mainstem Susitna River (Trihey 1982d). At the slough upwelling locations that are within the mainstem backwater, the ground water gradient between mainstem and slough is relatively unaffected by discharge until backwater effects are no longer present at the upwelling location. Hence, upwelling rates in backwater areas would remain virtually unchanged until the area is no longer affected by backwater. At locations where slough upwelling is unaffected by mainstem backwater effects, the reduced gradient will result in reduced slough upwelling rates. Under reservoir filling conditions, discharge will be reduced to about 1000 cfs at Gold Creek during the freezeup period. This will result in reduced staging compared with pre-project ice-staging levels. Hence, during winter, the mainstem slough water level differential will be reduced with a corresponding reduction in upwelling area. Reduced upwelling would affect the quality and quantity of both spawning and rearing habitat presently available in the system[1].

Filling flows will cause passage problems for adult salmon moving from the mainstem and side-channel habitats into slough habitats. Based on field observations during the low flows of August 1982, Susitna streamflows in the range of 12,000 to 14,000 cfs, combined with extremely low surface runoff into the sloughs, hampered or restricted the passage of adult salmon into several sloughs. The water depth at the slough entrance is a function of the water surface elevation of the mainstem and the discharge from the slough[2]. An incremental analysis was performed on the effects of various discharges on access of adult salmon into Slough 9. Data obtained during the 1981 and 1982 field seasons indicate that the flow from Slough 9 is quite small unless the mainstem has overtopped the alluvial berm at its upstream end (Trihey 1982d). Upstream passage into Slough 9 by adult chum salmon would not appear to be restricted when mainstem discharges were 18,000 cfs or higher. Access becomes

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1/ Additional information is presented in Appendix E.2.A.

2/ This relationship is presented in Appendix E.2.A for sloughs 8A, 9, and 21.

increasingly more difficult as mainstem discharge decreases. An acute access problem exists at streamflows of 12,000 cfs and less (Trihey 1982d). In general, upstream access into Slough 9 is somewhat more difficult than an average entrance condition encountered by adult salmon in the Devil Canyon to Talkeetna reach. Upstream access into Slough 9 is easier than access to Slough 16B or 19; but more difficult than access into Whiskers Slough or Slough 8A. It is a reasonable index of entrance conditions into Sloughs 20 and 21 (Trihey 1982d). Under Watana filling conditions, only the backwater areas would be affected. Surface runoff, which is controlled by rainfall, and snowmelt and ground water upwelling contribute to the flow in the sloughs. The flow in the slough controls the physical characteristics of the habitat upstream from the backwater during the open-water season.

A reduction in mainstem stage may degrade and reduce spawning habitat in the sloughs. Adult sockeye and chum appear to seek out areas with upwelling ground water in which to spawn. If a reduction in mainstem discharge reduces the amount of upwelling or the area influenced by upwelling, spawning habitat will be reduced or may be eliminated. In a worst case scenario, if all upwelling ceased such that all slough spawning was eliminated, the spawning area used by approximately 3700 chum in 1982, 2300 sockeye in 1981, and 740 pink salmon in 1982 would be eliminated (Table E.3.12). Losses of this magnitude would reduce the total run size by 11,840 chum; 9200 sockeye and 3550 pink salmon, assuming harvest in escapement ratios of 2.2:1; 3.0:1; and 3.8:1, respectively (Friese 1975). The sockeye that spawn in the sloughs upstream from Talkeetna, however, are considered to be strays from Chulitna and Talkeetna River stock (ADF&G 1983). If this is true, and this segment of the run is not self-perpetuating, then the run size of sockeye would not be reduced.

Since juvenile fish occupy habitats with a relatively wide range of depth, decreases in the depth of sloughs are expected to have little effect on the utility of rearing habitat. The greatest impact to juvenile habitat would occur if the reduction in depth also eliminates or reduces the utility of cover objects associated with slough habitats. In addition to object cover, young chinook have been observed occupying the interface between the turbid and clear-water portions of the backwater at the mouth of the slough. Under the proposed flow regime during reservoir filling, the amount of this particular habitat would be reduced by decreased backwater effects. Additional rearing habitat, however, is expected to become available in mainstem and side-channel habitats. (These habitats are discussed in their respective sections.)

The reduction of mainstem flows during the spring and the altered breakup process may affect out-migration from slough habitats. It is thought that changes in water levels and temperatures trigger out-migration in young salmon. Fish were observed to outmigrate on the receding edge of the high flows in spring 1982. Under the filling schedule, the high flows during the spring would be eliminated. However, flow from local runoff would be unaffected, and this flow and rising water temperatures should be sufficient to stimulate fry to out-migrate from the sloughs (Thomas 1975).

Under filling flows, increased beaver activity is expected to have an adverse effect on adult salmon utilization of slough habitats. The elimination of spring breakup flows will allow beaver to become established in most sloughs. During the low flows of August 1982, beaver dams located in Slough 8A, inhibited use of upstream slough habitats by adult salmon. An increase in beaver dams, however, would increase rearing habitat for juvenile chinook and coho.

- Tributary Habitats

Compared with other habitat types in the reach from Watana Dam to Talkeetna, tributary habitats receive the largest salmon escapement (Section 2.2.2(b)[iii]) of this chapter; ADF&G 1981b and 1983). Tributaries also provide important spawning habitat for grayling and rainbow trout and rearing habitat for chinook and coho salmon juveniles (ADF&G 1981d and 1981e).

With the exception of tributary mouths, tributary habitats below the impoundment will not be affected by the proposed project. Seasonal variations of the mainstem discharge changes the hydraulic conditions associated with the tributary mouths. During the open-water season, the present stage in the mainstem river causes a backwater to form at the tributary confluences. The backwater area provides rearing habitat for resident species and juvenile salmon (ADF&G 1981d and 1981e) and facilitates passage of upstream migrants into the tributary.

Lower mainstem flows during filling will reduce the backwater effects and decrease water depths at tributary mouths. Rearing fish are not expected to be impacted since similar backwater areas will reform in mainstem habitats downstream from tributary mouths.

A reduction in the stage of the mainstem river could cause some tributaries to become perched and impede migration by adult salmon and resident fish to upstream areas. As the tributary enters the mainstem river, the change in gradient causes the tributary water to drop transported materials. These gravels and sand form small deltas at the mouths of tributaries (Figure E.2.140). As the stage in the mainstem recedes, the tributaries become perched above the river. Since the flow in the tributaries is not regulated, the tributaries would continue to experience peak high flows. In most tributaries that support fish, these high flows will be sufficient to down cut through the delta material to establish a channel at a new gradient (R&M Consultants 1982f). Jack Long (RM 144.8), Sherman (RM 130.9), and Deadhorse (RM 121.0) Creeks are the only streams used by adult salmon that may remain perched under the proposed filling flows (R&M Consultants 1982f). Although adult pink salmon have been documented in Deadhorse and Sherman Creeks, it is questionable whether winter flows that drop below the surface can support successful salmon production.

An incremental analysis of access into Portage Creek and Indian River under project operational flows indicated that access by adult salmon is not expected to be a problem (Trihey 1983). If the tributary channels remain perched and mainstem flows are near 8000 cfs, tributary discharge will provide sufficient depth to maintain access. Velocities near the confluence of both tributaries are also not expected to block access. It is anticipated that the tributaries will down cut to a new streambed equilibrium (R&M Consultants 1982f) at a depth approximately the same magnitude as the difference between the water surface elevation associated with the most prevalent summer discharge of the mainstem.

The reduced flows through Devil Canyon will allow chinook salmon access to tributaries upstream from the rapids that have historically blocked salmon migrations (see mainstem section). Under the filling regime, chinook salmon will have access to Cheechako Creek (RM 152.5) and the unnamed tributary at RM 156.8 (Figure E.3.6) on an annual basis. In addition they are expected to have access to Tsusena, Fog, and Devil Creeks at RM 178.9, 173.9, and 161.0, respectively (Figure E.3.6). There appears to be adequate habitat in these creeks to allow for salmon production. Thus, the Watana development will increase the availability of spawning habitat in tributaries in this reach. Future development of the Devil Canyon dam would subsequently eliminate access to these tributaries.

(iii) Cook Inlet to Talkeetna

Project effects below Talkeetna are expected to be considerably reduced in magnitude from those presented for the Watana dam to Talkeetna reach. Just upstream from Talkeetna, the Chulitna and Talkeetna rivers join the Susitna River. These rivers contribute 39 and 18 percent, respectively, of the streamflow in this reach (R&M Consultants 1981c). Many other major tributaries enter the Susitna in this reach (Figure E.3.3). In order to evaluate the streamflows in this reach, two streamflow stations, the Sunshine and Susitna stations, were established. Tables E.3.29 and E.3.30 present a comparison of pre-project and proposed filling flow regimes for these stations.

Since the project will have no effect on the tributary basins, project-related physical changes in the Susitna River below Talkeetna will be of less magnitude than physical changes above Talkeetna. Impacts to fish habitats below Talkeetna are expected to be limited since only minor changes will occur in physical characteristics of mainstem habitats. Physical characteristics of side channels are generally more susceptible to changes in mainstem discharge and the proposed filling flows may affect side-channel habitats.

- Mainstem Habitats

During the open-water season, mainstem habitats in this reach of the Susitna River are used primarily for passage and limited spawning. The reach extending from approximately RM 4.5 to RM 29 is almost entirely eulachon spawning habitat sustaining a spawning adult population ranging in the millions of fish (ADF&G 1983). In addition, spawning areas for chum salmon and Bering cisco have been located (ADF&G 1981b, 1982d,e and 1983). To date, few rearing fish have been found in this reach (ADF&G 1981d). Resident fish including burbot, whitefish, and longnose sucker occupy mainstem habitats during the open-water season (ADF&G 1981e).

Little change is expected in water temperature or turbidity in this reach. The Chulitna River carries a much heavier sediment load and has approximately the same discharge as the pre-project Susitna River at their confluence (R&M Consultants 1981d). Under the proposed filling schedule, the water from the Susitna River would comprise approximately 14 percent of the streamflow below the confluence of the Chulitna and Talkeetna rivers in July and 25 percent in August. The influence of the Chulitna and Talkeetna rivers would dominate the thermal, water chemistry, and suspended sediment characteristics of the lower Susitna River (Chapter 2, Section 4.1.2[e][iii]).

Only a small reduction in the number and magnitude of peak flows from Talkeetna to Cook Inlet is anticipated. Since the project controls such a small portion of the runoff in this reach, a 1-in-2-year flow event at Susitna Station would become a 1-in-5 or 1-in-10 year event (R&M Consultants 1982). Thus, high, turbid flows in the lower Susitna River may still inhibit fish passage at times as well as limit benthic production.

2.3 - Anticipated Impacts to Aquatic Habitat

Under the proposed filling schedule, average monthly streamflow in July and August would be reduced by a maximum of 28 and 17 percent at Sunshine Station (Table E.3.29). Because of the channel geometry of the mainstem, flow reductions of this magnitude would probably not change the utilization of mainstem habitats with regard to salmon passage and resident fish summer activities. The reductions in depth resulting from this decrease in streamflow would not create passage problems. Nor is it likely that summer feeding areas would be eliminated. Flow reductions may have a more significant effect on spawning habitat, since this habitat tends to be located on the lateral margins of the mainstem and in side channel area.

Most salmon-spawning areas in the mainstem are located in broad or braided segments that are more sensitive to changes in flow. Small changes in stage near the threshold value necessary to overtop the upper end of the braided channels can potentially result in large changes in the availability of spawning areas within the braided area.

Salmon and Bering cisco spawning habitats may be subject to greater changes, since they occur primarily in the upper portion of this segment from RM 75 to 81 (ADF&G 1982a and 1983). Bering cisco spawned in mainstem habitats from RM 75 to RM 81 during October 1981 (ADF&G 1982b, and 1983). During filling, October flows would be reduced by 9 percent the second year and by 26 percent the third year at Sunshine Station (Table E.3.29). Reductions less than 10 percent are not expected to impact fish as changes in depth and velocity are small. Reductions of 26 percent may reduce Bering cisco spawning habitat.

Eulachon spawning areas would be subject to the least amount of change, since they occur in the lower part of the reach, RM 4.5 to 58 (ADF&G 1982d and 1983). Eulachon spawning areas were identified by ADF&G during spawning surveys in May 1982 in areas adjacent to cut banks and riffle zones or bars with moderate velocity where the substrate included deposits of unconsolidated sands and gravels. Because of the channel geometry in the broad, braided floodplain of this reach, similar habitats are expected to exist in this portion of the river under the proposed filling schedule. Reductions in long-term, average monthly streamflows of 12 percent (from 60,500 to 53,100 cfs) are predicted at Susitna Station during May (Table E.3.30). Even if some of the habitat presently utilized is dewatered, habitat available along the margins of the floodplain under the filling flows will provide replacement habitat.

Winter streamflow reductions are not expected to affect habitat utilization in the mainstem below Talkeetna. Low winter flows can stress overwintering fish and embryos and are often a limiting factor for fish populations in Alaska. In the Susitna River, flow generally reaches its lowest level in March. Flow reductions are not projected during this period (Tables E.3.29 and E.3.30). Therefore, overwintering success of fish or developing embryos in mainstem habitats is not expected to differ from existing conditions.

Spring breakup flows will be decreased during filling. Average monthly flows in May and June will be reduced by 26 percent at Sunshine Station and by 12 percent at Susitna Station. This reduction is not anticipated to adversely affect outmigrating salmon smolts in mainstem habitats; neither is it expected to affect the spawning migration of rainbow trout or grayling as they move to the tributaries.

- Side-Channel Habitats

Many of the effects identified for the mainstem under the proposed filling schedule would also pertain to side-channel habitats. Mainstem flow generally controls the characteristics of side-channel habitats; however, changes in stream discharge can result in greater effects on side-channel habitats than on mainstem habitats. As in mainstem areas, water temperature and turbidity are expected to be similar to existing conditions below Talkeetna.

During the open-water season, side-channel habitats are used for passage by adult and juvenile salmon and resident fish; for spawning by chum salmon; and for summer feeding areas by longnose sucker, burbot and whitefish. Only limited rearing of juvenile salmon has been observed in this habitat type during the open-water season.

Reductions in streamflow during August may dewater some salmon-spawning habitat in side channels. Six side-channel spawning areas were identified below Talkeetna in 1981; none were found in 1982 (Table E.3.13). Salmon spawning activity in this habitat type is generally located in side channels with relatively high streambed elevations at their upstream end. These areas are protected from the high scouring flows and are able to retain substrates suitably sized for spawning. The high streambed elevation also makes them susceptible to dewatering under reduced mainstem discharge. The lower streamflows proposed during August may reduce the availability of spawning habitat in these areas.

The proposed filling flow regime may affect rearing habitat in side channels below Talkeetna. Side channels have a gradation of streambed elevations from high overflow channels to low, nearly continuous flow channels. The effect of reduced streamflows on rearing habitat will depend on the streambed elevation of the side channel. Some rearing habitat for juvenile anadromous and resident fish will be lost if side channels dewater or water depths become too shallow. Generally, reduced flows increase the available rearing area as young fish prefer low velocities (ADF&G 1982a, Wilson et al. 1980, and Environaid 1982). If side channels with suitable streambed elevations exist in this reach, new rearing areas should become available where the flow reductions result in decreased velocities but still maintain sufficient depth. Thus, the potential exists for the location of the rearing habitat to change, but the availability of rearing habitat would be similar to pre-project levels.

Rearing habitat and summer feeding areas may be limited by the availability of food in side-channel habitats. Suspended sediment load and peak flows contribute to low benthic production in the Susitna River. Since little change is expected in these parameters below Talkeetna (R&M Consultants 1981, 1982c), the change in hydraulic characteristics is not expected to be sufficient to increase utilization of these habitats by anadromous juvenile and resident fish as feeding areas.

- Slough Habitats

Few sloughs below the confluence of the Chulitna River have been extensively sampled. Slough habitats in this reach have been identified as rearing and possible spawning areas (ADF&G 1981b, 1981d, 1981c). Many of these areas are influenced by tributary streams and, to a lesser degree, by the mainstem of the Susitna River. Chum, pink and sockeye salmon spawn in slough habitats below the Chulitna confluence. Juvenile coho and chinook salmon have been found using these areas for rearing and overwintering (ADF&G 1981d). Rainbow trout, burbot, longnose sucker, and whitefish use these habitats seasonally (ADF&G 1981e).

Sloughs in the Talkeetna to Cook Inlet reach may be generally affected in the same way as sloughs above Talkeetna. The magnitude of predicted change in mainstem flow is less in this reach; therefore, the magnitude of changes to slough habitats and the resultant impacts to fishery resources are expected to be smaller.

- Tributary Habitats

The tributary habitats in the Talkeetna to Cook Inlet reach of the Susitna River are not expected to be significantly affected by the project. The project would not alter any of the existing physical processes in the tributaries with the exception of the area near tributary mouths. The mainstem creates a backwater at the mouths of the tributaries, which provides habitat for rearing juveniles and resident fish (ADF&G 1981de).

The stage in the mainstem controls the extent of these backwater areas. Flow reductions under the proposed filling schedule may alter the physical characteristics of the tributary mouths in the upper portion of this reach. During the open-water season, mainstem discharge will be reduced by 12 to 34 percent at Sunshine Station (Table E.3.29). Reductions in flow in June (34 percent) and July (28 percent) may reduce the areal extent of these backwaters.

Tributaries that enter the mainstem Susitna River in the lower portion of this reach should be minimally affected, since the percent change in discharge will be relatively small. Flow reductions ranging from 13 to 8 percent are anticipated from June through August at Susitna Station (Table E.3.30). Tributaries are not expected to become perched because of these reductions in mainstem discharge.

During the winter, tributary mouths provide important overwintering habitat and may provide spawning habitat for burbot. Because there will be no reduction in mainstem discharge during the ice covered season, winter conditions are expected to remain the same as pre-project conditions.

(iv) Estuary

Since only minor increases in salinity are anticipated during reservoir filling, impacts to fishery resources are not expected.

(c) Operation of Watana Dam

Operation of Watana dam will substantially alter the physical environment both upstream and downstream from the dam.

A summary of major downstream impacts, both beneficial and adverse, is presented in Table E.3.31.

(i) Reservoir Habitats

The Watana reservoir will have an area of approximately 38,000 acres (15,200 ha) with depths up to 735 feet (223 m). The reservoir will experience an annual drawdown of about 95 feet (28.8 m) from 2185 feet (662 m) above mean sea level to 2090 feet (633 m). During a dry year, such as occurred in WY1970, the lowest operational level will be 2075 feet (629 m) occurring at the end of April (Chapter 2, Figure E.2.149). The minimum acceptable level for operation is 2065 (626 m) feet or a total drawdown of 120 feet (36 m) (Chapter 2, Figure E.2.169). Water quality conditions expected in the reservoir are discussed in Chapter 2, Section 4.1.2(e) and are not expected to preclude fish utilization of the reservoir.

Habitat potential of the reservoir is considered to be limited because of low productivity. The reservoir will be oligotrophic because of summer turbidity levels of 30-40 NTU, (Chapter 2, Section 4.1.3[c]) while the 95-foot (28.8-m) October to May drawdown will inhibit development of a littoral zone. Thus, food availability may limit fish populations in the reservoir.

As discussed under reservoir filling (Section 2.3.1(b), limited populations of grayling burbot, lake trout, whitefish, and Dolly Varden are expected to utilize the reservoir year-round. An analysis of spawning habitats in relation to the annual drawdown cycle was performed to evaluate the potential for successful reproduction in the reservoir. Filling of the Watana reservoir will usually be initiated in May, at a minimum pool level of about 2090 feet (633 m), and continue through August or early September as the water surface elevation reaches its maximum level (2185 feet [662 m] in wet years) a 95-foot (28.8-m) vertical gain (Figure E.3.22). Annual reservoir filling will progressively inundate mainstem and tributary habitats. Reservoir drawdown will commence in October and continue through the end of April as water levels decline to an average minimum elevation of 2090 feet (633 m) above mean sea level. Tributary and mainstem habitats of the Susitna River and shoreline habitats in the reservoir will be progressively dewatered during the winter season.

Arctic grayling select spawning sites within lotic habitats (Morrow 1980). Embryo incubation consequently occurs within tributary reaches, indicated as being above the reservoir water surface elevation in Figure E.3.22. Grayling within the Watana reservoir will spawn in tributaries upstream from the minimum reservoir pool in May and June. Rising water surface levels (Figure E.3.22) will cause sediment deposition in spawning areas resulting in mortalities to developing embryos. (This is discussed in Section 2.3.1 [b][i].) Survival of grayling embryos is thus expected to be low within reaches of tributaries that are inundated during May and June. Figure E.3.22 indicates that grayling embryos incubating below an elevation of 2133 feet (646 m) will be inundated prior to hatching. Embryos spawned above 2133 feet (646 m), a vertical rise of 30 to 35 feet (9 to 10.6 m) above the water surface elevation at the time of spawning, will not be affected. Table E.3.28 shows the length of the major tributaries that will be inundated during the May to June period.

Lake trout, humpback whitefish, and burbot are expected to spawn within the reservoir during the fall and winter with embryos incubating during winter and spring (Figure E.3.22). In Alaska and British Columbia, lake trout spawn in September and October at depths from 3 to 110 feet (0.9 to 33 m); humpback whitefish spawn in October and November within 20 feet (6 m) of the surface; and burbot spawn in December within 20 feet (6 m) of the surface (Morrow 1980).

The decrease in water surface elevation during winter is expected to dewater humpback whitefish and burbot embryos (Figure E.3.22). Lake trout embryos deposited above an elevation of 2120 feet (642 m) will be dewatered while those spawned below a depth of 65 feet (19.7 m) (elevation 2120 feet [642 m]) in September and October are expected to survive.

Dolly Varden embryos, which are deposited in tributaries during the fall, will not be affected by the drawdown cycle.

As presented in Section 2.3.1(b)(i), reservoir habitats will provide overwintering habitat for grayling, lake trout, burbot, whitefish, longnose sucker, and Dolly Varden.

(ii) Watana Dam to Talkeetna

- Mainstem Habitats

The primary impacts of Watana operation on the mainstem habitats between Talkeetna and Watana are,

. Altered seasonal flow regime;
. Altered temperature regime;
. Reduced sediment load downstream of the dam; and
. Altered water quality parameters.

. Open-Water Season

Open water post-project flows in the mainstem would be substantially reduced from pre-project conditions. Predicted reductions in average monthly flows at Gold Creek range from 22 to 62 percent of pre-project flows over the period of May through September (Table E.3.32). Secondary impacts of reduced flow include,

.. Decreased flow velocities;
.. Decreased depths in many mainstem habitats;
.. A reduction in the number and magnitude of flood events in this reach of the Susitna River; and
.. Decreased sediment transport.

Because use of mainstem habitats appears to be limited in part by high velocities, decreased streamflow and the corresponding decrease in velocity may improve the utility of mainstem habitats for both resident and anadromous fish. Prior to construction of Devil Canyon dam, chinook salmon will be able to pass through the canyon, which is presently unpassable, and utilize spawning habitat available in tributaries upstream from Devil Canyon and below Watana dam.

Operating flows are higher than filling flows from May through July and are thus expected to provide greater depths than filling flows (Section 2.3.2 (b)[ii]). Depths associated with operation flows are generally not expected to significantly decrease wetted perimeter because of the rectangular channel configuration of existing mainstem areas. Depths are expected to be sufficient for fish passage.

The significant reduction in the number and magnitude of flood events in this reach of the Susitna River can have several beneficial effects on mainstem habitats. Presently, the Susitna River at Gold Creek carries peak flows of 75,000 to 80,000 cfs (10-year frequency). These flows transport large amounts of sediment, scour the riverbed, and remove most of the suitable spawning gravels. Reduction of these peak flows would reduce these habitat disruptions. In addition, recent studies of high streamflows of 38,500 cfs in August 1981 (ADF&G 1981b and 1982a) indicate that flows of this magnitude inhibit upstream migration of adult salmon. Migration resumed when the flows receded. Operation of the project will decrease the magnitude and frequency of high flows and associated velocities, thus reducing disruptions in migrations.

During operation of Watana dam, approximately 80 percent of the sediment load upstream of Watana will settle out in the reservoir and be trapped behind the dam. Sediments less than 3 to 4-micron in diameter (20 percent of the sediment load) will pass through the dam and be transported downstream to Cook Inlet.

Decreased sediment load combined with post-project flow reductions will result in decreased open-water turbidity downstream of Watana. The relatively clear water will scour silts and sand from the substrate downstream from the dam and transport them down river. Over time, this will result in the removal of fine sediments from the streambed. However, much of the riverbed above Talkeetna is presently armored with large gravels and cobbles and silts probably will be removed only from the surface of the streambed. Decreased sediment load is also expected to improve benthic production, since siltation of interstitial spaces will be reduced and light penetration will increase. At present, high flows may limit benthic production in the mainstem as frequent bed movement may preclude the development of a stable environment.

The combination of impacts discussed above are expected to produce the following changes to spawning and rearing habitats during the open-water season of Watana operation.

.. Small, isolated spawning areas located on the river margins behind velocity barriers may be degraded or dewatered. The creation of new spawning habitat be natural process appears unlikely. Although adequate depth and velocities are likely to exist, the lack of suitable substrate would probably limit spawning in this type of habitat. The streambed of most of the mainstem channel is composed of large cobbles and boulders (R&M Consultants 1981c). Even though flood flows would no longer flush gravels from this reach, the recruitment of gravel to the river will be limited because of sediment trapping in the reservoir. Isolated deposits of gravel will occur downstream from tributary mouths and may provide some suitable spawning habitat.

.. Rearing habitat in the mainstem is expected to increase under post-project conditions. Reduced velocities and turbidity will probably benefit young fish and resident adults. Areas providing suitable habitat will likely still be limited to river margins or other low-velocity areas created by obstructions in the channel. Increased benthic production would also enhance rearing habitats by providing increased availability of prey items. Some fish presently use the turbidity as cover, thus increased clarity may result in greater predation on small fish. With increased water clarity, additional sport fishing may be imposed on the fish in this reach of the River.

. <u>Winter/Ice Season</u>

During the winter (October through April), mainstem habitats are used by rearing salmon and resident fish, including rainbow trout, burbot, whitefish, and longnose sucker. Fish move out of the tributaries to mainstem habitats where most overwintering occurs (ADF&G 1981d, 1981e). The impacts of Watana operation on these mainstem habitats include,

.. Increased water temperature leading to a change in ice cover;

.. Increased winter flows varying from 38 percent in October to 650 percent in February; and

.. Increased turbidity.

Winter thermal characteristics of the reservoir determine the outflow temperatures and directly influence downstream water temperatures. The outflow from the Watana reservoir will likely be about 4°C (39.2°F) at the beginning of winter, cool quickly and remain about 1° (33.8°F) to 2°C (35.6°F) throughout the remainder of the winter (Chapter 2, Section 4.1.3[c][i]). Temperatures such as these would preclude development of an ice cover in the upper section of this reach, thus eliminating the associated staging and backwater effect. Ice front progression above the confluence is expected to start in late December or early January with the upstream edge of the ice cover progressing to between Sherman (RM 130) and Portage Creek (RM 149) (Chapter 2, Section 4.1.3(c)[ii]). Assuming reservoir outflow temperatures decrease linearly from 4°C (39.2°F) on October 15 to 1°C (33.8°F) on January 1, an ice cover will form at RM 149. If the outflow temperatures are constant at 4°C (39.2°F), an ice cover will form by RM 130 (Chapter 2, Section 4.1.3(c)[ii]). Downstream from the upper end of the ice cover, winter water temperatures are expected to differ little from pre-project conditions.

Because backwater and staging effects will be eliminated in the post-project, open-water reach, the river in this reach is expected to have higher velocities, less depth and less wetted perimeter than under pre-project condition with an ice cover (Section 2.3.1(c)[ii]). In those areas that retain an ice cover, wetted perimeter and depth will greatly increase in many mainstem habitats because of staging and increased discharge, although high velocities in several steep gradient sections may prevent the formation of an ice cover in these areas. Staging will occur at the ice front, and if the stage of the river is raised sufficiently, mainstem waters will flood side-channels and sloughs.

Turbidity is projected to increase slightly over present winter conditions. Particles less than 3 to 4 microns will remain in suspension in the reservoir, increasing downstream turbidity levels (Chapter 2, Section 4.1.3(c)[iv]). This slight increase in turbidity is not expected to adversely affect fish populations using mainstem habitats. Fish apparently successfully overwinter in habitats with similar levels of turbidity in the Kenai River, Alaska (Burger et al. 1982). Increased post-project winter flows, warmer water temperatures, and altered ice processes may have the following impacts on fish in the Talkeetna to Watana reach.

2.3 - Anticipated Impacts to Aquatic Habitat

.. Increased flows will provide more under-ice overwintering habitat for juvenile anadromous and resident fish by increasing depth and wetted perimeter.

.. Warmer water temperatures are expected to benefit overwintering fish by reducing mortalities associated with freezing. Stream temperature and discharge will remain fairly stable, preventing fish from becoming trapped in unfavorable areas that freeze. During the winter of 1981-1982, information on fish distribution suggested that fish were seeking warmer water temperatures. Bustard and Narver (1975) reported that juvenile coho move to warmer water for overwintering when warmer water is available.

.. If the increased surface water temperatures cause an increase in intergravel water temperatures (i.e., the intergravel temperature is not controlled by upwelling ground water), then incubating embryos will be affected. Incubation rates of fish embryos and benthic invertebrates are closely tied to water temperatures. An increase in intergravel water temperatures would likely accelerate development and result in early emergence. Early emergence has been related to decreased survival rates in both benthic invertebrtates and Pacific salmon (Bailey et al. 1974). Pink salmon would be especially vulnerable to mortality related to early emergence, since they tend to select areas directly influenced by surface water and tend to out-migrate shortly after emergence. Young fish may begin to out-migrate before downstream conditions are suitable. Temperatures below the confluence of the Chulitna River are likely to be near 0°C (32°F). Out-migrants encountering these temperatures may experience thermal shock, which has been linked to increased mortality (Brett and Alderdice 1958 and Brett 1952). Chum salmon would be less susceptible to changes in surface water temperatures as the adults tend to select areas influenced by upwelling ground water, which is buffered from changes in mainstem surface water. In addition, chum salmon may rear for approximately a month before moving downstream. Early emergency should have little effect on coho salmon, since they remain in freshwater habitats for two years and have been found to seek out warmer areas in the spring. U.S. Fish and Wildlife is currently studying the effects of projected water temperature changes on incubation of Susitna River sockeye and chum salmon eggs. The four temperature regimes under study were chosen to provide an analysis of probable post-project temperature variations on incubation times as compared to pre-project mainstem and slough water temperatures.

Other than the turbidity and temperature changes discussed above, no impacts to water quality parameters are anticipated under winter or open-water conditions under Watana operation. Gas supersaturation, which is caused by water passing over a high spillway into a deep plunge pool and dissolving air into the water, will not be a problem at Watana. Mitigation through the use of cone valves in the spillway design is discussed in Section 2.4.4(d).

- Side-Channel Habitats

Many of the project-induced physical changes identified for mainstem habitats would also occur in side-channel habitats. Reductions from pre-project streamflow during the open-water season may dewater some spawning habitat presently used by salmon.

The lower operational flows during the spawning season may concentrate spawning salmon in areas that are less likely to dewater under the higher winter flows and thus increase spawning success. Side channels with lower streambed elevations are presently subject to scouring at high flows and many do not have substrates suitable for spawning. Most are armored with large cobbles and boulders that are underlain with large gravels embedded in silt and sand.

Operational flow should result in additional rearing areas becoming available in side-channel habitats during the open-water season. Lower discharges generally result in decreased velocities and depths. This would likely improve the quality of these areas as rearing habitat for some resident and juvenile anadromous fish.

2.3 - Anticipated Impacts to Aquatic Habitat

Post-project water temperatures in the side-channel areas will be similar to mainstem water temperatures, since mainstem water is the controlling factor. However, temperatures of water in lateral margins of the side channels may be slightly warmer than mainstem water because of shallower depths, slower velocities, and increased water clarity. Increased water temperatures may enhance the quality of rearing habitat in the side-channels (Abbad 1980; Clarke et al. 1981).

The approximate tenfold decrease in turbidity during the open water season will likely have a beneficial effect effect on food production in side-channel habitats. More energy would be available for primary production, thus increasing the food base for other trophic levels. The post-project flow will be carrying a lower sediment load and may also remove many of the silts and sands presently occupying the interstitial spaces of the substrate. This is expected to provide more habitat for benthic invertebrates.

During the late fall and winter period, mainstem discharges at Gold Creek will increase approximately 40 to 655 percent over pre-project flows (Table E.3.32). The magnitude of the increase in flow expected to occur in side-channel habitats is dependent on the stage in the mainstem and the streambed elevation of the upper end of the side-channels. Presently, the stages in the side-channels drop in the fall as mainstem flows decrease. As the river forms an ice cover, the side-channel stages increase because of the backwater effects caused by ice formation. During operation of Watana dam, the flow at Gold Creek will not drop significantly below 7700 cfs in the fall or winter period. Wetted perimeter, depth, and velocities are expected to increase in side-channels during the winter months. Side channels will be less susceptible to dewatering and freezing under the higher post-project winter flows than at present.

Incubation success in side-channel areas may improve under post-project conditions as the eggs will be less likely to dewater. Increased flows are expected to also provide greater intergravel flow, which would benefit incubating embryos and alevins. The increased post-project winter flows would also increase the availability of overwintering habitat for juvenile anadromous and resident fish in side-channel habitats by providing more living space and being less likely to freeze during the winter.

- Slough Habitats

During the open-water season, impacts to slough habitats above Talkeetna under operation of Watana dam are not expected to substantially differ from those resulting from filling the Watana reservoir. Streamflows during late fall, winter, and early spring will be increased, providing a higher stage in the mainstem. The increased stage is expected to increase the rate and areal extent of ground water upwelling in the sloughs and the potential for overtopping the upstream end of the slough causing flow through the slough and flooding. Incubation success of salmon embryos may be improved because of the increased ground water flow.

Post-project winter conditions may affect incubation and overwintering in the sloughs. The increased flows in conjunction with increased water temperatures will change the ice processes in this reach of river. Presently, as the mainstem forms an ice cover, the stage increases because of backwater effects. These staging effects were measured near Gold Creek between RM 135 and RM 138 on December 12, 1980 (R&M Consultants 1982d). The mainstem discharge was 1800 cfs. At 11:30 a.m., the stage at the leading edge of ice corresponded to a discharge of 19,000-29,000 cfs. By 2:00 p.m., the ice edge had advanced upstream about 2300 feet (690 m); the under-ice stage 5900 feet (1787 m) downstream from the edge was representative of a flow of 23,400 cfs. Under post-project conditions, the river is expected to form an ice cover up to RM 130 and, depending on meterological conditions, the ice cover may extend up to RM 149. Thus, the stage in the river and the wetted perimeter of sloughs and side channels would probably decrease relative to pre-project winter conditions upstream from the ice front. If the decrease in wetted perimeter and water depth results in dewatering or increased depth of freeze, eggs incubating in the gravels could be adversely affected. Overwintering areas may also be adversely affected by the same physical processes causing increased mortalities for juvenile anadromous and resident fish.

In sloughs at and downstream from the ice cover front, the post-project mainstem flow could overtop the head ends of the sloughs. The addition of near-freezing mainstem water would reduce the surface water temperatures of the sloughs and increase the formation of ice. In some cases, considerable icing could occur; and the value of these areas for overwintering would be reduced.

The ice would reduce surface water temperatures in the sloughs well into the spring. Since the mechanical breakup likely would not occur, these ice formations in the sloughs would melt out rather than being carried out by high flows. Ice may be present in the sloughs until late June. The presence of ice would reduce the surface water temperatures and may alter the quality of these areas as early nursery areas for emerging fry.

- Tributary Habitats

Tributary habitats in the Watana dam to Talkeetna reach would be affected similarly under both filling and operation during the open-water season.

Augmented winter flows will increase the amount of overwintering habitat associated with tributary mouths, since higher discharge in the mainstem will increase the water depth and extent of backwaters at the tributary mouths. Studies indicate that tributary mouths are important overwintering habitat (ADF&G 1981d, 1981e).

(iii) Talkeetna to Cook Inlet

Project effects in this reach of river are expected to be considerably reduced in magnitude from those presented for the Watana dam to Talkeetna reach because of the influence of the Chulitna and Talkeetna Rivers. Many of the changes identified under the filling schedule (Section 2.3) for the open-water season will be the same under operation flows. Winter flows will be increased.

2.3 - Anticipated Impacts to Aquatic Habitat

- Mainstem Habitats

During the open-water season, mainstem habitats will be similarly affected during filling of the Watana reservoir and operation of Watana dam. Operational flows during this period are slightly greater than filling flows in the late spring and early fall and nearly equal to filling flows during summer months (Tables E.3.29, E.3.30, E.3.33, and E.3.34).

Bering cisco spawned in mainstem habitats during October 1981 and 1982. Since little change in average monthly streamflow or in stream temperature is anticipated during October, these fish are not expected to be adversely affected by the project.

In the Susitna River, eulachon spawn mainly below the Yentna River in mainstem habitats. Eulachon spawning areas identified during spawning surveys in May 1982 were located in relatively shallow water adjacent to cut banks and in riffle cones or bars with moderate velocities (ADF&G 1983). These habitats would probably exist to the same extent in this portion of the river under post-project conditions as during pre-project conditions. This segment would be subjected to the least amount of change, since it is buffered by inflow from all major tributaries below Talkeetna. Reductions in average monthly streamflow of 10 to 26 percent at Sunshine (pre-project flows of 27,700-64,500 cfs to operational flows of 24,900-48,300 cfs) and 5 to 13 percent at Susitna (pre-project flows of 60,800-132,400 cfs to operational flows of 57,900-117,400 cfs) are predicted from May through September (Tables E.3.33 and E.3.34).

During the winter (October through April), increases in average monthly discharges of 17 to 277 percent at Sunshine (pre-project flows of 2600-13,800 cfs to operational flows of 9500-16,100 cfs) and 18 to 114 percent at Susitna (pre-project fows of 6300-30,400 cfs to operational flows of 13,300-32,700 cfs) are predicted (Tables E.3.33 and E.3.34). Water temperatures are not expected to differ from pre-project conditions. Increases in discharge will result in increases in wetter perimeter.

2.3 - Anticipated Impacts to Aquatic Habitat

The availability of overwintering habitat is expected to increase because of increased water depth and wetter perimeter. Since the flow will remain fairly constant, increased fish and embryo survival may result from reduction of mortality associated with freezing.

- Side-Channel Habitats

As discussed under the reservoir filling flow regime, reductions in streamflow during the open-water season may dewater or degrade some spawning habitat presently used by salmon, as well as affect rearing and summer feeding habitat for residents and anadromous juveniles.

During the winter period, streamflows in side-channel habitats will be increased because of the increased winter discharge (Tables E.3.33 and E.3.34). These increased winter discharges are expected to have a beneficial effect on overwintering fish and incubating embryos. Increased discharge will increase depths in side-channel areas. This will provide more living space and should prevent dessication and freezing in these areas. Increased surface flow may also result in increased intergravel flow, which would benefit embryo development and overwintering juveniles.

- Slough Habitats

Increases in winter streamflows are expected to have a beneficial effect on slough habitats. The augmented discharge will increase the areal extent of the backwater at the slough mouth, creating greater water depth within the slough. The upstream extent of the backwater effect will depend on the gradient of the slough. Increased water depth may prevent a portion of the slough from freezing and increase the availability of overwintering habitat.

- Tributary Habitats

Tributary mouths are expected to be affected similarly under both filling and operation of Watana dam during the open water season. During the winter, tributary mouths provide important overwintering habitat. The effects of higher discharge in the mainstem should increase the areal extent of the backwaters and increase the amount of overwintering habitat associated with tributary mouths.

(ii) Estuary Habitats

Since only minor changes in salinity are predicted under project operation (Chapter 2, Section 4.1.3 [f][iii]), no impacts to fish resources in the estuary are anticipated.

(d) Summary of Impacts Associated with Watana Dam

(i) Construction Impacts

The primary long-term aquatic impact related to construction of Watana dam will be the increase in harvest pressure resulting from the increased access afforded by the project roads. In the absence of stricter harvest regulations, the increase in access near the impoundments will cause substantial alterations in resident fish population structure, with the present population of large, long-lived grayling being replaced by younger individuals.

There will be degradation of aquatic habitat at stream crossings but with proper construction practices as discussed in Section 2.4.3, this impact is not expected to noticeably affect fish populations. Construction activities and reservoir clearing activities will cause temporary increases in siltation and turbidity in some of the project area clear-water streams. These impacts are not expected to extend beyond the construction period. Similarly, alterations in water quality and disturbance to fish populations are expected to impact fish only during the construction period. There will be a continuous possibility of fuel spills during the construction period when numerous construction vehicles are present in the project area. The possibility of acute spills will be reduced under operation, but chronic spills will occur for the life of the project. Acute spills could cause locally significant impacts to fish populations, while chronic spills will cause gradual habitat degradation, particularly along roadways.

2.3 - Anticipated Impacts on Aquatic Habitat

The borrow site at the mouth of Tsusena Creek will create aquatic habitat at the expense of riparian habitat. This new aquatic habitat is expected to provide productive feeding and overwintering habitat for fish.

(ii) Filling Impacts

Impacts associated with the three years needed to fill the Watana reservoir are divided into impoundment impacts and downstream impacts.

The primary long-term impact associated with the filling of the Watana reservoir is the loss of clear water tributary habitat. The tributary habitat that will be inundated currently supports a substantial population of grayling, estimated to be at least 15,100 in 1982 (Table E.3.17). Aquatic habitats within the reservoir are not expected to support a significant grayling population (Section 2.3.1(b)[i]).

Between Watana dam and Talkeetna, the primary impacts associated with filling will be a reduction in spring and summer flows, reduction in sediments, and altered temperature regime, particularly during the second year of filling. Mainstem and side-channel habitats will contain less turbid water and be subjected to less extreme fluctuation in water levels and flow during the summer. These changes are expected to provide more favorable fish habitat than now exists in these areas. During the second year of filling, 4°C (39.2°F) water will be released at the dam; this is expected to warm to 5° to 6°C (41° to 42.8°F) at Talkeetna. The adult salmon migration into the Watana dam to Talkeetna reach may be delayed, and some of the returning adults, particularly pink and coho salmon, may select alternative spawning areas because of the lower summer temperatures. This impact is expected to be confined to the second year of filling and have no long-term impacts on population levels. The decreased temperature is expected to decrease the growth of resident and juvenile anadromous fish for the one summer, but significant impacts to the populations are not expected (see Section 2.3.1(b)[ii]).

Slough habitats between Watana dam and Talkeetna are expected to be the habitat type most significantly by filling flows. In the absence of mitigation features, filling flows are expected to cause access problems for returning adult chum and sockeye salmon. For salmon that do gain access, the spawning area within the sloughs may be reduced in area because of the lower mainstem flows (see Section 2.3.1(b)[ii]). If un-mitigated, these impacts would reduce the number of spawning chum and sockeye salmon in the sloughs above Talkeetna. Under a worst case scenario in which all slough spawning is lost, the total run to the Susitna River would be reduced by an estimated 11,840 chum; 9200 sockeye, and 3550 pink salmon based on 1981 and 1982 escapement data (see Section 2.3.2(b)[ii] Slough Habitat). The sockeye spawning in sloughs upstream from Talkeetna are considered to be strays from Chulitna and Talkeetna stocks (ADF&G 1983), thus there may be no production from these adults. If this is true, there would be no loss of sockeye to the fishery.

Tributary habitats below Watana dam and all habitats below Talkeetna are not expected to be significantly impacted during the filling of the Watana reservoir (Section 2.3.1(b)[ii] and [iii]).

(iii) Operation Impacts

Operation impacts, as with filling, are divided into impacts due to the impoundment and downstream impacts.

The habitat within the reservoir is not expected to support substantial fish populations (Section 2.3.1 (c)[i]). The annual drawdown cycle will limit spawning habitat of grayling, lake trout, burbot, white fish and longnose sucker. Littoral rearing habitat is also not expected to be productive because of the drawdown cycle and summer turbidity levels. Grayling are expected to reside at the mouths of the tributaries. Lake trout and Dolly Varden are expected to develop reproducing populations within the reservoir. Other species are expected to migrate into the reservoir from upstream habitats, primarily to overwinter, and may residualize.

Between Watana dam and Talkeetna, the primary operational impacts will be similar to those discussed for filling: decreased summer flows, decreased flow variability and decreased sediment load. During winter, however, flows will increase over pre-project conditions and will be accompanied by increased temperature and turbidity.

2.3 - Anticipated Impacts to Aquatic Habitat

More stable summer flows and decreased turbidity are expected to improve rearing habitat in mainstem and side-channel habitats. Eventually, mainstem and side-channel spawning habitats are expected to become available, as the less turbid water removes interstitial silt from the presently cemented substrate (Section 2.3.1(c)[ii]).

The decreased summer flows, however, will likely cause passage problems for adult salmon entering slough spawning habitats, as was discussed under filling impacts. Similarly, spawning habitat within the sloughs will likely be reduced, since the area of ground water upwelling may be reduced with lower mainstem flows (Section 2.3.1(c) [ii]). If unmitigated, these impacts will reduce the number of chum and sockeye salmon spawning in the sloughs upstream from Talkeetna. The worst case scenario would be total loss of slough spawning habitat in this reach, with a reduction in the total run size, as discussed in the previous section (Section 2.3.1(d)[ii]).

The increase in winter flow is expected to increase overwintering habitat and will benefit resident and rearing anadromous species. The reduction of flow variability, peak flows, turbidity, and sediment load in the mainstem during summer combined with increased winter flow, may lead to increases in the populations of some resident species, such as rainbow trout and Dolly Varben, and rearing anadromous species, such as chinook and coho salmon. The amount of increase, if any, will depend on the extent to which these physical factors presently limit the populations.

The increased winter temperatures may increase embryo development in mainstem and side-channel spawning habitats and lead to early emergence of alevins. These early emerging fry are expected to experience increased mortality if they move downstream and encounter 0°C (32°F) water below Talkeetna. This impact will likely affect relatively few fish, primarily pink salmon, since only a small portion of the salmon spawning upstream from Talkeetna utilize mainstem and side-channel spawning habitats. Other salmon species using these habitats exhibit behavior patterns that reduce their vulnerability to these impacts (Section 2.3.1(c)[ii]). Impacts are not expected in tributary habitats upstream from Talkeetna.

2.3 - Anticipated Impacts to Aquatic Habitat

Downstream from Talkeetna the main impact will be an increase in overwintering habitat in the mainstem and side channels because of the increased winter flows (Section 2.3.1(c)[iii]). No significant adverse impacts are expected.

2.3.2 - Anticipated Impacts to Aquatic Habitat Associated with Devil Canyon Dam

Impacts sustained by aquatic habitats as a result of construction and operation of Devil Canyon dam will be similar to those occurring under construction and operation of Watana dam. This section addresses additional impacts and increased magnitude of impacts to aquatic habitats attributable to the development of Devil Canyon dam, assuming Watana dam is in place.

(a) Construction of Devil Canyon Dam and Related Facilities

(i) Devil Canyon Dam

Devil Canyon dam will be located at RM 152 of the Susitna River, approximately 32 miles (53 km) downstream from the Watana damsite. A concrete arch thin dam will be built at the downstream end of Devil Canyon and an earth/rockfill saddle dam will be constructed at the south end of the arch dam to provide closure of a low area at the south abutment. The reservoir behind Devil Canyon will cover 7800 acres (3120 ha) and will be about 32 miles (53 km) long and not more than 0.5 mile (0.8 km) wide (Figure E.3.23).

The concrete dam and foundation will be 646 feet (195 m) high and will have a crest length of 1650 feet (500 m). An estimated 2.7 million cubic yards (2,052,000 m^3) of concrete will be needed to construct the arch dam. The saddle dam will be 950 feet (287 m) across and 245 feet (74 m) high and will require about 1.2 million cubic yards (912,000 m^3) of material.

As with Watana, Devil Canyon dam will have an underground powerhouse, intake structure, outlet works, main and emergency spillway. A 39-foot (11.8-m) diameter tailrace tunnel will convey the turbine discharge approximately 1.3 miles (2.2 km) downstream from the arch dam.

2.3 - Anticipated Impacts to Aquatic Habitat

During construction of the dam, the river will be blocked above and below the construction site by cofferdams. The flow will be diverted into a 30-foot (9-m) diameter horseshoe tunnel, 1490 feet (451 m) long, and discharged back into the river channel. The upstream and downstream cofferdams will be about 400 feet (120 m) long and 200 to 400 feet (60 to 120 m) wide.

The adverse impacts upon aquatic habitat at the Devil Canyon damsite are expected to be similar to those at the Watana site but of lesser magnitude.

At the Devil Canyon damsite, the Susitna River is confined to a canyon approximately 600 feet (180 m) deep and 200 to 400 feet (60 to 120 m) wide at river level. The river bottom is primarily composed of cobbles, boulders, and blocks of rock; the water is extremely turbulent. It is expected that few fish live in the area of the damsite (ADF&G 1981e). Some chinook salmon migrated upstream from the Devil Canyon damsite during the low summer flows of 1982 (ADF&G 1982e) and are expected to pass through the canyon during the low spring flows associated with operation of Watana dam.

- Alteration of Waterbodies

Impacts from Devil Canyon Dam construction will be primarily restricted to the vicinity of the damsite. A 1100-foot (333-m) section of the Susitna River between the cofferdams will be dewatered for 7 years during construction. Although a small population of Dolly Varden and at least one sculpin species as well as possibly other resident species inhabit that stretch of river, it is not expected that dewatering will have more than a minor impact upon availability of suitable aquatic habitat. The dam foundation will cover about 90 feet (27 m) of river bottom. This is considered to be a minor impact.

Construction of the arch dam and the saddle dam will require excavation in the river channel at the damsite. Excavation by blasting or by mechanical means may result in the introduction of materials into the Susitna River that would be carried downstream. The turbulence of the water at the site would preclude sedimentation in that stretch of river. Adverse impacts from introduction of increased sediment are expected to be minor.

The greatest impacts during construction of the dam are likely to be associated with gravel mining and processing in Borrow Site G. Gravel for filter material and for concrete aggregate will be removed from the Susitna River and from Cheechako Creek alluvial areas upstream from the damsite (Borrow Site G). The effects of gravel mining on aquatic systems have been discussed under Section 2.3.1(a). Since the material removal sites will be inundated, impacts at the sites will be transitory.

- Changes in Water Quality

Potential impacts to water quality would primarily be caused by increases of turbidity due to erosion and through discharge of effluent from the concrete batching process. To minimize water quality impacts, all process waters will be treated before being discharged to the Susitna River. Turbidity increases in the Susitna River are expected to be neglible. See Section 2.3.1(a) for discussion.

- Disturbance of Fish Populations

Instream activities during material extraction near Cheechako Creek could disrupt fish movements, spawning, and rearing in the creek, depending upon location, type and duration of activities. It is unlikely that the damsite itself is located in a stretch of the Susitna regularly inhabited by fish; therefore, it is expected that the excavation and blasting required at the damsite would not be disruptive to fish populations.

(ii) Construction and Operation of Devil Canyon Camp and Village

During construction of Devil Canyon dam, housing will be constructed for 1900 persons (Chapter 3, Section 3.3.1[d]). The construction camp and construction village will be located between 1.7 and 3.4 miles (2.8 and 5.6 km) southwest of the damsite. The camp will include bachelor dormitories, cafeteria, warehouses, offices, hospital, and recreational buildings. The village will contain housing for 170 families and will include a school, stores, and a recreation area.

2.3 - Anticipated Impacts to Aquatic Habitat

The camp will be approximately 0.5 mile (0.8 km) from the village. Both developments will be more than 700 feet (210 m) above the Susitna River and more than 4000 feet (1200 m) from the edge of the canyon. Water, sewage, and solid waste disposal facilities will be shared by both developments. Water will be withdrawn from the Susitna River and effluent from a secondary treatment system discharged into the river below the water intake. The upper reaches of Jack Long Creek border the camp and the village to the south, coming to within 200 feet (60 m) of the camp. A small unnamed creek drains a series of lakes 3000 feet (900 m) to the east of the camp and enters the Susitna at RM 150. The creek is paralleled by the sewage outfall line for 1000 feet (300 m) or about 20 percent of its length.

Both the camps and the village are temporary developments to be removed when Devil Canyon construction is completed. Permanent personnel responsible for operations of the Devil Canyon dam will live at the Watana permanent town. No airstrip will be built; air access will be via the permanent runway at Watana.

The unnamed creek and lakes may support grayling. Jack Long Creek contains pink, chinook, chum, and coho salmon (Figure E.3.17). Portage Creek contains chum, pink, chinook, and coho salmon, rainbow trout, round whitefish, and humpback whitefish. Chinook salmon, grayling, and Dolly Varden are found in the lower reaches of Cheechako Creek. Temporary impacts resulting from camp/village operations are expected to be limited to the area within a few miles of the damsite.

- <u>Alteration of Waterbodies</u>

  No water bodies are expected to be alterated as a result of Devil Canyon camp construction other than those resulting from gravel mining within the Susitna River floodplain at Borrow Site G. Since this site will eventually be inundated, no permanent effects of gravel mining will occur. Camp construction is not anticipated to affect Jack Long Creek or the unnamed stream.

2.3 - Anticipated Impacts to Aquatic Habitat

- Changes in Water Quality

Erosion into the Susitna River from gravel mining at the mouth of Cheechako Creek is not expected to result in adverse impacts to fish. Because of its proximity to the developments, Jack Long Creek may receive uncontrolled runoff from the camp area. However, required drainage facilities and retention ponds should eliminate this impact and increased sediment levels should not adversely affect spawning habitats in Jack Long Creek.

Water for camp use will be withdrawn from the Susitna River, and treated effluent and wastewater will be returned to the river. The treated effluent will not affect the waste assimilative capacity of the Susitna and is expected to have no significant effect on the aquatic environment (Chapter 2, Section 3.3.1 [d]). Storm drainage and oily water runoff from the construction camp will be collected and treated as noted above.

The fuel storage area is located on the south side of the construction camp about 200 feet (60 m) above Jack Long Creek. Accidental fuel spills could reach the creek if storage facilities failed. It is not expected that runoff from the solid waste disposal site and the construction village will adversely affect any waterbodies, since both will be collected and treated the same as the runoff from the camp area.

- Direct Construction Activity

The camp and village at the Devil Canyon site will house 1900 workers for several years (Chapter 2, Section 3.3.1[d]). It is expected that, as a result, streams and lakes in the vicinity will be subjected to increased fishing pressure. This area has not been heavily utilized for sport fishing in the past.

The waterbodies most likely to be affected include Cheechako Creek, unnamed creeks and lakes, Jack Long Creek, and to a lesser extent, the Susitna River and Portage Creek. With the exception of Portage Creek, these waterbodies are within walking distance of the camp/village and the damsite.

Portage Creek enters the Susitna River from the north about 2.5 miles (4.1 km) downstream from the dam location on the opposite side of the Susitna River.

(b) Filling Devil Canyon Reservoir

The filling of the Devil Canyon reservoir will be done in two stages. Upon completion of the dam to a height sufficient to allow ponding above the lowlevel outlet facilities, the water level will be raised to an elevation above 1050 feet (315 m) but not exceeding 1135 feet (343 m). This filling will be accomplished in approximately 4 weeks. As soon as the power facilities and main spillway are completed (approximately one year or more), the reservoir will be raised to 1455 feet (440 m), the normal operation elevation, in 5 to 8 weeks. During filling of Devil Canyon, the downstream flows at Gold Creek will not drop below the project operational minimum flows.

(i) Inundation of Upstream Habitats

Filling Devil Canyon reservoir would inundate approximately 32 miles (53 km) of Susitna River mainstem habitat and 11 miles (18 km) of tributary habitats. These habitats would be converted from lotic to lentic systems with accompanying changes in hydraulic characteristics, substrate, turbidity, temperature, and nutrient levels (Chapter 2, Section 3.4.2[c]). These changes are expected to result in a shift in species composition. The area presently supports arctic grayling, burbot, longnose sucker, whitefish, and Dolly Varden (ADF&G 1981f). Impacts to mainstem habitats are expected to be similar to those presented in Section 2.3.1(b) for Watana Reservoir. The loss of clear-water tributary habitat in Tsusena and Fog Creeks will eliminate habitat utilized by approximately 1200 grayling longer than 8 inches (20 cm) (Table E.3.17). Effects on tributaries and associated fish are also expected to be similar to those presented for the Watana Reservoir. Most of the tributaries in the Devil Canyon impoundment area are characterized by steep slopes with occasional barriers, such as waterfalls. Cheechako, Devil and Tsusena Creeks, three tributaries entering the Devil Canyon impoundment, all contain waterfalls. These falls will not be inundated by the impoundment and would still function as barriers to fish passage.

The four tributaries that are expected to support chinook spawning during filling and operation of the Watana dam will be lost as chinook habitat after Devil Canyon dam is in place.

(c) Operation of Devil Canyon Dam

Post-project streamflows under the operation of Devil Canyon dam would be similar to those under the operation of Watana dam alone. Most of the impacts to the aquatic habitat would have occurred under the startup and operation of the Watana dam.

Few additional impacts are expected to result from operation of Devil Canyon during the open-water season. Changes in streamflow are presented in Tables E.3.35, E.3.36, and E.3.37.

(i) Reservoir Habitat

During operation of the Devil Canyon reservoir, the water surface elevation will remain at 1455 feet (440 m) above sea level from November through July, except during an extreme drought. During August, water will be released to maintain minimum downstream flows for returning adult salmon. The water surface elevation will normally decrease to 1405 feet (425 m) until downstream flow requirements diminish in late September. The water level will be returned to 1455 feet (440 m) by the end of October (Figure E.2.111).

The stable water level in Devil Canyon for most of the year will create favorable spawning conditions for most fish species. Arctic grayling, lake trout, burbot, whitefish and longnose sucker spawning is expected to be unaffected. Dolly Varden embryos that are deposited in the drawdown zone of reservoir tributaries during September and October may experience a higher mortality than those deposited above the draw-down zone. The impact to Dolly Varden populations in the reservoir is expected to be minor.

Productivity in the Devil Canyon reservoir is expected to be low because of the turbidity levels (Chapter 2, Section 3.4.2(c)(iii)), but should be greater than the productivity in the Watana reservoir because of the less extreme draw-down cycle. It is expected that the Devil Canyon reservoir will develop resident populations of lake trout, Dolly Varden, burbot, whitefish and other species. Arctic grayling will occur in and at the mouths of clear-water tributaries.

(ii) Devil Canyon Dam to Talkeetna

- Mainstem Habitats

Flow in approximately 1.5 mile (2.5 km) of river between the dam and the powerhouse outlet will be eliminated. Depending on backwater effects, this will result in a dry channel for approximately 3300 feet (1000 m) below Devil Canyon dam. The gradient below the dam is quite steep and the bed is composed of coarse substrates. The area is presently thought to provide marginal habitat for resident fish.

As described in Section 2.3.1(c), use of mainstem habitats may significantly change during operation of the Watana dam. Downstream from the Devil Canyon dam tailrace, however, there would likely be little additional changes in mainstem habitat use during the open-water season. Flow reductions in July and August of 9 and 6 percent, as compared to Watana alone, may slightly increase the magnitude of effects identified under operation of Watana dam.

Under operation of Devil Canyon dam, winter water temperatures in the Devil Canyon to Talkeetna reach will be increased. The ice front is expected to form between Talkeetna (RM 99) and Sherman (RM 130); thus, the staging and backwater affects associated with an ice cover would not occur upstream from RM 130 in this portion of the river (Chapter 2, Section 3.4.3[b]). Winter temperatures in the reach from Devil Canyon to Talkeetna are expected to range from 0 to 1.5°C (32.0 to 34.7°F) during the operation of the Watana dam. Outflow temperature from Devil Canyon dam will be 2 to 4°C (35.6 to 39.2°F), with downstream temperatures ranging from 0 to 3°C (32 to 37.4°F). Although this is only a slight increase over natural conditions, it will often preclude an ice cover on most of the river above Talkeetna. Impacts resulting from altered ice conditions are discussed under Operation of Watana Dam (Section 2.3.1(c)[ii]).

- Side-Channel Habitats

Side-channel habitats are expected to sustain impacts similar to those predicted for mainstem habitats under operation of Devil Canyon dam.

- Slough Habitats

The predicted streamflows during the open-water season under operation of Devil Canyon are not expected to have significant affect on slough habitats over those affects related to Watana operation alone. The slough habitats will have had approximately nine years to adjust to the Watana operational flow regime during construction of the Devil Canyon dam. Changes in flow at Gold Creek from Watana alone to Watana and Devil Canyon are listed in Table E.3.35. During the open water season, average monthly flows at Gold Creek will be reduced by 16 and 13 percent in May and June, respectively; and by 9 and 6 percent in July and August, respectively. Average September flows at Gold Creek will be 7 percent greater with the operation of both dams and during October will be 3 percent less. Thus, open-water season stream flow changes due to the operation of Devil Canyon dam are not anticipated to be significant to the slough habitat. Alteration of the thermal regime during winter will affect a greater number of sloughs than under operation of Watana, but effects are expected to be similar to those discussed in Section 2.3.1(c)[ii]).

(iii) Talkeetna to Cook Inlet

No additional impacts are expected to occur in this reach as a result of operation of Devil Canyon dam. The physical changes to habitats downstream from Talkeetna resulting from the operation of Watana dam would likely remain the same when Devil Canyon dam commences operation. A comparison of proposed downstream flows for Watana dam alone and with the addition of Devil Canyon is presented for Sunshine Station in Table E.3.36. Changes in streamflow range from a reduction of 7 to an increase of 11 percent. Changes in flow of this magnitude are not expected to result in effects different from those identified under the operation of Watana dam. The addition of Devil Canyon is not expected to result in substantial changes in water temperatures, water quality, or sediment transport in this reach. Thus, the addition of Devil Canyon dam is not expected to result in adverse effects on fishery resources associated with habitats below Talkeetna.

(iv) Estuary

The operation of Devil Canyon dam is not expected to impact the estuary. Physical changes occurring under operation of Watana alone would essentially remain the same under the operation of both dams.

(d) Summary of Impacts Associated with Devil Canyon Dam

(i) Construction Impacts

As with Watana dam, the most significant long-term impact associated with Devil Canyon dam will be the increase in fishing pressure. Other impacts resulting from construction activities will be transitory and are not expected to significantly affect fish populations.

(ii) Reservoir Filling

Filling the Devil Canyon reservoir will inundate portions of clear-water tributaries, two of which (Tsusena and Fog Creeks) presently provide summer habitat within the reaches to be inundated for approximately 1200 grayling longer than 8 inches (20 cm). Aquatic habitats in the reservoir are expected to support more productive resident fish populations than those in the Watana reservoir because of the timing and magnitude of the annual drawdown cycle. The reservoir will be filled in approximately 5 to 8 weeks without impacting downstream flows. Downstream impacts are not expected during this period.

(iii) Operation Impacts

No significant impacts are expected upstream from Devil Canyon dam. The reservoir is expected to support populations of lake trout, Dolly Varden, Arctic grayling, burbot, whitefish, and longnose sucker.

2.3 - Anticipated Impacts to Aquatic Habitat

The most significant downstream impact resulting from the addition of Devil Canyon dam will be the change in winter water temperature, which will cause the ice front to form between Talkeetna (RM 99) and Sherman (RM 130) instead of between Sherman (RM 130) and Portage Creek (RM 149) as with Watana alone. The river stage in the open-water reach will be lower than the stage present under an ice cover. This change will reduce available habitat in areas that previously formed an ice cover, as was discussed for impacts associated with Watana dam (Section 2.3.1(c)).

Additional impacts to habitats between Talkeetna and Cook Inlet are not expected.

2.3.3 - Impacts Associated with Access Roads, Site Roads, and Railroads

(a) Construction

(i) Construction of Watana Access Road and Auxiliary Roads

The main access to the Watana damsite will be from the Denali Highway (Alaska Power Authority 1982a). The Watana access road will depart the Denali Highway at Milepost 114 and will run 41.6 miles (69.3 km) south to the dam- and campsites. The northern portion of the route traverses high, rolling, tundra-covered hills. The road will cross numerous small streams such as Lily Creek, Seattle Creek, and Brushkana Creek (Table E.3.20). The northern streams, which are part of the Nenana River drainage, contain grayling and probably other resident species. The southern part of the road will cross and parallel Deadman Creek, which also contains grayling and other resident species.

The gravel road will have a crown width of 24 feet (7.3 m). Before road construction is begun, a corridor at least 10 feet (3 m) wide on either side of the road itself will be cleared.

Short access roads will be needed to reach material sites and disposal sites. The locations and alignments of these auxiliary access roads will be determined when material sites and disposal sites are identified during final road design.

2.3 - Anticipated Impacts to Aquatic Habitat

Access construction will also involve upgrading the Denali Highway from Cantwell to the intersection with the Watana access road, a distance of 21.3 miles (35.5 km). Upgrading will include straightening road curves, improving one bridge, and topping the road with more gravel.

Within the project area, the Denali Highway crosses several small drainages, side channels of the Nenana River, Edmonds Creek, and Jack River. Jack River contains grayling and the Nenana River in this region supports several species of resident fish (Table E.3.19).

Any bridge work or straightening associated with road upgrading will have potential impacts similar to those resulting from new construction. Extension of culverts in places where the road is widened could affect fish passage.

- Alteration of Waterbodies

  Stream crossings can be a cause of adverse impacts. Bridges and culverts used to cross streams containing primarily grayling on the main access road need to be properly sized and bedded to ensure fish passage. This subject is discussed further in Section 2.4.3. Other causes of adverse road construction impacts can result from the following:

  . Clearing

    Areas of dense or tall vegetation will have to be cleared before road building begins. In some upland areas with tundra vegetation, clearing will be minimal. Clearing causes degradation of habitat when:

    Cleared areas by streams and lakes are not stabilized and erode into the water body;

    Cleared material is pushed into water bodies causing blockage of fish movements, deposition of organics on substrates, and localized erosion; and

    Clearing along streams affects cover, availability of food organisms, and temperatures in the stream.

2.3 - Anticipated Impacts to Aquatic Habitat

. In-Stream Activity

During road construction, it is often necessary for heavy equipment to enter water bodies. This can alter the substrate and can cause local turbidity and sedimentation problems.

. Erosion

Erosion can result from in-stream use of heavy equipment, placement of fill with high organic and/or fines content, lack of stabilization or revegetation on fills and cuts, and inadequately placed or sized culverts. The increased sedimentation that may result can degrade downstream habitats.

. Fill Placement

Fills that are placed within floodplains and streams can remove habitat previously used by fish. The severity of the impact depends upon the type and amount of habitat covered.

Roads can block sheet flow to or across wetlands. When a road with insufficient drainage bisects a wetland, one side becomes ponded while the other side dries. The change in water quantity affects the vegetation and the nature of the wetland. Some wetlands that are contiguous with streams provide rearing habitat for juvenile fish. If the wetlands are dewatered, that habitat can be reduced or lost. Potential alterations of sheet flow are being considered during the detailed road design.

- Changes in Water Quality

As with dam construction, impacts on water quality during road construction will result mainly from erosion and petroleum product spills. Erosion may occur as the result of excavation for placement of drainage structures in streams, runoff from borrow sites, or unstabilized fills, placement of material within water bodies, and heavy equipment operating within streams. The road will primarily affect small, clear-water systems.

Since the systems to be crossed by the road are clear-water grayling streams, they will be among the habitats more sensitive to increase in turbidity and petroleum products. Chronic or large spills into these streams during construction could have severe effects upon the biota, either causing mortalities or causing fish and their food organisms to avoid contaminated areas (Maynard and Weber 1981; Weber et al. 1981). When equipment is operated in streams or refueling of equipment takes place within a floodplain, petroleum products are likely to enter the water.

- Disruptions of Fish Populations

Fish will tend to avoid areas where in-stream work is being conducted, areas contaminated by petroleum products or, depending on the circumstance, areas experiencing excessive turbidity. Barriers to fish movements and migrations are created when streams are diverted, flumed, or blocked during installation of drainage structures. Fish can also be prevented from moving upstream if drainage structures are incorrectly installed. Pumping of water from streams can adversely affect local populations by entraining juvenile fish.

During road construction, the area between the Denali Highway and the Watana damsite will be occupied by hundreds of workers. Although this area has been recreationally utilized in past years, it has never experienced such a large influx of people. Unless controlled, this influx will increase fishing pressure on the streams and lakes in the area.

(ii) Construction of Devil Canyon Access Road and Auxiliary Roads

Access to the Devil Canyon damsite will be by road north of the Susitna River from Watana and by rail from Gold Creek along the south side of the Susitna River. The road will depart from the Watana road north of the Watana townsite at 38.5, and will parallel Tsusena Creek for approximately 1.5 miles (2.5 km). The route then roughly follows the 2900-foot (878-m) contour west to Devil Creek. The road turns south along Devil Creek for about 2 miles (3 km) and proceeds southwesterly to intersect the

Susitna River at approximately RM 150, where the road crosses the Susitna and parallels an unnamed creek for a short distance, ending at the construction camp and village site. The road between Watana and Devil Canyon will be constructued in the same manner as the segment from the Denali Highway (see Section 2.3.3[a][i]).

The Devil Canyon access road traverses high tundra throughout most of its length. Dense shrub vegetation and trees are encountered when the road nears the Susitna River crossing downstream from Devil Canyon. The road crosses numerous small streams between Tsusena and Devil Creeks. Tsusena Creek contains grayling and possibly cottids and whitefish. Devil Creek may support populations of grayling, suckers, cottids and whitefish. Between Devil Creek and the Susitna River, there appear to be few areas that provide habitat for fish. The road between Watana and Devil Canyon will be constructed in the same manner as the Denali to Watana segment.

The railroad access will depart from existing railroad at Gold Creek and proceed north and east to the construction campsite. It will remain on the south side of the Susitna River. The railroad will cross Gold Creek, which is known to contain chinook salmon (ADF&G 1982a), and will cross several tributaries that enter the Susitna River between Gold Creek and Jack Long Creek (Table E.3.21). It is probable that these tributaries do not contain fish, but they may be an important source of clear water for Slough 19, which is a spawning area for salmon (Figure E.3.16). The railroad will then parallel Jack Long Creek for approximately 3 miles (5 km). Jack Long Creek has been documented to contain pink, coho, chinook, and chum salmon. The railroad terminus and turnaround at Devil Canyon will be adjacent to the upper reaches of Jack Long Creek.

- Alterations of Waterbodies

Impacts to aquatic habitat will result from stream crossings and other instream activities. Floodplain and side-channel habitat in Devil Creek, Tsusena Creek, and Jack Long Creek could be affected by road and railroad alignment. Stream crossings and drainage structures are discussed in Section 2.4.1(c). Impacts identified for the Denali Highway to Watana segment are also applicable to the Devil Canyon access.

Railroad construction between Devil Canyon and Gold Creek would have impacts similar to road construction: aquatic habitat will be affected by fills, clearing, and stream crossings.

- Changes in Water Quality

It is expected that water quality will be affected by turbidity and petroleum product spills as was discussed for Watana access.

- Disruptions of Fish Populations

Fish populations in areas affected by the Devil Canyon road, auxiliary roads, or the railroad will experience disruptions similar to those previously described for Watana access.

(b) Use and Maintenance of Roads

(i) Use and Maintenence of Watana Access Road and Auxiliary Roads

- Alteration of Waterbodies

Impacts on waterbodies during road operation will occur as a result of continued maintenance activities. Maintenance involves road grading and replacement of material. Improper maintenance techniques can result in gravel being pushed off the roadway into streams and wetlands and in increased erosion. Road maintenance will have a greater impact on the smaller streams, such as Deadman Creek, than on the Susitna River.

This section considers only the road section from the Denali Highway to Watana dam; therefore, impacts resulting from road construction will be confined to streams along this road alignment.

- Changes in Water Quality

During continued road use, changes in water quality can occur as a result of fuel spills and erosion from poorly stabilized road surfaces and fill areas. Large fuel spills would have the greatest impact on the aquatic habitat.

2.3 - Anticipated Impacts to Aquatic Habitat

The Watana access road will cross numerous streams, many of which contain grayling. In areas where the road crosses or encroaches on a waterbody, an accident involving transport vehicles, including those carrying petroleum products, could occur. The impacts associated with spills will depend upon the season, the type and amount of substance spilled, the size of the waterbody into which the spill occurs, and the fish species present.

Erosion from unstable road cuts could be locally chronic; however, these activities are not expected to cause major impacts.

- Disturbance to Fish Populations

Fish have been known to avoid areas contaminated with petroleum products (Maynard & Weber 1981; Weber et al. 1981) and areas of excessive sedimentation or turbidity. Chronic seepage of oil into streams or lakes could render some areas unusable. Fish impasses caused by either physical or velocity barriers have been discussed under Section 2.3.3(a)(i).

The greatest source of adverse impacts upon fish populations will be the increased accessibility of fish streams and lakes to fishing pressure via the network of access roads. Without appropriate management strategy, this will be a greater impact than that resulting from operation of the camp.

As stated in Section 2.3.3(a)(i), the Watana access road will cross Brushkana, Lily, Seattle, and Deadman Creeks as well as other small, unnamed streams. These creeks are clear-water streams and many are inhabited by grayling. Deadman Creek, in particular, is known for its large and abundant population of grayling. The reach of Deadman Creek between the falls and Deadman Lake is considered prime grayling habitat. By subjecting this stream to increased fishing pressure, many of the larger, older fish will be removed from the population, altering the age structure and possibly reducing reproductive potential. A similar impact may occur to other grayling streams in the area.

(ii) Use and Maintenance of Devil Canyon Access Road, Site Roads and Railroad

Aquatic habitat and fish populations will be influenced by the existence of roads and railroads through activities such as road traffic and road maintenance.

- Alteration of Waterbodies

The majority of adverse impacts will have occurred during road construction. Activities such as road grading and replacement of drainage structures will continue to affect stream systems.

- Changes in Water Quality

The impacts on water quality that may occur during operation of the Watana access road, are also applicable to the Devil Canyon access road and site roads.

- Disruptions of Fish Populations

Disruptions of fish populations resulting from operation of the Devil Canyon access road, auxiliary roads, and railroad most likely will be: avoidance of areas of unacceptable turbidity, sedimentation, and contamination; blockages of fish passage, and increased accessibility to lakes and streams for fisherman.

2.3.4 - Transmission Lines Impacts

(a) Construction of Transmission Line

(i) Watana Dam

The transmission line will be built from Watana dam to Gold Creek along the Devil Canyon access road and railroad spur. At Gold Creek the transmission system will converge with the Anchorage-Fairbanks intertie, which extends from Willow to Healy. The route south of Willow will extend to Point MacKenzie where a submarine cable will cross Knik Arm. The terminus of the southern leg will be the University substation in Anchorage. The northern leg will extend from Healy to Ester near Fairbanks.

2.3 - Anticipated Impacts to Aquatic Habitat

The transmission line will consist of a series of steel towers spaced approximately 1300 feet (393 m) apart that support conductors. In this case, the towers will be x-framed guyed towers that can carry three conductors. From Watana to Gold Creek, there will be two parallel sets of towers. At Gold Creek, two lines will go to Anchorage and one to Fairbanks. This will necessitate construction of one new line parallel to the existing intertie between Willow and Healy and one new line north of Healy and two new lines south of Willow. With the addition of the Devil Canyon dam, two more lines will be built from Devil Canyon to Gold Creek. This will result in an arrangement of four parallel sets of towers along this segment of the lines.

From Watana to Devil Canyon, a 300-foot (90-m) wide right-of-way will be designated. The Devil Canyon/ Gold Creek segment will require a 510-foot (153-m) wide right-of-way. Within the right-of-way, trees and shrubs within 55 feet (16.5 m) of the tower centerline will be cleared as well as any other trees or shrubs that may hamper construction or pose a threat to the completed line. The width of a 3-line corridor will be approximately 400 feet (120 m) (Commonwealth et al. 1982).

- Alteration of Waterbodies

Adverse impacts to waterbodies will result primarily from clearing stream crossings, road building, and other instream activities associated with installation of the towers and conductors. Permanent roads may be built to provide all-season access. The effects of clearing a right-of-way, and heavy equipment traffic on an aquatic environment have been previously discussed.

The transmission line can be divided into four segments: central (Watana to Gold Creek), intertie (Willow to Healy), northern (Healy to Ester), and southern (Willow to Anchorage). In the central section, the line will closely parallel the Watana-Devil Canyon access road and railroad spur for much of its length. It will cross Tsusena Creek, Jack Long Creek and several small tributaries of the Susitna River. The impact of constructing a transmission line through this area will be similar to, but less than, that of the access road. See Section 2.3.3 for a description of river and streams to be crossed in the central segment.

2.3 - Anticipated Impacts to Aquatic Habitat

The Anchorage-Fairbanks Intertie is being built as a separate project and will be completed in 1984 (Commonwealth et al. 1982). The Susitna project will add another line of towers within the same right-of-way. The impacts will be similar to those experienced during intertie construction. The Environmental Assessment Report for the intertie (Commonwealth et al. 1982) discusses the expected environmental effects of transmission line construction in this segment. Fish streams that will be crossed include the Nenana River, Talkeetna River, Chunila Creek, Susitna River, and the Kashwitna River.

In the southern segment, the transmission line will begin at the Willow substation approximately 0.5 mile (0.8 km) north of Willow Creek. Proceeding first west then south, the line will be routed between the Susitna River and the Nancy Lake area, passing within 0.75 mile (1.3 km) of the Susitna River. It will cross several Susitna River tributaries, including Fish Creek at Approximate Milepost (AMP) 18, before crossing the Little Susitna at AMP 26. Few streams are crossed between the Little Susitna River and Knik Arm at AMP 44. Knik Arm, which is approximately 2.5 miles (4.1 km) wide at that point, will be crossed by a submarine cable. The Knik Arm switching station is located between Sixmile Creek and Eagle River. From there the transmission line bypasses Otter Lake, and crosses the Alaska Railroad and Fossil Creek. After crossing the Davis Highway it parallels the Glenn Highway for about 2 miles (3 km). Ship Creek is crossed at AMP 75 and the line traverses the Chugach Foothills before terminating at the University substation near the corner of Tudor and Muldoon Roads. Table E.3.22 presents a list of major streams to be crossed and the species that inhabit them.

The streams and fish species for the northern leg are listed in Table E.3.23. The northern portion begins at the Healy substation and immediately crosses the Nenana River, proceeding west to Dry Creek at AMP 4.75. The line turns north at this point and roughly parallels the Parks Highway for the greatest part of its length. The Nenana River is crossed again at AMP 2.75 and AMP 58.75. The line ends at the Ester Substation (AMP 94.25).

2.3 - Anticipated Impacts to Aquatic Habitat

During the transmission line construction, it will be necessary for heavy equipment such as hydroaxes and drill rigs to cross streams. Several factors will influence the severity of impact on the aquatic habitat.

- Season in which construction takes place;
- Size of the stream;
- Type of habitat in the crossing area;
- Species present;
- Frequency of crossing;
- Type of crossing, i.e. temporary bridge, temporary culvert, low water crossing;
- Streambank configuration; and
- Streambed composition.

It is expected that small, confined streams will be more susceptible to adverse impacts from transmission line construction than will larger streams.

If "all-weather" access is maintained for the transmission line, a gravel road will be built along its entire length and permanent stream crossings installed, with attendant, long-lasting impacts. The road and stream crossings will have to be monitored to ensure that fish passage is maintained and aquatic habitat is not degraded. Although the transmission corridor would be many times longer than the access road previously described, the range of possible impacts is similar.

The access points for construction of the transmission line will be decided during the detailed design. The Willow to Healy section will probably use access established during construction of the Intertie. It is likely that access will require crossing streams and wetlands and thus will expand the area in which adverse impacts may occur because of transmission line construction.

Details of the installation of the cable under Knik Arm are to be developed during final design. Knik Arm is primarily a migration route for anadromous species that utilize the Knik and Matanuska River drainages including all five species of Pacific salmon, Dolly Varden, eulachon, and Bering cisco. Benthic organisms and other resident species are sparce because of the excessive amounts of glacial material on the sea floor. It is unlikely that alteration of this area will have any effect upon resident or anadromous species.

- Changes in Water Quality

It is expected that temporary increases in turbidity and sedimentation will occur in streams subjected to instream activities during construction of the transmission line. Small, clear water system populations will most likely be affected to a greater extent than will large systems. The effects are not expected to be long-term.

In addition, streams that are crossed will be exposed to possible contamination by petroleum products due primarily by vehicle accidents.

- Disturbance of Fish Populations

Avoidance reactions associated with increased turbidity may occur. Fish will also avoid areas where instream activities occur and, depending upon the timing, migrations may be affected. Where the transmission lines cross a stream, clearing may remove overhanging vegetation that provides cover for fish.

Construction of the line will open areas to increased fishing. During construction, this will most likely be confined to workers. The effects will be greater in the northern and central segments where access has previously been limited.

(ii) Devil Canyon

With the addition of Devil Canyon dam, two additional lines will be built from Devil Canyon to Gold Creek. Significant new impacts are not expected with this incremental addition.

(b) Operation of the Transmission Line

(i) Watana Dam

Once the transmission line has been built, there will be few activities associated with routine maintenance of towers and lines that could adversely affect aquatic habitat. However, maintenance of all-weather roads would entail efforts similar to that for the access road.

2.3 - Anticipated Impacts to Aquatic Habitat

- Alteration of Waterbodies

  Some localized habitat disruption could occur when maintenance vehicles need to cross wetlands and streams to repair damaged lines or towers. Where roads are not built in conjunction with transmission lines, revegetation is allowed to proceed to a certain extent around the towers. The vegetation is usually limited to grasses and shrubs and small trees by selective clearing so that vehicles are able to follow the cleared area associated with the lines. Streams may need to be forded in order to effect repairs. Depending on the season, crossing location, type and frequency of vehicle traffic, aquatic habitat in the immediate vicinity of the crossing could be affected. In addition, downstream reaches may be affected by increased sedimentation caused by erosion.

- Changes in Water Quality

  Changes in water quality during maintenance of the transmission lines are likely to result from increased turbidity, instream activities and fuel contamination.

- Disturbance to Fish Populations

  Instream activities associated with line repair and maintenance could cause disruptions of fish populations in limited areas. The greatest disruption will result from the increased accessibility to some fishing areas from the cleared transmission corridor. Because the vegetation is kept relatively low, hikers and all terrain vehicles can use the corridors as trails. In winter, snow machines will also be able to traverse these cleared areas. This will result in greater numbers of fishermen being able to reach areas the previously experienced little or no fishing pressure. This effect will be more acute in areas where the new transmission route diverges from existing roads and transmission lines, such as south of Willow and north of Healy. The area between Healy and Willow will have been subjected to disturbance and increased pressure during construction of the Anchorage/Fairbanks intertie. Any increased fishing pressure along the intertie as a result of the

Susitna lines being added to the corridor will probably be minor. The presence of an operating cable under Knik Arm should cause no impacts to fish populations.

(ii) Devil Canyon

The addition of two additional lines is not expected to result in significant incremental maintenance impacts over the Watana-only scenario.

2.4 - Mitigation Issues and Mitigating Measures

2.4.1 - Approach to Mitigation

The objective of fisheries mitigation planning for the Susitna Hydroelectric Project is to provide habitat of sufficient quality and quantity to maintain natural reproducing populations where compatible with project objectives. This is consistent with the the mitigation goals of the USFWS and the ADFG. In order to accomplish this objective, the Power Authority will avoid, minimize, or rectify impacts. In situations where it is not feasible to mitigate the impact in this manner, the Power Authority will provide compensation through propagation facilities. The first preference will be through habitat improvement measures to increase the productivity of the habitat or to provide additional habitat within the Susitna Basin. As the last resort, fish propagation facilities would be proposed as compensation.

The priorities of the fisheries mitigation, as discussed in Section 1.3, were determined by employing the hierarchical approach to mitigation contained in the Susitna Hydroelectric Project, USFWS and ADF&G mitigation policies. The five basic mitigative actions, in order of priority, are:

- Avoiding impacts through design features or scheduling activities to avoid loss of resources.

- Minimizing impacts by carefully scheduling and locating operations, timing and controlling flow releases, and controlling impacts through best management practices.

- Rectifying impacts by repairing disturbed areas to provide optional fish habitat and reestablishing fish in repaired areas.

- Reducing or eliminating impacts over time through monitoring, maintenance, and proper training of project personnel.

- Compensating for impacts by conducting habitat construction activities that rehabilitate altered habitat or by managing resources on project or nearby public lands to increase habitat values.

Each of the following impact issues is addressed in terms of these five mitigation actions. Table E.3.38 summarizes mitigation features for major impact issues associated with operation of the project. The proposed mitigation program and associated costs are in Table E.3.39. The schedule for implementing this program is in Table E.3.40.

2.4.2 - Selection of Project Evaluation Species

Selection of evaluation species is a necessary step in assessing impacts and in developing mitigation plans. Various species and life stages have different critical life requirements and respond differently to habitat alterations. A change in habitat conditions that benefits one species or life stage may adversely affect another, and mitigation plans for one species may conflict with those proposed for another. Selection of evaluation species can provide a mechanism to resolve potential conflicts and to focus the resources available for analysis and planning.

The evaluation species were selected after initial baseline studies and impact assessments had identified the dominant species and potential impacts on available habitats throughout the year. Mitigations were then developed that will reduce impacts on habitat parameters that are expected to control populations.

Fishery resources of the Susitna River and activities associated with the project proposal were reviewed. Evaluation species were selected on the basis of the following criteria:

- High human use value;
- Dominance in the ecosystem; and
- Sensitivity to project impacts.

Species with high regional visibility and commercial, sport, subsistence, or aesthetic value were given priority. Within this category, species sensitive to project effects were highly rated. Since the evaluation species play a dominant role in the ecosystem, they may serve as indicator species. By maintaining critical habitats for evaluation species, many of the potential impacts on less sensitive species or species with a lower evaluation priority will be mitigated.

2.4 - Mitigation Issues and Mitigating Measures

Based on the aquatic studies baseline reports, impact assessments, and harvest contributions, four species of Pacific salmon (chum, chinook, coho, and pink) were identified as evaluation species for the Susitna River downstream from Devil Canyon. Arctic grayling was selected as the evaluation species for the impoundment.

Since the greatest changes in downstream habitats are expected in the reach between Devil Canyon and Talkeetna, fish using that portion of the river were considered to be the most sensitive to project effects. Because of differences in their seasonal habitat requirements, not all salmon species would be equally affected by the proposed project. Of the five species, chum and sockeye salmon appear to be the most vulnerable in this reach, because of their dependence on slough habitats for spawning, incubation and early rearing (Sections 2.2.1 and 2.2.2). Of the two species, chum salmon are the dominant species (Section 2.2.1). The sockeye that spawn in the sloughs upstream from Talkeetna, however, are considered to be strays from stocks in the Chulitna and Talkeetna drainages (ADF&G 1983). Since these sockeye do not appear to support a viable stock, they are not included as an evaluation species. Chinook and coho salmon, are less likely to be impacted by the project because most of their critical life stages, such as spawning, incubation, rearing and overwintering, occur in habitats that are less likely to be altered by the project (Section 2.3.1). While some pink salmon spawn in slough habitats in the reach between Devil Canyon and Talkeetna, the majority of these fish utilize tributary habitats. The mitigations proposed to maintain chum salmon productivity should allow sockeye and pink salmon to be maintained as well. The chinook and coho salmon juveniles rear in the river for one to two years prior to out-migration with much of the rearing apparently occurring in clear water areas, such as in sloughs and tributary mouths. Improved conditions in the mainstem are expected to provide replacement habitat to mitigate for the potential loss of rearing areas in slough habitats. Juvenile overwintering habitats are not expected to be adversely affected.

The greatest change to resident fish will occur in the impoundment zone. In the impoundment zone, arctic grayling were selected as the evaluation species because of their abundance in the area, their sensitivity to impacts during all seasons and life stages, and their desirability as a sport fish.

In summary, the evaluation species and life stages selected for the Susitna Hydroelectric Project are:

2.4 - Mitigation Issues and Mitigating Measures

(a) Devil Canyon to Cook Inlet Reach

(i) Chum Salmon

- Spawning adults;
- Embryos and pre-emergent fry;
- Emergent fry;
- Returning adults; and
- Out-migrant juveniles.

(ii) Chinook Salmon

- Rearing juveniles; and
- Returning adults.

(iii) Coho Salmon

- Rearing juveniles; and
- Returning adults.

(iv) Pink Salmon

- Spawning adults; and
- embryos and pre-emergent fry;
- Emergent fry;
- Returning adults; and
- Out-migrant juveniles.

(b) Impoundment Zone

(i) Arctic Grayling

- Spawning adults;
- Incubating embryos;
- Rearing; and
- Overwintering.

2.4.3 - Mitigation of Construction Impacts Upon Fish and Aquatic Habitats

Mitigation of construction impacts is achieved primarily by incorporating environmental criteria into pre-construction planning and design, and by good construction practices. Incorporation of environmental criteria into design activities and construction of the Susitna dams and related facilities will avoid or minimize impacts to aquatic habitats. A design criteria manual and a construction practices manual are being prepared. The design criteria manual will be available in June 1983, and the construction practices manual will be one of the first tasks assigned to the construction manager.

2.4 - Mitigation Issues and Mitigating Measures

The aquatic studies program will continue to make major contributions to pre- construction planning and design. Studies will be used in siting, design, and scheduling of project facilities and activities. For example, the final alignment of the Watana access road will take into consideration the fish streams along its route. The route is sited to avoid encroachment on streams, to minimize stream crossings and impacts at required crossings, and to minimize cut banks.

Biological information will be incorporated into the design criteria and construction practices manuals. A high degree of communication and cooperation will be maintained between environmental staffs and design and construction personnel in order to facilitate integration of biological criteria into designs, specifications, and construction practices.

Scheduling of construction activities during preconstruction planning is another means of avoiding or minimizing adverse impacts to fish and aquatic habitats. Whenever possible, activities will be scheduled to avoid known sensitive periods.

Continued monitoring of the construction facilities and activities will ensure that impacts to the aquatic environment are avoided or minimized. Monitoring can identify areas that may need rehabilitation or maintenance and areas where previous mitigation measures are proved inadequate and remedial action must be taken. Costs associated with construction monitoring are outlined in Table E.3.41.

Potential impacts are identified in Section 2.3. The following is a discussion of the impact issues and the mitigation measures that will be applied during and after construction. Those issues considered to have the greatest potential for adverse impact to the aquatic environment are discussed first. Avoidance, minimization, rectification and reduction of impacts are discussed. There are no direct mitigation costs associated with these mitigations.

(a) Stream Crossings and Encroachments

(i) Impact Issue

Improperly constructed stream crossings can block fish movements and/or increase siltation in the stream. Roads with inadequate drainage structure can alter run-off patterns of nearby wetlands and streams. Encroachments on stream courses can alter hydraulic characteristics and increase siltation of streams, thereby affecting fish habitat.

(ii) Mitigation

The objective of constructing stream crossings is to maintain the natural stream configuration (Lauman 1976) and flow so that passage of fish is assured. Maintenance of fish passage is required under AS-16.05.840. Appropriate control measures will be undertaken as a part of routine maintenance to insure that beaver dams do not interfere with fish passage needs. For the project area, the evaluation species used in developing criteria for stream crossings is arctic grayling (see Table E.3.42 for criteria to be applied to stream crossings). In designing and constructing a crossing, consideration will be given to the following presence or absence of fish/fish habitat, location of crossing, type of crossing structure, flow regime, and method of installation.

- Presence or Absence of Fish/Fish Habitats

  Streams having documented fish or fish habitat at or upstream from the road crossing will be designed to pass fish. Only those streams without fish or fish habitat at, or upstream from, the road crossing will be designed solely on the basis of hydrologic and hydraulic criteria.

- Location of Crossing

  Project roads will be aligned and located to minimize the number of stream crossings. When crossings are unavoidable, they will be located at a right angle across the stream in a straight stretch (Lauman 1976), and with narrow, stable banks that do not require cutting or excessive stabilization. The crossings will be located so that important habitats, such as spawnings beds and overwintering areas, are not disrupted.

- Type of Crossing Structure

  Open-bottom arch culverts will be installed wherever possible (Figure E.3.24). Multiplate elliptical and oversized circular culverts can also be used to maintain the natural streambed (Joyce et al. 1980a; Lauman 1976) and will be used when open arch culverts are not feasible. Standard- size circular culverts will only be used in drainages that are not considered fish habitat.

Log stringer and temporary bridges will be used where infrequent, light vehicle traffic is expected. Their use on the Susitna Project will be limited to the transmission line corridor. During winter transmission line construction, snow and ice bridges will be used to cross streams. These will be removed before breakup to avoid blocking stream flows.

- Flow Regime

Culverts will be designed to allow grayling passage at critical times using the ADF&G velocity criteria (Table E.3.42). Multiplate elliptical and oversized circular culvert inverts will be set below the streambed elevation to avoid perching and will be armored, when necessary, to minimize erosion at the outlet. Natural stream substrate will be placed on the bottom of the culverts over their entire length.

- Methods of Installation

When culverts other than open-bottom arches are used, streams will be diverted around the work area until the crossing is completed. On small systems, the stream may be flumed. Diversion or fluming will reduce the amount of siltation downstream from the construction area. Diversion will be accomplished using ADF&G criteria (Table E.3.43).

In some areas, roads and transmission lines must parallel a stream or river. The alignment will be away from the floodplain to the greatest extent possible. Where this is not possible, the road will be aligned to preclude channelization of the stream.

The transmission towers will be aligned so structures are out of streams and floodplains to the best extent practicable. Instream activities will be confined to installation of drainage structures on access routes. Where practicable, construction will be scheduled for winter months when heavy equipment can cross frozen creeks without elaborate constructed crossings.

(b) Increased Fishing Pressure

(i) Impact Issue

The sport fishing pressure on the local streams and lake will substantially increase. The access road and transmission line will allow fishermen to reach areas previously unexploited.

(ii) Mitigation

During the construction phase, access to the streams will be limited by closing roads to unauthorized project personnel and general public. The Alaska Board of Fisheries will be provided such information as they require to manage the fisheries. Some watersheds, such as the Deadman Creek/Deadman Lake system, will require modification of current seasons and catch limits if current stocks are to be maintained. These regulations may take the form of reduced seasons or catch limits, imposition of maximum size limits, or control of fishing methods. Since public health regulations will not allow sport-caught fish to be stored or prepared at public food service facilities, the project policy will be that all fishing be restricted to catch-and-release unless stated otherwise by the Board of Fisheries.

(c) Erosion Control

(i) Impact Issue

Sustained high levels of sediment in a system can change the species composition and productivity of the system (Bell 1973, Alyeska Pipeline Service Company 1974). Siltation can affect development of fish eggs and benthic food organisms.

(ii) Mitigation

The primary mitigation measures that will be used to minimize construction erosion are: (1) locating facilities away from the clear water fish streams; (2) employing erosion control measures such as run off control, stilling basins and revegetation; (3) scheduling erosion-producing activities at biologically noncritical seasons (APSC 1974); (4) minimizing the time necessary to complete the activity so that erosion is a short-term, non-reoccurring problem; and (5) maintaining vegetated buffer zones.

The natural vegetation is a major factor in preventing erosion (APSC 1974). Clearing for roads, transmission lines, and other facilities will be confined to the minimum area and level necessary. For transmission lines, only taller trees and shrubs will be removed; the lower vegetation will not be disturbed. Adjacent to streams, especially small systems, clearing will be done by hand. Cleared material will be removed from the floodplain to approved disposal sites, salvaged or burned onsite.

Disposal sites that contain cleared slash and substandard materials (overburden) will be located in upland areas away from water bodies. Disposal sites will be constructed so that neither run off during breakup nor rainfall will wash silty material into streams. This may entail run off control structures, surrounding the disposal site with berms, or channeling run off through containment ponds.

To preclude run off from carrying silt to water bodies near construction sites, drainage control will direct silty water into settling basins. Clarified water will be discharged into receiving waters in accordance with the Alaska Department of Environmental Conservation (ADEC) permit requirements (AS-46.03.100).

Prompt grading, mulching, and revegetation of cut-and-fill areas will be used to minimize erosion.

(d) Material Removal

(i) Impact Issue

Removal of floodplain gravel can cause erosion, siltation, increased turbidity, increased ice buildup caused by ground water overflow, fish entrapment, and alteration of fish habitat.

(ii) Mitigation

Adverse impacts on aquatic habitats will be avoided or minimized by application of the following guidelines which are more fully discussed in Joyce et al. (1980a); and in Burger and Swenson (1977).

Before floodplain material sites are used, it will be determined that upland sources are inadequate to supply the needed material. Floodplain sites will be thoroughly explored to verify that they can supply the necessary quantities. Important habitats such as overwintering and spawning areas will be identified and avoided.

Buffers will be retained between the sites and any active channels except when draglining in the active channel. Material will be stockpiled outside the floodplain to avoid backing flow at higher stages and the possibility of material being eroded into downstream reaches. Overburden will be disposed of in upland sites or returned to the area from which it was removed and contoured and planted.

Material washing operations will use recycled water and will not discharge into adjacent streams.

The Tsusena Creek material site (Borrow Site E) will be rehabilitated after mining has ceased. The goal of rehabilitation will be to create productive aquatic habitat. The site will be shaped and contoured to enhance fish habitat, and all man-made items removed from the site (Figure E.3.25). Exposed slopes will be graded and seeded.

Rehabilitated areas will be monitored to ensure that grading, revegetation and other mitigative measures are effective. The Cheechako Creek and Susitna River borrow sites will be inundated and will not require rehabilitation beyond that needed to minimize erosion.

(e) Oil and Hazardous Material Spills

(i) Impact Issue

Spills of oil and other hazardous substances into streams are toxic to fish and their food organisms.

(ii) Mitigation

A Spill Prevention Containment and Countermeasure Plan (SPCC) will be developed as required by EPA (40 CFR 112.7).

2.4 - Mitigation Issues and Mitigating Measures

Equipment refueling or repair will not be allowed in or near floodplains without adequate provisions to prevent the escape of petroleum products. Waste oil will be removed from the site and be disposed of using ADEC/USEPA-approved procedures. Fuel storage tanks will be located away from waterbodies and within lined and bermed areas capable of containing 110 percent of the tank volume. Fuel tanks will be metered and all outflow of fuel accounted for. All fuel lines will be located in aboveground or ground surface utilidors to facilitate location of ruptured or sheared fuel lines.

Vehicle accidents, although difficult to fully protect against, can be minimized by constructing the roads with properly designed curves to accommodate winter driving conditions. The roads will be adequately signed, and during the winter, difficult stretches will be regularly cleared and sanded. In summer, dust control will be accomplished with water.

State law requires that all spills, no matter how small, be reported to DEC (18AAC70.080). Personnel will be assigned to monitor storage and transfer of oil and fuel and to identify and clean up spilled oil and other hazardous material.

All personnel employed on the project, especially field personnel, will be trained to respond to fuel spills in acordance with an approved oil spill contingency plan. The plan will include a manual and training program describing:

- Actions to take as a first line of defense in the event of a fuel spill.

- Persons to contact in the construction organization and in state agencies.

- Locations of sensitive habitats.

- Location of all oil spill control and cleanup equipment, the types of equipment at each location and appropriate procedures.

- Records to keep during an oil spill and cleanup operation.

Oil spill equipment will be prepositioned and adequate to handle the largest spill expected. Personnel will be trained in the operation of the equipment, and the equipment will be inventoried and tested regularly to make sure it is in proper working order in the event of an emergency (Bohme and Brushett 1979; Lindstedt-Siva 1979).

(f) Water Removal

(i) Impact Issue

Fish fry and juveniles can be impinged on intake screens or entrained into hoses and pumps when water is withdrawn from water bodies for miscellaneous uses during construction.

(ii) Mitigation

If possible, surface water withdrawal will be from streams or lakes that do not contain fish. If water must be withdrawn from a fish-bearing water body, the Alaska Department of Fish and Game intake design criteria will be used for all intakes.

The ADF&G criteria are that: (1) all intakes should be screened; (2) openings in the screen should not exceed 0.04 sq in; and (3) water velocity at the screen should not exceed 0.1 ft/sec (0.03 m/sec). No more than 20 percent of the instantaneous flow will be removed at any time.

(g) Blasting

(i) Impact Issue

Blasting in or near fish streams can rupture swim bladders and damage incubating embryos.

(ii) Mitigation

The ADF&G has standard blasting guidelines that establish the distance from waterbodies at which charges can be detonated without harming fish. Blasting will be accomplished using these guidelines (Table E.3.44).

(h) Susitna River Diversions

(i) Impact Issue

Fish passing downstream through the diversion tunnels are expected to be lost because of the high tunnel velocities. During summer, relatively few fish are present in the vicinity of the tunnel entrance. During winter, resident fish are expected to be entrained into the intake and passed downstream.

(ii) Mitigation

The segment of the fish population lost in the diversion tunnel would be lost subsequent to reservoir filling, because of lost tributary habitat and the expected low habitat value in the reservoir (see Section 2.3.1[b]). Mitigation for these losses will be achieved by the early initiation of grayling propagation, as discussed under Mitigation for Inundation Impacts in Section 2.4.4(c).

(i) Water Quality Changes

(i) Impact Issue

Discharge of camp effluents result in increased levels of metals and nutrient loading. Concrete batching plants release high alkaline effluents.

(ii) Mitigation

Effluents will comply with ADEC/USEPA effluent standards (AS 46.03.100; 18 AAC 70.020; 18 AAC 72.010).

The concrete batching effluent will be neutralized and treated prior to discharge to avoid impacts related to pH and toxic substances (see Chapter 2, Sections 3.2.1(b)[vi] and 3.3.1(b)[vi]).

(j) Clearing the Impoundment Area

(i) Statement of Issue

Adverse impacts associated with removing vegetation along streams are: (1) accelerated erosion into the streams; (2) altered temperature regimes; and (3) operation of equipment in perennial or ephemeral stream ways.

(ii) Mitigation

Clearing will be scheduled as close to reservoir filling as is feasible. Disturbance to the vegetative mat will be avoided. Erosion control methods will be employed wherever needed to minimize unnecessary erosion to streams. To the extent practicable, clearing will take place during the winter. Cleared vegetation will be dried for one season and burned in place. The construction practices manual will specify reservoir clearing practices.

2.4.4 - Mitigation of Filling and Operation Impacts

(a) Mitigation of Downstream Impacts Associated with Flow Regime

(i) Impact Issue

As described in Exhibit A, the proposed project consists of two stages: the first stage-Watana development and the second stage-Devil Canyon development. Each stage requires its own flow release schedule during both filling and operation. The flow release schedule is designed to provide a balance between filling power generation and instream flow requirements of the evaluation species. The initial filling of Watana reservoir will take approximately three years using a flow release schedule, as shown in Table E.3.26. After filling is complete, Watana dam power plant will be operated as outlined in Table E.3.32. Devil Canyon dam reservoir will be filled in two segments. The first segment will take approximately four weeks and the second segment, occurring one or more years later, will take five to eight weeks. The operation of the two dam stage will result in a flow regime as shown in Table E.3.35.

One criterion that influences the establishment of the flow release schedule is the choice of the key fish species and/or life stage to be protected. In the reach between Talkeetna and Devil Canyon, chum salmon were given highest priority followed by chinook, coho and pink salmon (Section 2.4.2).

As discussed in Section 2.3, a primary fishery concern is the provision of flows between Devil Canyon and Talkeetna that:

- Allow adult salmon access to tributary spawning areas;

- Allow adult salmon access to slough spawning habitat;

- Maintain a suitable water depth on the spawning beds throughout the spawning period;

- Maintain flow through the spawning gravels during the incubation and pre-emergence period; and

- Provide a flow-related stimulus to stimulate the out-migration of fry.

Additional fisheries concerns related to instream flow needs of resident and juvenile anadromous fishes include the need to:

- Maintain overwintering and summer feeding habitat; and

- Maintain access to tributary spawning and rearing habitat.

(ii) Measures to Avoid Impacts

Adverse impacts to fishery resources resulting from flow alteration can be avoided or minimized through selection of an appropriate flow regime. While hydroelectric developments with storage facilities alter the natural flow regime in the river, changes in streamflow patterns do not necessarily result in adverse impacts to fish populations. For example, if low flows are limiting fish populations, then supplementing low flow may result in enhancement to that population.

Three factors control water depth at the mouth of the sloughs: (1) mainstem stage; (2) channel geometry; and (3) flow in the slough. Of the three factors contributing to access, the project will only affect the stage at the mainstem. Thus, to avoid the impact on access to slough habitats by adult salmon, the project would have to provide mainstem stages sufficient to freely pass fish into the sloughs. This can only be accomplished by providing the appropriate mainstem stage at the sloughs during the spawning season. Under the proposed flow regime, free access to sloughs by adult salmon will be impaired and additional mitigation measures are needed to reduce these impacts.

(iii) Measures to Minimize Impacts

A flow release schedule will be used that minimizes the loss of downstream habitat and maintains normal timing of flow-related biological stimuli.

During project operation, minimum Gold Creek target flows from October through April will be maintained at 5000 cfs. From May to the last week of July, the target flow will be increased to 6000 cfs to allow for mainstem fish movement. During the last five days of July, flows will be increased from 6000 cfs to 12,000 cfs in increments of approximately 1000 cfs per day. Flows will be maintained at 12,000 cfs from August 1 through mid-September to coincide with the sockeye and chum spawning season in the sloughs upstream from Talkeetna.

- Winter Flow Regime (October-April)

The winter flow will be reduced during October of the second and third year of Watana filling and substantially increased during operation of both project stages. The filling flow regime from November 1 through April 30 is proposed to reflect the inflow to the reservoir. Since minor impacts are expected during filling, no mitigations are proposed.

The increase in winter flows during operation of Watana dam, however, are expected to cause substantial increases in stage as the ice cover forms. Stage increases of 3 to 4 feet (0.9 to 1.2 m) are predicted. These increases in stage are expected to overtop the berms at the upstream end of sloughs and cause mainstem water to flow through some sloughs. As discussed in Section 2.3.1(b)[iii], this would lead to reduced temperatures in the incubation gravels, increased ice formation and reduced slough water temperatures in the spring. The impacts associated with slough overtopping during the winter will be minimized by increasing the height of the berms at the upstream end of the most productive sloughs downstream from the ice front (Figure E.3.26). The ice front is expected to form between Sherman (RM 130) and Portage (RM 149), depending on climate conditions prior to ice formation (see Chapter 2, Sect. 3.2.). Productive sloughs that will be overtopped more frequently than once every five years will be protected.

It is anticipated that sloughs 8, 8A, 8B, 8C, Moose, A[1], B, 9, 9A and 11 will need protective berms. An estimate of costs associated with these protective berms is given in Table E.3.39.

- Spring Flow Regime (May-June)

Breakup flood flows are reduced in the regulated flow regimes. The primary species/life stage that would be impacted during spring flows are salmon fry. It is hypothesized that the spring breakup flows may induce salmon fry, particularly chum and pink salmon, to move out of the sloughs and other incubation gravels, and begin the process of out-migration. The effects of spring breakup on fry migration during the 1983 spring breakup period will identify the timing of out-migration in relation to flow. This information will form the basis for modifying the spring release schedule to provide a sufficient flow-related stimulus. The effectiveness of these releases will be evaluated during the filling and operational monitoring studies.

- Summer Flow Regime (July-September)

The five species of Pacific salmon enter the spawning areas during the summer high flow periods. Most of the spawning in the Devil Canyon to Talkeetna reach is confined to sloughs and tributaries. Access to the slough spawning areas is apparently provided by a combination of the high summer flows in the Susitna River mainstem and the summer surface inflow to the sloughs. In addition, the useable spawning area in sloughs is at least partly controlled by backwater levels from the mainstem into sloughs. Upwelling ground water in the sloughs attracts adults, maintains the permeability of spawning gravels, and provides a stable winter flow during the embryo incubation period. The primary species/life stage that would be impacted in the summer is adult chum salmon.

The proposed operational flows from August 1 to September 15 will provide 12,000 cfs at Gold Creek and will reduce, but not avoid impacts to spawning salmon. It is anticipated that adult salmon will still experience difficulty in gaining access to the sloughs. A refinement of these mitigation flows is being analyzed.

The mitigation increment proposed release for August 1 to September 15 is approximately 387,000 acre-feet. This water has been allocated to provide 12,000 cfs downstream flows during spawning season. At present, this volume is distributed evenly between July 25 and September 15, when adult chum and sockeye are returning to slough spawning areas. Alternatively, this mitigation volume can be allocated in a series of short-term augmented discharges of variable magnitude, frequency and duration that minimize impacts to different species life stages and maximize use of the available water volume. The optimal flow regime will be determined from an analysis of the habitat requirements of the evaluation species that is currently in progress through the aquatic studies program. This information will contribute to the evolution of the reservoir operation regimes.

Even though the use of short-duration pulsed flows will increase ease of access into sloughs, it is expected that impacts to spawning salmon will not be completely avoided through flow allocation. The flows are of sufficient magnitude, however, to permit rectifying impacts to salmon spawning activity.

(iv) Rectification of Impact

- Winter Flows

Since impacts are mitigated in the preceeding section, rectifying measures are not needed.

- Spring Flows

If salmon fry require a high flow at breakup in order to stimulate out-migration, a properly timed pulse of sufficient magnitude will be provided.

- Summer Flows

Impacts to salmon spawning areas will occur if mitigation measures are not employed in coordination with the proposed project flows (or the alternative regime of short-term augmented flows). The rectification methods selected are (1) to maintain access to the sloughs; and (2) to ensure suitable spawning and incubation habitat by physically modifying the sloughs, to maximize use of reduced filling and operational summer flows. The following habitat enhancement measures will be applied either singly or in combination on sloughs, depending on the type of impact that limits salmon production. These methods, especially if used in combination with short-term augmented flows during the spawning season, will maintain salmon productivity in the sloughs. Sloughs on which rectifying measures will be used are sloughs 8, 8A, 8B, 8C, Moose, A[1], B, 9, 9B, 9A, 11, 17, and 21. These sloughs accounted for over 97 percent of the spawning chum and 98 percent of the spawning sockeye using sloughs in 1981 and 1982. Estimates of costs associated with these mitigations are provided in Table E.3.39.

. Access Mitigation

The project flows during August may not create sufficient backwater effects at the mouths of some sloughs to permit free access by returning adult salmon. Access to these sloughs will be facilitated by restructuring the entrance of the slough to convey the majority of the slough discharge and thus provide a greater passage depth (Figure E.3.27). The mitigation plan provides for eight restructured slough mouths.

After the adults enter some of the sloughs, they ascend long reaches of shallow water over a steep gradient before entering the spawning pools. If the ground water flow is substantially reduced, the depth of the spawning pools is also likely to be reduced. In order to rectify these impacts, the streambed profile of the impacted sloughs will be lowered to re-establish the head between the mainstem and slough (Figure E.3.28). Lowering of the slough profile will reestablish the backwater effect at the mouth of the slough and allow free passage through the slough and use of the spawning areas. Lowering of the slough profile will reestablish the area of ground water upwelling that was reduced by the lower mainstem flows. Preliminary calculations indicate a lowering of 1.5 feet (0.5 m) will accomplish the objectives. The mitigation plan provides for lowering the profile of eight sloughs. Such techniques have been successfully used in British

Columbia to improve chum salmon spawning (Lister et al. 1980) and are further discussed in Ken Wood Leidal Association and D.B. Lister Association (1980).

During the lowering process, the slough will be structured to optimize spawning habitat (Figure E.3.28). If it is assumed that 50 percent of the area in these lowered sloughs will be useable spawning habitat, then 144,000 square feet (12,960 m^2) of spawning habitat will be made available by this process (Table E.3.46).

- Spawning Habitat Mitigation

If it is determined from the ongoing aquatic studies that the reduction of upwelling area under operational flows will reduce available spawning area to the extent that salmon productivity is decreased, then additional methods will be employed to augment upwelling in the sloughs.

This will be accomplished by piping water downgradient to a series of perforated drainage pipes to enhance the volume of upwelling in the slough (Figure E.3.29). The mitigation plan provides for four systems to augment upwelling. These four upwelling systems will serve 48,240 square feet (4341 m^2) of spawning habitat (Table E.3.46).

As the ongoing studies define the habitat requirements of the evaluation species, hydrology of the sloughs and as flow regimes are refined, it will be possible to determine mitigation measures appropriate to each of the sloughs. The final selection and design of mitigation features for each slough wll be derived in consultation with NMFS, USFWS and ADF&G.

(v) Reduction of Impacts Over Time

A monitoring program will be conducted to evaluate the effectiveness of mitigation measures (see Section 2.6).

(vi) Compensation for Impacts

If the flow-related impacts cannot be minimized, rectified, or adequately reduced with the implemented mitigation measures, it will be necessary to compensate for the lost fishery resources. The goal of this compensation will be to produce the number of fry expected to be lost from the impacted area. The first priority for compensating lost salmon productivity will consist of channel modifications in side-channels and mainstem areas to increase the suitability of these habitats for spawning.

The lack of suitable substrate may limit the availability of spawning habitat under project operation. In areas with suitable hydraulic conditions, the addition of gravels or the cleansing of gravels in areas with suitably sized particles will provide additional habitat needed to accommodate adults displaced from other habitats. Such projects have been successfully undertaken in Washington (Gerke 1974; Wilson 1976; Washington Department of Fisheries 1981) and British Columbia (Lister et al. 1980). Estimates of costs associated with these mitigations are provided in Table E.3.39.

- <u>Scarifying Side-Channels</u>

  Some of the existing side channels have substrates suitably sized for spawning, but the particles are cemented together by glacial silts and sands. The heavy sediment load and peak flows that presently exist in the Susitna River have resulted in a high degree of compaction in the substrate. If the sands and silts cementing the gravels together are removed, it is expected these areas will provide suitable spawning habitats. In some of these side channels, a bulldozer with a scarifier will be used, in combination with a high-flow release, to rake the streambed, stir up the fine sediments (Gerke 1974; Wilson 1976; Trihey 1982b; Kerr Wood Leidal Association and D.B. Lister Association 1980), and allow the fines to be carried away by the streamflow. This enhancement will be accomplished during reservoir filling. During filling and operation, there will be a reduction of the suspended sediment load and flood peaks (Chapter 2, Section 3.3.2 and 3.3.3), which will be beneficial in maintaining these areas after cleaning. The mitigation plan provides for scarifying four side channels. The four scarified side channels will provide 120,060 square feet (10,805 m^2) of spawning habitat (Table E.3.46).

- Slough Gravel Cleaning

In areas where the above technique will not work, a mobile gravel cleaning machine will be used to remove silts and sands from the substrates. "Gravel Gertie," developed by Washington State University, may be suitable for use on slough and side-channel substrate. "Gravel Gertie" is a mobile gravel cleaner that uses high-velocity water jets to flush and then collect the silts from gravels for disposal (Mih 1980). Silts and sands removed from the gravels will be discharged into the mainstem river or disposed of on land. Habitat improvement activities on side channels will be conducted in a downstream sequence to reduce the chance of sedimentation of fines from upstream sites impacting downstream sites. Rehabilitation projects of this nature have been successfully used for maintaining chum salmon sloughs in Washington (Washington Department of Fisheries 1981). It is anticipated that all productive sloughs will need maintenance cleaning on a 4- to 5-year cycle. The mitigation plan provides for cleaning gravel in three sloughs per year.

- Mainstem Spawning Beds

Under project operation, the peak flow events will be significantly reduced in the reach from Talkeetna to Devil Canyon (Chapter 2, Section 3.3.3[a]). Some side channels and areas of the mainstem will have suitable hydraulic conditions for spawning under project operation, but the streambed may not have substrate of appropriate particle size for spawning. In these areas, gravel spawning beds will be added to create spawning habitat (Figure E.3.30). Thus, gravels placed in side channels and the mainstem to create suitable spawning habitat will have a greater probability of remaining stable under operational conditions. The mitigation plan provides for construction of two mainstem spawning beds. These two beds will provide 120,015 square feet (10,800 m^2) of spawning habitat (Table E.3.46).

Cleaning and supplementing spawning gravel cannot be implemented until reservoir filling. Material added to the mainstem and many of the side channels prior to the control of flow would be quickly redistributed during pre-project summer floods. An analysis of candidate areas is being conducted to identify suitable sites.

- Chum Salmon Hatchery

A chum salmon hatchery facility will be constructed if the previously described, higher priority, fish mitigation alternatives cannot be successfully implemented. Nine potential chum salmon hatchery sites have been identified and evaluated within the Susitna River basin based on water quality, indigenous fish species, access to electricity and roads, soil characteristics, and land ownership status of the respective sites (Kramer, Chin and Mayo, Inc. 1983).

A decision to implement hatchery production of salmon within the Susitna basin would require definition of appropriate target species, management goals, stock selection, disease problems, and would cause competition with native stocks.

(b) Mitigation of Downstream Impacts Associated with Altered Water Temperature Regime

(i) Impact Issue

The creation of Watana and Devil Canyon reservoirs will change the downstream temperature regime of the Susitna River. Reservoirs act as heat sinks, reducing the annual variability and the rate of change in water temperatures by moderating summer and winter temperatures and introducing a time lag. The magnitude of change in the thermal regime downstream depends on the thermal stratification of the reservoir and the design of the power intake and release structures.

Some seasonal stratification is expected to occur in Watana Reservoir (Figure E.2.106). Reservoir thermal modeling indicates that surface water temperatures will reach 10°C (50°F) by August 1 and that the top 100 feet (30 m) of the water column will range between 8° to 9°C (44.4° to 48.2°F) (Chapter 2, Section 3.3.3(c)[i]).

The water temperatures downstream from the dam are set in part by the elevation of the intake structures, which in turn determine the temperature of the water drawn from the reservoir. Since growth rate in many aquatic organisms is temperature-dependent, changes in the thermal regime can have profound impacts on aquatic communities. Potential adverse effects of higher winter temperatures include acceleration of incubation and early emergence of salmonid embryos and benthic invertebrates. The impact of lower summer temperatures includes slower growth of invertebrates, juvenile anadromous, and resident fish. The lag effect may cause delayed spring spawning activity. Changes in the thermal character and its effects will decrease downstream as tributaries contribute to the flow and as the temperature regime approaches an equilibrium state. The impacts related to the thermal changes are expected to be confined to the Talkeetna to Devil Canyon reach.

(ii) Measures to Avoid Impacts

The only mitigative alternative that would completely avoid temperature changes downstream from the project is no project alternative. Hydroelectric project involving reservoir storage dams will alter the natural temperature regime.

(iii) Measures to Minimize Impacts

The impacts associated with alteration of the temperature regime during reservoir operation will be minimized by incorporating multiple-level gates in the power intake. Multiple level intakes have successfully regulated temperature of downstream releases (Nelson et al. 1978).

The success of temperature regulation depends on the thermal structure of the reservoir and the location of the intake ports. The reservoir operation model was used in the design of the multilevel intake structure. The cost of providing multilevel intake structure for temperature control is provided in Table E.3.39.

The summer pre-project temperatures range from 8° to 12°C (44.4° to 53.6°F) in the Devil Canyon to Talkeetna reach. Temperatures near this range are projected to exist in the top 100 feet (30 m) of the reservoir (Chapter 2, Figure E.2.106). By accessing this layer with the multiple-level intake, outlet water temperatures will approximate existing baseline water temperatures from the end of June to mid-September.

During the winter months, temperatures in the mainstem are near 0°C (32°F) in the Devil Canyon to Talkeetna reach. Water temperatures 1° to 4°C (33.8° to 39.2°F) are likely to occur in the Watana reservoir to a depth of 100 feet (30 cm), below which temperatures will be a uniform 4°C (39.2°F) (Chapter 2, Section 3.2.3[c]). Surface water released at 4°C (39.2°F) from Watana dam in early November are expected to reach 0°C (32°F) by RM 103, while later in the winter, surface water released at 2°C (35.6°F) from Watana dam in early January are expected to cool to near 0°C (32°F) by RM 156, just above Devil Canyon.

(c) Mitigation of Inundation Impacts on Mainstem and Tributary Habitats

(i) Impact Issue

In 1981, the arctic grayling population in the impoundment area of both reservoirs, exclusive of Watana Creek, was estimated to be approximately 9375 grayling greater than 8 inches (20 cm) (Table E.3.17), while in 1982 the total population was estimated as at least 16,300 (ADF&G 1982e). This population uses the clear-water tributaries as spawning and rearing habitat and the tributaries and Susitna River mainstem as overwintering habitat. A major project impact will be the loss of grayling spawning and rearing habitat in the inundated portion of the tributaries.

(ii) Measures to Avoid Impacts

The only mitigation alternative that will avoid impoundment impacts for the proposed project is the no project alternative.

(iii) Measures to Minimize Impacts

Mitigation measures that would substantially minimize impoundment impacts to fish populations would be to substantially lower the surface elevation of the reservoir or to maintain surface level during the embryo incubation period. Neither measure would be feasible.

(iv) Measures to Rectify Impacts

Since the impoundment is essentially a permanent impact, rectification measures are not feasible.

2.4 - Mitigation Issues and Mitigating Measures

Rectifying measures, such as providing replacement grayling spawning habitat within the impoundment are not considered feasible because of the timing and magnitude of the drawdown cycle.

(v) Reduction of Impacts

Impacts cannot be reduced over time since no effective mitigation measures have been identified.

(vi) Compensation for Impacts

A propagation program will be initiated to compensate for the loss of these grayling. In order to compensate for the loss of grayling, in-kind, in-basin replacement is planned. Compensation for loss of aquatic habitats in the two reservoirs will be accomplished by:

- Funding research on grayling propagation technology;
- Hatchery propagation of grayling or other resident species and subsequent planting of the reared fish;
- Introduction of rainbow trout into the Devil Canyon reservoir.

Estimated costs of these mitigations are provided in Table E.3.39.

- Grayling Propagation Technology

  Artificial propagation of arctic grayling using existing techniques is not expected to produce the number of adults or adult-equivalents needed to compensate for the expected losses. At present, grayling propagation in Alaska consists of stripping eggs from wild adults, incubating the embryos until hatching, then releasing the newly hatched larvae. This technique is limited by the availability of gravid wild adults, substantial larval mortality, and no satisfactory way of measuring success. If the larvae are artificially reared for two to three months until they are past the larval stage, the early mortality can be substantially reduced. Grayling of this size, approximately 1.4 to 2 in. (3.5 to 5 cm), can be marked so that the success of the program can be evaluated.

Prior to construction of Watana dam, the project will fund research on the rearing of grayling larvae so that the technology will be available when the compensating grayling are needed. This research will also provide the ADF&G with an additional fisheries management tool. The research program could be conducted under the auspices of ADF&G at an existing hatchery facility and financed by the project.

- Hatchery Propagation of Grayling or Other Resident Species

After the demonstration of a successful technology for grayling rearing, a grayling hatchery program will be undertaken either by expansion of an existing facility or construction of a new facility. A drawing for a grayling hatching and rearing facility is shown in Figure E.3.31.

Hatchery produced grayling will be planted in lakes in the project area. The number of grayling to be planted and number of lakes to receive grayling will be determined based on the carrying capacity of the selected lakes. Sufficient grayling will be planted so that the number of catchable grayling will be similar to that number lost. If suitable habitat does not exist in the vicinity of the impoundment to support the number of lost grayling, suitable areas outside the project area will be selected for stocking grayling. The lakes to be stocked will be selected in consultation with ADF&G, USFWS, BLM, and adjacent land owners. Preference will be given to areas near the project area that currently support high levels of harvest pressure.

If the grayling rearing program is not technically feasible or if appropriate planting areas do not exist, the alternative compensation is to provide artificially reared rainbow trout. The technology of rearing rainbow trout is well established and there is a high demand for the species. An existing facility would be expanded and the trout made available for stocking outside the project area in consultation with ADF&G, USFWS and BLM. Costs will be similar to those estimated for the grayling propagation program.

- Introduction of Rainbow Trout into Devil Canyon Reservoir

The Devil Canyon reservoir, unlike the Watana reservoir, is expected to contain habitats favorable for fish production. The Devil Canyon reservoir contains several tributaries that will support rainbow trout spawning, primarily Tsusena Creek and Fog Creek, but also Cheechako Creek and several unnamed tributaries. At present, the natural range of rainbow trout ends at Devil Canyon, where upstream movements are blocked.

It is expected that rainbow trout will make full use of reservoir habitats by spawning and rearing in clear-water tributaries and rearing and overwintering in the reservoir. Rainbow trout to be planted in the reservoir will be acquired from existing facilities within the state. A stocking program will be established in consultation with ADF&G.

(d) Mitigation of Downstream Impacts Associated with Nitrogen Supersaturation

(i) Impact Issue

Nitrogen supersaturation in outflow waters has caused significant fish mortalities from gas bubble disease. Water passing over a high spillway into a deep plunge pool entrains air. Nitrogen passes into solution at depth and a state of supersaturation exists when the water returns to the surface causing persaturation. The degree to which this occurs depends on the depth of the plunge pool, height of the spillway, amount of water being spilled, and downstream turbulence. Supersaturated water is unstable and eventually will return to equilibrium levels if exposed to the air. However, travel time downstream during high flow periods can be fairly short, causing supersaturation to extend considerable distances downstream.

(ii) Measures to Avoid Impacts

Gas supersaturation will be avoided by including fixed-cone valves in the outlet facilities. These valves, in combination with the powerhouse flows, will discharge all flood flows up to the 1:50-year flood without causing supersaturation. A prototype test of cone valves showed them to be effective in preventing gas supersaturation (Ecological Analysis Inc. 1982). Costs associated with providing the gas supersaturation control structures are provided in Table E.3.39.

(iii) Measures to Minimize Impacts

The likelihood of creating gas supersaturation downstream from the dam will be reduced by minimizing release through reservoir management. Releases occur when the reservoir is full and inflow exceeds outflow. By holding the reservoir below full pool for most of the year, flood control capacity would be increased, thus decreasing the probability of spills. The reservoir must reach maximum storage level by September 30 to meet winter power demands. Storms do occur in the Susitna drainage that may require release of water; however, the structures and operation criteria have been designed to minimize releases and spills.

2.4.5 - Cumulative Effectiveness of Mitigations

(a) Construction Mitigation

Through siting and designing of project facilities, appropriate construction practices, and careful scheduling activities as discussed in Section 2.4.3, it will be possible to minimize adverse impacts to aquatic habitats resulting from project construction: The indirect impacts caused by increased access to harvestable fish populations will be reduced during construction by providing workers with alternating recreational opportunities, by instituting a catch-and-release policy for project workers, and by supporting such harvest regulations as the Board of Fisheries imposes. It is expected that impacts will not be avoided and that increased access will have long-term impacts on fish populations caused by the increased harvest pressure.

Aquatic habitat will be altered by removing gravel from the floodplain. These impacts will be rectified by rehabilitation practices discussed in Section 2.4.3.

Fuel spills and road runoff will decrease water quality in streams downhill from project roads. These impacts will be reduced by having a properly trained and equipped spill response team at the construction site.

2.4 - Mitigation Issues and Mitigating Measures

The construction monitoring team will identify areas where remedial actions such as repair, realignment, or redesign are needed.

(b) Operation Mitigation

(i) Mitigations of Access and Impoundment Impacts

The primary program design is to mitigate residual impacts of the access road and reservoir and to compensate for these losses by artificially propagating grayling and introducing these grayling into suitable project and non-project area waters. As part of this compensation, research on grayling propogation will be funded to increase fishery management options. The target number of grayling to be produced will be equivalent to the number lost in the impoundment. The target number of grayling to be produced will be equivalent to the number lost in the impoundment. The primary areas considered for planting are project-area lakes that are capable of supporting grayling. If grayling propagation proves not feasible, rainbow trout will be substituted for planting outside the project area.

Where feasible, access will be provided to the stocked areas to divert harvest pressure from adjacent natural populations. Additional artificially produced grayling can be introduced into project-area streams if natural populations become depleted and population enhancement is deemed to be desirable by the ADF&G. If the carrying capacity of project-area enhancement sites is exceeded by the number of grayling available, the excess grayling will be made available for planting outside the project area. Final decisions on the distribution of residual grayling will be made in consultation with ADF&G, USFWS, BLM, and adjacent landowners.

Road access to the project area will result in increased resource use. Angling pressure would be controlled by the Board of Fisheries through harvest regulation including catch limits, restrictive capture techniques (e.g., fly fishing only and single hook), and adjustments in the open season.

(ii) Mitigation for Downstream Impacts

The goal of the downstream mitigation program is to provide adequate habitat downstream from Devil Canyon Dam that will minimize adverse impacts on fish resources. It is anticipated that the mitigation program will fully maintain, and probably enhance, salmon productivity in the Devil Canyon to Talkeetna reach. During the development of the mitigation program, volumetric, temporal, physical, and chemical needs of the anadromous fish resources between Devil Canyon and Talkeetna were evaluated. Studies and modeling of the inter-relationships of these parameters will continue to refine and quantify the mitigation program.

Several project features have been incorporated into the design to avoid or reduce impacts. Fixed-cone valves will be installed in the outlet facilities to prevent gas supersaturation. The multiple-level power intake gates will allow water to be withdrawn from the upper levels of the water column over the full drawdown range. This ability to withdraw water from the upper levels will allow control over downstream temperatures during periods of stratification.

The project operational flows were developed with an intent to provide a maximum flow during the summer that would not substantially affect the project economics or energy production capabilities. These operational flows will alter the physical characteristics of the sloughs, thereby reducing ease of access and available spawning area for adult salmon and increasing embryo mortality if the sloughs dewater or freeze after spawning is completed. Fry that survive may not leave the sloughs if the migration stimulus, possibly a combination of a proper temperature and flow pattern, is eliminated.

The project operational flows will allow downstream impacts to be minimized when used in conjunction with proposed rectifying and compensating measures. The primary rectifying measure is to use stream enhancement techniques to modify natural slough habitats to maintain natural salmon spawning and fry production. The slough enhancement process is composed of a series of steps to rectify the loss of natural slough habitat. These steps may be used singly or in combination in any particular area, depending on the controlling factors in an affected slough. These steps are:

- Providing an upstream berm that will prevent the river from entering the enhanced slough during winter staging. This control maintains the integrity of the spawning gravels and reduces thermal impacts.

- Selecting a slough that retains ground water flow with suitable thermal characteristics under operational flow levels. The selection process is evaluating a number of criteria to assess the potential for the slough to maintain sufficient ground water flow under operational flows to maintain salmon embryos through the winter and allow properly timed development. Emphasis will be on sloughs that are currently most productive.

- Providing adult salmon with access into the slough by enhancing the backwater effect at the slough mouth and lowering the slough profile.

- If ground water flow cannot be naturally maintained by lowering the slough profile, areas where the ground water flow can be artificially maintained will be considered.

The extent and type of habitat enhancement depends on natural site characteristics, such as ground water flow rates, size of natural features, and factors that appear to limit salmon productivity in each slough. The number of sloughs modified will depend on the desired level of production. It is the Power Authority's intent to maintain production at historical locations and levels.

In addition to slough modification, mainstem spawning beds will be provided as a compensation measure. Additional mainstem and side channel spawning areas will be provided by scarifying or cleaning compacted gravels.

The proposed rectifying and compensating actions will provide an estimated 432,315 square feet (38,902 m^2) of spawning habitat (Table E.3.46). This total is over 187,000 square feet (16,830 m^2) greater than the maximum estimated spawning habitat required by salmon spawning in sloughs upstream from Talkeetna in 1981 and 1982. It is expected that these mitigation features will allow salmon populations in the Devil Canyon to Talkeetna reach to increase over historical levels.

2.5 - Aquatic Studies Program

The aquatic studies program is an integral part of the continuing planning and design for the Susitna Hydroelectric Project. The information presented in this document is primarily based on results of 1981 field studies with some preliminary information from the 1982 study program. Interpretation and analysis of the 1982 data are in progress and supplemental reports containing the results of these analyses will be completed in June 1983. Continuing field data collections have been funded through the 1982-1983 winter season. Modeling efforts have been initiated to incorporate all project data into a quantified impact assessment. Scopes of work for the 1984 field season are being developed. As additional information becomes available from field studies and impact analysis, the mitigation plan will be refined and detailed plans specifying number, location, and design of mitigation features will be prepared. The Power Authority will provide details of these studies and plans as they become available.

As a more refined understanding of project impacts and viable mitigation features is acquired, the emphasis of the study program will shift towards providing the design criteria needed to implement the mitigation features. The aquatic studies will produce the information required to prepare mitigation programs for the preconstruction, construction, filling, and operational phases of the project and phases into a long-term monitoring program.

2.5.1 - Preconstruction Phase

During the preconstruction phase, the aquatic studies program will:

- Provide supplemental information required for support of the license application;

- Continue to define seasonal habitat relationships;

- Continue quantifying the predicted impacts; and

- Refine the proposed mitigating measures.

The need for specific tasks will be translated into field programs.

2.5.2 - Construction Phase

During the planning for construction, information will be needed to properly design site facilities and schedule construction activities to avoid impacts to aquatic habitats. Incorporating environmental design criteria into design, siting, and scheduling activities is a major feature of the construction mitigation plan. Review of proposed actions and facilities will generate the need for some additional data. These needs will be translated into an orderly field study program. Environmental design criteria will be incorporated during the planning stage in order to avoid or minimize impacts.

2.5.3 - Filling and Operation Phases

During filling and operation, monitoring studies, as discussed below, will permit refinement of mitigation features to improve performance.

2.6 - Monitoring Studies

As discussed in Section 1.3 and the Susitna Hydroelectric Project Mitigation Policy Report, monitoring studies are recognized as an essential project mitigation feature that provides for a reduction of impacts over time. Monitoring will be conducted during project construction and operation:

- To insure that good construction practices are being employed on the project;

- To evaluate the effectiveness of the operation and maintenance of mitigation features; and

- To recommend changes in construction practices or mitigation features to further avoid, minimize, or reduce impacts.

An interagency mitigation monitoring team will be established to ensure the proper and successful execution of the mitigation plan and to determine its effectiveness. The organization and operation of a monitoring team will be determined through discussions with resource agencies leading to a memorandum of understanding.

2.6.1 - Construction Monitoring

Construction monitoring will consist of monitoring construction activities to ensure that proper construction practices, as detailed in the project construction practices manual, are being followed and that project facilities are being properly maintained. This monitoring activity will cover all project facilities, including access road construction and maintenance, camp and village construction, material removal, washing operations for dam construction, reservoir clearing, abandonment, and rehabilitation activities.

2.6 - Monitoring Studies

As outlined in the project schedule, construction of the main access road will begin in January 1985. From that time, until construction of the project is complete, a team of construction monitors will be present at the project site. On a daily basis, the monitoring team will visit areas where construction is occurring. Their primary responsibility will be to provide guidance on permit compliance relative to daily activities.

Prior to constructing facilities, the environmental team will review the final designs and means of construction with regard to permits, license stipulations, and design and construction criteria manuals. This will ensure conformance to approved practices. Once construction has begun, onsite changes in permit stipulations may be required because of changes in construction techniques or accidents. If a variance is required, a representative from the regulatory agencies who will be present onsite, will have the authority to authorize field actions that were not specified in the permits. After facilities or portions of facilities have been constructed, the monitoring team will review the designs and verify that the facility is in compliance with permit and license stipulations.

Throughout the construction period, the implementation and execution of the monitoring program will be the responsibility of the Power Authority but daily management will be delegated to the design manager. The construction monitoring teams in the field will report on a regular basis to the design manager. The design manager, in turn, will be responsible for relaying appropriate information to the Power Authority. If a variance is requested by construction crews in the field, the construction and design managers as well as the Power Authority will be notified.

The construction monitoring crew will determine compliance with permit or license stipulations. If a facility or activity is found not to be in compliance with existing stipulations and if a variance was not requested prior to implementing the acitivity, a certificate of non-compliance will be issued and all responsible parties will be notified.

The construction schedule and proximity of activities will dictate the size and number of monitoring teams. Early in the construction phase (1985-1988), the monitoring team will be small, since activities will be limited to construction of the access road and to the Watana dam site. Beginning in 1989 and extending through 1991, the construction of the Anchorage to Fairbanks transmission line will necessitate a larger crew operating over a much larger area. By 1994, the transmission line and Watana dam will be complete; however, construction of site facilities at

Devil Canyon will just be starting. During this interim period, the number of monitoring teams and the extent of their coverage will be reduced. The construction of the main dam at Devil Canyon in 1996 will result in only a small increase in the size of the monitoring team, since most activities will be limited to the damsite and the access road. As indicated by the current schedule, construction activities, including the monitoring program, will end in 2002.

2.6.2 - Operational Monitoring

Operational monitoring will be conducted to (1) monitor salmon population and production levels to ensure that the predicted level of impact is not being exceeded, and (2) evaluate the effectiveness of the project mitigation plan. Costs associated with the operational monitoring are provided in Table E.3.47.

(a) Impact Monitoring of Salmon Populations

Salmon populations in the Devil Canyon to Talkeetna reach will be monitored to determine if populations maintain historical levels during the operation phase. Monitoring will consist of enumerating returning adults that pass Sunshine and Curry Stations and monitoring smolt out-migration from the reach. Adults will be enumerated using the fishwheel and tag/recapture program currently being used in the baseline studies. The smolt out-migration will be evaluated using a smolt trap program such as was conducted in the Spring 1982 study program.

The results of these studies will be used to evaluate changes in the population size, species composition or changes in stream use patterns of the five Pacific salmon species. Results of the mitigation monitoring described in Section 2.6.2 (b) will be used to determine the cause of changes.

(b) Mitigation Monitoring

Mitigation features to be monitored to evaluate whether any adequate level of mitigation is being achieved include:

- Sloughs;

- Mainstem and side channel salmon spawning areas;

- The resident fish population provided by the stocking program; and

- The fixed-cone valves designed to avoid gas supersaturation.

2.6 - Monitoring Studies

The monitoring activity will include evaluating the operation and maintenance procedures to ensure that the facilities are operating effectively.

If it is determined that a mitigation feature is not meeting the intended level of effectiveness, modifications to the migitation feature will be made to further reduce impacts. The specific modifications will be made on a site-specific basis in consultation with the monitoring team.

(i) Monitoring Slough Modifications

The various features incorporated for slough habitat enhancement will be monitored to determine whether they are meeting their intended function and are operating properly.

Mitigation features designed to allow adult salmon access into the sloughs will be annually inspected after breakup to identify and effect any needed repairs prior to the adult return. Annual monitoring of returning adults will identify access problems or passage delays and appropriate corrective actions as recommended by the monitoring team will be taken.

Modifications to sloughs designed to maintain spawning areas will be annually inspected prior to the spawning season to verify that the area contains suitable spawning conditions such as amount of flow, depth of water, and suitable substrate. Areas that become overly silted will be cleaned. If flows diminish so that spawning is no longer possible, the monitoring team will recommend appropriate corrective action.

The number of spawning adults returning to the sloughs will be monitored annually to measure changes in run size to determine if the combination of minimum flow and slough modifications is maintaining natural production. This monitoring will also serve to determine whether the capacity of the modified areas is being exceeded. Appropriate remedial actions, as recommended by the monitoring team, will be taken when spawning damsites are either too low or too high.

Fry production will be monitored annually to verify incubation success. Fry monitoring will include an assessment of out-migration timing and success.

2.6 - Monitoring Studies

The annual slough monitoring will include an evaluation of general slough conditions including vegetative encroachment, beaver occupation, and general condition of the spawning and rearing areas. Appropriate remedial actions recommended by the monitoring team will be performed to maintain slough productivity.

Following flow regulation, representative sloughs will be instrumented with temperature and flow recording instruments to monitor physical characteristics of the sloughs throughout the year. Monitoring of the physical processes will be continued until slough conditions stabilize under the regulated flow regime. This physical processes monitoring will be used in part to determine whether further modifications to the physical habitat must be made to maintain slough productivity.

Methods used to evaluate the slough mitigation features will be consistent with methods currently being used to assess baseline conditions of the parameters to be monitored. Specific study programs will be evaluated and approved by the monitoring team prior to implementation.

(ii) Monitoring of Mainstem and Side-Channel Spawning Areas

The mainstem and side channel spawning areas that are provided as mitigation features will be monitored to quantify adult salmon use of these areas. If the areas receive the expected level of use, the beds will be monitored and maintained on an annual basis.

Monitoring methodology will be similar to that currently used to evaluate mainstem and side-channel spawning habitats and will include standard physical and chemical measurements as well as biological analyses.

(iii) Monitoring of Stocked Grayling and Other Resident Fish

Areas that are stocked with grayling or other resident fish to compensate for impoundment losses will be monitored to ensure that the stocking program is providing a replacement population of harvestable fish. The monitoring program will include evaluations of abundance, growth and age structure. Restockings will be made as needed. If the initially stocked areas will not support the desired populations, additional habitats will be evaluated for stocking.

(iv) Monitoring of Fixed-Cone Valves

The performance of fixed-cone valves will be evaluated to determine whether gas supersaturation is being avoided. This monitoring will consist of a one-time evaluation of gas supersaturation during a release to verify that the valves are operating as designed.

2.7 - Cost of Mitigation

To develop estimates of mitigation cost, 1982 cost estimates were prepared for each activity (Tables E3.39, E3.41, E3.45 and E3.47). These cost estimates were based upon unit cost information derived from recent experience in Alaska or upon experience elsewhere and/or earlier, and escalated to arrive at 1982 cost estimates for southcentral Alaska. Costs for the mitigation program were separated into construction cost and average annual operating cost. For the major mitigation activities, these costs are:

Construction Cost

Downstream Mitigation (Table E.3.39)	$ 6,380,000
Impoundment Mitigation (Table E.3.39)	1,315,000
Dam Structure (Table E.3.39)	80,100,000
Water & Fisheries Quality Monitoring (Table E.3.41)	12,165,100
Aquatic Studies Program (Table E.3.45)	6,000,000
Total Construction Cost	$105,960,100

Average Annual Operating Costs

Fisheries Monitoring (Table E.3.47)	$ 511,400
Maintenance of Facilities (Table E.3.45)	1,064,000
Total Average Annual Operating Cost	$1,575,400

These costs do not include any contingency costs or owner's administrative costs.

2.8 - Agency Consultation on Fisheries Mitigation Measures

Three agencies, USFWS, ADF&G, and Alaska Department of Natural Resources provided comments on fisheries mitigation measures.

2.8.1. - U.S. Fish and Wildlife Service

The USFWS provided formal comments on fisheries mitigation measures on October 5, 1982, and January 14, 1983. The USFWS comments are divided into construction-related mitigations and operation-related mitigations.

(a) Construction Mitigations

Construction mitigations primarily concern siting, design, and scheduling. The comments are:

- Siting and Design

  The access road and transmission line between Watana and Devil Canyon should use the same corridor.

  The diversion tunnel should be screened to avoid entraining fish. The siting of construction and permanent villages and other facilities should be reviewed with the goal of minimizing impacts.

- Scheduling

  Construction activities and reservoir clearing should occur in the winter to minimize impacts. Work in aquatic systems should be scheduled to avoid conflicts with sensitive life history stages.

All of these comments have been addressed in Section 2.4.3. A design criteria manual and a construction practices manual are being prepared for the project that will detail the siting, design, and construction practices criteria that will be used on the project. These manuals will be prepared in consultation with the agencies. The manuals will include timing and scheduling based on the identified sensitive periods and the needs of the construction contractor.

(b) Operation Mitigations

Comments on operation mitigations were divided into those concerning reservoir mitigations and downstream mitigations.

(i) Reservoir Mitigations

Recommendation: Within and out-of-basin opportunities need to be examined to offset losses. Possible options include stream stocking, lake fertilization, extension of existing fisheries and increased access.

Response: The mitigation plan provides for a grayling hatchery and planting program that will introduce grayling into waters in, or in the vicinity of, the project to compensate for lost grayling habitat in the reservoirs. The waters to be stocked will be selected based on a review of water bodies in and near the project area, in consultation with USFWS, ADF&G, BLM, and adjacent land owners.

The project facilities and recreation plan will promote increased access and extension of existing fisheries.

Recommendation: The viability of a reservoir fishery needs to be evaluated.

Response: The Watana and Devil Canyon reservoirs were evaluated in terms of their suitability as fish habitat. It was concluded that the drawdown cycle in the Watana reservoir will limit fish populations and will probably not support a quality reservoir fishery. A grayling fishery, however, would develop in, and at the mouths of, tributaries discharging into the reservoir. For the Devil Canyon reservoir, it was concluded that a reservoir fishery is a viable option because of the timing and magnitude of drawdown cycle. The mitigation plans provide for introducing rainbow trout into the Devil Canyon reservoir, since this species is expected to utilize both reservoir and tributary habitats. This introduction would extend the range of rainbow trout past Devil Canyon, but the species would be precluded from entering the upper basin by Watana dam.

(ii) Downstream Mitigations

Recommendation: Mitigation options for the dewatered area between the Devil Canyon dam and its powerhouse need to be considered.

Response: The habitat lost between Devil Canyon dam and the powerhouse is typified by velocities between 9 and 16 ft/sec (2.7 and 4.8 m/sec), the substrate is bedrock. The area is not expected to provide significant fish habitat, thus the dewatering of the section is not expected to result in substantial impacts. The few chinook that migrate through the canyon during low water years (such as 1982) will be blocked by the dam. Milling areas will still be available at the powerhouse outlet. Because of these factors, mitigation measures are not proposed.

2.8 - Agency Consultation on Fisheries Mitigation Measures

Recommendation: The potential to establish/expand the salmon fishery between the Devil Canyon and Watana damsites, in the absence of a Devil Canyon dam, needs to be addressed.

Response: The flows downstream from Watana Dam are expected to permit chinook salmon to ascend to Tsusena Creek, at the base of the dam. If the Devil Canyon dam is eventually eliminated from the planned development, it would be possible to establish a fishery in this reach. Since Devil Canyon dam is a part of the present plan, developing these chinook stocks for the period between Watana development and Devil Canyon development is not considered cost-effective mitigation.

Recommendation: Adjustments to the Watana reservoir filling schedule to minimize impacts to fish resources should be considered. Addition of a low-level intake port should be evaluated.

Response: Lengthening the filling period would delay impacts to grayling but would not reduce these impacts. Lengthening the filling period would increase downstream impacts to salmon by increasing the number of years that returning adults are exposed to lower temperatures during the upstream migration. Shortening the filling period may eliminate the temperature impact, but would increase impacts caused by low flows. It may be possible to achieve a balance of low flows combined with short-term augmented flows during the second filling year that would minimize temperature/flow impacts and fill the reservoir on schedule. These options are being evaluated along with the desirability of a low-level intake port.

Recommendation: An expanded discussion of the salmon hatchery mitigation option should be provided.

Response: The salmon hatchery mitigation option is a low priority compensation alternative. It is anticipated that the proposed mitigation will maintain salmon populations in the historical locations and that a hatchery will not be needed. Nevertheless, a hatchery siting study has been completed (Kramer, Chin and Mayo, Inc. 1983).

Recommendation: Slough modifications to increase fish habitat need to be demonstrated.

Response: Investigations into the maintenance of salmon spawning habitat in sloughs is continuing as part of the design studies.

2.8.2 - Alaska Department of Fish and Game

The Alaska Department of Fish and Game (ADF&G) provided comments on mitigation measures on July 27, 1982 and January 13, 1983. The ADF&G comments related to mitigation of lost grayling habitat and mitigation for alterations to downstream salmon habitat.

Recommendaton: Hatchery propagation of grayling in Alaska is not well developed at present and grayling production in Alaska must be considered experimental.

Response: It is recognized that grayling propagation is not well developed. The mitigation plan provides for a three-year experimental phase to develop grayling propagation technology that will have utilization beyond project needs. Since ADF&G intends to develop grayling propagation techniques and the Power Authority has a need for such technology, a cooperative experimental effort would be desirable.

Recommendation: Instream flows and temperatures required to maintain present populations should be carefully evaluated to provide a basis for further migration measures.

Response: The ongoing studies are addressing these concerns and substantial analysis will be available on June 30, 1983. These will be further analyzed during refinement of the mitigation plan.

Recommendation: If onsite mitigation of fisheries impacts cannot be accomplished, hatcheries should be considered.

Response: The salmon hatchery option is a low priority compensation alternative. It is anticipated that onsite mitigation will be effective at maintaining production of slough and mainstem spawning salmon. Nevertheless, a hatchery siting study has been completed (Kramer, Chin and Mayo, Inc. 1983).

Recommendation: Results from the ADF&G study on the salmon enhancement potential of the upper Susitna River without the project should be included in the discussion of mitigation options.

Response: The study had not been received by the time this document went to press.

2.8 - Agency Consultation on Fisheries Mitigation Measures

2.8.3 - Alaska Department of Natural Resources

The Alaska Department of Natural Resources' comments of January 13, 1983, requested that downstream mitigation, other than slough modifications, be included. The discussion of downstream mitigation has been substantially revised to indicate more clearly that a series of habitat enhancement techniques will be undertaken, rather than construction of an artificial spawning channel. Also, enhancement of mainstem spawning habitats will provide new habitat in previously unutilized areas.

3 - BOTANICAL RESOURCES

3.1 - Introduction

The object of this report is to describe the existing botanical resources of the Susitna Basin; the impacts which the Susitna Hydroelectric Project will produce on those resources; and mitigative measures incorporated by the project to avoid, minimize, rectify, reduce, or compensate for the predicted adverse impacts. As stated in Section 1.2, the primary importance of botanical resources within the project area is their key role as components of wildlife habitat. The following discussions have been coordinated closely with baseline descriptions, impact assessments, and mitigative measures presented in Section 4 (Wildlife), and form an important basis for that section.

A diversity of plant communities occurs within the study area designated for botanical resources and wildlife of the Susitna Hydroelectric Project. The study area (Figures E.3.32 through E.3.35) includes the watershed of the Susitna River upstream from Gold Creek; a corridor extending approximately 1 mile (1.6 km) to each side of the downstream floodplain between Gold Creek and Cook Inlet; corridors approximately 5 miles (8 km) in width encompassing the transmission routes from Healy to Fairbanks and Willow to Anchorage; and the intertie transmission corridor from Willow to Healy, with a study area varying from approximately 4 to 18 miles (6.4 to 28.8 km) in width (Commonwealth Assoc. 1982).

In this report, the entire Susitna Basin has been subdivided into three component drainage basins: the upper, middle, and lower basins. These areas are delineated in Figure E.3.3, and the designations are used consistently throughout the discussions of botanical resources and wildlife (Exhibit E, Chapter 3, Sections 3 and 4, respectively). However, because the watershed of the Susitna River upstream from Gold Creek, at River Milepost (RM) 136.8 (Figure E.3.33), was distinguished for study purposes from the downstream floodplain study corridor (Figure E.3.34), data were evaluated separately for these two areas in certain cases. In these cases, the entire basin area upstream from Gold Creek is defined as the Watana and Gold Creek watersheds, as shown in Figure E.3.36. Data presented collectively for the Watana and Gold Creek watersheds therefore include all of the upper basin and all of the middle basin except that portion downstream from Gold Creek. The latter area is represented in the downstream floodplain study corridor.

Unless cited otherwise, the descriptions that follow are from McKendrick et al. (1982). Vegetation types are characterized in accordance with the terminology of Viereck and Dyrness (1980). Common names of plant species appear in the text; their scientific names are shown in Appendix ED. Species and varieties under review by the USFWS for official designation as endangered or threatened are referred to by scientific nomenclature in the text.

3 - BOTANICAL RESOURCES

3.1.1 - Regional Botanical Setting

The Susitna River system drains parts of the Alaska Range to the north and parts of the Talkeetna Mountains to the south. The vegetation communities of the region are typical of those covering vast areas of Alaska and northern Canada. They include forest and shrub communities on stream floodplains; coniferous and deciduous forests on canyon slopes adjacent to the floodplains; shrub communities, conifer stands, and tundra on benches above the canyon slopes; and tundra at higher elevations (Figure E.3.38). River action and fires contribute greatly to the ever-changing mosaic of plant communities and successional stages within the region.

Predominant vegetation of the lower mountains and lower slopes of the higher mountains in the project area is alpine tundra as classified by Viereck and Dyrness (1980). Some areas mapped as rock have pioneering species growing in crevices, but the plants provide negligible ground cover. These habitats are common in mountainous areas throughout Alaska. Permanent snowfields and glaciers are found at higher elevations of the Susitna watershed in the Alaska Range.

The benches bordering the middle basin portion of the Susitna River and the area around the Maclaren River are moist tundra. This type includes herbaceous meadows as well as shrub-dominated sites, both of which are widespread in Alaska, especially in the Brooks Range, on the Seward Peninsula, and near the Killuck Mountains.

Along east-west reaches of the Susitna River in the middle basin, steep canyon slopes and some adjacent areas are covered with closed spruce-hardwood forest (Viereck and Dyrness 1980). This type of vegetation is most common along rivers in the south-central and interior regions of Alaska.

Vegetation north of the Susitna River to the Denali Highway along portions of the Seattle, Brushkana, and Deadman Creek drainages is variously composed of mat and cushion tundra, sedge-grass tundra, low shrub types with birch and willow predominant, and alder-dominated tall shrub.

The southeast portion of the middle basin has extensive flat areas covered by low shrubland and woodland conifer communities. The flats in the lower Oshetna River and Lake Louise area are spruce woodland (Viereck and Dyrness 1980).

Each of the transmission corridors crosses several vegetation types. The Healy-to-Fairbanks transmission corridor includes ridges, wet flatland, and rolling hills with areas of open spruce, open deciduous, and mixed forest; shrublands; and wet tundra. The Willow-to-Anchorage transmission corridor passes through closed birch forest, mixed conifer-deciduous forest, wet sedge-grass marshes, and open and closed spruce stands. The Willow-to-Healy intertie corridor traverses a variety of vegetation types, from closed spruce-hardwood forests in the south to tundra and shrubland in the north.

3.1.2 - Floristics

Floristics surveys were made in the Susitna Basin and intertie corridor by McKendrick et al. (1982) and Commonwealth Assoc. (1982), respectively. These provided information on the numbers and distribution of plant species which occur within portions of the project area.

The following floristics data are summarized from McKendrick et al. (1982) and Commonwealth Assoc. (1982), where further details may be found.

(a) General

In the region including the Watana and Gold Creek watersheds, the downstream floodplain, and the intertie corridor, 295 vascular plant species belonging to 151 genera and 57 families were identified (McKendrick et al. 1982) (Appendix 3D). Two hundred fifty-five species were identified in the Watana and Gold Creek watersheds, and 76 species downstream from Gold Creek.

Plant families in the Watana and Gold Creek watersheds having the most represented species were the Compositae (Asteraceae), Salicaceae, Rosaceae, Gramineae (Poaceae), Cyperaceae, and Ericaceae. Within the non-vascular flora, 11 genera of lichens (including at least 12 species) and 7 taxa of mosses were identified in these areas.

The downstream floodplain flora was predominantly a subset of the Watana and Gold Creek watershed flora. Of the 76 plant species found downstream from Gold Creek, 54 also occurred in upstream areas. Downstream sites were confined to the floodplain, which reduced the number of habitats reprsented and floristic variability relative to the upstream area. Also, the larger study area and greater time spent in sampling the Watana and Gold Creek watersheds may in part account for the larger number of species found there.

In the intertie corridor from Willow to Healy, Commonwealth Assoc. (1982) identified 128 species of vascular plants. All but 18 of these species were also found in the Watana and Gold Creek watersheds by McKendrick et al. (1982) (Appendix 3D). Floristics surveys will be conducted in the Willow-to-Cook Inlet and Healy-to-Fairbanks transmission corridors in 1983.

(b) Range Extensions

McKendrick et al. (1982) found 22 vascular plant species in the Watana and Gold Creek watersheds and 9 in the downstream floodplain corridor which were outside their reported ranges (see Hulten 1968) (Table E.3.48). However, the Susitna River drainage upstream from Gold Creek is not well represented in existing plant collections, and range extensions may be expected from any additional botanical surveys in the area.

Two species found in the Watana and Gold Creek watersheds--Sheldon groundsel and timber oatgrass--represent appreciable range extensions. Sheldon groundsel had not been officially reported in Alaska previously, except as possibly present in the Skagway area. Timber oatgrass had been reported only in locations near upper Cook Inlet and near Skagway (Hulten 1968).

In August, McKendrick et al. (1982) found a single specimen of Sheldon groundsel in a mesic (moderately wet) midgrass community near upper Portage Creek. Its identity has not yet been verified. Timber oatgrass was identified in August in the grass portion of a mosaic of low birch and grass communities between the Maclaren River and the Denali Highway.

Two other plant occurrences of note were reported by McKendrick et al. (1982). Robbins pondweed, a submerged rooted aquatic, was found in Watana Lake (Figure E.3.36). There has been limited collection of this species in Alaska. Hulten (1968) reported it from Summit village south of Healy, and Welsh (1974) indicated that it is known from south-central Alaska, but is evidently rare. Black spruce, one of the most common trees found by McKendrick et al. (1982) in the middle Susitna Basin, had been reported by Hulten (1968) to be in areas north and south of the middle Susitna River drainage, but not in the drainage. Viereck and Little (1972), however, did include the Susitna drainage in their distribution map of this plant.

Most other range extensions reported by McKendrick et al. (1982) in the Watana and Gold Creek watersheds were less noteworthy. Most were extensions to the north (more inland) from their previous observations. For example, white bog-orchis had previously been found only near the coast in Alaska. Northern bog-orchis and sweet gale extensions involved sites between areas that were previously included in their ranges. Two-flower cinquefoil and Kane lousewort extensions were south of their previously reported ranges.

In the downstream floodplain corridor, McKendrick et al. (1982) found nine species outside their ranges as reported by Hulten (1968) (Table E.3.48). One of these, raspberry, though not reported to extend into the region by Hulten (1968), was reported by Viereck and Little (1972) to occur there. Devil's club showed a slight range extension upriver. Small-fruit bullrush had previously been found only in four areas outside southeast Alaska. An unverified specimen which appeared to be Chamisso's arnica represented a large extension from the Alaska Peninsula and southeast Alaska. The presence of enchanter's nightshade was an extension inland from coastal regions. Sweet-scented bedstraw and thinleaf alder were minor extensions, and baneberry and northern blackcurrant were extensions from the surrounding areas into the basin.

It is again emphasized that many of the range extensions reported above were merely the result of more intensive botanical collections by McKendrick et al. (1982) than had been made previously and did not represent plants growing in unexpected environments.

3.1.3 - Contribution to Wildlife, Recreation, Subsistence, and Commerce

In the Susitna watershed as elsewhere, botanical resources make essential contributions to human activities and land uses. Vegetation is necessary for the regional maintenance of surface water and ground water quality through water retention, determination of physical and chemical soil properties, and erosion control. Botanical resources are also essential as fish and wildlife habitat components. The structure and productivity of plant communities are requisite the occurrence and abundance of wildlife species within the project area, as discussed further in Section 4 (Wildlife). Wood is used by local residents for building and heating homes. In addition, the mosaic of plant communities and successional stages provides an important aesthetic contribution (Exhibit E, Chapter 8). Thus, botanical resources directly support all of the limited human activities and land uses of the project area (Exhibit E, Chapters 5, 7, and 9).

Commercial use of plant resources within the project area has been limited to small logging operations along the Susitna River floodplain in the lower basin (ADNR 1982b). Vegetation of the upper and middle basins is almost entirely undisturbed. Timber sales are planned for portions of public lands within management units of the Matanuska-Susitna-Beluga Cooperative Planning Program (ADNR 1982b). Lands with highest forestry potential within the project area are located along nearly the entire length of the Susitna River floodplain downstream from the confluence with Porage Creek. Eleven timber sales totalling approximately 325,100 acres (131,619 ha) within the lower basin are planned by the Alaska Department of Natural Resources and Matanuska-Susitna Borough; most are scheduled to begin no earlier than 1992 (ADNR 1982b).

3.2 - Baseline Description

3.2.1 - Threatened or Endangered Plants

At present, no endangered or threatened plant taxa are officially listed for Alaska by federal or state authorities; however, 37 plant taxa are currently under review by the U.S. Fish and Wildlife Service (1980a) for possible protection under the Endangered Species Act of 1973. Murray (1980) discusses the habitats, distributions, and key traits of most of the Alaskan candidate taxa. Searches for these plants were made in two areas--the Watana and Gold Creek watersheds (Figure E.2.36) (McKendrick et al. 1982) and the intertie transmission corridor between Willow and Healy (Commonwealth Assoc. 1982) (Figures E.3.35 and E.3.37.

No surveys of candidate taxa were conducted in the downstream floodplain corridor or the transmission corridors from Healy to Fairbanks and Willow to Anchorage. Changes in downstream water flow caused by the project are judged unlikely to affect any endangered species, because none of them (Table E.3.49) is normally found in association with river floodplains. Endangered plant surveys will be conducted along the Healy-to-Fairbanks and Willow-to-Anchorage transmission corridors in 1983.

(a) Watana and Gold Creek Watersheds

Table E.3.49 shows the plant taxa on Murray's (1980) list believed most likely to occur in the Susitna River drainage and in the habitats to be affected by construction of the proposed dams and associated facilities. McKendrick et al. (1982) conducted ground searches for these candidate taxa in the following areas of the Watana and Gold Creek watersheds: (1) alpine areas near the Susitna and West Fork Glaciers; (2) lowlands of the upper and middle basins, including those of the Maclaren and Tyone Rivers and their associated ridges, terraces, and periglacial features; (3) calcareous outcrops and promontories along the Susitna River near Watana and Kosina Creeks; (4) potential alternative access routes in the middle basin; and (5) borrow sites planned for dam construction. These areas were selected after reviewing the literature pertaining to the likely habitats of endangered plant taxa, conferring with specialists in Alaska plants, and conducting discussions with project geologists to identify calcareous soils (a habitat component of some of the species in question).

Well-drained rocky or scree slopes were searched in alpine areas of the upper drainage basin in the steep valleys adjacent to the Susitna and West Fork Glaciers. None of the taxa under federal review was found.

Well-drained, sandy or gravelly ridges and terraces in lowlands of the upper and middle drainage basins were searched. Shores of lakes and ox-bow ponds, and peri-glacial features were emphasized. A trip was made downstream as far as Devil Canyon, and two large gravel bars within the riverbed were surveyed. None of the taxa under federal review was found in these lowland surveys.

Several of the taxa listed by Murray (1980) were known calciphiles (plants that normally grow on calcareous soils). Three locations with calcareous soils were found in the project area. One was on the northwest flank of Mt. Watana at about 3700 ft (1128 m) elevation, another on the south side of the Susitna River immediately east of its confluence with Kosina Creek, and the third was on the north side of the Susitna River about 4.5 miles (7 km) west of Watana Creek. Calciphilic plants were found on two of these sites, but none of those found was listed by Murray (1980).

Three sites judged by substrate characteristics potentially to support rare plants were searched along the proposed access route section from the Denali Highway to Watana (Figure E.3.37). One site was a sandy blowout area on the northwest side of Deadman Mountain; one was a series of dry ridges (probably glacial moraines or terraces) on the south side of Deadman Mountain; and one was an area of windblown ridges on the east side of Deadman Mountain. No candidate threatened or endangered taxon was found at any of these sites, nor along any of the other proposed access corridors.

Vegetation in the vicinity of borrow sites proposed for dam construction (Figure E.3.37) was surveyed in July 1981. No candidate threatened or endangered taxon was found.

(b) Willow-to-Healy Intertie

The Willow-to-Healy intertie corridor (Figures E.3.35 and E.3.37 was surveyed for the presence of Smelowskia borealis var. villosa, Taraxacum carneocoloratum, and Montia bostockii, all of which appear on Murray's (1980) list (Table E.3.49). Geologic and topographic maps were used to identify potential habitat areas for these taxa within the intertie corridor. None of the candidate taxa was found in the locations surveyed (Commonwealth Assoc. 1982).

(c) Summary

In summary, the Susitna River watershed upstream from Gold Creek was surveyed at selected habitat sites for plant taxa under consideration for threatened or endangered status. Access routes, borrow areas, and the intertie corridor were also surveyed for the presence of these taxa. No candidate threatened or endangered plants were found. Further endangered plant surveys will be made in the Healy-to-Fairbanks and Willow-to-Anchorage transmission corridors in 1983.

3.2.2 - Plant Communities

(a) Methods

Vegetation of the project area was mapped at three different scales by McKendrick et al. (1982), using photo-interpretation of high-altitude (U-2) color infrared photographs and LANDSAT imagery, followed by confirmation of vegetation types in the field. Plant communities were classified in accordance with Viereck and Dyrness (1980). The Watana and Gold Creek watersheds (Figure E.3.36) were mapped at a scale of 1:250,000 (Figure E.3.38). The middle basin (Gold Creek to the Tyone River, RM 246.5) was further mapped at a scale of 1:63,360, encompassing land bordering the Susitna River to a distance of about 10 miles (16 km) and thus including all of the construction and borrow areas associated with the proposed Watana and Devil Canyon dams, all of the Watana-to-Devil Canyon and Devil Canyon-to-Gold Creek access and transmission routes, and approximately the southern one third of the Denali Highway-to-Watana access route and associated borrow areas (Figures E.3.39, E.3.40, and E.3.41). The Healy-to-Fairbanks and Willow-to- Anchorage transmission corridors were also mapped at a scale of 1:63,360 (Figures E.3.48 through E.3.52). Vegetation maps of the intertie corridor, presented at a scale of 1:250,000 in Commonwealth Assoc. (1982), were adapted from a map previously prepared by the Joint Federal-State Land Use Planning Commission for Alaska (1973) and adapted subsequently by the U.S. National Park Service (1976).

McKendrick et al. (1982) prepared vegetation maps of the Watana and Devil Canyon impoundment, construction, and borrow areas, and the Susitna floodplain downstream to Talkeetna, at a scale of 1:24,000 (Figures E.3.53 through E.3.65). Wetland vegetation types were mapped by McKendrick et al. (1982) at a scale of 1:24,000 from the Oshetna River to the Devil Canyon damsite, using the system of Cowardin et al. (as adopted by the Fish and Wildlife Service (1980b). (Figures E.3.66 through E.3.73. The wetlands maps were based on the 1:24,000-scale vegetation maps.

Whereas the vegetation maps show definite boundaries between vegetation types, such lines of demarcation do not exist in the field and are imposed by the judgment of the cartographer. Another consideration is that the smallest feasible units mappable at the 1:250,000, 1:63,360, and 1:24,000 scales are about 642 acres (260 ha), about 40 acres (16 ha), and about 7 acres (3 ha), respectively. Therefore, vegetation types shown on the larger scale maps and tables derived from them are sometimes absent from the smaller scale mapping and tables (McKendrick et al. 1982).

The classification system proposed by Viereck and Dyrness (1980) is a hierarchical system based on the characteristics of the vegetation itself. It is composed of four formations for terrestrial vegetation: forest, tundra, shrubland, and herbaceous vegetation; and one formation for aquatic vegetation. These formations constitute Level I of the classification system. At the finest level of resolution (Level V), units are discrete plant communities. Levels II, III, and IV are intermediate in resolution. In most cases, the Level III names were used for mapping; however, Level IV names were used for forested areas on the 1:24,000 and 1:63,360-scale maps. A total of 19 categories were used to map vegetation at the 1:250,000 scale; 25 were used on the 1:63,360-scale maps; and 21 were used on the 1:24,000-scale maps.

Vegetation studies by McKendrick et al. (1982) were conducted during the summers of 1980 and 1981. The study area during 1980 included the Watana and Gold Creek watersheds and the floodplain of the Susitna River from Gold Creek to Talkeetna. During 1981, the downstream floodplain received further attention, and the Healy-to-Fairbanks and Willow-to-Anchorage transmission corridors were mapped, in addition to further surveys upstream from Gold Creek. As shown in Figure E.3.33, areas closer to or including the proposed impoundment, dam, and ancillary facility locations were mapped at progressively larger scales, reflecting the relative extents of direct disturbance expected to result from the project in these areas (McKendrick et al. 1982).

For confirmation of mapped vegetation types, high-altitude (U-2) color photography at a scale of 1:120,000 with overlays of delineated vegetation units was taken into the field. More attention was given in the field to the areas mapped at larger scales (i.e., greater resolution), but locations throughout the entire study area were checked to include as many reprsentative terrain types and physiographic areas as feasibile. Ground-truth surveys emphasized vegetation types which were especially difficult to interpret from aerial photography (McKendrick et al. 1982). During field checking of the Healy-to-Fairbanks and Willow-to-Anchorage transmission corridors, color infrared photographs at scales of 1:63,360 and 1:120,000, black and white 1:48,000-scale prints, and 1:12,000-scale true-color photographs were variously used (McKendrick et al. 1982).

Additional vegetation mapping of the project area utilizing recently available real-color and color infrared aerial photography is currently planned. This mapping has three objectives: (1) to provide a quantifiable data base for precise type and areal extent of moose browse within the Watana and Gold Creek watersheds; (2) to delineate vegetation communities characteristic of wetlands (as defined by Cowardin et al. 1979) to a level of detail that will usefully support facility siting and design as well as preparation of permit applications required by Section 404 of the Clean Water Act; and (3) to provide general mapping of vegetation types based on improved aerial imagery as a data base for refined impact assessment and design support.

The mapping program will provide two vegetation map products: a detailed 1:24,000-scale map of wetland vegetation and moose browse types delineated to classification Level IV of Viereck, Dyrness, and Batten (1982); and a 1:63,360-scale map of vegetation types delineated to classification Level III of Viereck and Dyrness (1980). The 1:24,000-scale map will cover lands in the immediate project vicinity including all potential impact areas: the impoundments, damsites, borrow sites, construction camps and villages, access corridors, and the Watana-to-Gold Creek transmission corridor. The 1:63,360-scale map will cover the Watana and Gold Creek watersheds including the access corridor to the Denali Highway.

Both vegetation maps will be field-checked following initial photointerpretation with subsequent refinements. The 1:24,000-scale map will provide categorized detail for moose browse and wetland vegetation beyond the limits of the photography, based on field data. Applications of these maps to impact assessment and mitigation planning are discussed in Sections 3.3, 3.4, and 4.4. It is expected that preliminary mapping will be available by June 30, 1983.

Methods used for the qualitative and quantitative characterization of vegetation types are described in detail by McKendrick et al. (1982). The 64 locations and associated vegetation types surveyed in the Watana and Gold Creek watersheds during the summer of 1980 are indicated in Table E.3.50 and Figure E.3.74.

At these locations, plant species composition and community structure determinations were made; and data on elevation, slope, aspect, and landform also were gathered to relate to plant species composition.

The cover contributed by each plant species was measured within a series of vertical layers as percent area of each layer. The ground layer was defined to be all herbaceous and woody species less than 1.6 feet (0.5 m) tall. The shrub layer included woody species taller than 1.6 feet (0.5 m) with a diameter at breast height (dbh) less than 1 inch (2.5 cm). The understory layer consisted of woody species between 1 inch (2.5 cm) and 4 inches (10.0 cm) dbh. Overstory vegetation contained species larger than 4 inches (10.0 cm) dbh. This classification approach is used here to describe the vertical layering within plant communities of the project area.

Forest communities were defined as those with at least 10 percent cover by tree species regardless of tree height. Shrubland communities had at least 25 percent cover of erect-to-decumbent shrubs but were not located beyond the elevational limit of trees. Tundra stands were those communities above or beyond the elevational limit of trees and were dominated by shrub or herbaceous species.

Forests were divided into subtypes according to the dominant trees (conifer, deciduous, or mixed). Deciduous and conifer types had at least 75 percent of the tree cover provided by either deciduous or coniferous trees, respectively. Mixed types had smaller percentages of each. It should be noted that white and black spruce and common juniper were the only coniferous species in the study area.

Each forest subtype was further classed as woodland, open, or closed, depending on percent of tree canopy cover. The woodland type stands contained between 10 percent and 25 percent tree cover. Open stands contained 25 to 50 percent tree cover, and closed stands had over 50 percent tree cover.

Shrub communities were classed as open or closed by percent cover, open indicating up to 50 percent cover. Shrub vegetation was also classed as tall or low, with tall shrub distinguished primarily by the presence of Sitka alder frequently 6 to 12 feet (2 to 4 m) in height.

Low shrub communities were about 3 to 5 feet (1 to 1.5 m) tall and were classified into three subtypes: those dominated by birch, willow, and a mixture of the two. Resin and dwarf arctic birch were the predominant birches; and willows were typically represented by such species as diamondleaf and feltleaf willow, both important as moose browse.

Aquatic vegetation within the Watana and Gold Creek watersheds was examined during August 1980. In order to obtain site-specific information on aquatic plant species, 24 selected ponds and lakes and their adjacent uplands were surveyed on foot from Devil Canyon (RM 152) to the confluence of the Susitna and Oshetna Rivers (RM 233) (Figure E.3.75). During the surveys, species composition, dominance, and total cover (relative to the amount of water) were estimated. Elevation, estimated rooting depth, and width of surrounding wetland area were recorded. Surrounding wetland was limited by definition to the Lacustrine-Limnetic-Emergent Wetland-Vascular wetland class of Cowardin et al. (1979). Many remaining ponds and lakes were examined by helicopter overflights.

Quantitative descriptions of downstream floodplain plant communities were made during the summer of 1981 at the 29 locations shown in Figure E.3.34. Vegetation cover by species was measured along transects. Density of woody species was determined by counting individual stems of plants within specific height ranges growing inside designated measurement plots. Age, height, and diameter at breast height (dbh) of low shrubs, tall shrubs, and trees were measured for randomly selected plants along the transects, and the age of each measured tree or shrub was determined by counting growth rings taken from cross-sectional cuttings or cores. Crown dominance, a measure of which species within a stand were capturing the canopy sunlight, was evaluated as follows: (1) open growth (not encountered), (2) dominant - received sunlight from above and the sides, (3) codominant - received sunlight from above, but not from the sides, (4) intermediate - plant barely reached main canopy, (5) overtopped - plant was below general level of canopy, (6) subordinate - below the overtopped category, and (7) ground - the lowest level. The ground elevation of each floodplain stand relative to river surface elevation was measured by rod-and-level technique at two or three different times during the summer of 1981. Time of day for each measurement was recorded for later reference to rate of river flow.

(b) Watana and Gold Creek Watersheds

Figure E.3.38 shows the general distribution of vegetation in the Watana and Gold Creek watersheds, and Figures E.3.39 through E.3.41 and E.3.53 through E.3.65 provide greater detail. Table E.3.50 and Figure E.3.74 indicate field sampling locations and associated vegetation types characterized for ground truth and floristics during June, July, and August 1980 (McKendrick et al. 1982). Hectares and percentages of total area covered by vegetation types in the Watana and Gold Creek watersheds are shown in Table E.3.51, based on mapping at a scale of 1:250,000 (Figure E.3.38) (McKendrick et al. 1982). Table E3.52 shows hectares and percentages of total area covered by vegetation types in the 10-mile (16-km) area on each side of the Susitna River from Gold Creek to the Maclaren River, based on mapping at a scale of 1:63,360 (Figures E.3.39 through E.3.41 (McKendrick et al. 1982).

The structure and distribution of vegetation types at elevations below tundra in this area are strongly influenced by past fires, evidenced by fire scars on the trees. Post-fire succession for black spruce stands typically proceeds from the initial herbaceous and shrubby stages to young black spruce stands to dense and finally decadent black spruce/moss communities (Van Cleve and Viereck 1981). Post-fire succession in white spruce stands includes the initial herb and tree seedling stage; the shrub-tree sapling stage; and the dense hardwood stage of aspen, birch, or a mixture of aspen and birch. From this point the stand proceeds through a mature hardwood-spruce seedling stage, a mixed white spruce-hardwood stage, and finally a mature white spruce stage (Van Cleve and Viereck 1981). Most of the herbaceous, shrubby, deciduous, and mixed forest communities identified and described below may be successional stages in the process of transition to black or white spruce forest.

(i) Forests

Forest vegetation types were located at lower elevations and covered approximately 21 percent total area (860,481 acres, 348,232 ha) of the Watana and Gold Creek watersheds. The mean elevation of forest areas sampled was 1716 feet (523 m) (range 1100 to 2600 feet, 340 to 790 m).

Forested communities in this area were similar to those described by Viereck (1975). Black spruce generally occurred on wetter sites than white spruce, and both spruce species occurred on colder sites than those of deciduous or mixed forests. Black spruce forests on poorly drained soils are discussed as wetlands in Section 3.2.3. Closed forests occur on sites warmer than those of open forests. Deciduous and mixed forest stands in the project area were considered earlier successional stages of the conifer stands (Viereck 1970, 1975; Hettinger and Janz 1974).

- Coniferous Forest

Coniferous forests covered approximately 19 percent total area (760,045 acres; 307,586 ha) in the Watana and Gold Creek watersheds and consisted of spruce stands with a majority of either white or black spruce. These forests contained a well-developed ground layer with a high percent cover (94 percent) (Tables E.3.53 through E.3.56). The layering structures of white and black spruce stands were similar, except that white spruce stands usually had a greater overstory cover (35 percent compared to 14 percent), a reflection of the generally larger cover area of individual mature white spruce trees (Tables E.3.54 and E.3.55).

As evident in Tables E.3.54 and E.3.55, open white spruce and black spruce stands differed greatly with respect to species composition and percent cover contributed by the two spruce species within the vertical strata. In the open white spruce stands sampled, black spruce was absent; whereas in the open black spruce stands, total black spruce cover (22 percent) and white spruce cover (17 percent) were nearly equal. White spruce percent cover (13 percent) was greater in the overstory layer because of the larger cover area of individual white spruce trees as compared to black spruce (5 percent cover) which had reached the overstory.

Core sampling indicated that large white spruce ranged from 34 to 78 years in age and large black spruce from 77 to 171 years. Several white spruce stands examined appeared to be recovering from past disturbance, perhaps fire; black spruce stands showed less signs of disturbance.

Open spruce stands were usually found on riverine slopes or terraces at elevations averaging 1600 feet (487 m) (range 1100 to 1950 feet; 340 to 590 m) and covered approximately 1 percent of the total area. The cover contributed by the white spruce trees was concentrated in the overstory layer (35 percent overstory, 1 percent shrub), whereas percent cover provided by black spruce trees was proportionately greater in the shrub layer (5 percent overstory, 8 percent shrub) (Tables E.3.54 and E.3.55). Canopy cover of the ground layer in open spruce forests normally exceeded that of the overstory. Black spruce stands contained low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry, in the ground layer. Bluejoint was the predominant ground layer species by cover in open white spruce stands.

Cover of feather mosses in open stands of both white and black spruce approximated that of the trees. Low shrubs, such as crowberry, northern Labrador tea, bog blueberry, and mountain cranberry, accounted for much of the woody ground layer in open black spruce stands (Table E.3.55). Predominant herbaceous species common to both types of open stand were twinflower and horsetails.

All woodland spruce stands surveyed by McKendrick et al. (1982) were black spruce. This was the most widespread forest type and covered approximately 12 percent of the total area of the Watana and Gold Creek watersheds. Unlike open spruce forest, woodland stands were composed of scattered, stunted trees, and the overstory was almost negligible (Table E.3.56). This vegetation type was usually found on relatively level benches with poorly drained soils at elevations averaging 2,046 feet (range 1600 to 2600 feet; 490 m to 740 m). The trees were usually too small to qualify for the overstory layer because trunks were generally less than 4 inches (10 cm) dbh. In woodland spruce stands, sphagnum mosses, not feather mosses, were the most predominant cover species (62 percent cover); other important ground layer species included sedges, woodland horsetail, and low shrubs similar to those found in the open spruce stands (Table E.3.56).

Balsam poplar is the first tree to appear during successional development of vegetation an allurial deposits. Balsam poplar trees provided about 75 percent cover in the overstory, but contributed relatively small cover (5 percent) within the understory and shrub layers of balsam polar stands (Table E.3.57).

Closed paper birch stands occurred on steep, usually south-facing slopes that had typically been subjected to recent disturbance, as described by Hettinger and Janz (1974) for northeastern Alaska. The layer structure was similar to that of closed balsam poplar stands--73 percent overstory cover, a well-developed ground layer (95 percent cover), and relatively minor cover in the shrub and understory layers (3 and 9 percent, respectively) (Table E.3.58). Frequently the overstory contained a few scattered white spruce.

Trembling aspen stands were infrequently found on the upper portions of quickly draining, dry, south-facing slopes. Their general structure was similar to that of other closed deciduous stands in that there were well-developed overstory and ground layers (80 and 85 percent, respectively), but poorly developed shrub and understory layers (5 percent for both) (Table E.3.59).

- Mixed Conifer-Deciduous Forest

Mixed conifer-deciduous forests covered approximately 2 percent of the total area of the Watana and Gold Creek watersheds. This vegetation type had mean overstory cover values intermediate between mean cover values for spruce stands and those for deciduous stands. This forest type was typically dominated by white spruce and paper birch. Elevations for mixed conifer-deciduous forest average 1530 feet (466 m) (range 1200 to 2250 feet; 370 to 690 m), with closed stands having a mean elevation near 1394 feet (425 m) (range 1300 to 1450 feet; 400 to 440 m), and open stands occurring around 1581 feet (482 m) (range 1200 to 2250 feet; 370 to 690 m). Most of the larger stands were found on slopes downstream from Tsusena Creek (Figure E.3.36). These were successional stands which developed as spruce replaced deciduous trees.

Mixed conifer-deciduous forest had a well-developed ground layer with predominant species including bluejoint, bunchberry, woodland horsetail, and knight's plume-moss (Ptilium sp.) (Tables E.3.60 and E.3.61). Overstory cover in closed mixed stands is about 60 percent and that in open mixed stands is approximately 38 percent. Overstory height was sometimes up to 66 feet (20 m). The dbh of individual trees in these two-species overstories ranged from 0.5 to 1.0 feet (15 to 30 cm).

Cores from larger trees indicated that mature birch in mixed stands averaged about 90 years old or older. Rotten centers precluded accurate aging in older birch trees. White spruce ages ranged from 50 to 204 years, with most trees older than 100 years.

Plant species composition and abundance differed between open and closed stands of mixed conifer-deciduous forest. The shrub layer contributed greater cover (17 percent) in open stands than in closed stands (4 percent) because tall blueberry willow was more abundant there than in closed stands (Tables E.3.60 and E.3.61).

(ii) Tundra

Tundra communities covered 24 percent (975,267 acres, 394,685 ha) of the Watana and Gold Creek watersheds and usually occurred above the limit of tree growth (Figure E.3.38). Most of the well-vegetated communities occurred in flat to gently sloping areas. Sparser vegetation was present on steep or rocky terrain. Although tundra species composition was highly variable, four distinct subtypes were identified in areas large enough to map--wet sedge-grass tundra, mesic sedge-grass tundra, herbaceous alpine tundra, and closed mat and cushion tundra.

Wet sedge-grass tundra communities covered a small amount of the total area (0.3 percent) and occurred at a mean elevation of 1926 feet (587 m) (range 1400 to 2550 feet, 430-780m) in wet, depressed areas with poor drainage. They had almost 100 percent vegetation cover, with most species occurring in the ground layer (Table E.3.62). Predominant herbaceous species were water sedge, Bigelow sedge, sphagnum moss, and bluejoint. The shrub layer, when present, contained scattered individual willows. There was usually a large amount of organic matter in soils of wet sedge-grass communities, and in some cases a thick organic layer overlaying mineral soil. Wet sedge-grass tundra is noted as a wetland type in Section 3.2.3.

Mesic sedge-grass tundra was the largest tundra subtype (11 percent cover) and occurred at a mean elevation of 4502 feet (1372 m) on well-drained, rolling uplands. The underlying soil was well-developed in some areas, but in others the soil was patchy and interspersed with rocks. Mean Vegetation cover was 65 percent for the two locations surveyed (Table E.3.63). All vegetation was in the ground layer, and species were usually less than 1 foot (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 were found in the Watana and Gold Creek watersheds, although only one type, herb-sedge tundra, was predominant in areas large enough to map. Herb-sedge communities covered less than 1 percent of the total area and occurred at elevations of about 4249 feet (1295 m) (range unavailable), near the glaciers of the upper basin (particularly the West Fork Glacier) on gentle, well-drained slopes with relatively well-developed soils. Vegetation cover in herb-sedge tundra was nearly 100 percent. A list of the 42 species found in one stand of herb-sedge tundra is shown in Table E.2.64. Cover of each species could not be determined because of the complex vegetation pattern. The other type of herbaceous alpine community was present in small, isolated rocky areas. Small forbs and sometimes shrubs grew in pockets of mineral soil imbedded between the rocks.

The fourth major type of tundra community found within the Watana and Gold Creek watersheds was mat and cushion tundra (total 4 percent cover), found at high elevations (3280 feet; 1000 m) (range 2600 to 4000 feet; 302 to 1219 m) on dry, windy ridges. Vegetation cover was about 75 percent and was usually less than 8 to 12 inches (20 to 30 cm) tall (Table E.3.W16). Lichens and low mat-forming shrubs were major constituents. Soils were shallow and coarse. Uplands within the Gold Creek watershed supported extensive areas of a mixed vegetation type consisting of interspersed mat and cushion and sedge-grass tundras (9 percent total area) (Figure E.3.38).

(iii) Shrubland

Shrubland vegetation types were the most prevalent of all vegetation types and comprised almost 40 percent cover in the Watana and Gold Creek watersheds. Including approximately 65 plant species, shrublands generally occupied areas at higher elevations than forest communities, but at lower elevations than tundra types. Two main types were found: tall and low shrub. Most shrublands, particularly the low shrub, were found on extensive, fairly level benches at mid-elevations throughout the Watana and Gold Creek watersheds. Less extensive areas, usually tall shrubs, were found on steep slopes above the river. Tall and low shrub types were further divided by percent shrub cover into closed and open types.

- Tall Shrub Types

Tall shrub communities covered approximately 8 percent of the total area and were dominated by Sitka alder and were found mostly on steep slopes above the Susitna River or sometimes above flat benches at a mean elevation of 1880 feet (573 m) (range 1600 to 2550 feet; 490 to 780 m) (Figure E.3.38). Many of these stands were 7 to 13 feet (2 to 4 m) tall. Approximately 25 species were identified in the alder stands (Table E.3.66).

Alder stands frequently occurred as narrow strips through other vegetation types on the slopes adjacent to the Susitna River. Alder would also be present in rings at a particular elevation around mountains or in strips along tributary streams, such as Portage Creek. Closed stands had almost complete vegetation cover, contributed primarily by the ground layer and understory (Table E.3.66). One open alder stand surveyed had less vegetation cover than the closed stands (85 percent and 96 percent cover, respectively), with greatest percent cover in the understory layer (Table E.3.67). Bluejoint was the predominant ground layer species in open and closed stands.

- Low Shrub Types

Low shrub vegetation types were found to be common in the Watana and Gold Creek watersheds where they covered 32 percent of the total area. Low shrub communities were widespread on the extensive, relatively flat river benches (mean elevation: 2562 feet, 781 m) (range 2100 to 3200 feet, 640 to 980 m), where soils were frequently wet and gleyed, but usually without standing water. Birch and willow, generally 3.3 to 4.9 feet (1.0 to 1.5 m) tall, were predominant in both separate and mixed stands. The cover percentages of ten closed and two open low shrub stands sampled are shown in Tables E.3.68 and E.3.69, respectively.

Birch shrub stands were usually dominated by resin birch 3.3 feet (1 m) tall, and contained several other low shrub species, especially northern Labrador tea. Predominant ground layer species were bog blueberry, mosses and lichens. Willow shrub stands were usually in wetter areas than birch shrub stands. Diamondleaf willow was commonly predominant, forming thickets along small streams at high elevations. Because of the wetness, these communities were usually less botanically diverse than birch shrub stands. Water sedge, northern Labrador tea, and bog blueberry were the predominant ground layer species.

(iv) Herbaceous Communities

Two herbaceous community types were found in the Watana and Gold Creek watersheds. Grasslands dominated by bluejoint were present on level to sloping areas at lower elevations along the Susitna River and Portage Creek (less than 1 percent total area) (Table E.3.52 and Figure E.3.53 through E.3.65). Herbaceous communities were too small to map at a scale of 1:250,000 and do not appear in Table E.3.51. Herbaceous pioneer communities (too small to map) were present on recently vegetated gravel and sand bars where soils had little organic matter and often consisted primarily of cobble. Pioneer species included horsetails, lupines, and alpine sweetvetch.

(v) Aquatic Vegetation

Lakes and ponds surveyed for aquatic vegetation are shown in Figure E.3.75. Aquatic species identified during these surveys are listed by site in Table

E.3.70. A summary of the dominant aquatic species and factors which may influence their locations in and around many of the water bodies in the Watana and Gold Creek watersheds is presented in Figure E.3.76. Bur reed and yellow pond lily probably contributed more to total cover than all other aquatic species combined. Yellow pond lily, a submerged species with large floating leaves, was particularly prominent and formed large beds in several water bodies. It was absent along the edges of ponds and appeared to grow best at depths ranging from 2.0 to 7.0 feet (0.6 to 2.1 m), frequently forming a band around ponds and lakes between the shallows and deep water. Bur reed, in contrast, frequently dominated the shallows of the ponds from 0.5 to 2.0 feet (0.15 to 0.60 m) in depth. Horsetail, mare's tail, and bladderwort were also common in these shallows. Horsetail was common on rocky bottoms where little other vegetation was present. Bladderwort was prominent in shallows having a mud bottom or a bottom of organic matter.

Along the edges of water bodies, sedges appeared to contribute more to total cover than all other edge species combined. They were the prevalent species of the pond shallows, along the pond periphery, and also on floating mats when they are present.

Lakes and ponds with gently sloping substrates had more aquatic plants, both submerged and emergent, than did water bodies with steeply sloping substrates; but above 3100 feet (945 m) in elevation, there was usually sparse aquatic vegetation cover regardless of substrate morphology. Rocky bottoms supported less aquatic vegetation than did mud or sand bottoms. Floating mats of vegetation were sometimes a part of the associated emergent wetland. These mats were dominated by sedges, sphagnum moss, and other common bank species.

Watana Lake was unique in that it was dominated by Robbins pondweed, a submerged rooted aquatic species that grows in water from about 4.0 to 8.0 feet (1.2 to 2.4 m) in depth. The reason for the lack of other vascular plants in Watana Lake and the presence of Robbins pondweed is not understood. (See Section 3.1.2(b) for further discussion of this species.)

(vi) Unvegetated Areas

Unvegetated areas were found to cover 15 percent of the total area (601,422 acres, 243,392 ha) of the

Watana and Gold Creek watersheds and 6 percent of the total area (66,665 acres, 26,979 ha) 16 km on either side of the Susitna River from Gold Creek to the Maclaren River. Three classes of unvegetated area -- water, rock, and snow and ice -- were identified and mapped (Figures E.3.38, E.3.39 through E.3.41, and E.3.53 through E.3.65). 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 112 acres; 450 ha). Rock was bedrock or deposited geologic materials supporting little or no vascular vegetation. Rock occurred as outcroppings at high elevations, as steep cliffs along the Susitna River and tributaries, or as unconsolidated gravel in newly deposited river bars. These river bars were usually first colonized by horsetails, mountain- avens, and willows. Snow and ice included permanent snowfields and glaciers; these were most common at the northern end of the study area in the Alaska Range, but some occurred near the southern boundary in the Talkeetna Mountains.

(vii) Comparison of the Watana and Gold Creek Watersheds

Tables E.3.71 and E.3.72 provide an approximate comparison of vegetation communities and their relative areal extents for the Watana and Gold Creek watersheds, respectively (Figure E.3.36). A comparison of percent total area covered by each vegetation type in the two areas (Tables E.3.71 and E.3.72) shows several notable differences which are apparent also from inspection of vegetation patterns mapped at the 1:250,000 scale (Figure E.3.38). Differences in the abundance of vegetation types from one area to another are reflected in the impact analyses for botanical resources and wildlife (Exhibit E, Chapter 3, Sections 3.3 and 4.3, respectively).

Although the Watana and Gold Creek watersheds had nearly equal percent cover by forest, conifer forest was much more abundant in the Watana watershed (21 percent Watana, 4 percent Gold Creek). In the Gold Creek watershed, conifer forest types were confined mainly to north-facing slopes and adjacent benches in the Fog Lakes and Stephan Lake vicinities; whereas conifer forest occurred extensively throughout eastern, central, and northwestern areas of the Watana watershed.

By contrast, mixed forest types were far more abundant in the Gold Creek watershed (0.5 percent Watana, 18 percent Gold Creek), particularly along the mainstem Susitna River; Devil, Cheechako, and Portage Creeks; and the Indian River. Percent cover by deciduous forest was very small for both the Watana and Gold Creek watersheds. Balsam poplar stands (too small to map) were present in the Susitna River floodplain and along tributary streams. The percent of total area covered by tundra vegetation types within the Gold Creek watershed was nearly twice that of the Watana watershed (22 percent Watana, 41 percent Gold Creek). This difference was mainly due to the predominance of mixed mat and cushion/sedge-grass tundra on the uplands to the north and south of the Devil Canyon impoundment area, and to the relative scarcity of this type in the Watana watershed (6 percent Watana, 33 percent Gold Creek).

Mesic sedge-grass tundra was more abundant in the Watana watershed, where it occupied high-elevation, well-drained uplands in the northeast reaches of the Talkeetna Mountains south of the Susitna River (13 percent Watana, 0.3 percent Gold Creek).

The distribution of shrubland vegetation varied greatly between the Watana and Gold Creek watersheds (40 percent Watana, 28 percent Gold Creek). Tall shrub vegetation (alder stands) was abundant on steep slopes along the drainages of the Gold Creek watershed, occupying extensive areas north of the Susitna River. Large stands of tall shrub vegetation were much less abundant in the Watana watershed (7 percent Watana, 18 percent Gold Creek).

Low shrub vegetation, predominantly mixed birch-willow shrub, was extremely abundant throughout the southern, central, and eastern portions of the Watana watershed and covered a greater percent of the total area (34 percent) than any other vegetation type. Low shrub stands in the Gold Creek watershed were much more local, as on the slopes between Tsusena Creek and Swimming Bear Lake, and covered only 11 percent of the total area.

(c) Devil Canyon to Talkeetna

The Susitna River from Devil Canyon (RM 155) to Talkeetna (RM 103) flows through a steep canyon that opens out near Talkeetna. Vegetation is established slowly in the floodplain until sufficient silts and sands are deposited by wind and water to provide a parent material for soil development. Scouring by ice and water during spring breakup and fall freezeup, and by high water during summer floods accounts for much of the vegetation dynamics in the floodplain.

Willow and balsam poplar are common early successional (pioneer) species on the Susitna River floodplain. They become established on the most recently deposited river bars. As the pioneer communities mature, balsam poplar becomes dominant. The oldest, most stable areas are usually covered with mixed conifer-deciduous (birch-spruce) forest.

(i) Early Successional Stands

Early successional communities accounted for 5 to 10 percent of vegetated land on the floodplain. They were usually dominated by horsetail and/or Drummond mountain-avens in the ground layer and balsam poplar and/or willow in the shrub layer. Characteristically, these communities had little total vegetation cover and greater than 50 percent bare ground (Table E.3.73). Plant species in these types generally had rhizomes, or horizontal underground stems, which could extend for many meters and were effective in binding loose sand and silt. Avens was important in stabilizing gravelly sites. Early successional stands may be correlated with low willow or mixed shrub and tall shrub vegetation types.

In most stands, balsam poplar and willow occurred at greater densities than other woody species, but alder had a relatively rapid growth rate and began to overtop willow and balsam poplar within two or three years after its establishment.

Floodplain balsam poplar and willow stands may last up to ten years from the time of the last major disturbance. Aging of these stands is difficult because floods frequently bury several years' plant growth in silt, and new growth is present above the silt. This cycle may be repeated a number of times before vegetation succession advances to a later stage.

(ii) Mid-Successional Stands

Deposition of sands and silts that raise the elevation of sites above the level of frequent flooding is necessary for transition of early successional vegetation to mid-successional stages. Mid-successional types accounted for about one-fifth of vegetated land surveyed in the Susitna floodplain. Thinleaf alder, or balsam poplar that had developed into tall shrubs or immature trees, dominated these stands. Mid-successional stands include the open ann closed tall shrub and balsam poplar forests of Viereck and Dyrness (1980). The alder type was the first phase and appeared to persist from 10 to 25 years after stabilization. Balsam poplar appeared to dominate 25 to 55 years after stabilization, but stands of this type were much less common than the younger alder-dominated stands. As noted earlier, alder overtops balsam poplar during the transition from early- to mid-successional stages. However, after about 20 years, the balsam poplar that remains rapidly increases in height, thereby overshadowing the alder and developing into the immature balsam poplar phase of the mid-successional stage.

In both alder and balsam poplar stands, there was essentially no bare ground. As balsam poplar assumes greater dominance, its density and that of thinleaf alder and feltleaf willow decline from that found in the earlier alder stands, since the balsam poplar trees become larger; but Sitka alder, prickly rose, and highbush cranberry increase in density (Table E.3.74 and E.3.75).

(iii) Late Successional Stands

As the balsam poplar stands of mid-succession mature, white spruce may appear in the canopy. Mature balsam poplar stands probably are established by about 75 years after stabilization and live for about 30 more years. Eventually, the large balsam poplars die, leaving space for development of more balsam poplar or spruce and birch, if no disturbances interrupt the process. The corresponding vegetation types of the late successional stands are balsam poplar forest and mixed conifer-deciduous forest. Factors which cause development of the birch-spruce stands or alternatively promote continuation of the balsam poplar are not understood.

Mature and decadent (gradually dying) balsam poplar stands were found on 25 to 40 percent of the vegetated floodplain; mixed stands of birch and spruce occupied 23 to 32 percent of the area. Mature and decadent balsam poplar stands collectively averaged 90 percent total vegetation cover. Birch-spruce communities contained 12 percent cover of white spruce in the overstory (Table E.3.76).

Birch-spruce forest types had the greatest variation in stand structure of the vegetation types found on the floodplain. There is some evidence that these stands are self-perpetuating. Upon overmaturity, the birch overstory tends to fall, making the spruce more susceptible to wind-throw and thereby allowing a shrubby paper birch-alder-highbush cranberry-prickly rose community to develop. The shrub community then progresses to the birch-spruce forest stage.

(d) Talkeetna to Cook Inlet

Vegetation in the floodplain downstream from Talkeetna had a similar successional sequence to that upstream from Talkeetna. It consisted primarily of bottomland spruce-hardwood forests (Commonwealth Assoc. 1982). The islands and river bars were somewhat more stable than those upstream from Talkeetna because of the width of the floodplain, which reduces ice jam damage and the severity of flooding. This increase in stability correspondingly increases the average age and successional stage of the vegetation present in the floodplain.

Separate mapping of this area was not undertaken.

(e) Transmission Corridors

(i) Healy to Fairbanks

The classification system used to map the Healy-to-Fairbanks transmission corridor (Figures E.3.48 through E.3.50) was the same as that used for the Watana and Gold Creek watersheds (see Viereck and Dyrness 1980). The corridor crosses three distinct physiographically and phytosociologically distinct sections: Healy to Nenana River, Tanana Flats (Nenana River to Tanana River), and Tanana River to Fairbanks. Forest types accounted for almost 78 percent of the 274,000 acres (111,000 ha) of the corridor, with open forest types being dominant (Table E.3.77). Open spruce covered 28 percent of the area, open deciduous 11 percent, and open mixed conifer-deciduous 11 percent.

The Healy-to-Nenana River section includes 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 conifer (spruce), open mixed conifer-deciduous, and open deciduous forest. The flat area is predominantly low shrub with sedge-grass and open and closed conifer types. Most of the spruce trees are relatively short, except along the streams.

The Tanana Flats area extends from just beyond the Nenana River crossing to the Tanana River. This section has a mosaic of wet vegetation types (discussed further in Section 3.2.3) which include open spruce stands with larch, low shrub, and wet sedge-grass. The distribution of many vegetation types appears to be a consequence of old stream meanders and drainage patterns. Some patches of deciduous forest occur. Dry streambeds have stringers of other vegetation, such as low shrub, along them.

The section from the Tanana River to Fairbanks passes through rolling hills covered predominantly with open deciduous forest. Small areas of spruce are less common than in the Tanana Flats section. The mixed woodland patches in this section are generally cut-over areas. Many of the closed spruce areas produce very short shrub-like trees.

Most coniferous forest between the Tanana River and Fairbanks contain only spruce; few have larch. About half the areas in the Tanana Flats section contain larch as well. Spruce (presumably black spruce) occurs in low, poorly drained areas. Spruce in better-drained locations may be either black or white spruce. The black spruce-larch type, confined in Alaska to the interior, is generally found only on wet lowland sites with shallow permafrost (Viereck and Dyrness 1980).

(ii) Willow to Cook Inlet

The Willow-Cook Inlet transmission corridor passes through three principal kinds of plant communities--(1) closed birch and mixed conifer-deciduous forests, (2) wet sedge-grass marshes, and (3) open and closed spruce stands (Table E.3.78 and Figures E.3.51 and E.3.52).

The Willow-Cook Inlet corridor includes approximately 95,000 acres (39,000 ha) (Table E.3.78). It passes through relatively flat terrain that is 67 percent forested, predominantly with conifer-deciduous forests. Approximately 24 percent of the area is wet sedge-grass marsh, discussed further in Section 3.2.3.

Closed conifer-deciduous forest is the predominant vegetation type, covering 29 percent of the total area. These forests contain birch, white spruce, and balsam poplar trees. Birch is the predominant deciduous species. Many sites have developed either a woodland/shrubland or woodland/ grassland aspect. In the vicinity of Willow, localized stands of balsam poplar are associated with the active river floodplain.

Wet sedge-grass marsh is the second most common vegetation type in this area (24 percent cover). This type has an extensive distribution and is associated with diverse networks of ponds, lakes, and meandering streams. These areas support little other vegetation except for scattered islands of black spruce and low shrubs on drier sites. They are discussed further in Section 3.2.3.

White spruce, common in most of interior Alaska, is less common in this part of the Susitna Valley. However, most closed and open spruce stands (8 and 9 percent cover, respectively) in areas dominated by mixed conifer-deciduous forest are probably white spruce. Spruce stands skirting wet sedge-grass or low shrub areas may be white or black spruce or mixtures of the two. Most woodland spruce stands are black spruce.

(iii) Willow to Healy

The Willow-to-Healy intertie corridor is covered by interior forests, muskeg, shrub communities, and tundra. White spruce and paper birch dominate the drier forested landscapes; black spruce is primarily located on poorly drained sites. Additionally, balsam poplar and white spruce develop on the floodplains. Within or adjacent to these areas, about thirty species of willow and several species of alder occur in the understory or in thickets with little or no overstory.

The southern two-thirds of this corridor contain forested areas; the northern portion consists mainly of open woodland, shrubland, and tundra. The corridor contains fewer glaciers and ice fields than is common in similar sized areas in the region (Commonwealth Assoc. 1982). Upland and lowland spruce-hardwood forest together cover nearly three quarters (71 percent) of the total area within the Willow-to-Healy transmission corridor. Upland spruce-hardwood forest stands cover 2888 acres (1169 ha) and lowland spruce-hardwood forest stands cover 1503 acres (608 ha). Shrublands are the third most predominant cover type (nearly 12 percent) and occupy 713 acres (290 ha). Vegetation types within the intertie corridor, their areal extent, and percent toal area covered are presented in Table E.3.79 (modified from Commonwealth Assoc. 1982).

(iv) Dams to Intertie

Vegetation types crossed by the proposed centerline of the transmission corridor from the Watana and Devil Canyon damsites to the intertie junction are shown at a scale of 1:63,360 in Figures E.3.39 and E.3.40. Nearly one-half (49 percent) of the total area (938 acres, 380 ha) within the Watana-to-Devil Canyon section of the transmission corridor is shrubland. Predominant vegetation types crossed include closed tall shrubland (128 acres; 52 ha), low willow shrubland (218 acres, 88 ha), sedge-grass tundra (117 acres; 47 ha), sedge-shrub tundra (119 acres, 48 ha), and mat and cushion tundra (126 acres, 51 ha). The Devil Canyon-to-intertie section of the transmission corridor covers a total of 325 acres (132 ha), 277 acres (112 ha) of which is closed mixed forest. A small amount of wet sedge-grass tundra (28 acres, 11 ha) also exists within the corridor. The areal extent and percent total area for coverage by each vegetation type within the Watana-to-Devil Canyon and Devil Canyon- to-intertie sections of the transmission corridor are presented in Table E.3.80.

3.2.3 - Wetlands

Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. These areas are characterized by soil or substrate that is at least periodically saturated with or covered by water

(Cowardin et al. 1979). Because wetlands are recognized to have important resource values, they are protected by state and federal regulations (Alaska Office of Coastal Management 1982). Examination of potential project impacts to wetlands, and how such impacts can be avoided, is mandated by Executive Orders 11988, 11990, and 11991, and by Section 404 of the Clean Water Act as amended (86 Stat. 884, USC 1344).

The classification system of Cowardin et al. (1979) recently adopted by the USFWS (1980b) defines wetlands as having one or more of the following characteristics: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; or (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Section 404 of the Clean Water Act extends permit authority to the U.S. Army Corps of Engineers (COE) for all waters of the United States, including wetlands. The COE's reguations (33 CRF 320-330) define "wetlands" to mean "those areas that are inundated or saturated by surface or ground water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

In Exhibit E, Chapter 3, the term "wetland" is used in three different ways. In discussions of impacts and mitigation involving wetlands in general, the term is used to denote areas at least partly characterized by hydrophilic vegetation and the presence of standing water or sheet flows. In addition, wetlands mapping of the impoundment zones, adjoining borrow and construction areas, and access corridors by McKendrick et al. (1982) uses wetland types defined by Cowardin et al. (1979) based on correlation with Viereck and Dyrness (1980) vegetation types mapped to classification Level III (Section 3.2.2(a)). Finally, two vegetation types characteristic of wet or poorly drained areas, wet sedge-grass and black spruce forest, were mapped for the Healy- to-Fairbanks and Willow-to-Anchorage transmission corridors by TES and Acres American Incorporated (1982, modified from McKendrick et al. 1982). Only wetland types mapped as defined by Cowardin et al. (1979) are described in quantitative terms or shown as fiures herein.

(a) Methods

Wetland vegetation types were mapped by McKendrick et al. (1982) at a scale of 1:24,000 from the Oshetna River to the Devil Canyon damsite, using the system of Cowardin et al. (1979) (Figures E.3.66 through E.3.73). This mapping covered the impoundment areas and adjoining construction and borrow areas. The access corridors were mapped at a scale of 1:63,360 (Figures E.3.47 through E.3.47).

Wetland maps were produced by first correlating the vegetation types from Viereck and Dyrness (1980) with cover designations from the wetlands classification of Cowardin et al. (1979) (Table E.3.81). Corresponding wetlands categories were then superimposed over the vegetation maps of the 1:24,000 scale prepared by McKendrick et al. (1982). The presence of steep slope and likely good drainage was interpreted to rule out classification as wetland. Lakes, ponds, rivers, and streams were not specifically classified.

Because the system of Cowardin et al. (1979) requires additional data on hydric soils and periodic ambient water conditions to characterize wetlands completely, the mapping is liberal and indicates areas which potentially qualify as wetlands under that system. Portions of these areas may be eliminated by further considerations of soil and water conditions. Data on soils and water will be collected in the future during detailed construction planning and used to refine the identification of wetland areas in accordance with the requirements of Section 404 of the Clean Water Act.

Aquatic vegetation of the Watana and Gold Creek watersheds was examined during August 1982. In order to obtain site-specific information on aquatic plant species, 24 selected ponds and lakes and their adjacent uplands were surveyed on foot, from Devil Canyon (RM 152) to the confluence of the Susitna and Oshetna Rivers (RM 233) (Figure E.3.75). During the surveys, species composition, dominance, and total cover (relative to the amount of water) were estimated. Elevation, estimated rooting depth, and width of surrounding wetland area were recorded. Surrounding wetland was limited by definition to the Lacustrine-Limnetic-Emergent Wetland-Vascular wetland class of Cowardin et al. (1979). Many remaining ponds and lakes were examined by helicopter overflights.

(b) General Description

Wetlands within the Susitna project area include riparian zones, ponds and lakes on upland plateaus, and wet tundra. These wetlands support waterfowl in the summer (23.8 adults/km^2 censused in July 1981), and are also used by migratory birds in spring and fall. Although the density and diversity of bird species are lower for the Susitna project area than for many other areas of Alaska (Kessel et al. 1982a), scoters, terns, scaup, mallards, American widgeons, swans, and other waterfowl were found during wetland surveys (Section 4.2.3[6]).

Wetland areas in the vicinity of the project include upper Brushkana Creek and Tsusena Creek, the area between lower Deadman Creek and Tsusena Creek, the Fog Lakes area, the Stephan Lake area, Swimming Bear Lake, and Jack Long Creek (Figure E.3.36). There are large number of lakes in the extensive flats of the Watana watershed, such as those in the Lake Louise area. Vegetation types indicating potential wetlands within the Watana and Devil Canyon impoundment areas and within borrow sites proposed for dam construction are shown in Figures E.3.66 through E.3.73.

As illustrated in Table E.3.81, the wetlands classification of Cowardin et al. (1979) may be used as a second level of classification applied to the vegetation types previously discussed (Section 3.2.2). Areal extent of vegetation types in the Watana and Gold Creek watersheds are listed in Tables E.3.51 and E.3.52. The most common vegetation type occurring in this area was the low shrub type (32 percent total cover). This vegetation type corresponds to the potential palustrine scrub-shrub wetland type of the Cowardin system (1979). The areal extent listed indicates the potential areal extent of palustrine scrub-shrub wetland type. Woodland spruce forests cover nearly 12 percent of the Watana and Gold Creek watersheds and include a portion of the potential palustrine forested areas. Wet sedge-grass tundra covers less than 1 percent of the total area. Lakes and rivers comprised a total of 21.4 percent of the entire Watana and Gold Creek watersheds.

The areal extents of different potential wetland vegetation types which will be affected by the Watana and Devil Canyon developments are indicated in Table E.3.82. The estimates of total palustrine wetland areas shown in this table are extremely liberal, because the wetlands were highly integrated with non-wetlands, and supporting soil and water data were not used to refine the areas mapped. As described below additional wetland mapping is in progress. Therefore, the values shown in Table E.3.82 should be considered preliminary.

Wet sedge-gress and potential wet spruce areas occur within the Healy-to-Fairbanks and Willow-to-Anchorage transmission corridor study areas. As discussed further in Section 3.4.2(c) the centerlines will be further evaluated in the field and adjusted to avoid wetland areas as determined by the analysis of vegetation, soils, and water data.

Aquatic species identified in the Watana and Gold Creek watersheds, percent cover of aquatic vegetation, and surrounding wetland width are listed by site in Table E.3.70. Wetland sites sampled ranged in elevation from 1700 feet to 3000 feet (518 m to 914 m). A summary of the dominant aquatic species and factors which may influence their location in and around many of the waterbodies in the Watana and Gold Creek watersheds is presented in Figure E.3.76 (see Section 3.2.2[b][v] Aquatic Vegetation for further discussion).

Additional mapping of wetlands is being conducted (Section 3.2.2[a]); preliminary maps and estimates of wetland areal coverage will be available in June 1983. Maps are being prepared at a scale of 1:24,000, using low-altitude color infrared and true-color photography taken in 1980-1982. The herbaceous vegetation type of Viereck et al. (1982) is being mapped to Level IV, and forest and shrub types are being mapped to at least Level IV with wetland modifiers (modifiers indicate which areas are subject to flooding). The area being mapped includes the impoundment and dam areas, borrow sites, construction camps and village, and access corridors.

3.3 - Impacts

Impacts of the Susitna Hydroelectric Project on vegetation are of two general kinds -- (1) loss of all vegetative cover; and (2) change in the nature of vegetatative cover (i.e., alterations in plant community types). The first kind of impact is considered adverse; while the second kind may be considered adverse or beneficial depending upon its effect on wildlife. The following discussions treat both kinds of impact.

3.3.1 - Watana Development

The Watana development includes areas affected by the Watana impoundment zone, borrow sites, dam and spillway, construction camp and airport, and permanent village. Impacts of access roads and transmissions corridors are discussed separately.

(a) Construction

(i) Vegetation Removal

Construction of the Watana development will result in the direct removal of vegetation within an area of approximately 40,974 acres (16,582 ha) covering a range of elevations from approximately 1400 to 2400 feet (430 to 730 m). Within the dam, spillway, and impoundment areas, about 36,642 acres (14,329 ha) of vegetation will be removed by construction and clearing operation. Included are 26,730 acres (10,818 ha) of forest that is composed primarily of large stands of both woodland and open black and white spruce, as well as some open mixed forest types. The camp, village, airstrip, and borrow areas will remove an additional 4300 acres (1742 ha), most of which is shrubland or black spruce forest. Spoil areas will alter vegetation between 1400 and 1600 feet (430 and 488 m). All vegetation removed during construction of the Watana dam, reservoir, and ancillary support facilities will represent about 1 percent of the total vegetation of the Watana and Gold Creek watersheds (defined in Section 3.2.2; see Figure E.3.36).

Table E.3.83 lists the area of each vegetation type to be directly removed by the Watana development, and compares each value to the total area of that vegetation type within the Watana and Gold Creek watersheds. Approximately one-third (34 percent) of the open birch stands, and all large closed birch stands in the Watana and Gold Creek watersheds will be removed by the Watana development. The relative loss of other types is small when compared to their availability in the basin. For example, only 3.4 percent of forested areas, 0.1 percent of tundra types, and 0.4 percent of shrubland cover types will be directly removed by the development.

(ii) Vegetation Loss by Erosion

Erosion is a persistent problem at dam construction sites in northern latitudes (Baxter 1977, Baxter and Glaude 1980). Erosion following the clearing of vegetation may be promoted by the following:

- Destabilization of till;
- Blowdown of trees near cleared areas;
- Thawing of permafrost;
- Desiccation of exposed soils; and
- Changes in drainage patterns.

Slope stability studies by Acres American (1982) indicate that areas particularly vulnerable to vegetation loss through erosional effects include side slopes of the canyon from the south abutment of the Watana damsite (RM 184) to Vee Canyon (RM 225), along Watana Creek (RM 194), and from the Watana reservoir headwaters to the Oshetna-Goose Creek area (RM 243 - 233). Approximately 1379 acres (558 ha) above the impoundment shoreline were shown as potentially unstable and thus subject to vegetation loss.

(iii) Vegetation Damage by Wind and Dust

Blowdown of trees is a recognized problem in cleared areas (Todd 1982). Near reservoirs, it is promoted by increased winds due to a greater fetch as areas are cleared (Baxter and Glaude 1980, Brown 1972). Since northeasterly winds predominate in the project area most of the year, the greatest blowdown potential is in the woodland black spruce stands on the south side of the Watana damsite. The shallow rooting depth typical of black spruce 12 inches (35 cm) indicates that this vegetation type is subject to blowdown (McKendricle 1982 pers. comm).

Wind-generated dust is expected to occur during construction activities, particularly during and following clearing of the impoundment and borrow areas. Increased wind fetch is expected to result from clearing. Accumulations of thick dust on vegetation can potentially retard snowmelt (Drake 1981). The vegetation types which will be affected by dust in the Watana area include woodland and open black and white spruce, mixed forest types and shrubland. The direct effect of dust on plants varies with plant species and the chemical composition of dust. For example, densities of cottongrass (*Eriophorum* spp.) are likely to increase, but stiff clubmoss, sphagnum moss, and some fructicose lichens may decrease in abundance when exposed to dust (CRREL 1980). Mosses and lichens are important components of the ground cover in open and woodland spruce and closed mat and cushion tundra stands (see Section 3.2.2).

(iv) Effects of Altered Drainage

Local alteration of drainage patterns and surface water regimes may result from clearing, ditching, and other construction activities. Blocking drainage patterns may cause waterlogging of soils, thermal and hydraulic erosion, and shifts of surface flow to adjacent drainages (CRREL 1980). Resulting changes in surface water regimes will cause plant communities to shift accordingly. The time required for these changes to occur, and the extent of the change, will depend on the extent of hydrologic alterations and on plant successional dynamics (Neiland and Viereck 1977).

(v) Effects of Change in Albedo

Cleared soils usually absorb more solar radiation than do vegetated soils and consequently thaw sooner in spring and deeper over the summer. Conversely, with less insulation soils freeze earlier and deeper in the winter. Resulting changes in surface hydrology will cause plant communities to change.

(vi) Indirect Consequences of Vegetation Removal

Methods of vegetation removal may have indirect impacts on other vegetation. Spruce budworm disease, which occurs in areas adjacent to the Susitna watershed (Hegg 1970), may be more likely to invade the area if spruce trees are cut but not removed or burned. Clearing may also enable other insects and decay organisms to increase in abundance (Kimmey and Stevenson 1957).

(vii) Effects of Increased Fires

The increased numbers of people in the area during the construction period may cause increased incidences of fires. Fire has been a natural factor shaping plant communities in the area, so increased fires will cause changes in plant communities similar to those that can already be observed there.

Because successional patterns following project-related fires are more likely to manifest themselves during the operations phase, they are discussed in Section 3.3.1(b).

(b) Filling and Operation

The Watana facility is scheduled to begin filling in 1990. Some construction-related impacts such as fugitive dust will diminish, but other problems such as erosion will continue. The most conspicuous filling and operation-related changes in vegetation will be downstream as a result of streamflow regulation, but less drastic changes may be caused by micro- and mesoclimatic changes, increased fire incidence, and increased off-road vehicle (ORV) use. In many instances, vegetation will respond to these disturbances through characteristic successional recovery patterns. The following subsections describe filling and operation-related changes and the successional patterns of plant communities as they recover from development-induced change.

(i) Vegetation Succession Following Removal

On sites where vegetation has been removed, natural plant succession will occur unless prevented by inundation or facility maintenance. Successional patterns expected in forests, shrublands, and tundra are discussed below.

- Forest Areas and Shrubland

Within forest and shrubland areas, newly cleared sites with largely intact mineral and organic soils will rapidly revegetate with plants native to the original community. Herbs, shrubs, and deciduous trees will resprout, and some herbs and shrubs will regenerate from buried seed (Neiland and Viereck 1977, VanCleve and Viereck 1981, Conn and DeLapp 1982a, b).

In interior Alaska, characteristic early successional herbs and shrubs are bluejoint reedgrass, field horsetail, prickly rose, bluebell, bunchberry, northern bedstraw, Labrador tea, American twinflower, goosefoot, pale corydalis, American dragonhead, fireweed, crazyweed, and rough cinquefoil. Early successional trees are willow, aspen, and poplar.

From 6 to 25 years after clearing, willow and/or alder will typically dominate areas that were originally black spruce forest or shrubland (see reviews of forest succession by Neiland and Viereck 1977, VanCleve and Viereck 1981). McKendrick et al. (1982) found that typical heights for willow and alder between 3 to 6 years old were 15 inches (60 cm) and 68 inches (170 cm), respectively. Soon thereafter a tree canopy of young black spruce, willow, and alder will develop. Dense stands of spruce with well-developed moss and lichen components will not develop for 50 to 100 years. Mature black spruce trees in typical 100 year old stands usually do not exceed 45 feet (15 m) in height.

- Tundra

Clearing of tundra and concurrent removal of topsoil will, except in certain rocky alpine sites, typically result in higher soil temperatures and, if permafrost is present, a deeper thaw (Bliss and Wein 1972, Hernandez 1973, Gersper and Challinor 1975, Chapin and Shaver 1981). Either of these conditions may lead to the development of a different plant community from that originally present and possibly a very long restoration period. One to several centuries may be required for recovery from disturbance where the topsoil is lost (Brown et al. 1978). But if topsoil is retained, recovery to the same community type can be rapid. The topsoils contain most of the available nutrients, rhizomes, and seeds required for rapid recolonization (see discussion by Chapin and VanCleve 1978).

Although natural successional trends of tundra are far less predictable than for forested areas, the following sequence is likely to occur. The first vegetation types to reestablish in moist or wet tundra (with the organic layer retained) are likely to be cottongrass species and, if buried seed is present, sedges on wet sites. Grasses may predominate on drier sites (see Chapin and Chapin 1980, Chapin and Shaver 1981, Gartner 1982). Within 5 to 10 years after normal revegetation begins, at least 50 percent and often 100 percent of vegetation cover recurs on sites on which the original organic layer was retained. Native woody and herbaceous species characteristic of adjacent areas will also begin to invade within 10 years; likely species in the project area include willows, bog blueberry, mountain cranberry, northern Labrador tea, shrubby cinquefoil, prickly rose, field oxytrope, lupine, green alder, and dwarf and resin birch. Reestablishment of normal densities, however, may require several decades.

(ii) Effects of Erosion and Deposition

If the drawdown zone of the Watana impoundment is typical of that of other northern reservoirs, it will remain unstable until bedrock or gravel/cobble/boulder substrates are exposed. The drawdown zone will remain essentially unvegetated. This will result in an unvegetated area between the elevations of 2095 feet and 2185 feet (639 m and 666 m) along the reservoir. (Range equals 90 feet [27 m] as shown by the rule curve for Watana Reservoir, Exhibit B, Figure B.53). Shoreline recession is likely, with consequent loss of vegetation (Baxter and Glaude 1980). Except during a series of drought years, vegetation is not expected to invade the drawdown zone, and no effects on vegetation from ice shelving are anticipated. Although some of the evolving shoreline above the drawdown zone will be readily colonized by early seral stages such as grasses and herbaceous species, stabilization of this upper shoreline may require 30 years or more (Newbury and Malaher 1972).

After the reservoir is filled, the water will warm adjacent hillsides, causing permafrost to melt and slides to occur. On the south side of the Watana impoundment, the permafrost layer is 200 to 300 feet (60 to 90 m) thick and is within 1.8°F (1°C) of thawing. Slides and land slumpages are therefore likely on the south side of the reservoir. If these slides are small and the organic soil layers have not been lost, encroachment by rhizomatous species may enable rapid recolonization. If large slides occur, a full cycle of forest succession on melted permafrost may ensue, leading to black spruce and bog vegetation over 100 to 200 years.

Following beach (mudflat) development, flooding of upland areas may occasionally occur as a result of water displacement from slumpage (Kerr 1973) and during high flows. This occasional flooding of adjacent areas will likely stimulate new vegetation growth. Propagation of deltas into the reservoir at a number of creek tributary mouths is likely since deposition will occur when fast creek currents empty into slow- moving reservoir water. These deltas may eventually be vegetated in the same manner as downstream floodplain areas (see discussion below).

(iii) Effects of Regulated Flows

A mosaic of plant communities in various stages of floodplain succession is found in the floodplain of the Susitna River. This diversity is the result of processes of vegetative recession; the replacement of an established plant community with a younger community. Vegetative recession results from changes in river morphology, which is controlled in the Susitna River floodplain primarily by ice processes and flooding events. These processes are effective mainly during river freezeup and breakup. To a lesser degree, vegetative recession also results from bank erosion and deposition of bed material throughout the open water period, but this is a minor, localized process in the Susitna River floodplain. Figure E.3.78 illustrates patterns of vegetation succession.

The effects of regulated flows on vegetation at a particular location will vary considerably with channel morphology and the distance downstream from the Watana dam. Potential impacts on floodplain vegetation will be discussed separately for the river reaches between Watana and Devil Canyon, Devil Canyon to Talkeetna, Talkeetna to the Yentna River, and from there to Cook Inlet. Additional information on channel morphology and changes in the hydrologic regime can be found in Chapter 2, Sections 2.1 and 3.2.3.

- Watana to Devil Canyon (RM 184 to RM 152)

This reach of the river is mostly a single channel with steep armored banks and bedrock outcroppings. The two dominant processes presently controlling vegetative recession are ice scouring at river freezeup and at breakup.

During river freezeup, the steep gradient of the river stretch restricts ice formation to the borders of the river channel in most areas (see Chapter 2). Growth of border ice and ice in the center of the channel of slower reaches results in increased stage. Buoyant forces on the border ice resulting from increased staging cause scouring of attached vegetation as the ice fractures, rises, and disintegrates. In addition, ice blockage in the channel can result in ice scouring of vegetation higher on the banks and islands and can also cause the river to overflow into side channels where additional scouring of bed materials and vegetation occurs.

The effects of river breakup on vegetation are greatest when breakup occurs rapidly before extensive in-place melting and deterioration (rotting) occurs and in association with high spring flows. Ice jamming in spring at constricted points has effects similar to those occurring at freezeup but can have much more dramatic local effects due to the typically higher discharges which occur during breakup.

The increased temperatures of the water released from Watana in winter will preclude the formation of an ice cover in this reach. In addition, the mean annual flood will be reduced by 75 percent to 12,000 cfs. These changes will result in vegetation encroachment toward the main channel, the establishment of vegetation in overflow channels and newly-exposed areas with adequate soils, and the gradual succession of existing and newly-established vegetation stands along the bank and on islands to mature poplar and white spruce forest. Although the rate of vegetative recession may be reduced by as much as 90 percent, the amount of area affected will be limited by the steep banks and poor substrates found throughout most of this reach.

The open-water area in winter may promote ice fog conditions and rime ice formation on vegetation, particularly at the dam outflow. Buildup of rime ice may result in loads sufficient to break twigs. Birch trees may be particularly susceptible to this damage because of their many small branches. Sapling tree stands heavily damaged by ice have been found to produce more brush, whereas ice damage in mixed oak tree stands resulted in loss of understory saplings and low tree branches (Wood et al. 1975).

- Devil Canyon to Talkeetna RM 152 to RM 97)

The Susitna River in this reach comprises alternately single channel and split channel configurations. The channel is armored with boulders and cobbles and alignment has changed little since 1951. A comparison of aerial photographs taken in 1951 with those taken in 1980 showed vegetative recession resulting from shifts in the outermost banks of the river. The photography did not allow an estimation of the actual areas affected. The rate of vegetative recession is controlled primarily by ice processes during freezeup and breakup, with summer flooding events having a lesser but important effect. R&M (1982) listed several locations in this reach where channel constrictions cause recurrent ice jamming during breakup. Vegetation patterns just upstream from these locations are influenced primarily by ice scouring during breakup, but along the majority of this reach ice processes accompanying river freezeup appear to have the greatest influence on vegetative recession. The fact that the vegetation line at a point 0.5 mi (18 km) upstream from Gold Creek (RM 136.8) is at the same elevation as ice staging during freezeup in fall 1980 is evidence of the influence of ice scouring during breakup in this reach (T. Lavender 1982 pers. comm.).

The mean annual flood at Gold Creek will be reduced from 49,500 cfs to 12,000 cfs by the Watana project. Ice will still form in this reach, but the ice front at the end of winter is expected to occur between Portage Creek (RM 149) and Curry (RM 120.5), and its formation there will be delayed by 3 to 4 weeks (see Chapter 2, Section 3.2.3). Because air temperatures will be lower once ice formation begins, the ice layer will progress more rapidly than it does under pre-project conditions. Regulated winter flows at Gold Creek will be similar to existing conditions during filling, but during operation will be at least five times greater than pre-project winter flows (Chapter 2, Section 3.2.3). This will result in a 3 to 4 foot increase in river stage over existing conditions when an ice cover is present in this reach. During the early years of the operation phase, this increased ice staging will scour existing stands of vegetation, thus causing an increase in the width of the unvegetated channel and a decrease in the amount of vegetation found on islands. Because spring flood stage will be reduced considerably and because the ice cover will no longer have a greater tendency to melt in place, ice scouring during breakup will no longer be an important factor causing vegetative recession in this reach. The area affected by these post-project processes will be directly related to winter flow releases, which will vary between 5,000 - 19,300 cfs depending on downstream flow requirements, power demand, reservoir operating rule curve, and attenuation of discharge due to floodplain storage capacity.

- Talkeetna to Yentna River (RM 97 to RM 28)

There is a dramatic change in the morphology of the Susitna River from a split channel to a braided channel at the confluence of the Susitna, Chulitna, and Talkeetna Rivers. The flows contributed by each of these rivers at the confluence are 40 percent each for the Chulitna and Susitna Rivers, and 20 percent for the Talkeetna River.

Downstream from Talkeetna, the importance of ice processes in vegetative recession is reduced, and large changes in channel position and form presently occur whenever the river attains bankfull stage. The importance of ice processes in vegetative recession in this reach is local and depends on channel morphology.

Upstream from channel constrictions, ice processes during freezeup and breakup may continue to play a major role in regulating vegetative recession. If ice processes cause greatly increased stages during either freezeup or breakup at such a constricted point, vegetation immediately upstream and/or along overflow channels may be scoured by water and ice action. This increased staging at channel constrictions may occur even at relatively low flows. However, because of the localized importance of ice processes, summer flood events may control vegetative recession as much as ice processes associated with freezeup through their effect on the rate of bank erosion and sediment deposition in this reach. Where the floodplain is wide with braided channels, there is generally a relatively small increase in stage when an ice cover is present, and ice processes have a lesser effect on vegetative recession. In such areas, numerous islands with mature forest stands are present.

It is impossible to predict with certainty the vegetation changes that will occur post-project in this reach. The bankfull flood will have a post-project recurrence interval of once every 5 to 10 years, as opposed to the present 2-year interval (R&M 1982). In areas where such floods control the vegetation, early-successional stands may develop for about 5 to 10 years before being removed by the next bankfull flood. In some of these stands, however, silt deposition or vegetation growth may be rapid enough to stabilize the area against subsequent floods. Increased winter flows with subsequent increases in ice staging may cause other areas to undergo regular ice scouring during freezeup. The amount of area supporting mature stands of vegetation will be directly influenced by floods and the flow releases from Watana each winter.

- Yentna River to Cook Inlet (RM 28 to RM 0)

The Yentna River contributes about 40 percent of the mean annual flow entering Cook Inlet from the Susitna River. Between the Yentna confluence at RM 28 and the beginning of the delta at RM 20 (Figure E.3.3), the bankfull flows (80 percent of which are contributed from rivers other than the Susitna upstream from Talkeetna) are probably the dominant factor in controlling vegetative recession. The river begins to branch out into its delta channels at RM 20. The water surface elevation at this point is approximately 30 feet (9.1m), which corresponds to be the 30-foot (9.1-m) tides in Cook Inlet.

Post-project changes in vegetation cannot be precisely predicted, but should be substantially mediated by the large flow contribution from the Yentna River and the tidal influence as far north as RM 20. As R&M (1982) state, "the dilution effect of major and minor tributaries as well as the balancing of changes by the Susitna River system should mask any measurable changes that could occur as a result of the project for several decades."

(iv) Climatic Changes and Effects on Vegetation

Reservoirs act as a heat source or sink, warming and cooling less rapidly than the surrounding terrestrial substrate. These effects may delay the normal spring warming and fall cooling of adjacent environments and so affect the phenology and distribution of nearby vegetation. Temperature effects most likely would not extend beyond 2 miles (3.0 km) of the water mass. Due to the prevailing northeasterly winds, the area along the south shore of the reservoir would be most likely affected. Vegetation types in this area consist mainly of open and woodland black spruce, open mixed forest, and a limited amount of shrubland. Crowberry, Labrador tea, blueberry, willow, and mountain cranberry are important components of the shrub layers of these types and would be the species to be affected by changes in timing of bud break or flowering.

Spring air temperatures in the immediate vicinity of the reservoir will be cooler on the average than at present. The cumulative effects of a cooler spring environment on the entire plant community are not well understood. Phenology studies are now in progress to determine the pattern of greenup near the proposed impoundment. Results from 1982 will be reported in April 1983.

The Watana impoundment should act as a heat source in fall, maintaining slightly warmer air temperatures than normal. The probable effects of this warming on vegetation cannot be predicted with any certainty. For example, it is not known how local climatic changes will affect characteristics of the growing season.

Another thermal effect of the Watana impoundment will be its moderation of diurnal changes such that nearby nighttime temperatures during May and June will be higher and daytime temperatures will be lower than prior to development. Average fall temperatures near a lake of similar size to the Watana reservoir were characterized by a 9.9°f (5.5°C) lower maximum and 4.0°F (2.2°C) higher minimum than temperatures away from the lake (Baxter and Glaude 1980). The effects of these thermal changes on the vegetation are, again, difficult to predict in any quantitative way.

During winter, the development of extensive fog banks near the Watana impoundment may also affect vegetation. Fog banks tend to be persistent at reservoir sites after breakup (Baxter and Glaude 1980), and can result in the deposition of copious quantities of hoar frost on trees and shrubs. Buckler (1973) reported that ice crystals 2 to 3 in (5 to 7 cm) in length were found on vegetation close to a reservoir when temperatures below -9.4°F (-23°C) created steam fog. Such buildup of ice may result in damage to understory or reduction in browse quality or availability (see Section 3.3.1(b)[iii]).

(v) Effects of Increased Human Use

During the filling and operation stages of the Watana facility, project personnel and their families will have an impact on the vegetation of the middle Susitna basin. The most severe human-use impacts will probably be associated with off-road vehicles (ORVs) and accidental fires, assuming that no regulation of project personnel is enforced to mitigate these impacts. Similar but more extensive impacts are expected from use by the general public and are discussed in Section 3.3.3 Access.

- Off-Road Vehicles

The effects on vegetation of ORV use varies with season, soil moisture and depth, the presence or absence of permafrost, vehicle weight, frequency of use, and other factors (Chapin and Van Cleve 1978, Sparrow et al. 1978).

The ground layer of vegetation is more susceptible to damage by ORVs than are other layers. Vegetation is most susceptible to damage in summer. In winter, snow and ice layers minimize damage to the underlying vegetation and organic mat. Dry habitats are relatively immune to damage by ORVs. A few passes of light-track vehicles over relatively dry well-drained soils may result in slight compaction of the organic and/or plant layer, a net soil temperature gain, and deeper thaw of the active soil layer. The typical result is minor subsidence and an influx of ground water.

Tundra and wetlands, especially sites with underlying permafrost, are the most vulnerable habitats. Repetitive off-road traffic or use of heavy vehicles in moist areas is likely to remove vegetation and also the underlying organic mat. This would cause soil temperature increases, deeper thaw, subsidence to 3 feet (1 m) or more, groundwater input, and severe erosion that may last 5 to 50 years or more (Hok 1969, Rickard 1972, Lawson et al. 1978, Chapin and Shaver 1981). Quagmires may form as a result of ponding of surface water (Sparrow et al. 1978), or gully formation may result. Near the Denali Highway, Sparrow et al. (1978) observed gullies formed after ORV use as wide as 20 to 26 feet (6 to 8 m) and up to 10 feet (3 m) deep, with severe side erosion and cave-ins, as well as active transport of sediment downhill. A similar effect was noted when firelines were established on Wickersham Dome, near Fairbanks (Lotspeich 1979). The above effects will be most severe where ground ice content is high (Bliss and Wein 1972). Natural restoration of the organic layer of tundra soils may require more than a century (Chapin and Van Cleve 1978). However, some grasses, such as bluejoint reedgrass, may be able to invade mineral substrates rapidly (Gartner 1982).

- Fires

Although the results of tundra fires are extremely variable, in most cases all signs of the fire have disappeared after 6 to 8 years. Recovery can take much longer in areas with abundant lichen cover (Viereck and Schandelmeier 1980). In shrubland and forest, a variety of successional patterns might result from a fire, depending on fire intensity and burning patterns, vegetation type, soil moisture and temperature, time of year, and post-fire weather patterns (Figure E.3.77). For example, some willow species, while highly adapted for reseeding burned areas, produce seeds that are viable for only short periods of time in the spring or fall (Zasada and Viereck 1975, Zasada and Densmore 1977).

Trees and shrubs, including aspen, birch, willow and alder, resprout and grow vigorously after burns. Shallow-rooted shrubs such as cranberry are destroyed in areas heavily burned to mineral soil; however, burning to mineral soil is necessary for establishment of willow seedlings (Densmore and Zasada 1977, Densmore 1979). In the short term, increased productivity of browse plants such as willow, aspen, and birch is likely as a result of the release of soil nutrients (Figure E.3.117). Many berry producing plants also increase in density after fire (Friedman 1981).

The ecological effects of fire on Alaskan vegetation have received considerable attention during recent years, and the accumulated knowledge allows a degree of prediction of the effects of a given type of fire on a specific area. (This knowledge plus increasingly effective fire control methods have resulted in fire being used as a land management tool to create desired vegetation changes -- Section 3.4).

Wildfire is a common and natural phenomenon throughout the needleleaf forests of interior Alaska. Characteristics affected by fire in these forests include: live biomass, dead and decaying biomass, available nutrients, soil temperature and soil moisture. Fire in black spruce forest greatly reduces the overstory biomass, although standing dead snags may persist. Burning may partially or completely oxidize organic constituents of the forest floor, releasing large quantities of available nutrients such as phosphorus. Soil temperatures become warmer through enhanced absorption of solar radiation. Permafrost, where present, recedes because of several factors including changes in albedo and loss of vegetative insulation. Thus the active layer significantly increases in depth (Viereck and Schandelmeier 1980).

Fire generally causes vegetation to revert to an earlier successional stage. The primary effect of increased fire frequency in the coniferous communities of the Susitna Basin will be to change the vegetation to earlier herb or shrub seral stages, significantly increasing available moose browse on those areas (Figure E.3.117).

Coniferous forests usually revert to a herbaceous or shrub stage (Foote 1979) characterized by rapid nutrient turnover, high productivity, and relatively high decomposition rates (Viereck and Schandelmeier 1980).

Production of moose browse, especially willow, is often very high during the shrub stage. Wolff and Zasada (1979) found that 3 to 7 years after a fire in black spruce forest, the amount of willow browse available to moose increased 680 percent from 6.5 to 44.1 kg/ha. The Bureau of Land Management (unpublished data) reported a 1280 percent increase in willow density from 1,800 to 23,000 stems/ha in 7 years following a fire of moderate intensity in white spruce.

In constrast to these potentially beneficial effects of fire on browse and berry production, negative impacts may also occur as a result of vegetation removal and consequent soil instability. Fires on steep slopes result in increased runoff due to vegetation loss, and may cause mud or landslides. In other areas thermokarst topography and gullies may result from fires (Viereck and Schandelmeier 1980).

3.3.2 - Devil Canyon Development

(a) Construction

(i) Vegetation Removal

Because of the narrow, steep configuration of Devil Canyon, vegetation losses will be substantially less than for the Watana Dam. Approximately 5700 acres (2305 ha) of forest and 170 acres (70 ha) of shrubland will be inundated or cleared (Table E.3.84). An additional 551 acres (223 ha) will be altered or lost as a result of the camp, village, and borrow areas. As discussed in the previous section, natural revegetation of some disturbed sites will probably occur. Typical successional sequences reviewed in Section 3.3.1(b)(i) also apply to the Devil Canyon region.

(ii) Vegetation Loss by Erosion

The most likely source of vegetation loss by erosion at the Devil Canyon site will be rock slides along steep banks, especially on the south side of the reservoir. Although most rockfalls will occur at elevations of 900 to 1300 feet (274 to 396 m) and thus will be below the eventual fill level, some slides may also occur above this zone. Only sporadic concentrations of permafrost have been found in Devil Canyon. Resulting erosional problems and vegetation loss through permafrost melting should therefore be minimal. Clearing may be a significant source of erosion which may in turn result in further vegetation loss in adjacent uncleared areas.

(iii) Vegetation Damage by Wind and Dust

Wind-related phenomena such as tree blowdown are less likely at the Devil Canyon site than at the Watana site because the maximum fetch will be far less at Devil Canyon. Dust will be generated by clearing of the Devil Canyon impoundment area, but because the impoundment area is in a narrow valley that is more protected from wind than the Watana impoundment area, resulting impacts to vegetation are expected to be relatively minor.

(iv) Effects of Altered Drainage

Excavation and construction activities will impinge on a number of small lakes and ponds south of the Devil Canyon site. A total of 32 acres (13 ha) are covered by lakes within 10 miles (16 km) of the Susitna River at the Devil Canyon facility. Excavation in these areas may result in the creation of new aquatic or bog habitat with ensuing development of bog vegetation (Neiland and Viereck 1977). The steep configuration of the canyon will limit other changes in drainage patterns or water table levels. Any downslope cuts made during construction may, however, promote active gully formation and associated vegetation loss. Proposed Borrow Area K (Figure E.3.37) may affect an additional 99 acres (40 ha) of potential wetlands.

(v) Effects of Change in Albedo

Clearing of the Devil Canyon impoundment area will result in a warming of underlying soils prior to filling. Since permafrost is not generally present, impacts on adjacent vegetation will be minimal.

(vi) Indirect Consequences of Vegetation Removal

Indirect effects of different clearing methodologies were reviewed previously for the Watana site (Section 3.3.1(a)). These effects are also applicable to the Devil Canyon area, although the steep configuration of the canyon may make recontouring and topsoil replacement efforts less effective.

(b) Filling and Operation

The Devil Canyon impoundment will be filled in about two months. No appreciable downstream effects on vegetation should be evident during filling. Upstream from the dam, filling will result in diminished dust in summer and perhaps will slightly alter microclimate, especially on the windward side of the reservoir (see Section 3.3.1(b)[iii]).

Because the drawdown zone for the Devil Canyon impoundment will cover a range of 55 feet (17 m) during most of the year as shown by the rule curve for Devil Canyon reservoir (Exhibit B, Figure B.53), the rise and fall of the water table will probably affect vegetation only in a narrow band adjacent to the reservoir. The consolidated, rocky character of the substratum will in most cases limit water intrusion and soil waterlogging, and few shifts toward wet or bog vegetation are likely.

Relatively few additional impacts on vegetation are expected during operation of the Devil Canyon development. The old large landslide at River Mile 175 (Figure E.3.3) could move after filling, temporarily blocking river flow and flooding upstream areas. This could cause a loss of mid- and late-successional vegetation in areas such as the mouths and floodplains of Fog and Tsusena Creeks. However, the areal extent of such impact cannot be reliably predicted.

Meso- and microclimatic effects on vegetation will be very small and probably well within the range of normal variation, due to the relatively small size of the reservoir.

(i) Vegetation Succession Following Clearing

The same general vegetational succession patterns will occur on cleared, unsubmerged lands of the Devil Canyon area that were described for the Watana site (see 3.3.1(b)[i]). However, due to the steep, rocky character of Devil Canyon a much greater mosaic of vegetation types may develop. On some slopes, loss of soil may result in shifts to low-lying alpine communities dominated by mountain-avens, rather than a gradual return to shrubland and forests.

(ii) Erosion and Deposition

Due to the geological character of the Devil Canyon region, erosional/depositional changes affecting vegetation will be minimal following filling of the reservoir.

(iii) Effects of Regulated Flows

Downstream effects of the Devil Canyon dam in the reaches downstream of Talkeetna will be similar to those discussed in Section 3.3.1(b)(iii). The factors controlling vegetation in the Devil Canyon-Talkeetna reach, however, will change as a result of the lack of ice formation in this reach. With Watana only, the rate of vegetative recession will be controlled primarily by increased ice staging during freezeup and secondarily by ice scouring at breakup. The width of the unvegetated floodplain will increase with a corresponding decrease in the size of vegetated islands. Once Devil Canyon is operating, ice scouring will be completely eliminated, and vegetation will be controlled by peak flows. Since the peak flows will have a stage that is at least 5 feet below that when ice is present, many areas will be available for primary succession after the construction of the Devil Canyon dam. Succession will follow the pattern shown in Figure E.3.78.

3.3.3 - Access

(a) Construction

Approximately 477 acres (193 ha) of primarily shrub and tundra vegetation will be cleared along a 44 mi (70 km) corridor for the Denali Highway-to-Watana access route (Table E.3.85). The vegetation adjacent to the access road will be subject to indirect effects including dust deposition, erosion, leaching of nutrients in recently drained regions, and waterlogging in areas of blocked drainage. These effects are all discussed in more detail in Section 3.3.1(a).

When the Devil Canyon dam is built, an additional road segment will connect the Devil Canyon and Watana sites along a 37 mi (59 km) corridor north of the Susitna River (Figure 37). Construction of this road will entail clearing an additional 468 acres (189 ha) of roadway. A 12 mi (19 km) railroad extension between Devil Canyon and Gold Creek will be constructed on the south side of the Susitna River, removing an additional 72 acres (29 ha) of vegetation. Spruce and mixed forest, tall and low shrubland, and tundra vegetation types will all be crossed by these corridors (Table 85).

Many of the same impacts experienced in clearing the Watana and Devil Canyon impoundments (Sections 3.3.1(a), and 3.3.2(a)) will occur during and following access-related clearing. These include erosion, dust deposition, and drainage changes.

(b) Operation

Use of the access roads will result in continued dust- and erosion-related effects on vegetation bordering the access road. In addition, access roads will facilitate increased human disturbances, including ORV use and a higher incidence of fire. These disturbances and their impact on vegetation are discussed in Section 3.3.1(b).

In contrast to the access roads, the proposed rail connection from Devil Canyon to Gold Creek will minimize off-road access and fire incidence. The rail connection will primarily traverse spruce and mixed deciduous type forests.

3.3.4 - Transmission Corridors

(a) Construction

Transmission corridor comprise a total of 18,040 acres (7300 ha) and will consitute another source of vegetation loss and/or disturbance (Tables E.3.79, E.3.80, and E.3.86). The transmission lines from Healy to Fairbanks cover a total of 7106 acres (2876 ha). Open black spruce (1270 acres, 514 ha) constitutes the main vegetation type in the right-of- way. The Willow-to-Cook Inlet transmission corridor (total cover 3209 acres, 1299 ha) will cross primarily closed conifer-deciduous forest (568 acres, 229 ha). The Willow-to-Healy transmission corridor (6184 acres, 2503 ha) is composed primarily of upland (2888 acres, 1169 ha) and lowland (1503 acres, 608 ha) spruce hardwood forest types. Shrubland (457 acres, 185 ha), tundra (390 acres, 158 ha), and forest (417 acres, 117 ha) are included in the proposed rights-of-way for the Watana-to-Gold Creek transmission corridors (total area 1541 acres, 512 ha).

In all the above cases, the vegetation types affected represent small fractions (less than 4.2 percent) of the total available vegetation types within the corridors. Of this portion only a negligible fraction of the vegetation will be totally eliminated by intermittent placement of control stations, relay buildings, and towers. The remaining vegetation will be subject to selective clearing of trees and tall shrubs There will be no clearing of low shrub or tundra types. Thus low-lying vegetation and small shrubs will remain largely undisturbed. Such cleared areas have the potential of increased browse production by willow and birch shrubs following over-story removal. Transmission corridor construction is described in Section 3.4.2(a).

(b) Operation

After establishment of the transmission corridors, periodic maintenance via selective clearing or trimming will be required. Such manual clipping may stimulate leaf and twig growth of willow and other browse species (Wolff 1978). On the other hand, evergreen shrubs such as Labrador tea and other woody shrubs are likely to show increased mortality if damaged in the process of clearing (Chapin et al. 1975, Chapin 1980, Chapin and Shaver 1981). But the potentially most damaging aspect of operation may be increased ORV use in the rights-of-way (see Section 3.3.1(b)(v).

3.3.5 - Impacts to Wetlands

(a) Construction

The direct removal of vegetation as a result of construction and clearing operations relative to the Watana and Devil Canyon developments have been quantified in Sections 3.3.1(a)(i) and 3.3.2(a)(i). The primary vegetation types to be removed by the impoundments, dam, and spillways of the Watana development include stands of woodland and open black and white spruce forest as well as some open mixed forest types. Construction of the Devil Canyon facility will result in the direct loss of forest and shrubland. As indicated in Section 3.2.3 Wetlands, wetland classifications may also be applied as a second level of classification to many of the above vegetation types (Table E.3.81). Table E.3.82 illustrates the areal extent of different potential wetland vegetation types within the locations which will be affected by the Watana and Devil Canyon developments. As indicated previously (Secton 3.2.3), the estimates of total palustrine wetland areas shown in the table are extremely liberal and all values should be considered preliminary.

Far more potential wetland areas are included within the Watana development (30,705 acres, 12,341 ha) than occur within the Devil Canyon project area (4214 acres, 1706 ha) (Table E.3.82). The proportion of the area occupied by wetland types also differs within the two areas. Although potential palustrine forested areas occupy the greatest areal extent of wetland types in the Watana facility (60 percent of total potential wetlands), this type occupies 48 percent of the potential wetlands to be affected by the Devil Canyon facility. Because of the configuration of Devil Canyon, riverine wetland types occupy a greater proportion of the potential wetlands of the Devil Canyon facility (47 percent) than of the Watana facility (18 percent).

Within the Watana development area, about 11 percent of the potential wetland areas occur within non-impoundment borrow sites proposed for dam and ancillary facility construction, whereas about 98 percent of potential wetlands within the immediate vicinity of the Devil Canyon development occur within the dam, spillway, and impoundment areas.

Vegetation removal as a result of construction of access corridors, Watana dam-to-intertie transmission corridors, and the Healy-to-Fairbanks and Willow-to-Cook Inlet transmission lines has been quantified in Tables E.3.85, E.3.80, E.3.86, respectively. As indicated in Section 3.2.3, wetland classifications may also be applied as a second level of classificaton to many of the vegetation types of Viereck and Dyrness (1980). The reader is referred to the above tables to review impacts to potential wetlands of the access and transmission corridors, and to Table E.3.82 for a general review.

3.3.6 - Prioritization of Impact Issues

In this section, impacts to vegetation are prioritized in order from most important to least important. As discussed in Section 1.2, impacts are prioritized based on resource vulnerability, the probability of the impact occurring, and the duration of the impact. Direct losses of vegetation are judged most important because of the certainty and the permanance of the impact. The importance of losses of particular vegetation communities is in proportion to the total acreage lost and in indirect proportion to the amounts of each type present regionally.

Plant community changes are judged to be less important than actual losses. These impacts are less predictable and of a shorter duration than vegetation losses.

(a) Direct Loss of Vegetation

(i) Watana

Direct losses for the Watana project include 31,300 acres (12,667 ha) of vegetation for the dam, impoundment and spillway. An additional 4300 acres (1742 ha) have been designated for use as camp, village, airstrip, and borrow areas. These potential losses account for only 1 percent of all vegetation in the middle Susitna basin, but 3.6 percent of the vegetation present in a 20 mile (32 km) wide area spanning the Susitna River from the mouth of the Maclaren River to Gold Creek. More importantly, substantial losses of certain vegetation types will be sustained during construction of the Watana Dam. Losses of forested areas may total 8.3 percent of the 20 mile (16 km) wide area. Losses of open and closed birch forest will be particularly large, greater than 20 percent for the 20 mile (16 km) wide area. The losses of these forest types will mean substantial habitat losses for some wildlife, especially black bear, moose, pine marten, beaver, raptors, small mammals, and passerine birds.

(ii) Devil Canyon

Direct losses for the Devil Canyon project will include 5871 acres (2376 ha) of forests, tundra and shrubland. Negligible amounts of tundra and shrubland (<.05 percent) will be lost, but 0.7 percent of all forested lands in the middle basin (1.8 percent of the 10 miles (16 km) area will be affected. Because of the steepness of Devil Canyon, these losses are relatively small compared to Watana and comparatively less important for wildlife. Again, however, appreciable quantities of closed birch forest (18.6 percent of the 10 mile, (16 km area) will be eliminated.

(iii) Access Roads

The Watana access road will result in a loss of approximately 568 acres (230 ha) of mixed tundra vegetation types. Additional losses of about 494 acres (200 ha) for access roads and 78 ha (193 acres) for rail will be utilized for access to the Devil Canyon facility. These routes will span spruce forests, tall and low shrubland and tundra vegetation types. In relation to possible losses from other aspects of the project, these direct losses are small.

(iv) Transmission Corridors

Of the total 18,040 acres (7300 ha) of vegetation on rights-of-way for transmission lines, only a small fraction need be subject to initial clearing since there will be no clearing of low shrub or tundra types. Access trails for transport of personnel and materials, plus smaller areas for placement of control stations, relay buildings, and towers, will need to be cleared; other portions of the transmission corridors will only require selective clearing or top-cutting of tall shrubs and trees.

(b) Indirect Loss of Vegetation

Additional losses of vegetation may occur due to erosion, permafrost melting and subsequent land slides and slumpage, ORV use, blowdown of trees and other causes (see Section 3.3.1(a)). While some of these losses will be short-term with typical vegetational succession ensuing, or with shifts to new vegetation types for that area, long-term vegetational losses enduring for 30 to more than 100 years may occur on sites of continual erosion, land slumpage, or ORV use. The amounts that will be lost because of these factors are small compared to amounts inundated by the reservoirs.

(i) Watana

Indirect losses of vegetation are projected to be greatest at the Watana site, where large areas on the south side of the impoundment are underlain by 200 to 300 feet (60 to 90 m) of permafrost at near melting temperature. Also, because of the expected large size of the reservoir, other erosional processes such as wind erosion, together with effects of dust, may cause very localized vegetation loss, especially in wind-exposed areas.

(ii) Devil Canyon

The smaller, steeper nature of Devil Canyon will severely limit indirect losses of vegetation. Except for the possibility of one massive flow near River Mile 175, rock slides occurring above the impoundment represent the greatest threats and these will result in only small scale losses.

(iii) Access Roads

Some indirect loss of vegetation is expected due to erosion caused by changes in drainage patterns and dust deposition on the road edges. Increased utilization of ORVs along access roads and road maintenance may damage adjacent areas.

(iv) Transmission Corridors

Little indirect loss is likely as a result of direct clearing or construction, but uncontrolled ORV access could affect vegetation on and adjacent to corridors. Forests, shrublands, tundra and wetlands are dispersed along this area.

(c) Alteration of Vegetation Types

Alteration of vegetation types will be caused by succession, changes in drainage patterns, altered river flows, and fire. In many instances, natural succession of cleared or disturbed areas not subject to inundation will result in vegetation type changes. For example, primary herbaceous and weedy vegetation and secondary shrub growth may follow clearing of sites. There may be development of fast-growing algal species and floating vegetation in shallow areas of the impoundment(s). Successional trends following man-caused fires are generally predictable. These impact issues are discussed further in the mitigation section (Section 3.4).

(i) Downstream Floodplain

The most important alteration to result from the dam(s) will be downstream between Gold Creek and Talkeetna, where annual spring and summer flooding and scour by ice jams will be reduced. As a result, some of the previously pulse-stabilized communities will mature. The willow and balsam poplar shrub will change to mature balsam poplar and thence to spruce. Within the license period, the development of vegetation on newly exposed banks and islands will proceed only to the medium and tall shrub stages.

(ii) Watana

One area of potentially important impacts is tundra vegetation surrounding the Watana Reservoir. Disturbance may cause warming of the soil, melting of the permafrost, and deepening of the active layer. In well-drained areas, this may result in increased growth and productivity by the existing plant community, but in waterlogged areas a shift to bog vegetation is likely. If the organic layer is lost during disturbance, long-term losses of vegetation may result.

Most forest and shrub areas disturbed near the reservoir will recover naturally. The ensuing patterns of vegetational succession will be accelerated if the organic layer is retained and if root suckers or seeds of vegetation remain.

(iii) Devil Canyon

Outside the actual impoundment and dam site, very few alterations of vegetation types are anticipated at Devil Canyon. Forest types will be subject to minor alterations, primarily near borrow sites G and K, and near camp and village sites. Likewise, changes in drainage, waterlogging of soil or permafrost melting will be highly localized because the soil is generally very rocky and well drained, with only sporadic occurrences of permafrost. The smaller, steeper character of Devil Canyon will also act to limit micro-climatic and mesoclimatic alterations.

(iv) Access Roads and Railroads

The access roads between the Devil Canyon and Watana sites and between Watana and the Denali Highway, as well as rail construction between Devil Canyon and Gold Creek, will alter surface drainage patterns and may induce dust-related alterations in vegetation at roadsides. The effects of altered drainages have been summarized above.

(v) Transmission Corridors

Selective clearing or top-cutting of tall vegetation will result in local shifts in plant types from trees to shrubs. Wet and moist tundra areas and their peripheries will be more susceptible to water logging by vehicular traffic with subsequent development of bog species and/or black spruce in place of cottongrass and shrub species.

3.4 - Mitigation Plan

3.4.1 - Introduction

This mitigation plan addresses the impacts to botanical resources described in Section 3.3. Mitigation measures for each impact issue have been developed according to the approach discussed in Sections 1.2 and 1.3, and are prioritized as follows: avoidance, minimization, rectification, reduction, and compensation. Mitigation measures are described with respect to locations, procedures, and costs. Recommendations by state of Alaska and federal agencies are reviewed, and their relationship to the mitigation plan explained.

3.4 - Mitigation Plan

The mitigation plan is organized as follows:

(a) Section 3.4.2, Option Analysis:

- The range of available mitigation options is explained for each of the impact issues prioritized in Section 3.3.6.

- Selected mitigation measures or facilities are described along with the reasons supporting each selection.

- The extent to which mitigation will be achieved by area and over time is indicated where available information allows.

- Residual impact estimates are provided.

- Implementation schedules are presented commensurate with the level of detail provided by Exhibit C, Construction Schedule.

- Implementation costs are provided for measures or facilities which are not included as project capital costs (Section 4.4.3). Project capital costs are described in Exhibit D.

- Mitigation measures or facilities recommended through agency consultation are documented. Where such recommendations have been incorporated in the mitigation plan, explanation is provided. Cases where alternative measures have been adopted are also explained.

- Illustrations of mitigative project design features are presented.

(b) Section 3.4.3, Mitigation Summary:

- Mitigation measures for botanical resources are summarized including schedules and cost estimates for future studies (Table E.3.177).

(c) Section 4.4.4, Agency Consultation (including wildlife):

- Mitigation recommendations provided through agency consultation are summarized, along with reasons for incorporation of alternative measures where appropriate.

3.4 - Mitigation Plan

Environmental protection guidelines provided to project engineers are shown in Appendix 3.B. A majority of these recommendations have been incorporated into engineering design and construction planning, resulting in modifications to avoid or minimize adverse impacts to botanical resources during project construction and operation. These measures include changes in facility siting and layout, realignment of access roads and transmission corridors, alterations in road design and construction, and constraints on gravel extraction locations and procedures. Because removal of vegetation will produce the greatest direct impact to botanical resources of the project area, measures to minimize the areal extent of vegetation removal are treated in greatest detail in the following discussions.

Rectification of adverse impacts to wetlands has also received particular attention, especially with regard to correcting blockage of sheet flow and siltation conditions caused by construction of access and service roads. Rehabilitation measures to rectify vegetation and soil loss at temporary construction sites and borrow areas have also been incorporated, including procedures to conserve and replace soils and to revegetate disturbed areas.

Project planning has emphasized the reduction of adverse impacts to wetlands and downstream riparian vegetation during construction and operation through monitoring and corrective measures to be implemented during the license period. Measures to compensate for impacts to vegetation reflect the importance of botanical resources as components of wildlife habitat, and have been designed primarily to mitigate impacts to wildlife through habitat enhancement and replacement. Thus, the mitigation plans for botanical resources and wildlife complement each other, and measures designed largely to reduce or compensate for loss of wildlife habitat are discussed more fully in Section 4.4.

As the Power Authority continues to sponsor field studies to refine and further quantify information obtained during the past three years of baseline and impact research, and as engineering design and construction planning proceed, features of this mitigation plan will be correspondingly refined with respect to specific locations, procedures, and costs.

3.4.2 - Option Analysis

(a) Direct Loss of Vegetation

Without mitigation, construction of all project facilities would remove vegetation from a total of about 68,537 acres (27,744 ha), apportioned as follows:

3.4 - Mitigation Plan

	acres	hectares
- Dams and spillways	274	111
- Impoundments	44,292	17,932
- Camps	245	99
- Villages	269	109
- Airstrip	42	17
- Damsite borrow areas	4,325	1,751
- Access borrow areas	35	14
- Access routes	1,015	411
- Transmission corridors*	18,040	7,300

* Ground layer and soil not removed.

Of this cumulative impact, vegetation removal resulting from dams and spillways, impoundments, access routes, and the Watana operational village will be permanent, accounting for about 70 percent (45,581 acres, 18,454 ha). The remaining 30 percent (19,236 acres, 7788 ha) will allow application of the following range of mitigation options:

- Avoidance: Vegetation removal cannot be entirely avoided.

- Minimization: This measure is feasible by reducing clearing requirements. Options include:

  . Minimizing facility dimensions;

  . Consolidating structures;

  . Siting facilities in areas of low biomass;

  . Siting facilities to minimize clearing of less abundant vegetation types;

  . Siting facilities to minimize clearing of vegetation types productive as wildlife habitat components;

  . Minimizing volume requirements for borrow extraction;

  . Disposal of spoil within the impoundments or previously excavated areas; and

  . Designing transmission corridors to allow selective cutting of trees and to accommodate uncleared low shrub and tundra vegetation types within the rights-of-way.

- Rectification: Site rehabilitation measures can rectify impacts of vegetation removal. Options include:

  . Dismantling nonessential structures as soon as they are vacated;

  . Storing removed organic layer and mineral soil for subsequent replacement;

  . Scarification and fertilization; and

  . Artificial seeding.

- Reduction: Impacts of construction-related vegetation removal can be reduced over time by:

  . Monitoring progress of site rehabilitation to identify locations requiring repeated application of fertilizer and/or seed;

  . Systematically identifying and rehabilitating areas where construction activities have ceased and are no longer required.

  . Coordinating rehabilitation efforts with closure or removal of service roads no longer required.

- Compensation: This approach is feasible through the acquisition and management of replacement lands. Options include:

  . Acquiring lands with areal coverages of vegetation types equivalent to those lost, and protecting these lands from future development.

  . Prioritizing lost vegetation types relative to value as wildlife habitat, and selectively changing vegetation on acquired lands to replace or exceed lost areal coverages of the high-priority vegetation types.

(i) Minimization

All of the minimization options summarized above will be applied to reduce clearing requirements to the least necessary for project construction. Dimensions of the construction camps and villages have been kept small by designing compact arrays of uniformly-sized, contiguous residential modules, as shown in Exhibit F, Plates F36, F37, F71, and F72. This approach has afforded significant structural consolidation, enhanced by combining the permanent village or townsite with the temporary construction village at Watana (Exhibit F, Plate F36). Structural consolidation has been achieved further by confining the entire infrastructure of camps, villages, temporary roads, fuel and equipment storage areas, and other construction support facilities to the vicinity of the damsite. At Watana, the construction camp is sited about 2.5 miles (4 km) and the village about 1 mile (1.6 km) northeast from the emergency spillway (Exhibit F, Plate F3). At Devil Canyon, the construction village is about 2.7 miles (4.3 km) and the construction camp about 1.5 miles (2.4 km) west from the emergency spillway, and the railhead pad (approximately 2500 by 800 feet) is about 1.5 miles (2.4 km) to the southwest (Exhibit F, Plate F70). These siting arrangements have been determined primarily by the nearest available flat terrain to the damsites.

A major consolidation feature incorporated into project design is the common corridor of the Watana-to-Gold Creek access and transmission routes (Figures E.3.37, E.3.39, and E.3.40). Vegetation removal required for both facilities will affect approximately similar plant communities in approximately the same locations (compare Tables E.3.80 and E.3.85, and see Figures E.3.39 and E.3.40). Consolidation of the two routes will minimize traffic-related vegetation removal by reducing distances required for transport of equipment from the nearest road to the transmission corridor. In the stretch between Watana and Devil Canyon, the adjacent access road will allow direct overland entry of equipment across a distance ranging from about 0.1 to 0.75 miles (up to 1.2 km). Equipment will be mounted on flat-tread, balloon-tire vehicles to minimize soil or ground-cover disturbance.

Further consolidation has been achieved by siting borrow areas which may be required for access road construction immediately adjacent to the route. As shown in Figure E.3.37, 14 borrow areas have been identified along the access route from the Denali Highway to Devil Canyon. Access routing has been refined to emphasize well-drained soils which will allow maximum use of side-borrow techniques in level terrain and balanced cut-and-fill in sidehill cut areas (Figure E.3.83). Therefore, the borrow areas shown in Figure E.3.37 are not expected to be fully excavated, as they will be used only to augment material requirements where side-borrow or balanced cut-and-fill techniques cannot be fully utilized. In general, it is expected that each site will be excavated at most to a depth of 8 feet (2.5 m) and will range in area from less than 10 to no more than 20 acres (4 to 8 ha).

By minimizing gravel extraction requirements and utilizing borrow areas which, if necessary, will be sited immediately adjacent to the access road, the need for individual access roads to borrow areas has been eliminated, further reducing requirements for vegetation removal.

Facility siting has emphasized areas of low biomass. The Watana construction camp and village have been sited in low shrub types (birch and mixed; see Table E.3.83); these have relatively low clearing requirements in comparison to the open mixed forest and tall shrub stands also in the vicinity, which have been avoided (Figure E.3.40). At Devil Canyon, the camp and village have been sited in comparatively well-drained, closed, conifer-deciduous forest (Table E.3.84) to avoid nearby low, wet areas of black spruce and wet sedge-grass (Figure E.3.39). Hence, the Devil Canyon ancillary facilities will remove more biomass than facilities of equivalent area at Watana.

Minimizing clearing requirements has been a major consideration in the siting of access roads, particularly the Denali Highway-to-Watana section where completion within the first year of construction, 1985, is required (Exhibit C, Figure C.1; Exhibit E, Chapter 10, Section 2.3.7[b]). The Denali Highway-to-Watana route will remove about 343 acres (139 ha) of shrubland and about 132 acres (53 ha) of tundra types, accounting for about 0.1 percent of total shrubland in the Watana and Gold Creek watersheds and a lower percentage of total tundra cover (Table E.3.85). Only 0.9 acres (0.3 ha) of open white spruce forest will be affected, and the number of individual trees actually cut in this low-density vegetation type will be statistically insignificant on a local or regional basis.

Opposition to the Denali Highway-to-Watana route has been stated in letters from the ADF&G (1980, 1982), the

the Susitna Hydroelectric Steering Committee (1981), and the USFWS (1982, 1983). The major wildlife concern expressed is that habitat for caribou, moose, brown bear, and black bear will be crossed by this access alternative. The route has been selected because of the scheduling requirement cited above for completion of access to Watana during the first year of construction. This route is discussed further below and in Section 3.4.2(b), and in the fish and wildlife impact and mitigation discussions, Sections 2.3, 2.4, 4.3, and 4.4, respectively.

The Watana-to-Devil Canyon route also is characterized by vegetation types of predominantly low biomass, although it crosses a greater variety of plant communities. About 48 percent of the route is shrubland (224 acres, 91 ha), 32 percent is tundra (151 acres, 61 ha), and 20 percent is forest (92 acres, 37 ha) (Table E.3.85). This routing has been recommended by the ADF&G (1980), the Susitna Hydroelectric Steering Committee (1981), and the USFWS (1982). The route has been incorporated as recommended, and is discussed further below and in Sections 3.4.2(b), 4.3, and 4.4.

The Devil Canyon-to-Gold Creek railroad route will traverse almost entirely closed mixed forest (about 50 acres, 20 ha) and open mixed forest (about 14 acres, 6 ha) (Table E.3.85). In this case, constraints imposed by criteria for maximum 2.5 percent grades and 10-degree horizontal curves have necessitated routing through a heavier-biomass vegetation type. However, the rail mode is itself a mitigation measure in this respect, because clearing width (50 feet, 15 m) is less than half that required for road construction (120 feet, 37 m).

Rail access to at least Devil Canyon, and preferably excluding a road system connecting with Alaska highways, has been recommended by the Susitna Hydroelectric Steering Commmittee (1981) and the U.S. Fish and Wildlife Service (1982). The rail mode has been incorporated as recommended. However, a connecting road system has also been incorporated, although through Watana and the Denali Highway and not directly west to the Parks Highway. This issue is discussed further in Section 3.4.2(b).

3.4 - Mitigation Plan

Transmission corridors traverse a variety of vegetation types with different biomass characteristics (Tables E.3.77-79 and E.3.86, Figures E.3.39-40 and E.3.49-52). Their routing has been determined largely by access and land ownership considerations. Because it shares a common corridor, the Watana-to-Devil Canyon transmission route traverses low-biomass vegetation types similar to those crossed by the adjoining access road. Clearing of vegetation of any type will be minimal during transmission corridor construction. Mitigative clearing techniques specifically designed to minimize vegetation removal by transmission corridors are discussed below.

Impacts of vegetation removal are relatively greater if the vegetation types removed are less abundant (have lower total areal coverage) than other plant communities in the project area. Vegetation types with low areal coverage within the Watana and Gold Creek watersheds are closed spruce forest, open and closed birch forest, herbaceous alpine tundra, and wet sedge-grass tundra (Table E.3.51). Within the 20-mile-wide (32 km) area surveyed in greater detail along the Susitna River from the Maclaren River (RM 260) to Gold Creek (RM 136.8), less abundant vegetation types are herbaceous, closed balsam poplar forest, grassland, open and closed birch forest, and wet sedge-grass tundra (Table E.3.52). Herbaceous alpine tundra will not be affected by the project (McKendrick et al. 1982). The herbaceous, balsam poplar, and grassland types occur primarily along the downstream floodplain and tributaries of the Susitna River (McKendrick et al. 1982) and will not require direct vegetation removal for facility construction with the exception of 111 acres (45 ha) of herbaceous floodplain pioneer vegetation to be inundated by the Watana impoundment and 0.7 acres (0.3 ha) of closed balsam poplar to be cleared for railroad construction (Tables E.3.83 and E.3.85). However, these vegetation types will potentially be affected by regulated flows, as discussed in Section 3.3.1(c). A balsam poplar stand near Deadman Creek at access milepost 37.5 has been avoided by a one-half-mile route realignment to protect a bald eagle nest in the stand (Section 4.4, Figure E.3.81).

Low abundance vegetation types which will receive the greatest cumulative impact from construction of the impoundments and dams, access and transmission corridors, and all ancillary facilities will be closed spruce forest, open and closed birch forest, and wet sedge-grass tundra (Tables E.3.80 and E.3.83-86). A total of 252 acres (102 ha) of closed spruce forest will be traversed by the transmission corridors. Based on 1:250,000-scale mapping of the project area (Table E.3.51), as much as 32 percent of the total coverage of closed spruce forest in the Watana and Gold Creek watersheds (i.e., 798 acres or 323 ha) could potentially be cleared during the winter of 1989-1990. However, the application of selective clearing and other mitigative techniques involving transmission corridor construction will reduce the actual number of individual trees removed, as discussed below.

A cumulative total of 3428 acres (1388 ha) of open and closed birch forest could be affected by construction-related clearing between 1985 and 2002. Based on the 1:63,360-scale mapping of the 20-mile (32-km) strip along the Susitna River for which the greatest detail is available (Table E.3.52), 36 percent of the total 9440 acres (3822 ha) of this vegetation type could be removed by construction. About 2250 acres (911 ha) or 24 percent of the total coverage will be entirely removed by clearing of the impoundments (Tables E.3.83-84). The remaining 1178 acres (477 ha) will be selectively cleared as discussed further below.

The third low-abundance vegetation type to be affected by construction, wet sedge-grass tundra, will be crossed by access and transmission corridors (481 acres, 195 ha) (Tables E.3.80 and E.3.85-86) and inundated within the impoundment areas (235 acres, 95 ha) (Tables E.3.83-84). Borrow Area D (Figure E.3.37) will potentially remove an additional 20 acres (8 ha) (Table E.3.83). The siting of all pads, buildings, and other structural facilities has entirely avoided this vegetation type. Therefore, a total of 736 acres (298 ha) of wet sedge-grass tundra will be potentially affected by construction between 1985 and 2002. This cumulative impact represents about 9 percent of the total 8687 acres (3517 ha) present within the 20-mile (32-km) strip mapped at 1:63,360 (Table E.3.52). Mitigative measures which will minimize drainage alterations in this wet vegetation type are discussed in Section 3.4.2(c).

In summary, siting of pads, buildings, the Watana airstrip, and other ancillary facilities has minimized clearing requirements for low-abundance vegetation types. As residual impact, the impoundments and access and transmission corridors will remove about 32 percent of closed spruce forest in the Watana and Gold Creek watersheds, as well as 36 percent and 9 percent of birch forest and wet sedge-grass tundra, respectively, within the 20-mile (32-km) strip mapped at 1:63,360.

Construction-related impacts of vegetation removal can be minimized further by siting facilities to avoid productive wildlife habitat. In this sense, the affected vegetation has less value, and thus its removal contributes less to cumulative impact. However, this option applies only to facilities with flexible siting requirements. Because the dam and impoundment sites are fixed, loss of vegetation as a result of their construction cannot be minimized, rectified, or reduced over time, but can be offset only through compensation, as explained later in this section.

Without mitigation, the clearing of vegetation for permanent facilities will reduce carrying capacity for wildlife, as discussed in Sections 4.3 and 4.4.1; mitigation plans to offset this loss are presented in Section 4.4.2. These plans include the selective siting of access roads, transmission corridors, borrow areas, and the Devil Canyon railhead facility to minimize removal or disturbance of wildlife habitat. Siting and route alterations for this purpose have been made through the interaction of environmental specialists with project engineers and are summarized in Figures E.3.79-82.

Vegetation removal resulting from access road construction would be minimized most completely by selection of the shortest alternative route (Access Plan 13--see Chapter 10, Section 2.3). However, as stated above, schedule constraints have necessitated selection of the 93-mile (149-km) Plan 18 route, which provides road access from the Denali Highway and rail access from Gold Creek. This route incorporates siting and design features which will minimize removal of wildlife habitat. A major advantage is that moose and brown bear habitat south of the Susitna River, particularly near Prairie Creek, Stephan Lake, and the Fog Lakes, will not be directly affected by vegetation removal and other construction-related impacts. This avoidance of productive habitat south of the Susitna River agrees with and implements recommendations of the ADF&G (1980, 1982), the Susitna Hydroelectric Steering Committee (1981), and the USFWS (1982).

3.4 - Mitigation Plan

As shown in Figure E.3.79, two major realignments have been made to the 42-mile (67-km) Denali Highway-to-Watana segment, progressively moving the route westward from relatively flat, low terrain (2000-3500-foot (600-1050 m) elevation) to the lower slopes of mountainous terrain in the northern portion of the project area (3500-4000-foot (1050-1200 m) elevation). These realignments have provided several advantages. First, potential drainage and siltation impacts associated with construction in the low, wet terrain to the east have been avoided. Second, the two earlier route alternatives joining the Denali Highway near Snodgrass and Butte Lakes were longer and would have crossed more streams and wet areas. For example, the Butte Lake alternative passes within 100 yards (91 m) of Deadman Lake for a continuous distance of 2 miles (3.2 km) and closely transits Deadman Creek along a 5-mile (8-km) stretch. In addition, the earlier alternatives crossed flat terrain historically within the range of the Nelchina caribou herd (Section 4.2). The adjusted route follows the transition zone between level range and mountainous terrain, leaving the lowland area uncrossed by any potentially disturbing structure. Third, the adjusted route now follows relatively well-drained terrain and soil types which, for the most part, allow construction using side-borrow or balanced cut-and-fill techniques, rather than the bermed construction mode required for roadbeds crossing wet, poorly drained areas.

As discussed in greater detail below, side-borrow and balanced cut-and-fill techniques provide road sections which present less of a physical and visual barrier to passing wildlife such as caribou and moose. Thus, where vegetation is replaced by a physical structure, the potential for that structure to block free passage of big game has been reduced by selective siting which allows preferred construction modes.

Using side-borrow and balanced cut-and-fill techniques also reduces gravel requirements, thereby minimizing the areal extent of vegetation removal, and confines gravel extraction to the access corridor itself, thus consolidating the impact. Similar terrain and soil considerations have governed routing of the 37-mile (59-km) Watana-to-Devil Canyon road and the 12-mile (19-km) railroad extension, which will also rely on balanced cut-and-fill construction to minimize removal of wildlife and habitat.

3.4 - Mitigation Plan

In addition to the major realignments described above, options for smaller route adjustments have been fully exercised to avoid site-specific habitat loss or direct disturbance of wildlife. These local modifications and the features avoided are documented in Figures E.3.80-82. Red fox den complexes and surrounding habitat (characteristic of well-drained, sloping terrain) have been avoided by careful original routing or changes in alignment at MP 28, 32, 34, and 36. At MP 38, the original alignment passed through a balsam poplar stand containing a bald eagle nest. In compliance with provisions of the Bald Eagle Protection Act (16 USC 668-668c), the route has been realigned to pass 0.5 mile (0.8 km) west of the nest location. As shown in Figures E.3.80 and E.3.81, additional route changes have been made to avoid impacts to surrounding palustrine vegetation, water quality, and resident fish of Deadman and Tsusena Creeks. These realignments are discussed from a fisheries standpoint in Section 2.4.

West of the Watana damsite, access routing has been adjusted to avoid potential disturbance to the fox den complex (not shown) at Swimming Bear Lake (MP 18 of the Watana-to-Devil Canyon route). Beaver concentrations at MP 34 and 36 in the vicinity of the Devil Canyon damsite have also been avoided by road realignments, as shown in Figure E.3.82. Particular attention has been given to the golden eagle nest on the cliff along the north side of Devil Canyon at MP 34.5. The access route in this vicinity was realigned to avoid the nest site by 0.5 mile (0.8 km) to the north (Figure E.3.82).

Jack Long Creek, a productive beaver stream, occupies a swale approximately 1700 feet (515 m) south of the Devil Canyon construction village and campsite (Figure E.3.82). This stream and the surrounding wet area are vulnerable to impacts of vegetation removal associated with construction of the camp and village, transmission corridor, and access route. Options to minimize disturbance to Jack Long Creek and resident beaver include resiting the camp and village, selecting road instead of rail access from Gold Creek to provide greater flexibility in access routing, realigning the rail route to the extent feasible, and aligning the transmission corridor away from the creek.

As explained earlier in this section and shown in Figure E.3.39, the camp and village are subject to siting constraints imposed by the occurrence of wet sedge-grass vegetation type in the area, and have been sited on locally higher, drier terrain supporting closed mixed forest. Their locations are considered to be sufficiently flat and distant from Jack Long Creek to prevent erosion runoff into the drainage following vegetation removal.

Selection criteria and rationale for rail access from Gold Creek are explained in Exhibit E, Chapter 10, Section 2.3, and are considered sufficiently favorable to prevent changing access from Gold Creek to road instead of rail. Agency recommendations have consistently supported this position (SHSC 1981, USFWS 1982). Therefore, the rail alignment has been modified to follow the hillside south of Jack Long Creek at approximately the 1600 to 1800 feet (500 to 550 m) contour level, instead of the original alignment on lower ground along the north side of the creek (Figure E.3.82). The modified alignment will keep the railroad extension away from the active drainage area of Jack Long Creek.

The railhead facility at Devil Canyon will consist of a poured concrete pad approximately 2500 feet (758 m) long and 800 feet (242 m) wide, accommodating the main track, two sidings, and areas for equipment, offloading, and storage. The Jack Long Creek drainage and a beaver pond near the head of the drainage system impose difficult constraints on the siting of this facility. The pad was originally sited on the north side of the creek between the streambed and the Devil Canyon campsite. With realignment of the rail extension to avoid impacts to the drainage, the railhead facility has also been relocated south of the creek on relatively flat ground at an elevation of about 1500 feet (454 m). This siting avoids both Jack Long Creek and the beaver pond, and removes any necessity for the rail extension to cross the drainage at this point (Figure E.3.82). Crossing of the drainage to allow access to the camp and construction areas will be accomplished by construction of a bridge with minimal vegetation removal. This issue is discussed further in Section 3.4.2(c) with respect to potential drainage alteration.

The transmission corridor has been aligned to avoid Jack Long Creek and is not expected to produce construction- related impacts on beaver habitat. Access to the corridor for construction will be by temporary bridge across Jack Long Creek from the rail corridor.

In summary, potential effects of construction-related vegetation removal on wildlife habitat have been minimized by routing access and transmission corridors as much as possible away from areas where these structures would disturb big game and fishery resources. In all cases, specific locations of nests, dens, and beaver activity have been entirely avoided by facility siting.

Impacts of vegetation removal during construction have also been minimized by reducing volume requirements for borrow extraction. The options chosen to accomplish this are use of side-borrow and balanced cut-and-fill techniques in access road design, and incorporation of a flexible design speed. As explained above, application of construction procedures depends on types of terrain and soil traversed. Siting of access routes has therefore avoided low, wet areas and made maximum use of well-drained, higher terrain where gravelly soils are available as construction material. This approach has the additional advantage of avoiding potential wetlands and waterbodies, thus minimizing drainage- and siltation-related impacts to aquatic resources.

The section of road from the Denali Highway to the Watana camp (41.6 miles, 66.6 km) follows terrain and soil types which will allow construction using primarily side-borrow techniques. This approach minimizes vegetation removal away from the alignment by confining road construction activities to an approximately 20-feet (6-m) strip along each side of the roadbed. A typical cross-section of a road constructed by side-borrow is shown in Figure E.3.83. The finished road section using side-borrow construction is such that the crown of the road is only 2 to 3 feet (less than 1 m) above original ground level compared with 5 to 6 feet (up to 2 m) for a conventional berm-type, end-dumped section. Thus the side-borrow approach not only minimizes vegetation removal and consolidates disturbance, but also produces less of a visual and physical barrier to passing wildlife.

In side-borrow construction, the road is developed in 800 to 1000 feet (240 to 300 m) segments. Overburden is removed, hauled to the previously constructed segment, and deposited in the previously excavated borrow trenches. Only at the start of construction is overburden deposited on undisturbed vegetation, and then only within the corridor which will be developed subsequently. As the borrow trenches alongside the roadbed are excavated, the borrow is used to build the road. Upon completion, the removed overburden is hauled back from its temporary storage location in borrow trenches of the previously constructed road segment and used to backfill the newly excavated side trenches to provide a 4:1 to 6:1 slope which helps to stabilize and insulate the shoulder (Figure E.3.83). The overburden is then fertilized and seeded.

In contrast to end-dumping, side-borrow does not require the excavation of material sites away from the alignment. As shown in Figure E.3.37, nine borrow areas have been identified along the Denali Highway-to-Watana segment as far as MP 32. These will be excavated only on a contingency basis to support road construction in cases where side-borrow material is not available in sufficient quantities. In this event, excavation required for maximum material extraction to develop a given segment of road will average about 8 feet (2.5 m) in depth and remove vegetation over an area of from 10 to no more than 20 acres (up to 8 ha).

Removed overburden will be stockpiled temporarily in nearby locations selected and prepared on a site-specific basis to minimize runoff potential (i.e., flat, well-drained upland locations not above streams and with no active or intermittent drainage nearby, with appropriate berms and/or trenches), then deposited back in the borrow area and immediately fertilized, scarified and seeded. Material required to support construction of the Denali Highway-to-Watana segment south of MP 32 will be obtained from damsite borrow areas D or E (Figures E.3.37 and E.3.40).

The connecting road between Watana and Devil Canyon crosses primarily low shrub and tundra vegetation types (Table E.3.85, Figures E.3.39-40 and E.3.43- 44) underlain by usable soils with bedrock at or near the surface. This road segment will be constructed by sidehill cutting emphasizing balanced cut-and-fill to minimize ancillary material extraction. As shown in Figure E.3.37, five potential borrow areas have been identified along the route on a contingency basis in the event that additional fill is needed to augment material obtained from sidehill cuts. These borrow areas, if used, will have excavated dimensions not exceeding those described above for the Denali Highway-to-Watana segment.

Balanced cut-and-fill construction generally is feasible only where excessively deep cuts are not required to minimize grades. Routing of the Watana-to-Devil Canyon road has followed gentle-to-moderate slopes where deep cutting will not be required. However, in steeper terrain such as approaches to stream crossings and the high-level Susitna River bridge, requirements for deep cutting have been greatly reduced by incorporating a flexible design speed which will allow steeper grades and shorter-radius horizontal curves than a uniform 55 mph design speed would accommodate. In these cases, design speed will be reduced to no less than 40 mph, minimizing the need for fill material from extraneous material sites. Incorporation of design speed flexibility has also allowed the alterations in alignment to avoid biologically sensitive features described above, as shorter-radius curves were required in some cases.

In summary, impacts of construction-related vegetation removal have been minimized by reducing volume requirements for borrow extraction. This has been accomplished by:

- Access alignments which follow well-drained upland terrain with soils suitable for use as construction material;

- Use of side-borrow and balanced cut-and-fill road and railroad construction techniques; and

- Incorporation of a flexible road design speed to avoid the necessity for deep sidehill cuts with excessive fill requirements.

The disposal of spoil from construction and borrow excavations will create a potential for vegetation removal either through direct burial or through clearing for spoil disposal sites. Spoil will be produced primarily from the processing of excavated rock and gravel required for dam construction, concrete aggregate, and support pads for buildings and temporary service roads. The locations of proposed excavation areas are shown in Exhibit E, Chapter 2, Figures E.2.132-135 and E.2.187-189, and in Figures E.3.37 and E.3.39-40; borrow areas are described in Chapter 10, Sections 2.5.1 (Watana) and 2.5.2 (Devil Canyon).

Large volumes of spoil will be produced between 1986 and 1991. For example, about 60 mcy of material will be required from borrow areas E and I for the outer shell of the Watana dam. About 32 percent by volume of pit-run material from these sites is estimated to be silt and sand which will be removed by washing and screening (wet processing). Therefore a total of about 88 mcy will be excavated, producing about 28 mcy of spoil requiring disposal.

The only cost-effective way to avoid removing vegetation for disposal of the large volumes of spoil produced by dam construction will be to deposit the spoil within the impoundment areas. However, this option must be limited by the need to prevent fines from being entrained by surface water flow. Thus locations for spoil disposal within the impoundment areas must be carefully selected and clearly designated in areas which will quietly pond during filling, well away from turbulent flows associated bed with intake structures.

Approximately 10 mcy of material will be required from Borrow Area D for construction of the impervious core of the Watana dam. Wet-processed spoil from Borrow Area D will be deposited on relatively flat sites within the impoundment area away from the diversion tunnel intakes and main intake approach channel (Exhibit F, Plan F4). Exact locations of spoil disposal areas within the Watana impoundment will be determined during detailed engineering design. Prior to the start of filling in 1991, and while the cofferdams and diversion tunnels are operative, fines will be sequestered by temporary construction berms. However, protection from entrainment during diversion and filling will be provided by locating spoil disposal sites away from areas of turbulence or high-velocity currents, and not solely by berms or other temporary construction measures.

The approximately 28 mcy of spoil produced by dragline mining and processing of material from borrow areas E and I will be disposed of within the excavation limits. It is expected that the mined areas of these sites will pond at river level (1420-1440 feet, 430-436 m) prior to construction of the Devil Canyon dam, and that a larger area pool will form at reservoir level (1455 feet, 441 m) following Devil Canyon development. The pool area will depend on actual excavation limits. A conceptual drawing of the pool is provided in Figure E.2.25.

During excavation of borrow areas E and I, spoil will be deposited temporarily in the vicinity of the gravel processing plants, generally along the northern perimeter of excavation at any given stage in mining. The fines will be contained by temporary construction berms or in temporary pits. Permanent deposition will be above the estimated 50-year flood level of about 1473 feet (442 m). During filling of the Devil Canyon reservoir, the deposited fines will be covered with vegetation slash and debris produced during reservoir clearing. A more detailed description of construction methods--including spoil disposal, siltation control, and site rehabilitation--to be employed at borrow areas E and I will be submitted in March 1983 as part of a supplement to the Susitna Hydroelectric Project Feasibility Report.

Borrow Area G will be excavated between 1995 and 2000 as a source of concrete aggregate for construction of the Devil Canyon dam and ancillary facilities. This borrow area is a first-level terrace site on the south side of the Susitna River, occupying the area between Cheechako Creek and the Devil Canyon damsite. The terrace elevation ranges from about 925 to 1175 feet (280 to 356 m). Aggregate will be processed on the site and spoil deposited in the vicinity of the processing plant, which will change as excavation proceeds. Excavation spoil from construction of the Devil Canyon saddledam will be hauled or transported by conveyor belt and also deposited in Borrow Area G. Fines will be sequestered in bermed cells within excavated portions of the borrow area above the diversion tunnel intake elevation of 870 feet. Spoil will not be inundated until blockage of the diversion tunnel at the start of reservoir filling in 2001. All of Borrow Area G and spoil deposited therein will be entirely inundated by the Devil Canyon reservoir and will lie about 500 feet (151 m) below the surface elevation of 1455 feet (441 m).

Access road construction is not expected to produce non-usable spoil requiring separate disposal sites. Geotechnical alignment studies will be conducted during detailed engineering design to provide data necessary to avoid ice-rich soils. Road construction will utilize materials which allow side-borrow and balanced cut- and-fill techniques which generate no excess spoil.

In summary, vegetation removal will not be required for major spoil disposal during construction of the Susitna Hydroelectric Project. Spoil produced during the Watana and Devil Canyon developments will be deposited in the impoundment areas in a manner which will avoid entrainment during construction or operation, and entirely inundated. This mitigation measure is in agreement with a recommendation of the USFWS (1983).

3.4 - Mitigation Plan

Access road construction is not expected to produce excess spoil.

Construction of the 42-mile (67 km) transmission corridor from Watana to the Gold Creek switching station will occur from 1989 through 1992 (Figures E.3.37-40 and E.3.81-82). This corridor will consist of a right-of-way 300 feet (91 m) in width with two parallel lines of towers spaced 115 feet (35 m) apart from centerline to centerline, and with tower-to-tower spans of 1200 to 1300 feet (364 to 394 m) (Figure E.3.85). During this construction, the Anchorage-to-Fairbanks transmission corridor (including the Willow-to-Healy intertie) will be widened to accommodate an additional single-tower right-of-way 190 feet (58 m) wide. The alignment of the added right-of-way may depart from the previously established corridor in locations where constraints of land ownership, environmental features, or aesthetics are present.

From 1999 through 2001, an 8-mile (13-km) corridor will be built from the Devil Canyon damsite to Gold Creek switching station. This additional corridor will consist of two parallel lines of towers adjacent to the previously constructed Watana-to-Gold Creek configuration, requiring the right-of-way to be widened to 510 feet (155 m) to accommodate the towers four abreast. At that time, the Gold Creek-to- Anchorage transmission corridor will be widened by 190 feet (58 m) to accommodate an additional line of towers. Thus, with construction of the Watana and Devil Canyon dams, two lines of transmission towers will extend from Gold Creek to Fairbanks, and three lines of towers from Gold Creek to Anchorage. A more detailed description of the transmission corridors and their selection is provided in Chapter 10, Section 2.4.

At the start of Watana development in 1985, a 69 kv service transmission line will be constructed along the Denali Highway-to-Watana access road. This line will be constructed using conventional utility poles and removed in 1994 or 1995 upon commissioning of the Watana facility. Clearing of vegetation is not anticipated for construction or maintenance of the temporary service line.

The areal extents of vegetation types potentially to be affected by the Susitna project transmission corridors are summarized in Tables E.3.79, 80, and 86. It should be noted that these areas may change to a limited extent as alignments are refined during detailed engineering design and construction planning. It is further emphasized that these quantities do not indicate areas of vegetation which will actually be removed by transmission corridor construction and maintenance. In fact, as stated in Sections 3.3.4(a) and 3.3.6(a)(iv), the 18,040 acres (7300 ha) required for transmission corridor rights-of-way will be cleared only to a limited extent, as explained in the following discussion.

The Power Authority has developed a mitigative approach for construction and maintenance of transmission corridors in Alaska. Much of the following description is presented in the Power Authority's environmental assessment report for the Anchorage-Fairbanks transmission intertie (Commonwealth Assoc. 1982), an integral part of the Susitna transmission system. However, clearing limits apply specifically to the Susitna project.

Surveying will be required along rights-of-way to locate centerlines and transmission tower positions. The survey work will involve limited cutting of trees and shrub vegetation for line-of-sight staking and distance measuring. No roads will be established during surveying.

Clearing of rights-of-way will be done selectively, with typical clearing limits as shown in Figure E.3.85. The illustrated clearing limits would apply to guyed X-type towers up to 85 feet (26 m) tall on level terrain. Detailed criteria for different types and heights of towers and for differing terrain will be prepared during detailed engineering design. In general, cleaning will be limited as follows:

- The maximum height of vegetation on the inside buffer edge will be 10 feet (3 m).

- The maximum height of vegetation on the outside buffer edge will be 60 feet (18 m).

- A corridor of vegetation not exceeding 10 feet (3 m) in height will be maintained between the transmission lines except at tower sites.

- At tower sites, transverse strips 30 feet (9 m) in width will be cut through to adjacent lines.

- Tower-to-tower span will be 1200 to 1300 feet (364 to 394 m).

3.4 - Mitigation Plan

- The area under the lines, including 5 feet (1.5 m) beyond the outside phases, will be clear cut to within 6 inches (15 cm) of ground level, with growth under 24 inches (62 cm) left in place.

- At tower sites and in areas occupied by access trails (described below) or temporary construction facilities, all vegetation may be cut. Grubbing of stumps and stripping of the organic surface layer will be required for tower erection in some cases.

The above clearing limits will apply only to vegetation within rights-of-way. Outside rights-of-way, there will be additional, limited clearing to remove danger trees and to allow access (described below). Danger trees are trees located outside the clearing limits which are of sufficient height to come in contact with towers, guys, or lines if the tree were to fall. Such trees will be located, flagged, and felled by hand tools or portable power saws, then hauled into the right-of-way for disposal. Special permission will be requested of landowners or land management agencies to allow removal of danger trees.

Clearing of vegetation will be done by Hydro-axe, vehicle-mounted shears, and hand-held power saws. Additional equipment, including bulldozers, will be used to stockpile slash and debris within rights-of-way prior to burning. The stockpiled vegetation will be allowed to dry through the summer immediately following clearing and control-burned under constant supervision at the end of the summer. Burning will help to reduce the potential for spread of spruce budworm and other insects.

The Power Authority intends that ground access be used for construction and maintenance of the transmission corridors. The use of helicopters for these purposes has been carefully considered, because it is recognized that this option would reduce requirements for access-related clearing of vegetation and thus serve a significant mitigative function. However, the limitations of helicopter use include high cost, limited load-carrying capacity, weather-related restrictions, daylight use only (particularly during winter months), and unacceptable safety risks in the vicinity of high-voltage lines and guyed towers.

Construction and maintenance contractors will be required to prepare access plans acceptable to the Power

Authority and controlling agencies or landowners. Minimizing requirements for clearing of vegetation will be an important criterion for the evaluation and approval of these plans. Basic elements of access planning will include:

- Stipulation that existing roads must be used to the nearest point of transmission corridor access;

- Permission for contractors to build construction trails from the nearest points on existing roads to the rights-of-way;

- Stipulation that construction trails be established only after thorough onsite assessment of alternative routes and procedures to ensure minimal environmental disturbance, including avoidance wherever feasible of dense vegetation, stream crossings, wetland and floodplain areas (identified with the concurrence of the COE and USFWS), and extensive switchbacks on steep, erosion-prone terrain; and

- Use of minimum standard trails from tower to tower along the inside cleared portions of the rights-of-way.

For construction of the Watana-to-Gold Creek transmission corridor during 1989-1992, the connecting road between the two damsites will be built as planned and maintained year-round. Construction trails from the main access road to the rights-of-way will be cleared along approved alignments. Because use of the construction trails will be limited to flat-tread or balloon-tire vehicles, fill placement or removal of the organic layer will not be required. From the south bank of the Susitna River to Gold Creek switching station, the railroad extension right-of-way will be developed as a minimum-standard (approximately 20 feet or 6 m wide) road to support transmission corridor construction. Equipment access to Gold Creek switching station will be provided along the intertie right-of-way.

It is anticipated that maintenance-related clearing of transmission corridor rights-of-way will be necessary approximately every 10 years. During intervals between periodic clearing, vegetation within the rights-of-way will be allowed to grow without disturbance, except for the occasional removal of danger trees as required, or localized clearing associated with tower and line maintenance or repair. It is the established policy of the Power Authority that herbicides are not used for any aspect of transmission corridor construction or maintenance.

The selective clearing of transmission rights-of-way will result in enhanced browse production associated with sprouting and succession. Clearing will thus augment other measures to compensate for project-related loss of browse, as discussed in Section 4.4.2(b). Further benefit will be derived by goshawks, sharp-shinned hawks, and other raptors and owls which will hunt along the rights-of-way as discussed in Section 4.3.4(c). These benefits must be weighed against the potentially adverse effect of increased public access which portions of the rights-of-way may provide. The issue of increased access is discussed in Sections 3.3.1(b)(v) and 4.3.3, and below in Section 3.4.2(b).

On-ground evaluations will be made during detailed engineering design and construction planning regarding appropriate management procedures for specific portions of the transmission corridors (e.g., the extent of clearing, maintenance requirements, and potential seeding of areas disturbed during construction). These site assessments will be conducted in coordination with representatives of the USFWS, the ADF&G, and the Alaska Plant Materials Center, as recommended by the USFWS (1983).

Access to transmission corridors has been coordinated closely with access along roads, the railroad extension, and already existing adjacent transmission corridors, as recommended by the USFWS (1983), the Susitna Hydroelectric Steering Committee (1981) and the EPA (1981). Policies on public access during and after construction and along the length of the corridors will be consistent with management policies of agencies and landowners with jurisdiction over the properties traversed by the corridors.

In summary, the direct removal of vegetation as a result of transmission corridor construction and maintenance will be minimized through the application of selective clearing techniques which will remove only vegetation that might impede access, construction, or maintenance of the transmission system. Vegetation removal will be minimized further by constraints imposed on the routing of access trails to the rights-of-way, and especially by alignment of the Watana-to-Devil Canyon access road and transmission right-of-way together along a common corridor. Herbicides will not be used. Selective clearing repeated approximately every 10 years will enhance browse and hunting habitat for moose and certain raptors, respectively, by maintaining cleared portions of the rights-of-way in early successional stages.

The Power Authority will apply all of the minimization measures described above to mitigate impacts of vegetation removal during construction and operation of the Susitna Hydroelectric Project. These measures will begin with potential FERC licensing and scheduled construction startup in 1985, and continue through the 50-year license period to 2035.

Minimization of vegetation removal will affect a significant area and make an important contribution toward mitigating the cumulative impact of the Susitna project on vegetation. The precise areal extent of vegetation cover saved from removal cannot be quantified defensibly until detailed engineering designs and construction plans are formulated, and even then, only on a provisional basis. However, some examples can be provided as follows.

Of the approximately 66,679 acres (26,995 ha) potentially subject to vegetation removal on a cumulative basis, about 30 percent, or 19,236 acres (7788 ha), will allow application of the mitigation measures described above. Approximately 46 percent of the total area covered by transmission corridors (7444 acres [2978 ha] of the total 16,182 acres [6473 ha]) will be left uncleared or partly cleared. In addition, use of side-borrow and balanced cut-and-fill techniques for construction of the access roads and railroad extension will protect up to 280 acres (112 ha) of vegetated area.

Using the two examples cited above, measures to minimize vegetation removal will conserve about 7724 acres (3127 ha), or up to about 40 percent of the land area in question. If spoil produced by processing of borrow material needed for dam construction were deposited outside borrow area excavation limits or outside the impoundment areas, additional vegetation would be removed or burned. For example, deposition of spoil from borrow areas E and I to a depth of 3 feet (.09 m) would cover 5782 acres (2341 ha).

Although the quantities in these examples must be considered hypothetical at the present stage of design, it is nevertheless evident that measures to minimize vegetation removal will have an appreciable mitigative effect on the cumulative impact of project construction and operation.

(ii) Rectification

Certain ancillary project facilities will be required on a temporary basis during construction and vacated when construction has been completed. Vegetation removal resulting from development and use of these facilities can be partially rectified by dismantling the structures, rehabilitating the underlying soils, and preparing the soils to allow reestablishment of vegetation. These options will be followed to rectify effects of vegetation removal during construction of the Watana and Devil Canyon dams.

Lands associated with the following temporary facilities will be rehabilitated in accordance with the schedules shown:

WATANA

Facility & Vegetation	Action	Year	Area (acres)
Construction Camp	Start Const.	1985	78
- Birch Shrub	Complete Const.	1986	78
- Mixed Low Shrub	Dismantle & Reclaim	1994	78
	Dismantle & Reclaim	1995	78
Village	Start Const.	1986	86
- Birch Shrub	Complete Const.	1987	87
- Mixed Low Shrub	Dismantle & Reclaim	1994	86
Construction Roads	Start Const.	1985	120
- Closed Birch Forest	Continue Const.	1986	120
- Closed Mixed Forest	Complete Const.	1987	60
- Open Mixed Forest	Grade & Reclaim	1994	150
- Closed Tall Shrub	Grade & Reclaim	1995	150
- Mixed Low Shrub			
Contractor Work Areas	Start Const.	1985	190
- Closed Birch Forest	Continue Const.	1986	360
- Closed Mixed Forest	Complete Const.	1987	190
- Open Mixed Forest	Dismantle & Clear	1994	740
- Closed Tall Shrub	Grade & Reclaim	1995	370
- Mixed Low Shrub	Grade & Reclaim	1996	370

WATANA (CONT.)

Facility & Vegetation	Action	Year	Area (acres)
Borrow Area D	Excavate	1985	70
- Woodland Black Spruce	Excavate & Reclaim	1986	70
- Closed Birch Forest	Excavate & Reclaim	1987	70 & 70
- Open Mixed Forest	Excavate & Reclaim	1988	100 & 70
- Wet Sedge-Grass Tundra	Excavate & Reclaim	1989	100 & 100
- Closed Tall Shrub	Excavate & Reclaim	1990	100 & 100
- Birch Shrub	Excavate & Reclaim	1991	100 & 100
- Mixed Low	Excavate & Reclaim	1992	100 & 100
Shrub	Reclaim	1993	100

DEVIL CANYON

Facility & Vegetation	Action	Year	Area (acres)
Construction Camp	Start Const.	1994	45
- Closed Mixed Forest	Complete Const.	1995	45
	Dismantle & Reclaim	2002	89
Village	Start Const.	1995	48
- Closed Mixed Forest	Complete Const.	1996	48
	Dismantle & Reclaim	2002	96
Construction Roads	Start Const.	1994	75
- Open Black Spruce Forest	Complete Const.	1995	25
- Closed Birch Forest	Grade & Reclaim	2003	100
- Open Mixed Forest			
- Closed Mixed Forest			

DEVIL CANYON (CONT.)

Facility & Vegetation	Action	Year	Area (acres)
Contractor Work Areas	Start Const.	1994	150
- Open Black Spruce Forest	Continue Const.	1995	150
- Closed Birch Forest	Continue Const.	1996	150
- Open Mixed Forest	Complete Const.	1997	30
- Closed Mixed Forest	Dismantle & Clear	2002	480
	Grade & Reclaim	2003	480
Borrow Area K	Excavate	1995	100
- Open Black Spruce Forest	Excavate & Reclaim	1996	100 & 100
- Closed Mixed Forest	Excavate & Reclaim	1997	100 & 100
- Closed Tall Shrub	Excavate & Reclaim	1998	65 & 100
- Lake	Reclaim	1999	65

TOTAL REHABILITATED AREAS--

- Watana	1986-1996	2079
- Devil Canyon	1996-2003	1130
- Total	1986-2003	3209

Rehabilitation of temporary facility sites will only partially rectify the vegetation loss resulting from their construction. Provided soils are restored, plant succession will proceed at various unquantifiable rates depending on slope, aspect, elevation, soil types, moisture and drainage conditions, and other factors. Without restoration of mineral and organic soils, recovery of forest and shrubland within the project area would require 150 years at the very minimum (McKendrick 1982 personnel communication. Therefore it may be assumed that some semblance of the original pattern of lost vegetation will be restored within 150 years on lands prepared for rehabilitation, but predictions of how plant succession will proceed on these lands over time would be difficult to justify.

3.4 - Mitigation Plan

Because rehabilitation procedures for disturbed lands in Alaska are best developed on a site-specific basis (Brown *et al.* 1978), preparation of a comprehensive restoration plan for the Susitna project has been designated as a task for the detailed engineering design phase. An individual restoration plan will be developed for each area to be rehabilitated. The individual plans will incorporate the following information for use by rehabilitation contractors and monitors:

- Plan view (drawing) of area to be rehabilitated, with limits clearly delineated along with overburden stockpile locations and areas of special concern (e.g., erosion, slumping, oil saturation from equipment maintenance shops, etc.);

- Aerial photographs of the area shown in the plan view, to serve as a photo base for the following overlays;

  . Overlays of original vegetation and soil types and appropriate revegetation classes (Alaska Rural Development Council 1977);

  . Overlay of areas requiring special treatment (e.g., seeding for erosion control, waterbars, extra topsoil, extra fertilizer application, etc.);

- Specific locations for the stockpiling of organic overburden, with special protective measures against drying, wind erosion, and runoff;

- Specific depths and procedures for ripping and scarification during soil preparation;

- Specific quantities and types of fertilizers to be applied; and

- Specific revegetation mixtures to be used for seeding, with application rates (lbs/acre) and methods (drilling or hand broadcasting).

In general, the following procedural overview gives an indication of the approach which will be used for site rehabilitation, based on experience from other projects involving non-arctic interior regions of Alaska (for example, see Pamplin 1979). However, specific restoration plans will provide much greater detail, as described above.

3.4 - Mitigation Plan

The land surface of disturbed areas will be ripped prior to application of topsoil, then graded to contour and evenly covered with organic overburden and topsoil previously stockpiled for this purpose. Fertilizer high in phosphorus (e.g., 10-20-10 or 8-32-16, N-P-K) will be applied at a rate sufficient to supply 85 to 110 kg of nitrogen per hectare.

Following the spreading of organic overburden, topsoil, and fertilizer, the site surface will be scarified to a depth of 12 inches (40 cm) using a rake towed by a mini-Rolligon type vehicle. This procedure will mix the organics with the underlying mineral soil, aerate the mixture, and lightly compact the surface. During the second and third growing seasons, followup applications of fertilizer will be made at one half to one third the original rates.

Where erosion potential or aesthetic considerations can be demonstrated not to be involved, site rehabilitation will emphasize application of organics and nutrients and minimize seeding. The USFWS (1983) concurs with this approach, which will encourage the reinvasion of native species from the surrounding parent population. For lightly disturbed sites with intact topsoil, fertilization alone should be sufficient to facilitate revegetation.

Sites with high erosion or visual impact potential will be fertilized and seeded with fast-growing native grasses appropriate to the climate and geography of the Susitna Basin. To minimize erosion, all sites will be rehabilitated by the first growing season following removal of structures and equipment. Sufficient quantities of seeds for sites requiring revegetation will be stockpiled, and regrowth potentials of available native strains will be tested prior to project abandonment of distrubed sites. Choice of plants for site rehabilitation will be made after consultation with federal and state natural resource agencies. This approach has been recommended by the USFWS (1983).

In summary, rectification will restore vegetation to approximately 3209 acres (1299 ha) temporarily lost to ancillary facilities. This represents about 5 percent of the cumulative total land area affected by direct loss of vegetation during project construction and operation (68,537 acres, 27,339 ha).

Rectification will only be partial because of the long periods (up to 150 years) required for plant succession to preexisting conditions. Individual restoration plans will stipulate detailed procedures to facilitate revegetation on specific sites. Development of these plans is a designated task of the detailed engineering design phase of the project.

(iii) Reduction

Options for the reduction of direct vegetation removal over time involve monitoring project facilities and activities to ensure the most effective use of rehabilitation measures. During project construction and operation, the following three tasks will be performed on a continuing basis:

- Monitoring progress of site rehabilitation to identify locations requiring repeated or altered application of fertilizer and/or seed;

- Systematically identifying and rehabilitating areas where construction activities have ceased and are no longer required; and

- Coordinating rehabilitation efforts with closure and removal of service or temporary access roads no longer required.

These measures will be included in the comprehensive restoration plan described above in Section 3.4.2(a)(ii) and, in fact, will help to focus and implement that plan.

In the construction zone of a large project, disturbed areas partially or wholly without vegetation develop with expansion of the infrastructure of temporary roads, residential quarters, storage yards, equipment maintenance shops, and other ancillary facilities. Although areal extents have been quantified with respect to camps, service roads, contractor work areas, borrow sites, and other facilities, these quantifications can only estimate the actual extent of vegetation removal, because zones of activity will surround these sites. Foot traffic and the movement of vehicles and equipment will tend to enlarge areas of disturbance around centers of activity, despite the consolidation measures described in Section 3.4.2(a)(iii).

One objective of monitoring is to maintain awareness of disturbed areas as they enlarge or as activities diminish, so that rehabilitation can begin as early as feasible. Monitoring of vegetation removal during construction will provide for the application of rehabilitation measures in locations other than or adjacent to the areas specifically targeted in the individual restoration plans, and on an as-needed basis throughout the construction period. Monitoring of vegetation loss will also be conducted during pre-construction field activities and throughout the license period to detect later disturbances during operation and maintenance.

The monitoring program described above will be a component of the project-wide monitoring plan to be established formally during the detailed engineering design and construction planning phase of the project (Section 1.3).

(iv) Compensation

By its very nature, a large hydroelectric development such as the Susitna project will permanently remove a considerable area of vegetation dedicated to the damsites, impoundment areas, access routes, and permanent buildings. For the Susitna project, the cumulative area lost in this way will total about 45,581 acres (18,454 ha), with 44,292 acres (17,932 ha) covered by the impoundments. Actual acreages of vegetation types which will be removed were discussed previously and quantified in Tables E.3.83 and E.3.84.

From the preceding options analysis, it is evident that measures for minimization, rectification, and reduction of vegetation loss will apply, at most, to about 30 percent (19,236 acres, 7788 ha) of the total area of vegetation which will be removed by the project. Loss of the remaining 70 percent can be mitigated only through compensation.

Two compensation options have been considered to mitigate direct loss of vegetation resulting from project constuction and subsequent operation:

- Acquiring lands with areal coverages of vegetation types equivalent to those lost, and protecting the lands from future development; and

- Prioritizing lost vegetation types relative to value as wildlife habitat, and then selectively altering vegetation on acquired lands to replace or exceed lost areal coverages of the high-priority vegetation types.

The second option described above has been selected because habitat enhancement measurs that alter vegetation will allow compensation for loss of high-priority vegetation types while requiring relatively small areas of replacement land.

As indicated in the wildlife impact discussion (Section 4.3), impacts to moose, brown bear, and black bear through habitat loss and alteration have received high priority by project planners. Compensation for loss of vegetation types important to these species will therefore be implemented through habitat enhancement measures on replacement lands in the middle basin and downstream from Gold Creek. A detailed description of this program is provided in Mitigation Plan 6, Section 4.4.2(b). Costs and schedules for the program are presented in Section 4.4.3.

In conjunction with the ADF&G, the USFWS, and the University of Alaska, the Power Authority is currently developing a habitat-based model for moose carrying capacity based on moose bioenergetic requirements and browse nutritional value. This program is described as Nitigation Plan 7 in Section 4.4.2(b) and explained further in Appendix 3.H. Vegetation studies now in progress are providing data to support the modeling program, as described below.

Inventories to quantify physical and nutritional characteristics of moose browse vegetation were conducted in the project area during the summer of 1982, with data analysis continuing through early 1983. A plant phenology study focusing on spring green-up of riparian vegetation along the Susitna River floodplain in the middle basin also was conducted in 1982. Early green-up of riparian vegetation may be an important nutritional source for moose and bears, especially following severe winters. Third, species distribution, abundance, and percent cover of vegetation within a designated 6400-acre controlled burn area on Bureau of Land Management (BLM) land in the Alphabet Hills (east of the project area) were quantified in 1982. This program is being conducted in cooperation with the

Institute of Northern Forestry of the National Forest Service, the ADF&G, and BLM. As described further in Mitigation Plan 6, Section 4.4.2(b), controlled burning is scheduled for August 1983, provided suitable weather conditions occur. Followup studies characterizing post-burn plant succession will be conducted in the future to help assess the suitability of controlled burning as a method for browse enhancement. It is likely that burning woodland conifer forest will produce a herbaceous or shrub stage (Foote 1979) characterized by rapid nutrient turnover, high productivity, and relatively high decomposition rates (Viereck and Schandelmeier 1980). The resulting low shrub stands will provide approximately a three-fold increase in browse biomass (Table E.3.92, Figure E.3.117).

Mapping of moose browse vegetation within the central portion of the middle basin is currently planned. This program, described in Section 3.2.2(a), will provide a means for detailed quantification of browse loss inside and browse availability outside direct impact areas, and facilitate application of the moose modeling program to specific features of the project area. Integrating the mapping and modeling efforts will allow more accurate quantification of carrying capacity loss resulting from the project and will also provide a means for quantifying replacement land requirements.

The identification of replacement lands for habitat enhancement will place highest priority on state and federal lands which can be acquired at minimal or no cost. Alaska Department of Natural Resources (ADNR) statutes (Title 38) set forth provisions for exchanges of state-owned lands on an equal-value basis following appraisal. Because state-owned lands supporting black spruce vegetation types with high enhancement potential are readily available in the project vicinity, it is anticipated that exchanges of state lands with ADNR review and concurrence may provide an avenue for acquisition of replacement lands.

A second avenue for replacement land acquisition is provided by Section 907 of the Alaska National Interest Lands Conservation Act of 1980 (Public Law 96-487). This provision establishes the Alaska Land Bank Program, whereby tax incentives and other benefits are afforded private landowners who make lands available for management of fish and wildlife in accordance with policies of state or federal agencies.

In summary, compensation for permanent vegetation loss will be implemented through the acquisition of replacement lands to be managed for browse habitat enhancement. Vegetation studies and mapping are being conducted to support habitat-based modeling of moose carrying capacity. Modeling results will in turn be used to quantify project-related loss of carrying capacity and requirements for replacement land acquisition. Costs and schedules for elements of these programs are summarized in Sections 3.4.4 and 4.4.3, and in Tables E.3.177 and 178.

(b) Indirect Loss of Vegetation

Vegetation loss will result from slope instability effects during and after filling of the impoundment areas (Sections 3.3.1, 3.3.2, and 3.3.6(b)). As reservoir soils become saturated and slopes settle to new angles of repose, slumping and landslides will occur above and below surface levels. Erosion and slumping will result from melting of permafrost, particularly along the south side of the Watana impoundment where deep permafrost occurs (Section 3.3.1[b][ii]). These effects will be intensified in the Watana reservoir by the yearly periodic freezing, thawing, saturation, and dessication of soils within the 90-foot (27-m) drawdown zone, by hydraulic erosion, and by ice formation. Although precise areal extents and elevation ranges of these effects cannot be reliably quantified in advance, the following areas will be susceptible to vegetation loss (Duncan 19B3 personal communication).

- The 10-mile (16-km) reach from the headwaters of the Watana reservoir (RM 243) to the Oshetna River-Goose Creek area (RM 233), where cliffs of frozen silts and clays occur. Predominant vegetation types bordering the impoundment area in this reach are woodland black spruce and birch shrub (Figure E.3.65).

- The 49-mile (78-km) reach along the south side of the Watana reservoir from the Oshetna River-Vee Canyon area (RM 233-225) to the Watana damsite (RM 184). This reach is underlain by 200- to 300-foot deep (60- to 90-m) discontinuous permafrost. Predominant vegetation along the reservoir margin is woodland and open black spruce and low shrub types (Figures E.3.65- 61).

- The 10-mile (16-km) reach along the north side of the Watana reservoir between the Watana Creek area (RM 194) and the Watana damsite (RM 184). This reach is characterized by unconsolidated glacial outwash, much of it in the 9-foot (27-m) drawdown zone. Predominant vegetation types types along the northern reservoir margin in this reach are woodland and open black spruce, birch shrub, and mixed low shrub (Figures E.3.62-61).

- An old landslide area on the south side of the Devil Canyon impoundment at RM 175, about 2 miles (3.2 km) downstream from the mouth of Fog Creek (RM 177), and 9 miles (14.4 km) downstream from the Watana damsite (RM 194-184). Aerial photographs show this location as forested; and Figures E.3.61 and 60 indicate that woodland and open black spruce, open white spruce, and open mixed forest are the predominant vegetation types.

It is evident that vegetation loss from slope instability, erosion, and blowdown along the reservoir margins will produce a cumulative impact in addition to the direct losses described in Section 3.4.2(a). However, the precise vegetation types, locations, areal extents, and elevation ranges which will be affected by these indirect losses cannot be reliably quantified in advance. Without altering fixed characteristics of the dams and reservoirs, there is no way to avoid, minimize, rectify, or reduce these impacts. Loss of low shrub vegetation, important for browse and berry production, will be compensated for by the land acquisition and habitat enhancement programs described in Sections 3.4.2(a)(iv), 4.4.2(b), and 4.4.3.

Additional indirect losses of vegetation will result from increased human activity within the project area during construction and operation (Sections 3.3.1(b)(v), 3.3.3(a) and (b), 3.3.4(a) and (b), and 3.3.6(b). Nonessential disturbances to vegetation and soils by construction workers cannot be avoided entirely, but substantial minimization will be possible through consolidation of facilities and careful planning of traffic patterns and service roads (Section 3.4.2(a)(i)). Particular attention will be given to infrastructure layout during detailed engineering design and construction planning, including design participation and review by project environmental specialists.

Thoughtful planning and implementation of an environmental briefings program requiring the participation of all field personnel will make an important contribution towards minimizing unnecessary disturbances to soil and vegetation during project construction and operation (Appendix 3.B).

Rectification and reduction of vegetation losses, resulting from activities of construction workers, will be accomplished through the rehabilitation and monitoring programs described in Sections 3.4.2(a)(ii) and (iii).

Increased human activity on public lands surrounding the project (discussed also in Exhibit E, Chapter 5 - Socioeconomics - and Chapter 7 - Recreation) could be greatly diminished by fencing and gating access roads and transmission corridors. However, even with these measures, access would still be available by off-road vehicle (ORV) or all-terrain vehicle (ATV) from the Parks and Denali Highways and through the use of small aircraft. Moreover, fencing along the lengths of access routes and transmission corridors would block free passage of big game.

During construction of the Watana and Devil Canyon projects (1985-2002), public access along the Denali Highway-to--Watana road will be restricted by use of a locked gate supervised by security guards. Public use of the Gold Creek-to-Devil Canyon railroad extension will not be available. These measures will largely avoid increased impacts to vegetation resulting from recreational users and others attracted by the project during construction. It should again be noted, however, that restricting access along the Denali Highway-to-Watana road will not necessarily deter or diminish the existing pattern of access by ORV and ATV from the Denali Highway, Parks Highway, and Gold Creek onto public and private lands surrounding the project.

Vegetation loss and soil damage from public access-related vehicle use will occur following construction and throughout the license period (2003-2035) and may intensify over time as population growth and recreational and hunting pressures increase (see Exhibit E, Chapter 7 - Recreation). ORV and ATV use already is occurring on lands surrounding the project and has resulted in obvious soil damage and vegetation loss, as shown in Exhibit E, Chapter 8 - Aesthetics, Photos 8.D.5 and 8.D.6.

Increased public access as an indirect consequence of the project cannot be entirely avoided by the Power Authority because access to lands surrounding the project is available through ORV, ATV, and aircraft use, as noted above. The project access route does, however, avoid areas south of the Susitna River (Stephan Lake, Prairie Creek, Fog Lakes, as well as the Indian River area) which are valuable as wildlife habitat in keeping with recommendations of the Susitna Hydroelectric Steering Committee (1981).

3.4 - Mitigation Plan

Options to minimize access-related impacts during the postconstruction period include gating on the Denali Highway-toWatana road to restrict access, use of signs to deter vehicle departures from the road, special regulatory designation of the access route to discourage ORV and ATV use, and consolidation of access-related activities through design of the project recreation plan.

Policies governing public access to the project area during the postconstruction years of the license period are currently under consideration. Such policies will require agreement among the land and resource management agencies and private landowners with jurisdiction over lands surrounding the project. Access-related measures of the Power Authority will conform with those policies.

A variety of regulatory options are available for reducing human activity on public lands in the project area. For example, the ADF&G (1983) has noted that measures may be taken by the Boards of Game and Fisheries and by the Commissioner of Fish and Game to relieve hunting and fishing pressures (see Section 4.4.1[b]). These options include entirely closing an area to hunting and fishing or creating a special use area where motorized vehicles are prohibited from hunting. Because hunting and fishing are the primary reasons for use of motorized vehicles within the project area, such measures could substantially change user patterns.

Signs may be used to deter road users from driving their vehicles off the access road onto surrounding terrain, possibly in conjunction with special regulatory designation. For example, the Denali Highway is under review by the BLM for inclusion in the National Scenic Highway System (Ward and Wrabetz 1982 personal communication). The project access route may also be eligible for this designation, which would entail restrictions on off-road vehicle use and other potentially disturbing activities initiated from the access road. However, this measure would also attract people to the project area.

The Susitna Hydroelectric Project Recreation Plan is presented in Exhibit E, Section 7. A major objective of the Recreation Plan is to establish patterns of public access that will minimize and localize access-related impacts through the use of trails and designated camping area. The Recreation Plan is consistent with fish and wildlife habitat protection priorities established for the project. In addition, the phased design of the Recreation Plan will ensure that implementation will be gradual and based on monitoring of fish, vegetation, and wildlife impacts as well as recreational user needs. Implementation of each phase will be subject to interagency review and concurrence.

In summary, vegetation loss resulting from instability along the margins of the impoundment areas and from increased public access to lands surrounding the project will produce a cumulative impact augmenting the impact of direct construction-related vegetation removal. Loss of shrubland browse species will be compensated for by acquisition of replacement lands and habitat enhancement measures, as described in Sections 3.4.2(a)(iv) and 4.4.2(b). Vegetation loss resulting from increased public access will be minimized by confining access routes to areas north of the Susitna River, use of signs and possibly of special regulatory designation to discourage ORV and ATV use, and by phased implementation of the project Recreation Plan with interagency review and concurrence. In addition, a variety of regulatory options are available to resource management agencies to limit access on public lands under their jurisdiction.

(c) Alteration of Vegetation Types

Alteration of vegetation types will be caused by plant succession, changes in drainage patterns, regulated downstream flows, and fire. Plant successional changes will occur along the margins of the impoundment areas as a result of the slope instability processes described in Section 3.4.2(b). Because such changes cannot be quantitatively predicted and because they will involve an increase in productive early-successional stages of value as browse or forage, special mitigative measures are not planned.

Potential changes in surface drainage patterns are of greatest importance where wetland areas are involved. Under Army Corps of Engineers regulations promulgated by Sections 301 and 404 of the Clean Water Act (33 USC 1344), wetlands are defined as "those areas that are inundated or saturated by surface or ground water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR 323.2[c]).

As explained in Section 3.2.3, potential wetlands of the impoundment borrow areas and of the access corridors were mapped using the system of Cowardin et al. (1974), as adopted by the USFWS (1980). Further mapping is being initiated at a scale of 1:250,000 and will delineate wetland vegetation types to classification Level IV of Viereck, Dyrness, and Batten (1982). Preliminary mapping will be available in June 1983 prior to field confirmation during June through October 1983. It is expected that this mapping will provide a detailed and accurate representation of wetland vegetation types within the project area at a scale and resolution satisfactory for Section 404 permit evaluation by the COE in coordination with the USFWS. Two meetings with representatives of these agencies were held in December 1982 to review and define plans for the mapping and to initiate consultation for the purpose of Section 4 permit application planning.

It is not anticipated that the Susitna Project will produce major impacts on wetlands outside the impoundment areas. Two locations of concern have been identified:

(1) The 14-mile (22-km) portion of the Denali Highway-to-Watana access route (MP 24-38) passing near the Deadman Creek drainage (Figures E.3.80-81); and

(2) The Jack Long Creek area (Figure E.3.82).

Major impacts to wetlands in these areas will be avoided by the routing changes and special siting and construction procedures described in Section 3.4.2(a)(i).

During detailed engineering design and construction planning, coordination with the COE and USFWS will continue so that incorporation of proper engineering design to mitigate for potential drainage alterations is assured. The high-resolution wetlands mapping, along with color aerial photographs, will be an important tool in this regard. Proper engineering design and construction planning for wetland areas are considered to be a top-priority component of the project civil engineering program.

During detailed alignment studies for the transmission corridors, project engineers, hydrologists, and environmental specialists will inspect the corridors from the air and ground and make site-specific alignment adjustments to minimize wetland and floodplain crossings. No fill placement will be associated with transmission corridor construction.

As explained in Section 3.3.1(b)(iii), regulated flows will produce changes in vegetation distribution and successional patterns in the downstream floodplain. These changes will be monitored during the postconstruction years of the license period in conjunction with ongoing studies of moose, raptors, and other wildlife by the ADF&G and the USFWS. Downstream aerial photography of the floodplain will be conducted at ten-year intervals beginning in 1988 to document and facilitate analysis of floodplain configuration and vegetation changes in coordination with hydrology and wildlife monitoring.

The effect of fire as a natural process in regulating patterns of plant succession was discussed in Section 3.3.1(b)(v). Fire control will be the responsibility of resource management agencies with jurisdiction over public lands of the project area. The BLM will be responsible for control measures associated with the Alphabet Hills burn (Sections 3.4.2[a][iv] and 4.4.2[b]). Plans and procedures for subsequent controlled burning by the Power Authority as a habitat-enhancement measure will be closely coordinated with BLM.

In summary, the highest priority and greatest effort with respect to mitigation of project-related changes in vegetation will be in regard to wetlands. Detailed engineering design and construction planning will be coordinated with the COE and USFWS representatives as part of the Section 404 planning process.

3.4.3 - Mitigation Summary

As discussed in Section 3.4.2, project impacts to vegetation will be important mainly from the standpoint of loss of wildlife habitat. Therefore, mitigation plans for botanical resources have been determined primarily to support the wildlife mitigation program. Major mitigation plan elements described in Section 3.4.2 are:

(1) Minimizing facility dimensions.

(2) Consolidating structures.

(3) Siting facilities in areas of low biomass.

(4) Siting facilities to minimize clearing of less abundant vegetation types.

(5) Siting facilities to minimize clearing of vegetation types productive as wildlife habitat components.

(6) Minimizing volume requirements for borrow extraction.

(7) Disposal of spoil within the impoundments or previously excavated areas.

(8) Designing transmission corridors to allow selective cutting of trees and to accommodate uncleared low shrub and tundra vegetation within rights-of-way.

(9) Dismantling nonessential structures as soon as they are vacated.

(10) Development of a comprehensive site rehabilitation plan.

(11) Monitoring progress of rehabilitation to identify locations requiring further attention.

(12) Acquisition of replacement lands for implementation of habitat enhancement measures.

(13) Planning and development of an environmental briefings program for all field personnel.

(14) Avoidance of the Prairie Creek, Stephan Lake, Fog Lakes, and Indian River areas by access routing.

(15) Restriction of public access during construction by gating the access road.

(16) Use of signs and possibly regulatory designations and measures to discourage use of ORVs and ATVs.

(17) Phased implementation of the project Recreation Plan with interagency review and concurrence.

(18) Siting and alignment of all facilities to avoid wetlands to the maximum extent feasible.

(19) Agency coordination and participation in detailed engineering design and construction planning of civil engineering measures to minimize potential wetlands impacts.

(20) High-resolution mapping of wetland vegetation within the project area, in coordination with COE and USFWS representatives to be conducted in 1983.

Mitigation schedules and costs are presented in Table E.3.177. A summary of agency consultation is provided in Section 4.4.4.

4 - WILDLIFE

4.1 - Introduction

Populations of many wildlife species inhabit the Susitna project study areas, which for wildlife include the watershed of the Susitna River upstream from Gold Creek (Figure E3.33), a corridor extending approximately 1 mile (1.6 km) to each side of the downstream flood plain between Gold Creek and Cook Inlet (Figure E3.34), transmission corridor study areas 5 miles (8 km) in width from Healy to Fairbanks and Willow to Anchorage (Figure E3.35), and the intertie transmission corridor from Willow to Healy, with a study area varying from approximately 4 to 18 miles (6.5 to 29 km) (Figures E3.35 and E3.37). While the ecological importance of all species that are members of the Susitna basin community is recognized, the emphasis of this report is on the wildlife resources which can be assigned priority based on the irrelative abundance, regional rarity, or their contribution to recreation, susbistence, or commerce. Species classified as threatened or endangered are considered particularly important.

The complexity of interactions and relationships between species in any ecosystem necessitates a system of priorities in the development of mitigation plans. Consequently, some species require less intensive study then others. The content of Section 4.2, the Baseline Description of wildlife resources, reflects this prioritization of species. It should be recognized that the priorities assigned are an aid in developing a mitigation plan with compatible components--with recognized tradeoffs in benefits to some species at the expense of others, but with as little antagonism between incompatible mitigation measures as possible.

Data on the vertebrate fauna in the Susitna basin were collected in several independent investigations. The ADF&G and University of Alaska reports (listed below) provided most of the data and analysis presented in this document. Raw data and quantification to support interpretations are presented whenever these source documents have provided such numbers. In many instances, such quantification has not been provided and this discussion then relies on the interpretation of the investigators. In such cases, a reference to the source document is given to allow the reader access to the same information in its original form. Data sources are as follows: moose - ADF&G (1982a and 1982b); caribou - ADF&G (1982c); Dall sheep - ADF&G (1982d); brown bear and black bear - ADF&G (1982e); wolf - ADF&G (1982f); wolverine - ADF&G (1982g); furbearers - Gipson et al. (1982); and birds and small mammals - Kessel et al. (1982a and 1982b). The most recent information from these continuing investigations was provided by personal communications and unpublished tables to allow the most up-to-date analysis for this report.

4.1.1 - The Vertebrate Fauna

Birds and mammals are the wildlife groups of interest in this study. Kessel et al. (1982a, 1982b) encountered 135 species of birds in the Susitna Basin upstream from Gold Creek (Appendix 3E); 82 species were found along the Susitna River floodplain downstream from Devil Canyon in June 1982 (Appendix 3F). Sixteen species of small mammals--shrews, rodents, and hares are known to occur in the middle Susitna Basin (Kessel et al. 1982a). The middle basin is that area extending outward to the watershed boundary from the Susitna River between its confluences with the Tyone River and the Chulitna and Talkectna Rivers (Figure E.3.3). Moose, caribou, Dall sheep, brown bear, black bear, wolf, and wolverine are big game species that occur in the project area. Furbearers include beaver, muskrat, river otter, mink, pine marten, red fox, lynx, coyote, and short- tailed and least weasel (Gipson et al. 1982). Scientific names of bird and mammal species are listed in Appendices 3.E, 3.F, and 3.G.

4.1.2 - Threatened or Endangered Species

No threatened or endangered species of wildlife has been encountered recently in the Susitna project area. White (1974) observed two peregrine falcons in 1974 along the Susitna River in the Devil Canyon impoundment area, and one inactive nest near the northern transmission line. Kessel et al. (1982a) observed no peregrine falcons or other threatened or endangered species during their 1981 and 1982 studies. The potential presence of peregrine falcons is discussed in greater detail in Section 4.2.3 (a). With the exception of the peregrine falcon, none of the species known to occur in the project area is rare, threatened, or endangered in the state of Alaska.

4.1.3 - Species Contributing to Recreation, Subsistence and Commerce

All big game species of the project area contribute to recreation, and the yearly big game harvest contributes to local and regional subsistence (Exhibit E, Chapter 5). Furbearers contribute to the commerce of fur trappers in the Susitna region. Few birds are hunted in the project area. In theory, birds contribute to nonconsumptive forms of recreation such as bird-watching, but the area is too remote to attract many people who come solely to see birds.

Moose, caribou, black bear, and brown bear are the most abundant big game species in the project area and are given highest priority. Dall sheep, wolf, and wolverine are regionally less abundant and are assigned secondary importance. Furbearers are considered less important than big game species. Beaver, marten, and muskrat are common enough to be readily available to trappers but have limited economic importance. Otter, mink, red fox, coyote, lynx, and weasel are given low priority.

4.2 - Baseline Description

Bird and small mammal species contribute little to consumptive use in the Susitna basin. Certain bird species, such as bald and golden eagles (which have received national protection), trumpeter swans and other waterfowl, can be identified as high profile species and assigned priority on that basis. Other birds and small mammals have historically contributed little to recreation, subsistence, or commerce in the project area. In addition, each group includes a large number of regionally abundant species of which few can be assigned priority over others. These factors preclude a detailed analysis of the biology and anticipated impacts to individual species of small mammals and birds of the middle and lower Susitna basin. However, behavioral characteristics of these small-bodied animals, such as small movements and home range and use of micro-habitats, serve to justify their treatment in groups of organisms with superficially similar requirements that will be affected in similar ways. These biases in treatment relative to the higher priority species are alleviated somewhat by the fact that mitigation serving to preserve habitat for larger species will also serve to protect an assemblage of the small birds and mammals essential to the maintenance of a functioning wildlife community.

4.2 - Baseline Description

4.2.1 - Big Game

(a) Moose

Studies of moose in the Susitna Basin have been conducted by the Alaska Department of Fish and Game in two discrete areas: (1) the middle and upper Susitna Basin, including all parts of the watershed upstream from the Devil Canyon damsite, and (2) the lower Susitna Basin, including the major valley and floodplain of the Susitna River from Devil Canyon downstream to the river mouth at Cook Inlet. The river basin below Devil Canyon can be divided into 3 sections based on river morphology. Between Devil Canyon and Talkeetna the river is then characterized by rapid flow in a single channel less than 500 feet (150m) wide, with widely separated islands covered with mature forest. The banks are steep and covered with alder shrub and spruce-birch forests. Between Talkeetna and Montana Creek the river widens 1.2 miles (2 km) and becomes braided with many small islands in a broad floodplain. Below Montana Creek the river is generally very broad, between 3 and 12 miles (5-19 km), with up to 15 channels and numerous sloughs and oxbow lakes. Disturbed habitats are much more abundant because of a long history of settlement and other development effects. Adjacent shores and large islands are heavily forested.

4.2 - Baseline Description

Studies in the middle and lower Susitna basins have addressed different aspects of moose ecology. The differences in approach primarily reflect the differences in topography and vegetation in each portion of the basin, as well as differences in the development scenarios and potential impacts in the two areas. Consequently, comparable information on moose in all areas of the Susitna Basin is not always available. The following discussion of moose ecology in the Susitna basin provides a summary of the current state of knowledge for moose in the middle and lower portions of the basin. Similarities and differences in various aspects of moose ecology that may be influenced by the Watana and Devil Canyon projects will also be discussed.

Most of the information contained in the following discussion is based on studies by ADF&G (1982a,b) in the middle and lower Susitna basins. Additional studies and communications are cited as necessary.

(i) Distribution

Moose occur throughout the Susitna River drainage and, because of their regional contribution to subsistence, are one of the most economically important wildlife species in the region (see Chapter 5). Within the Susitna Basin, moose tend to be most abundant in the upstream area east of and including Tsusena and Kosina Creeks and within the main Susitna valley downstream from Montana Creek to the river mouth at Cook Inlet. Low numbers of moose presently inhabit the area between Devil Canyon and Talkeetna.

- Seasonal Movements

Moose in many northern areas undergo regular seasonal movements or migrations (see LeResche 1974 and Coady 1982 for a review). LeResche (1974) described moose migrations as regular annual movements that involve return to at least one common area each year. In some areas such as the Arctic Coastal Plain of Alaska (Mould 1979) or northern Minnesota (Van Ballenberghe and Peek 1971), migratory movements may involve distances of only 1.2-6.2 miles (2-10 km) with little change in elevation. Migrations in mountainous areas usually involve large changes in elevation. Horizontal differences between summer and winter ranges may be as little as 1.2 miles (2 km) (Knowlton 1960) or as great as 105 miles (170 km) (Barry 1961). In interior Alaska, moose spend the summer at low elevations, move to high elevations during fall and early winter, and return to lower elevations during mid- to late-winter (Bishop 1969). Migration of moose appears to be an adaptation to optimize seasonal use of forage habitats (Coady 1982).

Weather conditions, particularly snow depth and structure, are among the most important factors associated with moose migration (Coady 1974, LeResche 1974). Winter severity may influence the distance moved by individuals as well as the proportions of moose in a population that migrate to different areas. For example, during a winter of light snow in south-central Alaska, some groups of moose overwintered on summer ranges while other groups migrated to adjacent winter range (Van Ballenberghe 1978). During winters of deep snow, however, almost all of the moose migrated from the summer ranges to low elevation winter ranges.

In the middle Susitna Basin, some groups of moose exhibit seasonal shifts in distribution. Other groups undergo very limited seasonal movements and remain in low elevation riparian and forest communities year-round. ADF&G (1982a) delineated 13 subpopulations of moose in the middle Susitna Basin on the basis of seasonal movement patterns.

Over 2700 radio locations obtained from 207 moose during the period from October 1976 through August 1981 indicated that most moose in the middle Susitna Basin moved to lower elevations during late spring and early summer; mean elevations of relocations for April and May were 2575 feet (785 m) and 2641 feet (805 m), respectively (ADF&G 1982a). As summer progressed, moose moved to higher elevations and commonly remained there throughout the winter period. The highest mean elevation of 2956 feet (901 m) occurred in December.

These seasonal trends in elevation are quite different from seasonal patterns observed during previous studies in the middle Susitna and Nelchina river basins. Van Ballenberghe (1978) and Ballard and Taylor (1980) both observed that moose tended to occupy areas at 2500-2999 feet (762-914 m) elevation during the summer and moved to elevations of 1798-2202 feet (548-671 m) during the winter. ADF&G (1982a) attributed the use of higher elevations by moose during 1980 and 1981 to mild winters, and suggested that high winds and temperature inversions resulted in reduced snow depths at higher elevations. Browse was consequently more accessible in these areas than at lower elevations.

Use of regional areas within the middle Susitna Basin by moose also appears to be influenced by slope steepness. Slopes were classified into four broad categories: flat--0 to 10°, gentle--11 to 30°, moderate--31 to 60°, and steep--61 to 90°. During both summer (May to August) and winter (November to April), 91 percent of moose relocations occurred on flat and gentle slopes (ADF&G 1982a). The aspect of the slope, however, did not appear to influence moose locations.

Detailed information on the distribution of moose in the lower Susitna Basin is limited to the current studies being sponsored by the Power Authority (ADF&G 1982b). An unspecified total number of relocations for 3 males and 3 females between mid-April 1980 to mid-March 1981, and 7 males and 25 females between mid-March and October 1981 are presented by ADF&G (1982b).

In general, riparian habitats are at least seasonally important to moose in all reaches of the lower Susitna River. Winter ranges for moose throughout the lower Susitna Basin are located in riparian areas. Riparian communities are also commonly used as calving areas by moose north of Talkeetna, as year-round habitat for moose in the Delta Island area, and as transition range for moose south of Talkeetna (ADF&G 1982b). (Moose in the area south of Talkeetna appear to utilize seasonal ranges on both sides of the river valley.)

- Special Use Areas

  . Calving Areas

  Parturition generally occurred between May 15 and June 15 in the years 1977 to 1980. To determine whether calving concentrations occurred in or adjacent to the proposed impoundment areas, all observations of radio-collared cow moose (n=37 in 1980; n=53 in 1981) in the middle Susitna Basin were plotted (see Figure E.3.86) (ADF&G 1982a). Although this method includes some cows which were not observed with calves, it does provide locations of areas where cows probably calve. (This error is likely small because calf mortality immediately following birth is high [Ballard and Taylor 1980, Ballard et al. 1981a] and many parturient cows would consequently not be observed with calves.)

Cow moose were distributed throughout the middle Susitna Basin, but several concentrations of radio-collared cow moose were observed (ADF&G 1982a). These included: Coal Creek and its tributaries; the Susitna River from the mouth of the Tyone River downstream to a point several miles downstream from Clarence Lake Creek; Jay Creek to Watana Creek; the area in the vicinity of the mouths of Deadman and Tsusena creeks; Fog Creek to Stephan Lake; and opposite Fog Creek to Devil Creek. Low shrub and open spruce habitats were the most common cover types in the vicinity of these concentrations. The importance of these sites as traditional calving areas is not known.

Calving ranges for 36 moose were obtained in the lower Susitna Basin (ADF&G 1982b). Within the lower Susitna Basin, calving concentrations upstream from Talkeetna occurred in cover types different from those used downstream from Talkeetna. Six of 10 females and neither of two males north of Talkeetna were in riparian habitat during calving. Only 4 of 21 moose south of Talkeetna were in riparian habitats during calving. Radio-collared females upstream from Talkeetna generally moved to riparian or island habitats during the calving period (ADF&G 1982b). Cottonwood was the predominant cover type in the vicinity of most relocations during the calving period.

In contrast, radio-collared cow moose in the Susitna Valley south of Talkeetna generally left the overwintering riparian areas by late April and did not return to these areas until well after the calving period (ADF&G 1982b). A possible calving concentration was observed in the vicinity of Trapper Lake, but most cow moose were widely dispersed at varying distances from the

Susitna River (ADF&G 1982b). On average, cow moose were located 9.1 miles (14.7 km) from the river during the calving period. However, several females calved on the river islands and remained there throughout the year. Cow moose in the area south of Talkeetna were generally observed in cover types more typical of calving habitat in other areas of Alaska (e.g., Rausch 1958; Bailey and Bangs 1980); a mosaic of spruce and alder interspersed with muskeg bog meadows was the most common cover type near relocations (ADF&G 1982b).

A common feature of calving habitats in the lower Susitna Basin is their close proximity to water (ADF&G 1982b). Although the presence of water may be an important attribute of calving sites, it is more likely that cow moose seek these areas because of the availability of newly growing herbaceous vegetation (LeResche and Davis 1973, ADF&G 1982b). Such vegetation would provide lactating cows and newborn calves with a readily available source of easily digestible, highly nutritious forage (Weeks and Kirkpatrick 1976, Fraser et al. 1980).

- Breeding Areas

Breeding concentrations in the middle Susitna Basin were determined by plotting the locations of all radio-collared cow moose (n=37 in 1980) between September 20 and October 20 during 1977 to 1980 (see Figure E.3.87) (ADF&G 1982a). Most cow moose occupied upland sites away from the proposed impoundment areas (ADF&G 1982a). Concentrations occurred in the following areas: Coal Creek to the big bend in the Susitna River; Clarence Lake; uplands between Watana and Jay Creeks; Stephan Lake to Fog Lake; and the uplands above the mouth of Tsusena Creek. Other concentration areas away from the proposed impoundments include northwestern Alphabet Hills, the Maclaren River, and the area upstream from the mouth of Valdez Creek (ADF&G 1982a).

In the lower Susitna Basin, few moose were observed in riparian habitats during the breeding period (ADF&G 1982b). With the exception of moose that remained in riparian communities or on the river islands throughout the year, most moose were located farther from the Susitna River during the rut than during the calving period (ADF&G 1982b). Average distances from the river were 9.6 miles (15.5 km) and 15.4 miles (24.8 km) for cow and bull moose, respectively. Use of specific cover types during the breeding period was not assessed.

- River Crossings

Between October 1976 and December 1981, 33 radio-collared moose made a minimum of 73 crossings of the middle Susitna River. Of 40 river crossings by radio-collared animals during 1980-1981, all occurred during the months of May through November. Distributions of the crossings were: May - 20 percent, June - 7.5 percent, July - 12.5 percent, August - 12.5 percent, September - 25 percent, October - 12.5 percent, and November - 10 percent (ADF&G 1982a).

Track surveys on March 24, 1981, provided observations of an additional 73 crossings of the Susitna River by moose. Based both on crossings by radio-collared animals and on track sightings, records of crossings of the Susitna River occurred throughout the proposed impoundment areas. However, crossings tended to be concentrated in several major areas along the Susitna River; these included from Goose Creek to Clearwater Creek, Jay to Watana Creeks, from the mouth of Deadman Creek upstream for approximately 5 miles (8 km), and the mouth of Fog Creek downstream to an area near Stephan Lake (ADF&G 1982a).

Information on movements of radio-collared moose in the middle Susitna Basin between October 1976 and mid-August 1981 suggests that some of the above crossing concentrations may be associated with migratory movements. In general, movement patterns of most moose approximated the drainage patterns of creeks and tributaries of the mainstem rivers (Figure E.3.88). Consequently, most movements in the middle Susitna Basin involved a north-south movement pattern. Crossing sites for these generalized movements that occur within the proposed impoundment areas include the lower portion of Watana Creek, the Jay-Kosina creeks area, and the movement corridor along the Susitna River. No river crossings by moose have been documented in the reach between Devil Canyon and Portage Creek, where steep canyon walls physically prevent crossings.

(ii) Habitat Use

- Cover Requirements

Because moose are largely dependent on woody browse during winter and late spring, their distributions are more closely associated with the distribution of commonly utilized browse species than with other environmental factors (Coady 1982). However, the minimum requirements of moose for winter food and cover appear to be satisfied by a great diversity of habitat types across North America, suggesting that moose are adaptable to a variety of conditions.

Habitat use by moose is most extensive areally during the summer and fall and is gradually restricted during the winter (LeResche et al. 1974). Lowland and upland climax shrub communities are heavily utilized during summer and fall. By early winter, moose commonly move to upland and lowland seral communities. During winters of deep snow, upland seral communities are abandoned in favor of lowland areas (ADF&G 1982a).

In western North America, shrub communities are the most important winter habitats for moose (LeResche et al. 1974). In particular, riparian willow (Salix spp.) stands provide high quality winter range. (However, moose highly prefer some species of willow over others.) Maximum use of these areas occurs during mid- to late-winter and during severe winters. Areas of coniferous forests adjacent to riparian communities provide bedding areas and cover and so enhance the value of these shrublands for moose.

Riparian communities are perhaps the most important shrub habitats for moose (Coady 1982). Because riparian areas are frequently disturbed by alluvial action, they provide permanent seral habitats. Important seral shrub habitat is also created by fire, clear-cutting, and other disturbances that remove climax vegetation cover (LeResche et al.

1974, Davis and Franzmann 1979). However, because moose avoid large clear-cut areas (Hamilton and Drysdale 1975), widescale removal of mature forest cover can result in a reduction in moose habitat value, despite the increase in shrub growth. Following fire in Alaska, the optimum age of browse growth is less than 50 years and moose utilization of these areas usually peaks 20-25 years after burning (LeResche et al. 1974).

Site-specific information on habitat use by moose in the middle and lower Susitna basins was based on aerial assessments of the dominant plant species in the vicinity of each moose relocation (ADF&G 1982a, 1982b). Although this method of evaluating habitat use provided some information on the apparent preference for different forest cover types, two problems were apparent.

The first problem is associated with diurnal differences in habitat use by moose. Linkswiler (1982) showed that habitat use by moose in Denali National Park was strongly associated with the time of day. In general, it appeared that moose rested in forested areas during the day and became active in more open cover types during the early morning and evening. Observations of habitat use in the Susitna Basin consequently may not accurately reflect the importance of some habitats to moose for activities such as feeding or nursing, except during the winter when habitat use is not greatly influenced by time of day.

The second problem associated with the assessment of moose habitat use during aerial surveys is that overstory cover types may not accurately reflect habitat components, such as browse availability, that strongly influence use by moose (see Section 4.3.1(a) [iii]). For example, ADF&G (1982a) indicated that the middle Susitna and Nelchina River basins contain approximately 24 species of willow (Salix spp.); yet moose commonly utilize only a few species of willow as browse (Wolff 1976). Because the distributions of willows and other shrubs are not directly related to forest cover types, assessments of habitat use by moose on the basis of forest cover types is probably misleading. Approximate equivalents for aerially assessed cover types and Viereck and Dyrness (1980) vegetation types are shown in Table E.3.87. Complete descriptions of the plant communities associated with each vegetation type appear in Tables E.3.53 to E.3.69.

. Habitat Use in the Middle Susitna Basin

In all seasons, spruce cover types were the areas most frequently used by 207 radio-collared moose in the middle Susitna Basin during the period October 1976 to August 1981, with sparse- and medium-density, medium-height black spruce (see Table E.3.88) comprising 40.5 percent of the total observations (ADF&G 1982a). Assuming that Linkswiler's (1982) results apply to the Susitna Basin, spruce habitats likely represent bedding or resting habitats. The combined areas of conifer forest and shrubland account for only 59 percent of the total area in the middle Susitna Basin, but based on the aerial surveys, received over 90 percent of the year-round use by moose.

Moose use of upland shrub habitats corresponded closely with observed elevational movements of moose in this part of the Susitna Basin (Table E.3.88). Moose were rarely observed in upland shrub habitats just prior to calving in April when they tended to be at low elevations (ADF&G 1982a). Use of the upland shrub habitat increased during the summer and peaked in October when 43 percent of all moose observed were in upland shrub habitat (ADF&G 1982a). High proportions of moose observed were in upland shrub habitat throughout the winter (ADF&G 1982a). As discussed earlier, the high use of this cover type during the winter is likely the result of mild winter conditions and consequently may not accurately represent moose habitat affinities during more severe winters.

During calving in May, 140 (52 percent) of 271 moose in the middle Susitna Basin were observed in sparse-to-medium-density, medium-height spruce habitats (ADF&G 1982a). These habitats, which generally occur near the river and its tributaries, may be selected by parturient females because of the availability of escape cover and the early green-up of the vegetation (ADF&G 1982a). Habitats such as birch, alder, and dense spruce cover types were not commonly used during the calving period (ADF&G 1982a).

. Habitat Use in the Lower Susitna Basin

Habitat use data in the lower Susitna Basin are derived from relocations of 10 moose captured and and radio-collared in April 1980 and 29 moose captured and collared in March 1981. Winter relocations are available only for the 10 moose captured in 1980. Additional data on winter habitat use in the lower basin are being collected and will be available in June 1983 (Modafferi 1983, pers. comm.).

Habitat affinities of moose in the lower Susitna Basin differed among the areas south of and north of Talkeetna and, in some cases, appeared to be influenced by both the sex of the animal and the season (E.3.89, E.3.90 and E.3.91). Because these results are based on a relatively small number of relocations for a small number of moose, differrences in habitat use among male and female moose and among seasons may not be significant.

Fifty-four relocations were made of the 2 male moose collared north of Talkeetna between mid-March and mid-October 1981. All relocations were in nonriparian communities and most were dominated by alder, spruce and birch cover.

Eight females collared north of Talkeetna provided 217 relocations. One hundred and ninety-six were in nonriparian communities dominated by alder, birch, and spruce. Seventy-six percent of the 21 riparian relocations were during the calving period. Riparian relocation sites were dominated by balsam poplar, alder, and willow.

Five males radio-collared south of Talkeetna provided 160 relocations, 147 in nonriparian habitats dominated by alder, birch, and spruce. The 13 riparian relocations were in sites dominated by alder, birch, spruce, and willow (Table E.3.90). Nineteen females south of Talkeetna provided 512 relocations. Four hundred and nine nonriparian relocations were dominated by alder, birch, and spruce. One hundred and three riparian relocations were in sites dominated by alder, spruce, birch, and balsam poplar (Table E.3.91).

4.2 - Baseline Description

- Food Habits

Moose are primarily browsers, feeding predominantly on deciduous woody browse during winter months and on emergent and herbaceous plants as well as leaves and leaders of shrubs and trees during the summer (see Peek 1974 for a review). Food habits of moose are strongly influenced by browse availability, and thus there are some differences in the importance of various browse species to moose in the middle and lower portions of the Susitna Basin.

Browse utilization studies using the point-centered quarter method were conducted at randomly selected sites in the middle basin in 1982 (McKendrick 1982 unpublished data). Only twigs at least 19 inches (50 cm) above ground were included, since snow precluded use of twigs below that height during most winters. The percent utilization of the most common moose browse species for all stands combined (n=2712) were as follows: Richardson willow (9.8 percent); grayleaf willow (8.9 percent); diamondleaf willow (8.3 percent); Sitka alder (5.3 percent); and resin birch (5.0 percent). Resin birch is the most common browse species in the middle basin.

A preliminary estimate of the winter carrying capacity for moose of the Watana impoundment zone (including all borrow areas, camps, village, and damsite) and the Susitna watershed upstream from Gold Creek was calculated from browse biomass estimates (n=678) obtained in 1982 (Table E.3.92). A detailed description of the methods used to determine the browse biomass and the assumptions involved in calculating carrying capacity are included in Appendix EH. The number of moose-days the area can support is based on a winter food intake value of 5.0 kg dry weight per day (Gasaway and Coady 1974), and includes only the twigs of the primary browse species listed above. Based on the assumptions, the areas within the impoundment zone and facilities near the damsite could support a resident population of 301 moose for 180 winter days. The upper and middle basins together have a winter carrying capacity of 23,037 resident moose. This estimate will be greatly improved through the use of simulation modeling of moose energy and protein needs (see Section 4.3.1(a) [iii]). The summer carrying capacity of the impoundment zone and nearby facilities (based on a daily consumption of 11 kg dry weight) is about 5 times that calculated for winter.

4.2 - Baseline Decription

Chatelain (1951) examined rumen contents of moose obtained from kills along the Alaska railway and from hunter kills in the lower Susitna Valley in the Talkeetna-Houston area. Willows, paper birch, balsam poplar, and trembling aspen constituted most of the winter diet. Shrubs such as alder, wild rose, and high-bush cranberry were rarely consumed. A similar analysis by Shepherd (1958) also indicated that the winter diet of moose in the lower Susitna Valley was composed primarily of willows, paper birch, and trembling aspen. However, because both of these studies involved moose from nonriparian habitats at some distance from the Susitna River, they probably do not accurately reflect the diets of moose overwintering in riparian communities and on river islands in the Susitna River. In particular, trembling aspen is not present in riparian communities and so would be unavailable to moose as a winter forage.

Browse availability and utilization measurements were obtained from a number of riparian sample sites along the Susitna River during 1980 (ADF&G 1981). Five browse species were considered: willows, balsam poplar, paper birch, highbush cranberry, and wild rose. A mean of 0.13 browse plants/ft^2 (1.4/m^2) was recorded for all habitat types in the Susitna River valley between Portage Creek and the Delta Islands. Browse species were most utilized in equisetum/willow and medium-tall poplar/willow/alder habitats and least utilized in medium-dense climax poplar/spruce and sparse climax birch/spruce.

Percent utilization of willow and poplar was greatest in habitats where they occurred less frequently (ADF&G 1981). Birch was seldom found on floodplain habitats, but where it occurred near the river, it was well utilized (26.9 percent). Highbush cranberry and rose were found mostly in tall or climax habitats but were less abundant than willows. Utilization of highbush cranberry and rose was also less than that of willows.

General observations indicated that alder was seldom browsed by moose but in some localities a small alder clump would be heavily browsed (ADF&G 1981). Some islands with high quality browse were not used by moose every winter; moose sign on some islands indicated heavy use in the past but no use during the winter of 1979-1980.

4.2 - Baseline Description

- Home Ranges

Moose population studies in both the middle and lower Susitna basins involved biotelemetry assessment of local and seasonal movements and home ranges (ADF&G 1982a, 1982b). A considerable volume of information on home range locations, sizes, and distance relationships to the proposed impoundments or river channel was obtained. The following discussion of home ranges will concentrate on the numbers of home ranges that may be potentially affected by the impoundments in the middle Susitna Basin and by modification of riparian communities in the lower Susitna Basin.

. Middle Susitna Basin

To determine the number of moose that seasonally and annually occupy areas within or immediately adjacent to the impoundment areas, ADF&G (1982a) delineated a 28.7-km (17.8 mile) zone around the impoundment area. The width of the zone was the average length of the annual home ranges of 162 radio-collared moose in the middle Susitna Basin for which four or more observations had been made during 1980-1981. Based on total home range polygons for 168 radio-collared moose, ADF&G (1982a) found that 19 had home ranges that fell outside the 28.7-km (17.8 mile) zone. Of the 149 moose with home range polygons either partially or entirely within this zone, 79 moose had home range polygons which were either partly or entirely contained within an area that encompassed the proposed impoundments and an arbitrarily selected 5-mile (8-km) wide zone adjacent to the impoundment (8 km is approximately 1/3 of the average home range length). Based on an estimate of 4500 moose for the middle Susitna Basin, ADF&G (1982a) calculated that up to 2402 moose may have home ranges that completely or partly overlap the proposed impoundment area and the area within 5-miles (8-km) of the impoundment. A number of problems concerning equal catchability of animals, sampling intensity, and emigration/immigration of animals probably invalidate the results of the above analysis (ADF&G 1982a). However, it does provide an approximation of the number of moose that could conceivably be affected by the proposed impoundments and facilities.

. Lower Susitna Basin

All moose for which home range data is available in the lower basin were captured on or immediately adjacent to the Susitna River on April 17, 1980 or March 10-12, 1981. Riparian habitats of the lower basin are assumed to be winter range used in at least some years by all of these individuals. Most individuals of both sexes leave the riparian areas by mid-April (Table E.3.93), the males leaving 2-3 weeks earlier than females. ADF&G (1982b) divided the radio-collared sample into 3 loosely defined subpopulations, based on capture and relocation data (Table E.3.94). All of these groups were found at greatest distances from the Susitna River in the summer (July 1 to August 31) and/or breeding (September 14 to October 31) periods. Downstream westside moose (moose radio-collared downstream from Talkeetna and spending the breeding season on the west side of the Susitna River) were found farther from the river than other groups; 4 miles (10.74 km) average for 13 females in the breeding period, and 12 miles (31.5 km) average for 2 males in the summer period.

Moose collared in the area upstream from Talkeetna and on the west side of the river were commonly relocated either within the river downstream from Talkeetna (i.e., river islands) or within 1 mile (1.6 km) of the river (most of this area would presumably be riparian communities) (Table E.3.95) (ADF&G 1982b). In contrast, moose on the east side of the river downstream from Talkeetna did not commonly frequent the river or riparian areas (ADF&G 1982b). However, because of small samples, the above use patterns should be considered preliminary. Biotelemetry studies of moose in these riparian communities are continuing so that the number of moose potentially influenced by these changes can be better assessed. These data will be available in June 1983.

(iii) Population Characteristics

- Historical Population Trends

Although moose population studies specific to much of the middle Susitna Basin were not initiated until the late 1970s, the Alaska Department of Fish and Game has been conducting annual aerial censuses in Game Management Unit (GMU) 13 since 1955 (ADF&G 1982a). Portions of GMU 13, specifically Count Area (CA) 6, CA 7 and CA 14, occur partly or entirely within the middle Susitna Basin (Figure E.3.89); survey data for those areas are presented in Tables E.3.96 through E.3.98. Historical descriptions of moose populations within GMU 13 are provided by Rausch (1969), Bishop and Rausch (1974), McIlroy (1974), and Ballard and Taylor (1980). The following discussion is based on ADF&G (1982a).

During the 1950s, moose populations in GMU 13 increased rapidly and reached high densities about 1960. After the severe winter of 1961-1962, the population declined and continued to decline with severe winters occurring in 1965-66, 1970-71, 1971-72, and 1978-79. Fall cow-calf ratios, as well as several other indices of population productivity, declined sharply and reached a record low for the basin in 1975. Sex and age composition data for CA 7 and CA 14 have basically exhibited the same patterns described for the unit. Since 1975, the moose population appears to have increased slightly or remained stable, even though calf survival has remained relatively low.

- Population Estimates - Middle Susitna Basin

In order to obtain accurate estimates of moose population sizes in portions of the middle Susitna Basin, ADF&G (1982a) intensively surveyed CA 7 and CA 14 during November 5-8, 1980. Moose populations in all portions of the middle basin were not surveyed because of unfavorable snow conditions and the high costs of intensively surveying such a large area. During the aerial surveys of CA 7 and CA 14, a total of 743 moose were observed within 26 sample areas comprising 234,240 acres (948 km^2), or an equivalent of 39 percent of the two count areas combined.

A moose census is conducted by first stratifying, or partitioning, the census area into subunits (strata) having similar moose densities. Moose densities within strata designations are relative values within a particular census area only. The evaluation of moose densities during a stratification flight is based on the number of moose sighted, the density of moose tracks, vegetation type and elevation, and prior knowledge of the area. Each strata contains numerous sample units (SU), which are areas of 8-20 mi^2 (21-52 km^2) aligned around topographic features. A subset of SUs from each strata are randomly selected to be intensively surveyed, and the results are then extrapolated to the entire census area based on the density estimate for each strata.

Table E.3.99 summarizes the calculations utilized to estimate the fall moose population in CAs 7 and 14 east of Jay and Kosina Creeks during the early winter of 1980. Of the 604,800 acres (2447 km^2) census area, 35 percent was classified as low moose density, 38 percent as medium moose density, and 27 percent as high moose density. Based upon census data, each stratification was estimated to contain the following number of moose/acre: low - 0.0045, medium - 0.0075, and high - 0.0151 (1.12, 1.85, and 3.73 moose/km^2, respectively). The estimated total fall population for CAs 7 and 14 was 1986 $\pm$ 371 (90 percent confidence interval) (ADF&G 1982a).

Because all moose would not be observed at a survey intensity of 0.007 min/acre (1.7 minutes/km^2), portions of 10 sample areas were randomly chosen and were resurveyed at a sampling intensity of approximately 0.019 min/acre (4.6 minutes/km^2) in an effort to generate a sightability correction factor. Based on comparisons of total moose counts during both sets of surveys, it was estimated that 98 percent of the moose were observed during the first surveys, yielding a correction factor of 1.03. The corrected population estimate for CA 7 and CA 14 was 2046 $\pm$ 382 (90 percent CI), of which 22 percent were calves (ADF&G 1982a).

ADF&G (1982a) were unable to intensively census the portion of the middle Susitna study area west of Delusion and Kosina Creeks because of unfavorable snow conditions, but an estimate of moose numbers in this area was obtained during a short survey on November 29, 1980. Stratification of the survey area indicated that of the 531,200 acres (2150 km^2) considered, 359,680 acres (1456 km^2) were classified as low density, 156,160 acres (663 km^2) as medium density, and 7,680 acres (7,680 acres) as high-density moose areas. Based on this stratification, a crude population estimate of 1151 moose was obtained.

Similar calculations to those described above were used to estimate the number of moose in CA 6 (ADF&G 1982a). Population estimates for this area were derived separately because a migratory group of moose is known to overwinter near the mouth of the Oshetna River. During the survey on November 9, 1980, a total of 205 moose were observed. Of the 300,800 acres (1217 km^2) stratified, 130,560 acres (528 km^2) were classified as low-moose density; 132,480 acres (536 km^2) as medium-moose density; and 37,760 acres (153 km^2) as high-moose density areas. If it is assumed that the moose stratum densities in CAs 7 and 14 are equivalent to those in CA 6, a rough estimate of 830 animals is obtained. The estimated number of moose in the middle Susitna Basin study area, excluding the far southeastern portion of the drainage, was 4027 during November 1980.

Because of cost constraints and unfavorable snow conditions, no population estimates were obtained for a number of areas in the upper Susitna Basin (the western Alphabet Hills, the Lake Louise flats, and the Tyone and Sanona Creek drainages) (ADF&G 1982a).

- <u>Population Estimates - Lower Susitna Basin</u>

Estimates of moose density in the lower Susitna Basin (Table E.3.100) are based on ten aerial surveys conducted in riparian communities within four zones along the lower Susitna River (Figure E.3.90) (ADF&G 1982b, and unpublished data). Surveys were flown during periods of snow cover, since moose are more easily observed at that time, and greater numbers of moose are using the river.

An average of 267 moose was observed during 6 surveys conducted during the winter of 1981-82 (range of 82 to 309). These surveys indicate that moose were generally most abundant along the Susitna River during early March. Heavy snowfall in October to December 1982 resulted in much higher use of the lower river by moose. In early December 1982, 826 moose were observed within the survey area. During all surveys, moose densities were consistently higher downstream from Montana Creek than between Devil Canyon and Montana Creek.

- Population Structure

. Middle Susitna Basin

Information on the population structure of moose in a portion of the Susitna Basin (GMU 13) is available since 1955 (ADF&G 1982a); summaries of a number of population ratios such as cow:calf ratios and sex ratios are summarized for CA 6, CA 7, and CA 14 in Tables E.3.96 to E.3.98. In all three count areas, the number of males per 100 females has declined substantially since 1955. Declines in the number of calves and twin calves per 100 females have also been observed. These data suggest that moose productivity in the middle Susitna Valley has declined over the past 25 years. Recent declines in productivity have been attributed largely to brown bear predation of young calves (Ballard and Spraker 1979; Ballard et al. 1980, 1981a). ADF&G regulates moose harvest in _____ 13 by limiting the legal take to large males (36-in. wide neck). This further reduces the number of males per 100 females, but is designed to protect the productive population because of low recruitment (due to high predation mortality).

. Lower Susitna Basin

Information on the sex and age composition of moose in the lower Susitna Basin was obtained during the surveys described earlier for population estimates (ADF&G 1982b and unpublished data). Because composition surveys in the lower Susitna Basin included only information obtained during the late fall and winter of each year, (when males and females are more difficult to distinguish) only sex and age composition data from the early surveys in December 1981 and 1982 will be considered (Table E.3.101). Males tended to be less abundant than females in both years. Comparisons of the number of calves per 100 females in 1981 for the lower Susitna Basin (48.4) and the middle Susitna Basin (32.2, based on estimates from the census surveys) suggest that moose populations in the lower Susitna Basin may be slightly more productive than moose in the middle basin.

- Mortality Factors

Moose populations in several areas of Alaska, including GMU 13 (which includes part of the Susitna Basin) have undergone population declines in recent years (McIlroy 1976). A series of severe winters during the 1970s was believed to have resulted in these declines, and low annual recruitment associated primarily with poor calf survival prior to November has been suggested as the predominant factor maintaining these populations at low levels (Ballard et al. 1980). Predation of moose calves by wolf and brown bear is believed to be the most important factor contributing to low calf survival. Other factors such as decreasing range quality, low bull:cow ratios, and periodic severe winters are thought to be less important influences on calf survival (McIlroy 1974).

Intensive studies of moose populations in the Nelchina Basin were undertaken by the Alaska Department of Fish and Game during the mid-1970s to determine which factors were most important in determining calf survival. Studies by Van Ballenberghe (1978) and Ballard and Taylor (1978) suggested that bull:cow ratios were not a major influence on population productivity. Several measures of physical condition of moose also suggested that moose in the Nelchina Basin were in good physical condition and that deteriorating range conditions were not a problem (Franzmann and LeResche 1978). Furthermore, artificial reductions in wolf populations resulted in no large increases in calf survival, suggesting that although moose were an important component of wolves' diets, wolf predation on moose was not a major factor in declining productivity (Ballard and Spraker 1979). In the course of these investigations, it became apparent that brown bear predation of young moose calves was a major source of calf mortality (Ballard and Taylor 1978, Spraker and Ballard 1979). A recent study of moose calf mortality in the Nelchina and upper Susitna River basins (Ballard et al. 1980) showed that of 136 calves radio-collared shortly after parturition, 55 percent died of natural causes by the following November. Brown bear predation of moose calves accounted for 79 percent of the natural deaths.

Mortality of newborn moose calves in the middle Susitna Basin during 1980 and 1981 was high (ADF&G 1982a). By August 1, 1980, 23 (77 percent) of the calves were missing. Rates of 1980 calf loss were compared with those observed in 1977 and 1978 (Figure E3.91). Although causes of moose calf mortality were not determined in 1980, the pattern of loss was quite similar to that observed in GMU 13 during 1977 and 1978 where predation by brown bear accounted for a high proportion of the natural calf deaths (Ballard et al. 1981a).

Calf mortality was not directly monitored during 1981 but indices of calf production suggest that brown bear predation may again have accounted for a large proportion of the natural deaths (ADF&G 1982a). Of the 46 sexually mature cow moose which could have produced calves, only 20 (43.5 percent) were observed with calves; four (20 percent) produced twins. The calving rate for known producers was 1.2 calves/cow. Of the 24 known calves, 14 (58.3 percent) were missing by July 28. This pattern of calf loss is again quite similar to that of 1977, 1978, and 1980 when predation by bears accounted for most of the losses.

Although predation by brown bears does appear to be the major cause of calf moose mortality during the summer and fall periods, winter severity is likely an important factor in determining productivity and survival. Ballard et al. (1981a) found that snow depths from the Monahan Flats area were significantly correlated with subsequent fall calf:cow ratios in CA 3 of GMU 13. During the period from 1970 to 1978, 45 percent of the variation in cow:calf ratios could be attributed to snow depth. Snow may alter the energy balance of moose by increasing metabolic requirements for locomotion and decreasing accessible energy reserves by limiting food availability (Coady 1974). Assuming that snow depths are an adequate index of winter severity, the strong relationship between cow:calf ratios and snow depths suggest that overwinter conditions and their influence on the condition of pregnant cows are an important factor in determining calf survival, and hence, population productivity. As discussed earlier, winters during the two years of study of moose populations in the middle Susitna Basin have been mild. Consequently, it has not been possible to obtain site-specific information on the influence of severe winter conditions on population productivity, habitat use, or browse utilization.

Ballard and Taylor (1980) examined mortality rates of adult females based on the loss of radio-tagged cows in the middle Susitna Basin during 1976-1978. During the three-year study, they estimated that annual adult cow mortality averaged 6 percent.

No instances of predation of calves or adult moose in the lower Susitna Basin were observed during 1981 or early 1982. ADF&G (1982b) suggests, however, that most predation which does occur in the lower Susitna Basin is probably attributable to brown bears and black bears. Both species of bear occur throughout the lower Susitna Basin; whereas wolves, another major predator of some moose populations, are rare.

- Dispersal

Limited evidence obtained during the radio-tracking program suggest that young moose from the middle Susitna basin may disperse into other major drainages in the region (ADF&G 1982a). One male calf was observed to move 46.5 miles (75 km) from Swimming Bear Lake to Coal Lake. Another male calf moved from near the mouth of Watana Creek to the upper reaches of Windy and Clearwater Creeks north of the Denali Highway.

Based on these 2 observations, ADF&G (1982a) suggests that moose populations in other drainages removed from the Susitna drainage may be partly dependent on the immigration of Susitna moose. Information on population sizes in the Susitna Basin during 1980 and 1981 similarly suggest that a portion of the increase in numbers of adult moose may have been the result of immigration from other areas. During 1980, 178 calves and 766 adults were observed in CA 7. In 1981, a total of 1006 adults were observed. Even if all of the 1980 calves had survived (which is unlikely), the increase is 21.1 percent greater than expected. Although sampling errors might account for a major portion of this difference, immigration from adjacent areas may partly explain this increase in adult moose.

Evidence from moose studies in areas adjacent to the lower Susitna Basin suggest that the lower Susitna population is discrete from those in adjacent drainages. Moose-tagging studies in the Matanuska River valley (Rausch 1971) and in the Peter-Dutch Hills (Didrickson and Taylor 1978) found that emigration from these areas to the Susitna Basin was extremely low to nil.

(b) Caribou

Caribou in the area affected by the proposed Susitna Hydroelectric Project are members of the Nelchina herd. This 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 south-central Alaska. Currently, the Nelchina herd contains about 21,000 animals (approximately 6 percent of the total statewide caribou population of 325,000).

Despite the great interest by hunters in harvesting Nelchina caribou (6662 applications for 1600 permits in 1981), the range remains relatively inaccessible. Human development is largely limited to the peripheries and consists primarily of the Alaska Railroad, Parks Highway, Denali Highway, Richardson Highway, Trans-Alaska Pipeline, and Glenn Highway.

Caribou studies for the Susitna project were conducted by ADF&G (1982c). All data in this section not otherwise cited were obtained from that source. Data from that report are derived from 659 radio-locations of 41 individuals (an average of 16.5 locations for each individual, range 7 to 26), which were collared for varying amounts of time between April 1980 and September 1981. Thirty-two were caribou from the main Nelchina herd, 3 from the upper Talkeetna River, 3 from the Chunilna Hills, and 3 from the upper Susitna - Nenana area.

(i) Distribution and Movement Patterns

The Nelchina herd occupies an area of approximately 12,800,000 acres (51,800 km^2) bounded by 4 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 (Figure E.3.92). The Nelchina range contains a variety of habitats, from spruce-covered lowlands to steep, barren mountains.

4.2 - Baseline Description

The Nelchina herd has been studied by the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game since 1948. During this time, it has remained essentially within the area outlined above; however, with the exception of the calving area, seasonal use of particular areas has varied.

Early records indicate that the herd wintered (January to March) in the upper Nenana River area in the early 1930s and in the Talkeetna Mountains in the late 1930s (Skoog 1968). From 1950-1955, the herd wintered from the Little Nelchina River and Glenn Highway north through the Lake Louise Flats to the Denali Highway. As the herd increased in size through the later 1950s and early 1960s, its winter range also increased in size, encompassing the upper Nenana River area, Monahan Flats, Talkeetna Mountains, and extending east across the Richardson Highway (Hemming 1971). The most recent studies of radio-collared caribou in 1981 and 1982 indicate that over 85 percent of the caribou in the herd wintered (1) on the Lake Louise Flats and the middle portion of the Gakona and Chistochina River drainages and (2) in the western foothills of the Alphabet Hills, areas distant from the proposed impoundments (K. Pitcher 1982 pers. comm.).

Since 1949, the first year for which records are available, Nelchina caribou have utilized an area of about 640,000 acres (1609 $km^2$0 in the northern Talkeetna Mountains for calving (Skoog 1968, Hemming 1971, Bos 1974). Although the precise areas used have varied, calving has taken place between Fog Lakes and the Little Nelchina River between about 3000 and 4500 feet elevation. The only deviations have been during years with extremely heavy snow accumulations when some calving took place during the migration to the traditional calving grounds (Lentfer 1965, Skoog 1968, Bos 1973). In 1980 and 1981, calving took place between May 15 and June 10 in the drainages of Kosina Creek, Goose Creek, Black River, and Oshetna River (Figure E.3.93) (ADF&G 1982c).

The primary migratory route in 1980 and 1981 from winter range on the Lake Louise Flats to the calving grounds in the eastern Talkeetna Mountains was westward across the flats from Crosswind Lake and Lake Louise into the Talkeetna Mountains on a front from Lone Butte to Kosina Creek (ADF&G 1982c).

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 (ADF&G 1982c). In the spring of 1980 one radio-collared animal, and presumably also a small portion of the main herd, 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).

During spring migration and calving, there is some segregation of sex and age groups. Although yearlings and barren cows lag somewhat behind parturient cows, they also move to the calving area, remaining scattered along its periphery (Skoog 1968). Radio-collared Nelchina bulls were found in a wide variety of locations mostly in transit to summer ranges during calving in 1980 and 1981 (ADF&G 1982c).

Historically, the female-calf segment of the Nelchina herd has summered primarily 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 percent) 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 (June 11 through July 31) of both 1980 and 1981 in the northern and eastern slopes of the Talkeetna Mountains (ADF&G 1982c). Summering radio-collared males were found in many locations in the high country of the Nelchina Basin.

In both 1980 and 1981, autumn (August 1 through September 31) was a time of considerable movement and dispersal by both cows and bulls (ADF&G 1982c). Compared to the obvious segregation in June and July, it appeared that 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 Flats, 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 Flats, and the Alphabet Hills.

data. Pitcher estimated that 2500 caribou were in the count area, based on an actual count of 2077 caribou and his subjective impressions of sightability and area coverage.

During early May 1980, four adult females and one adult male were radio-collared from this subherd (ADF&G 1982c). 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 Flats during the rut and early winter. The other three females remained in the upper Susitna-Nenana area throughout the study period, producing two calves in 1980 and two in 1981. The bull summered in the Clearwater Mountains, then joined the main Nelchina herd during the rut on the Lake Louise Flats.

The Chunilna Hills group appears to be a resident subherd numbering fewer than 340 animals (ADF&G 1982c). One radio-collared bull remained in the Chunilna Hills from April to November 1980 when it shed its collar. Two females were collared in the spring of 1981, both of which subsequently gave birth to calves in the area. No overlap with radio-collared animals from the main herd or other subherds was noted, although one female did move across the Talkeetna River.

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 another resident subherd, probably of fewer than 400 animals, and having some spatial overlap with the main Nelchina herd. Three caribou in this upper Talkeetna River subherd (two adult females and one adult male) were collared on April 18, 1980 (ADF&G 1982c). 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 E.3.94. 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.

(iii) Habitat Use

Habitat use was analyzed from aerial determination of vegetation cover at each caribou relocation (ADF&G 1982c).

At one time or another during their annual movements, Nelchina caribou probably use most of the vegetation types in the Susitna area. However, ADF&G (1982c) found caribou mostly in spruce forest, shrubland, herbaceous vegetation types, and bare substrate types, with virtually no use of mixed or deciduous forests.

Nelchina caribou show considerable variation in habitat types used seasonally, and types used most by bulls are different from types used most by cows (Table E.3.102) (ADF&G 1982c). Bulls tend to use spruce forests more than cows in all seasons except autumn, whereas cow use of tundra-herbaceous types is greater during all seasons than bull use. These differences are likely a reflection of the tendency of bulls to remain much longer in the forested wintering areas and to summer at lower elevations than cows (see Figure E.3.95). Use of shrubland is similar for cows and bulls overall but differs seasonally. Bulls tend to use this habitat most in summer and autumn, whereas cows use it most during spring, calving, and summer (ADF&G 1982c).

As mentioned, differences between bulls and cows in habitat use were partly related to differences in elevation. The sexes occurred at about the same elevations during autumn, the rut, and winter, but females were consistently found at higher elevations during spring migration, calving, and summer (Figure E.3.95) (ADF&G 1982c).

The food habits of caribou vary seasonally with available plant forage (Skoog 1968). In spring and summer, grasses, sedges and the buds of willow and birch are important, and a wide variety of forbs are eaten as they become available. Except during years of late snowmelt when new growth is slow to appear, lichens are unimportant in the spring diet. In late summer, mushrooms are an actively sought, but minor, diet item. During autumn, browse becomes less important but sedges and grasses remain major diet components and lichens assume greater importance. Through the winter the diet of Nelchina caribou consists of about equal portions of graminoids and lichens (Skoog 1968).

(iv) Population Characteristics

The Nelchina herd was estimated to consist of about

40,000 animals when first surveyed in 1955. Subsequently, the herd grew to 71,000 in 1962, decreased to about 7700 in 1973, and currently numbers about 21,000 (Table E.3.103) (ADF&G 1982c). The management plan for the Nelchina herd (ADF&G 1976) calls for maintenance of the herd at about 20,000 adult animals through harvest of the annual increment.

The sex and age composition of the Nelchina herd remained almost the same from fall 1980 to fall 1981. Cows and bulls older than one year comprised 49.1 percent and 29.9 percent, respectively, of the herd in October 1981. Calves comprised 21.1 percent or 42.9 calves per hundred females one year and older (ADF&G 1982c). The proportion of bulls was high compared to the proportion observed in earlier years, a finding that would be expected in a growing population that had previously had a low proportion of males (Bergerud 1980).

Skoog (1968) estimated the overall pregnancy rate of Nelchina caribou to be 72 percent for females one year and older from 1957 to 1962. Full reproductive potential was not realized even in the fully adult age classes. Only 13 percent of yearling females were pregnant compared to 61 percent of two-year-olds and 89 percent of females three years and older. In 1980 and 1981, the proportion of calves in the post-calving aggregations averaged about 56 calves per 100 females one year and older (ADF&G 1982c). These data suggest that considerable calf mortality occurs shortly after birth. K. Pitcher (1982 pers. comm.) estimated that calf survival to 11 months was 43 percent for 1980 calves and 60 percent for 1981 calves. Survival rates for older caribou (>1 year) were 93.5 percent for females and 87 percent for males.

Survival rates of caribou are influenced by many factors including disease, parasitism, weather, accidents, food availability, predation, and hunting. Parasitism and disease may kill a few caribou each year in the Nelchina herd, but these are not major mortality factors. Wet, cold weather during calving can result in high levels of calf mortality which Skoog (1968) believed could ultimately control caribou population levels. However, this is a factor that is more likely to affect coastal herds and more northerly herds than the Nelchina herd (Skoog 1968).

4.2 - Baseline Description

The major factors that are believed to control caribou mortality and, ultimately, population levels, both in Alaska and elsewhere, are food availability and predation (including hunting). In mainland North America, the population density of most caribou herds appears to be much below range-carrying capacity and, indeed, in many herds is much less than the range has historically supported (e.g., Parker 1972, LeResche 1975, Bergerud 1980). Food availability in winter, because of snow cover, is likely to be more critical than availability in summer, and many early workers speculated that declines in caribou numbers in North America in the early 1900s were caused by winter forage (mainly lichen) destruction by forest fires (Scotter 1967). However, evaluations of more rigorous analyses (e.g., Henshaw 1968, Kelsall and Klein 1979, Klein 1967, Roby 1980, and Bergerud 1974a) show that starvation or even observable debilitation in caribou during winter is rare except in populations insulated from predators and prevented from dispersing to unoccupied habitats (Scheffer 1951, Klein 1968, Leader-Williams 1980).

Skoog (1968) believed that neither overgrazing nor fire had greatly affected the Nelchina range in the early 1960s. The herd was considerably larger than now, and food availability is unlikely to be a major factor affecting survival in the present herd.

Several authors have presented evidence that caribou numbers are effectively controlled by predation. For example, Kelsall (1968), Parker (1972), Miller and Broughton (1974), and Davis et al. (1980) all report evidence that caribou numbers have declines as predator (mainly wolf) numbers increased, or that caribou numbers have increased as predator numbers decreased. Bergerud, in two reviews (1974a, 1980), demonstrates convincingly that where capable predators (wolves, bears, lynx) are common and hunting by man is insignificant, caribou populations are effectively regulated by predation.

Since the introduction of firearms to North America, hunting has probably been the major cause of population declines (Bergerud 1974a, Calef 1980). Calef (1980) reported that in some herds in the Northwest Territories, hunter kill is in excess of annual recruitment. Doerr (1980) isolated excessive hunting as the primary cause of population declines in the Nelchina and Western Arcic herds in Alaska.

Hunting and wolf predation probably account for about equal portions of the annual mortality of the present Nelchina herd (ADF&G 1982c). Table E.3.104 shows the level of hunter harvest from 1972 to 1981. During that time, hunter harvest in years for which herd size data are available has varied from 1.4 percent to 9.6 percent of the herd. Hunter harvest was about 4 percent in 1981.

Wolf predation has reportedly varied with the size of the wolf population (ADF&G 1982c). Skoog (1968) estimated that wolves took 1.1 - 2.6 percent of the herd from 1957 - 1962. More recently ADF&G (1982f) estimated wolf predation rates varying from 7 - 10 percent of the herd in 1973 to 2 - 3 percent in 1981. There appears to be no clear relationship between wolf and caribou population levels, apparently due to the high harvest of wolves and, in particular, way control measures in the early 1950's, appears in (Figure E.3.96) (Bergerud 1980).

The average natural mortality rate for caribou 1 year and older of both sexes in 1981 was 8.1 percent. If ADF&G (1982f) estimate of 2 - 3 percent mortality applies to adults as well as calves (as they suggest), then wolf predation combined with hunter harvest (3.9 percent--Table E.3.104) account for 50-60 percent of the annual adult mortality in the Nelchina herd.

(c) Dall Sheep

Dall sheep studies were conducted in the middle Susitna River basin during the summer of 1980, spring and summer of 1981, and spring of 1982 (ADF&G 1982d, ADF&G unpublished data). The purpose of these studies was to determine the locations and seasons when sheep might be affected by project activities. The study area includes all drainages flowing into the Susitna River between Kosina Creek and Gold Creek and all drainages west of the Susitna River between the Denali Highway and Kosina Creek. Survey efforts were confined to areas of known or suspected Dall sheep habitat within this area (Figure E.3.97) (ADF&G 1982d). These areas contain semi-open, precipitous terrain, with rocky slopes, ridges, and cliffs.

4.2 - Baseline Description

(i) Distribution

There are three general areas in the middle Susitna Basin that have steep rocky slopes at sufficient elevation to be potential Dall sheep habitat (ADF&G 1982d). The first of these areas is north of the Susitna River between the proposed Devil Canyon and Watana damsites. Aerial surveys were conducted in this area in the Portage Creek and Tsusena Creek drainages (Figure E.3.97). The second potential site for Dall sheep is in the mountains between the Susitna and Talkeetna Rivers, extending eastward from the Fog Lakes to Kosina Creek. The third area is north of the Susitna River, to the east of Watana Creek. This area was established as a population trend count area for Dall sheep by ADF&G in 1967 (Figure E.3.97).

ADF&G (1982d unpublished data) conducted aerial surveys to determine the seasonal distribution and abundance of Dall sheep in the areas described above on July 22-23, 1980; on March 13 and 25, 1981; between May 13 and June 24, 1981; on July 28, 1981; and on March 23, 1982. The date, location, number, sex, and age of sheep were recorded for all sightings (ADF&G 1982d).

A total of 72 sheep (7 legal rams, 12 lambs, and 54 unidentified) were counted in the Portage Creek and Tsusena Creek drainages in July 1980. Four sheep were seen north of Portage Creek, two east of Tsusena Creek, and the other 66 were seen in the headwaters region of Tsusena Creek. The only previous ADF&G survey in this area was a 1977 count of 91 sheep (8 legal rams, 18 lambs, 65 others). The 1977 survey included the Jack River drainage (north of Tsusena Creek), which was not surveyed in 1980. All of the sightings were far from the proposed impoundments and access roads.

During July 1980, only eight sheep (1 ram, 7 unidentified) were observed in the Watana Mountain - Grebe Mountain area. This area is used by sheep from a larger Talkeetna Mountains population. Earlier observations in 1977 suggested that at least 34 sheep were present on Mt. Watana. Numerous observations of sheep in the Terrace Creek area (a southern tributary of Kosina Creek) have been made, but no sheep were observed during the 1980 survey.

4.2 - Baseline Description

On March 25, 1981, a winter distribution survey was conducted in the same area surveyed in July 1980. Twenty-two sheep were sighted, and two groups of 3-4 tracks were seen. These data suggest that groups of sheep from the larger Talkeetna Mountains population are migrating into the area during winter. All sheep observations were located on the southern extreme of the count area, well away from the impoundment.

The Watana Hills area has been surveyed for Dall sheep by ADF&G yearly since 1967 (ADF&G 1982d). The data from the 1980 and 1981 surveys show the same general patterns as previous surveys (Table E.3.105). The 1981 count of 209 sheep was the second highest number of sheep recorded for this area. The percentage of lambs was similar to that of past years and suggests that productivity and survival are remaining constant. The small number of legal rams counted could reflect the rather high (13) sport harvest taken from this area in 1980 (R. Tobey 1982 pers. comm.). Although the 1981 count was relatively high, it is suspected that the population has remained stable or perhaps increased slightly (ADF&G 1982d).

Sheep in the Watana Hills area were surveyed in March of 1981 and 1982. Eighty-seven sheep were sighted in 1981 and 77 in 1982, all on south-facing slopes. Geist (1971a) suggested that south-facing slopes are an important part of Dall sheep winter range. They provide maximum exposure to winter sun and frequently have shallower snow than slopes with different aspects. Fewer sheep were observed than in the summer surveys, probably because of poor observability due to snow cover and/or movement of sheep from the area.

(ii) Mineral Lick Use

Mineral licks are known to be important for Dall sheep and are a common component of spring ranges. Heimer (1973) suggested that they be considered a critical habitat requirement. The sheep in the Watana Hills area have been observed frequenting a mineral lick along the lower elevations of Jay Creek at an elevation of about 2200 feet (671 m).

The Jay Creek mineral lick was overflown from May 6 through June 24, 1980; the number, sex, and age of the sheep recorded are shown in Table E.3.18 (ADF&G

1982d). Sheep were sighted on 28 of 33 occasions (85 percent). The largest single group observed was 15, representing approximately 7 percent of the observed Watana Hills summer population, and approximately 17 percent of the observed winter population.

Sheep were observed frequenting other locations adjacent to the Jay Creek mineral site (ADF&G 1982d). On May 23 and 25, 1981, groups of 6 and 12 rams, respectively, were observed scraping and eating soil on the ridge located on the east side of Jay Creek at an elevation of 2270 feet (692 m), directly opposite the main lick area (Table E.3.106). Since only rams were observed on these 2 occasions, the observation could represent a preferential use of certain areas by sex or age classes. Also, on 6 days in June, sheep of different age classes were observed at an area approximately 2 miles (3.2 km) upstream from the main mineral area (Table E.3.106). This area also appears to be mineralized.

No sheep were observed at the Jay Creek area during an aerial survey of summer distribution on July 28, 1982. However, ten ewes and yearlings were observed actively utilizing a known mineral lick in the drainage of the east fork of Watana Creek, approximately 7 miles (11.3 km) north of the Jay Creek site.

The Jay Creek mineral lick was also visited by ADF&G biologists on May 9, 1981. Sheep usage of the area ranged from the Jay Creek streambed 2000 feet (610 m), to the top of the bluff 2450 feet (747 m), and for an undetermined distance away from the bluff. Signs of heavy moose utilization were evident as well.

(d) Brown Bear

Most of the site-specific information for brown bears in the Susitna Basin was obtained from recent studies by ADF&G (1982e). Additional site-specific information was obtained from studies in the upper Susitna and Nelchina River basins during 1979 (Miller and Ballard 1980, Spraker et al. 1981).

(i) Distribution

Brown bears or grizzly bears (the former term will be used throughout this report) are widely distributed and abundant in most parts of Alaska. Brown bears appear best adapted to relatively open, undisturbed areas with good cover and an abundance of perennial succulent herbs and/or fruit-bearing shrubs (Mealy et al. 1981). The omnivorous food habits of brown bears as well as their nongregarious social structure and high degree of mobility allow them to utilize resources in a large number of habitats throughout an expansive area (Knight 1980). Brown bears appear to be able to adapt to a variety of man-caused disturbances in their habitat. However, experience has amply demonstrated that brown bear abundance is usually incompatible with human presence; human-bear interactions commonly have resulted in the extermination of brown bears from settled areas through intensive hunting, trapping, and/or poisoning programs.

Brown bear research in the middle Susitna and Nelchina River basins has been ongoing since 1978 (Ballard et al. 1980, Spraker et al. 1981). Most studies were initially concerned with the effects of brown bear predation on moose, but more recent studies have concentrated on all aspects of brown bear ecology (ADF&G 1982e). No site-specific information is available on brown bear in the lower Susitna Basin. Within the middle Susitna Basin, brown bears generally are most abundant in open tundra habitats during most of the late spring and early fall periods. Many brown bears appear to utilize lower elevation spruce habitats during the early spring. Current information suggests that brown bears in the middle Susitna Basin are abundant and that populations are young and productive.

- Seasonal Movements

The brown bear's omnivorous feeding habits, social structure, behavioral interactions, and winter denning requirements necessitate extensive movements throughout large areas (Craighead and Mitchell 1982). It appears that the utilization patterns of large geographic areas by brown bears is largely dependent on the spatial and temporal availability of food. Information from a number of areas in Canada and the United States suggests that brown bears establish traditional movements to exploit dependable sources of food. Often these food sources are only seasonally available for short periods of time. Extensive traditional movements are common in many populations of brown bear (Pearson 1976, Reynolds 1979, Craighead 1980).

4.2 - Baseline Description

Based on 530 relocations of radio-collared brown bears in the middle Susitna Basin during 1980 (n=15) and 1981 (n=18), ADF&G (1982e) documented regular seasonal movements of brown bears that appeared to be associated with regional and elevational differences in food availability. Movements of brown bears from the middle Susitna Basin to Prairie Creek during July and August were perhaps the most notable regional movements observed during the study. These regular seasonal movements of brown bears appeared to be associated with high concentrations of spawning king salmon in Prairie Creek during this time of year.

Although bad flying conditions in 1981 prevented complete documentation of the number of brown bears that move the middle Susitna Basin to Prairie Creek, 3 of 11 (27 percent) of the radio-collared bears were found in the Prairie Creek area sometime between July and December in 1980 (exact dates not given), and 2 of these same individuals (of 18 collared bears, 11 percent) were found there sometime between July and December 1981 (ADF&G 1982e). Local residents report that large concentrations of brown bears occur in the area during king salmon runs in July and August. Although a large number of animals may utilize this food source, it is not clear whether brown bears are dependent on the supply of salmon. For example, moderately dense brown bear populations exist in the adjacent Nelchina Basin without access to salmon (Miller and Ballard 1982). As suggested by ADF&G (1982e), Prairie Creek salmon may be an important buffer when other food sources such as berry crops are less available, and this additional food source results in a higher carrying capacity of the middle basin for brown bears. All of the radio-collared brown bears that moved to the Prairie Creek area 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.

Movements of brown bear in the early spring also appeared to be related to elevation and the availability of new plant growth (ADF&G 1982e). With the exception of sows with cubs, it appeared that most brown bear moved to lower elevations on or near the Susitna River following emergence from overwintering dens. This was attributed to the relatively earlier melt-off of snow, particularly on south-facing slopes, and the subsequent availability of overwintered berries and new plant growth. Carcasses of winter-killed ungulates and new-born calves in these areas also would provide food for brown bears. Radio locations of brown bears in the middle Susitna Basin during the springs of 1980 and 1981 indicated that, excluding sows with newborn cubs (which remained at higher elevations), 62 percent and 52 percent of the radio-collared animals, respectively, moved to areas on or adjacent to the Susitna River (ADF&G 1982e). S. Miller (1982 pers. comm.) feels that these figures are minimum estimates, since spring use of the impoundment zone by other bears may have been missed because of infrequent monitoring. However, since it was impossible to capture a random sample of bears within the basin, these figures most likely over-estimate use of the area by the basin-wide population. Females with newborn cubs remained at high elevations throughout the year. Brown bears were at the lowest mean elevations during June to August (ADF&G 1982e).

Although some of the regional and elevational movements of brown bears in the middle Susitna Basin may be related to forage availability, these movements may also be associated with brown bear predation of moose and caribou calves. Directional movements by four radio-collared brown bears to and from the calving grounds of the Nelchina caribou herd suggest that brown bears may move to calving areas primarily because of the availability of calves (ADF&G 1982e).

- Denning

Brown bear dens in the middle Susitna Basin were on moderately sloping southern exposures, and were generally dug in gravelly soils either in tussock or shrub habitats (ADF&G 1982e). (Use of vegetation types for denning is discussed below.) None of the bears in this study reused den sites. Brown bear den sites ranged in elevation from 2330-5151 feet (710-1570 m) with an average elevation of 4180 feet (1274 m).

Radio-collared brown bears in the middle Susitna Basin entered dens in early October 1980 and in late September-early October 1981. During the spring of 1981, most bears emerged from their dens in late April-early May (ADF&G 1982e).

(ii) Habitat Use

Brown bears in other areas of Alaska and northern Canada utilize a wide range of vegetation communities. Habitat affinities of brown bear in the middle Susitna Basin were based on the predominant vegetation types in the vicinity of each relocation of the radio-collared bears as determined from aerial observations. Brown bear use of spruce vegetation types, which are concentrated around and in the proposed impoundments, was highest in May and June (Table E.3.107) (ADF&G 1982e). Bears tended to move to shrublands at higher elevations later in the summer (58 percent of the observations in September were in shrubland, whereas only 28 percent of the May sightings were in this type) (ADF&G 1982e).

Comparisons of the use of vegetation types by brown bears during the spring and the remaining portion of the year indicated that brown bears used spruce forests significantly more often during the spring than during other times of the year (ADF&G 1982e). As discussed earlier, sows with newborn cubs tended to remain at higher elevations; of 68 observations of sows with cubs, only 1 occurred in spruce habitat. Shrublands were most commonly used by sows with cubs (49 percent of the observations) followed by "other" habitats (35 percent), tundra (10 percent), and riparian communities (4 percent).

- Food Habits

Studies of the feeding habits of brown bears indicate that the species is omnivorous, feeding on a wide range of plants and animals. Although plant material may commonly comprise a major portion of the diet, it appears that brown bears prefer high-protein animal food (Craighead and Mitchell 1982).

From dietary studies of brown bears in interior Yukon (Pearson 1976) and in Yellowstone National Park (Craighead and Sumner 1980), it appears that brown bears most commonly utilize graminoids and forbs during the spring and early summer. As berries and fruits become more available, these also are incorporated into the diet. Brown bears will eat carrion, if available, and may also kill ungulates or other large mammals. Small rodents such as ground squirrels are most often consumed during the late summer.

4.2 - Baseline Description

As discussed earlier, brown bear are attracted to both natural and artificial food sources, particularly if food is abundant and readily available. Some brown bear populations traditionally form aggregations to feed on salmon during the major fish runs (Stornorov and Stokes 1972).

Information on the diets of brown bear in the middle Susitna Basin is limited. Overwintering berries and new green shoots of grasses and forbs are consumed during the early spring. Winter-killed ungulates as well as moose and caribou calves also are eaten. King salmon likely comprise much of the diet of bears moving to Prairie Creek during the salmon run in July and August. Berries such as Vaccinium spp. are likely consumed throughout the late summer and fall period.

One of the most notable results of the brown bear studies in the middle Susitna Basin is recognition of the importance of brown bear predation to moose recruitment. Ballard et al. (1981a) found that of 123 radio-tagged moose calves, 55 percent had died of natural causes by November (following their birth) and that 79 percent of all natural mortalities were caused by brown bear predation. Relocations of 23 radio-collared brown bears that were intensively monitored (twice per day) during the spring of 1978, showed that 14 of the 23 bears regularly relocated were observed at least once on a moose calf kill (Ballard et al. 1981a, Spraker et al. 1981). During the latter study, a total of 37 calf moose, 28 adult moose, 4 unidentified moose, 3 caribou, and 6 other species of mammals were killed by brown bears, yielding a total of 1 kill/5.6 observation days (1 moose/6.3 observation days). The lower kill rate of 1 kill/10.2 days given by ADF&G (1982e) is probably an underestimate because of less frequent monitoring of radio-collared animals (compared to Ballard et al. 1981a) and is based on only 3 moose calves, 2 adult moose, and 3 unidentified prey species. Although the full importance of this highly preferred food source to brown bear is not known, Craighead and Mitchell (1982) found spring weight gains only in brown bear able to secure ungulate calves or similar high protein diets.

- Home Range

The average home range size of male brown bears in the middle Susitna Basin is 195,200 (790 km^2, n=14); for females it is 78,090 acres (316 km^2, n=19) (ADF&G 1982e).

Comparisons of the home range sizes of brown bears in the middle Susitna Basin with brown bears in other areas indicate that bears in the Susitna Basin have relatively large home ranges (Table E.3.108) (ADF&G 1982e). Only home ranges of bears from northwestern Alaska (a relatively unproductive population) were larger. On the basis of this information, ADF&G (1982e) suggested that home range size and brown bear densities are inversely related and that both are a function of the distribution and abundance of food resources. The large home ranges of brown bears in the Susitna Basin, therefore, may reflect relatively low productivity of food items that are important to brown bears and/or a patchy distribution of important food items.

As discussed previously for moose, home range analyses are useful in assessing the number of animals that may be affected by the proposed impoundments. ADF&G (1982e) examined the relationships between the home ranges of radio-collared brown bear during 1980-1981 and three arbitrarily chosen areas that included: (1) the proposed impoundment, (2) a 1 mile (1.6 km) zone around the proposed impoundments, and (3) a zone occupying areas 1 to 5 miles (1.6 to 8 km) from the proposed impoundments.

The mean overlap of the home ranges of 19 brown bears with the impoundment was 5 percent (range of 0-25 percent), for the 1-mile (1.6 km) zone it was 15 percent (0-48 percent), and for the 5-mile (8 km) zone it was 52 percent (0-100 percent) (ADF&G 1982e). These figures under-represent the actual use by brown bears of the area in and adjacent to the impoundment area because the home range figures used in calculating the percent overlap are the total annual home ranges. Seasonal use by brown bears, particularly during the spring, is more intensive.

Analyses of the proximity of relocations to the proposed impoundments similarly show that radio-collared brown bears selectively use areas that are close to the Susitna River, particularly during the spring period. Comparisons of the number of bear relocations in the impoundment areas, as well as in the two "impact" zones discussed earlier, indicate that use in the actual impoundment area was greater than expected during all periods (almost 4 times greater during the spring) and that use of the outermost zone (1 to 5 miles, 1.6 to 8 km), was less than expected (ADF&G 1982e). However, these analyses probably overestimate use of the impoundment zone by the middle basin population because of sampling bias.

(iii) Population Characteristics

- Population Size

Brown bear population estimates are extremely difficult and expensive to obtain because of the wide-ranging behavior of most individuals and their use of some habitats where sightability is poor. Miller and Ballard (1980) used a Lincoln Index to calculate a rough density estimate of 1 bear/10,112 to 15,296 acres (1 bear/41-62 km^2) in the Susitna River headwaters during 1979. This estimate suggests that brown bear densities are intermediate between densities in southern and coastal Alaska and the Brooks Range (Table E.3.109). Based on an estimate of 1 bear/10,112 acres (1 bear/41 km^2), the brown bear study area (an area of 2,093,678 acres [8473 km^2]) that includes the middle basin (see ADF&G 1982e) would have a population of approximately 206 brown bears. It was the opinion of ADF&G (1982e) that brown bear densities in this area were likely to be higher than this estimate.

- Population Structure

Information on the sex and age structure of the brown bear population in the middle Susitna Basin was available from GMU 13 harvest data during 1970 to 1980, the 1979 study of brown bears in the middle Susitna and Nelchina river basins (Miller and Ballard 1980), and from capture data from the recent brown bear study (ADF&G 1982e) (Table E.3.110.

The age composition of brown bears captured in the middle Susitna Basin during 1980-1981 was 19.6 percent cubs, 11.8 percent yearlings, 12.7 percent two-year olds, 15.7 percent three- and four-year olds, and 39.2 percent adults. The moderately high percentages of young animals in the Susitna brown bear population suggest that the population is young and productive.

- Productivity

The mean litter size for brown bears in the middle Susitna Basin was 2.3 (range of 1 to 3), based on nine litters of newborn cubs observed with radio-collared females since 1978 (ADF&G 1982e). The mean litter size for the basin is comparable to those in highly productive brown bear populations on Kodiak Island and on the Alaska Peninsula, and is higher than litter sizes in the relatively unproductive Brooks Range brown bears (Table E.3.111).

Of 10 cubs in 5 known litters produced in the middle Susitna Basin during 1981, 3 (in 3 litters) were lost during the summer of 1981 (ADF&G 1982e). One of these losses may have been capture-related. Tait (1980) has suggested that abandonment of litters of single cubs may be an adaptive strategy for brown bears. Physical evidence (lactation) suggests that another bear may have had a litter in 1981, but cubs were never observed; they may have been lost prior to the recapture of this bear during summer 1981. In 1979, studies showed that two cubs in a litter of 3 were lost as were 2 yearlings or cubs in a another litter of 3. No other losses from yearling or 2-year-old litters were observed, suggesting that offspring mortality is concentrated on cub classes. Causes of cub losses were not determined, but predation by male brown bears was considered most probable (ADF&G 1982e).

Comparisons of the reproductive rates of brown bears in the middle Susitna and Nelchina basins with reproductive rates of other brown bear populations indicate that the Susitna-Nelchina Basins support some of the most productive brown bear populations in Alaska (Table E.3.112).

- Dispersal

ADF&G (1982e) believed that dispersal of sub-adult brown bears, both to and from the study area, was probably common. Several instances of dispersal by radio-collared brown bears were recorded. One male, originally tagged as a 2-year-old in 1978 on the Susitna River north of the Denali Highway, was recaptured and radio-collared near Clarence Creek on the Susitna River. Another 2-year-old male was captured near Deadman Creek during the spring of 1981 and mvoed downstream (54.9 miles, 88.5 km) to the vicinity of Moose Creek. During the fall, the same animal moved back to the vicinity of Sherman and Curry. The importance of dispersal in maintaining brown bear population levels in the Susitna River basin and in adjacent river drainages is not known.

- Sport Harvest

ADF&G harvest data for brown bear in GMU 13 are presented in Table E.3.113 (ADF&G 1982e). From 1973-1980, harvests averaged 64/year (44-84). The mean age of brown bears taken during the period 1973-1980 was 6.5 years (6.3 for males and 6.8 for females). This relatively young age suggests that many GMU 13 hunters are not selecting large trophy bears. Of 656 bears that have been harvested and aged in GMU 13 during the period 1970-1980, 10 percent were yearlings, 29 percent were 2-years-old or less, 41 percent were 3-years-old or less, and 52 percent were 4-years-old or less (ADF&G 1982e). In recent years, sport hunters have applied pressure to extend brown bear seasons and bag limits in GMU 13. This pressure has largely resulted from research showing that brown bears are a major predator on moose calves (Ballard et al. 1980, 1981a). In addition, Miller and Ballard (1980) suggest that there may be a harvestable surplus of brown bears in GMU 13.

(e) Black Bear

All site-specific information on black bear populations in the Susitna Basin was obtained from the recent study by ADF&G (1982e) during 1980-1982. Most of the data for 1981-82 was for the middle Susitna Basin (upstream from the Devil Canyon damsite), but the studies now underway are also focusing on bears downstream from Devil Canyon.

(i) Distribution

Black bears are the most common and widely distributed of the three bear species in North America. They occur in most areas of Alaska as far north as the Brooks Range. Black bears are highly adaptable and are able to utilize a wide variety of habitats. Like brown bears, they are omnivores and their ranges and diet respond to regional and temporal changes in food availability. Prime black bear habitat can be generally characterized by relatively inaccessible forested terrain, thick understory vegetation, and abundant sources of plant foods such as succulent herbs and forbs, berries, and fruits (Pelton 1982).

Black bears appear to be moderately abundant in the middle Susitna Basin. However, because of the limited distribution of suitable habitats, black bears generally occur only in a narrow fringe of forested habitat along the Susitna River.

- Seasonal Movements

Based on relocations of 53 radio-tagged black bears during 1980-81, ADF&G (1982e) described the probable seasonal movements of black bears in the middle Susitna Basin as follows. In years of normal or abundant berry crops, many bears move in late summer, to somewhat higher country adjacent to the spruce habitats along the river, returning to their spring and early summer home ranges near the river to den. Most of these late summer movements are upstream (east) and in a northerly direction (ADF&G 1982e). In years of subnormal berry crops, most individuals make more extensive movements, moving long distances upstream or downstream in search of acceptable foraging areas or areas where salmon are available. These movements occur primarily along the main Susitna River, indicating that it is a main transportation corridor. Most individuals making these extensive movements return to their former home ranges, but some do not. In late summer and fall, particularly during poor berry years, these extensive movements of black bears may bring them in close contact with brown bears, possibly resulting in increased mortality of black bears through inter-specific predation (ADF&G 1982e).

Females with newborn cubs are exceptions to this general pattern of seasonal movements. Females with cubs make less extensive movements than other bears regardless of the berry crop.

- Denning

Distributions of den sites of black bears in the Susitna Basin indicate that dens occur most commonly in steep terrain along the main Susitna River and its tributaries (ADF&G 1982e). However, the band of acceptable denning habitat appears to become narrower and more confined in upstream areas where dens are restricted to the immediate vicinity of the Susitn River.

Black bear dens in the Susitna basin were generally located on moderately sloping hillsides; the mean slope of 15 dens located during 1980-1981 was 36° (range of 18°-53°). Half of the dens were located on south-facing slopes, and the remainder were on east- to north-facing slopes.

Black bears in the middle Susitna Basin generally denned at elevations between 1499 feet (457 m) and 2500 feet (762 m). The average elevation of 16 dens between Tsusena Creek and Devil Canyon was 2178 feet (664 m) (range 1400-4340 feet, 427-1323 m). The average elevation of 13 dens in the vicinity of the proposed Watana impoundment was 2179 feet (664 m) (range 1801-2749 feet, 549-838 m). Two black bears denned downstream from the Devil Canyon site during 1981.

Of the 14 dens located during 1980-1981, 8 were in natural cavities and 6 were excavated. All of the dens in natural cavities and 1 of the excavated dens had been used prior to the winter of 1980-1981, and 4 of the dens were used again by radio-collared bears during the winter of 1981-1982. In contrast, black bears on the Kenai Peninsula were rarely found to reuse dens during successive years (Schwartz and Franzmann 1981). ADF&G (1982e) suggest that the relatively high reuse of dens by black bears in the Susitna Basin may indicate a scarcity of acceptable den sites and/or habituation to specific sites.

Radio-collared black bears in the middle Susitna Basin entered dens in mid-September to mid-October 1980 and exited dens in early April to mid-May 1981. During the fall of 1981, black bears entered dens about 2 weeks earlier than in the fall 1980, probably as a result of the 1981 berry crop failure (ADF&G 1982e).

(ii) Habitat Use

Habitat use by black bears in the middle Susitna Basin appears to be similar to general use patterns reported elsewhere in North America, where black bears most commonly inhabit forested areas with dense understory vegetation (Jonkel and Cowan 1971, Fuller and Keith 1980). Of 908 aerial observations of 53 bears in the Susitna Basin, black bears were most often located in shrubland (42.7 percent of observations) and spruce (39.4 percent) habitats (Table E.3.114) (ADF&G 1982e). Use of spruce habitats remained high throughout the year but was much less prevalent during the summer months. During August, black bears were often present in shrubland habitats adjacent to the spruce forests. This use of shrubland areas was thought to be related to seasonal increases in the availability of ripening berries (ADF&G 1982e). Use of spruce habitats appeared to differ among male and female bears; of 126 locations of female bears during the summer period, 43 percent occurred in spruce habitats, whereas of 125 locations of males, only 30 percent occurred in spruce habitats.

An examination of habitat use by black bears within the proposed impoundment area for the Watana dam showed that deciduous forests and shrublands were used significantly more often than expected. Other habitat types were used approximately in proportion to their availability. In the deciduous forest cover type, closed birch and open birch forests accounted for all of the locations. Similar habitat associations were observed in black bear populations in northern Alberta (Fuller and Keith 1980).

- Food Habits

Throughout their range in North America, black bears consume primarily grasses and forbs during the spring, soft mast (fruits and berries) of trees and shrubs during the summer, and a mixture of hard and soft mast during the fall. Only a small portion of black bear diets typically consist of animal matter and then primarily in the form of insects or carrion. Spring is generally a period of food scarcity and bears may often subsist on remaining fat reserves (Rogers 1976). Preferred high-quality foods of black bears are generally more abundant during the summer, and animals develop most of their fat reserves during this period.

Little site-specific information is available on the food habits of black bears in the Susitna Basin. As discussed earlier, berry crops are an important component of the late summer diet, and movement of black bears into shrubland habitat is thought to be related to the availability of berries in these areas. Although plant foods may constitute the staple diet during most of the year, black bears may also prey on moose calves during the spring (ADF&G 1982e). Black bear predation on moose calves is prevalent on the Kenai Pennisula, where 70 percent of the known predator-caused deaths were attributed to black bears (Franzmann et al. 1980). During intensive radio-monitoring of black bears during May 22 - June 22, 1981, one male bear was observed on one calf moose kill and one adult caribou kill. Later in July, the same bear was observed on a kill of a radio-collared adult moose. It is not known if the bear had killed these animals or if it was scavenging kills of another predator.

- Home Range

During 1980, the mean home range size of 20 black bears in the middle Susitna Basin was 7616 acres (31 km^2), 3968 acres (16 km^2) for 10 females and 11,392 acres (46 km^2) for 10 males. During 1981, however, the average home range size was 53,888 acres (218 km^2): 49,408 acres (200 km^2) for 11 females and 57,792 acres (234 km^2)for 12 males. Although the large increase in home range size between years may be partly related to the greater number of observations of bears during 1981, ADF&G (1982e) suggests that the larger home ranges may reflect the relatively poor berry crop during 1981 and the subsequent need for black bears to move greater distances to find suitable foraging areas. The observation of black bears north of the Denali Highway (a rare occurrence) during 1981 supports the suggestion that black bears made atypically long movements during the summer of 1981 (ADF&G 1982e). Comparisons of home range sizes of black bears on the Kenai Peninsula (4096 acres [16.7 km^2] for females and 24,192 acres [98 km^2 for males) (Schwartz and Franzmann 1981) with those of black bears in the Susitna area suggest that home ranges of black bears in the middle basin are large.

The proximity of black bear home ranges to the proposed impoundments suggest that black bear distributions are closely associated with lower elevation habitats along the Susitna River. ADF&G (1982e) delineated two arbitrarily chosen zones around the proposed impoundment areas (one included all areas within 1 mile (1.6 km) of the impoundments and the other included all areas 1-5 miles (1.6-8.0 km) from the impoundments) to assess the potential effects of the impoundments and associated development on black bear populations. The mean overlap of 27 black bear home ranges with the impoundment areas was 14 percent (0-45 percent). Overlap in the two adjacent zones was 50 percent (0-100 percent) and 122 percent (56-195 percent) for the 1 mile (1.6 km) and the 1-5 mile (1.6-8.0 km) zones, respectively.

(iii) Population Characteristics

- Population Size

ADF&G (unpublished data) attempted a black bear census in August 1982 using radio-collared bears and the Lincoln Index method. The study area included all black bear habitat in the middle basin east of High Lake; areas west of High Lake were not included because thick vegetation hindered sightability. During the survey flights, 38 black bears were sighted of which 9 were marked. The population was known to contain at least 21 marked bears, and thus an estimate of 90 bears (95 percent CI = 50-170) was derived. S. Miller (1982 pers. comm.) felt that this estimate was too low, and the technique will be repeated in spring of 1983.

- Productivity

Black bear populations in the middle Susitna Basin appear to be productive and healthy (ADF&G 1982e). This suggests that habitat is adequate, even if limited in extent.

Eight litters with a total of 16 cubs were observed with radio-collared females during 1980 and 1981 (ADF&G 1982e). Five of these litters were not observed until June - August and may have experienced some losses by this time. Because of this bias, the observed litter size of 2.0 cubs/litter may be a slight underestimate. The observed litter size for 7 litters of yearling black bears was 1.9.

Litter sizes in the Susitna Basin appear to be similar to those reported for litters in other parts of North America. The mean litter size for black bears on the Kenai Peninsula was 1.9 cubs/litter, based on radio-collared animals (Schwartz and Franzmann 1981). Erickson and Nellor (1964) reported an average litter size of 2.15 for black bears in Michigan and 2.0 for Alaska (the exact locale was not identified). Jonkel and Cowan (1971) documented litter sizes of 1.5-1.8 cubs/litter for a relatively unproductive black bear population in Montana over a several-year period.

Although cub production appears to be quite high in the Susitna Basin, cub loss also is high. Based on only 4 litters that were observed prior to June 1981, 4 of 9 (44 percent) cubs were lost. No losses of cubs from litters were observed on the Kenai Peninsula (Schwartz and Franzmann 1981). The high rates of cub loss in the Susitna Basin are believed to be related to the vulnerability of cubs to predation by brown bears and to the relatively high black bear densities (and intra-specific competition for suitable habitats) (ADF&G 1982e).

ADF&G (1982e) suggests, on the basis of available productivity indices, that the Susitna populations are not as productive as black bear populations on the Kenai Peninsula. This was based primarily on the older age of reproductive maturity in the Susitna Basin and the high rate of cub loss.

- Dispersal

Dispersal of black bears from the middle Susitna Basin may contribute to bear populations in adjacent areas. Dispersal of bears into the Susitna Basin appears less likely, however, because of the apparently saturated nature of black bear habitat along the Susitna River (ADF&G 1982e). Several instances of dispersal from the study area have been documented. One sub-adult male was captured at Clark Creek and was later shot near Hurricane on the Parks Highway. A 4-year old male was captured north of the Susitna River and was later shot in an area 44 miles (72 km) to the south. Three adult black bears moved downstream from the middle

Susitna Valley to areas downstream from the Devil Canyon damsite. Two of these bears denned in the downstream areas.

- Sport Harvest

Based on Alaska Department of Fish and Game records for the 1973-1980 period, black bear harvests for GMU 13 averaged 66/year (range 45-85) during a 365 day season with a bag limit of 3 bears (cubs and females with cubs excluded from legal bag limit) (Table E.3.115) (ADF&G 1982e). Males constituted 74 percent of spring harvests and 65 percent of fall harvests. Most of the harvest (74 percent) occurred in the fall season when bears were taken incidental to moose or caribou hunts.

The current harvest is well below the sustainable harvest level. At present, it appears that few hunters sufficiently prize black bear meat or pelts from GMU 13 to charter an aircraft to hunt away from the road system; only 35 percent of the hunters taking black bear during 1973-1980 recorded aircraft as their primary means of transportation (Table E.3.115). However, it is probable that the increasingly restrictive seasons and conditions for moose and caribou hunting in GMU 13 will result in increased black bear hunting in this area, especially as more hunters become aware of the existence of substantial black bear populations in the unit.

Recorded black bear harvests in the Susitna study area during 1973-1980 averaged 8/year (a range of 1-15). In general, black bear harvests have been increasing in recent years with the largest recorded annual take occurring in 1980. The largest harvests have occurred in the downstream region of the Susitna River between the Indian and Talkeetna rivers, the only portion of the study area currently accessible by river boat or highway vehicle.

(f) Wolf

Wolves in GMU 13 have been the focus of many studies and a subject of controversy for over 30 years (Ballard 1981). The history of GMU 13 wolves between 1957-1968 is summarized by Rausch (1969). From 1948-1953, poisoning and aerial shooting by the federal government reduced wolf populations to low levels. By 1953, only 12 wolves were estimated to remain in the basin. The population expanded to a peak number of 400-450 by 1965 after federal predator control efforts were curtailed (Rausch 1969). Moose populations declined to low levels in the area, stimulating a series of predator-prey interaction investigations beginning in 1975 (Stephenson 1978, Ballard and Spraker 1979, Ballard and Taylor 1980, Ballard et al. 1980). Wolf control efforts were renewed in 1976-1978, but by 1980, the wolf population had returned to pre-control levels (Ballard 1981). Recent data on wolf distribution, habitat use, population characteristics, and detailed histories of individual wolves and their packs are provided by ADF&G (1982f).

(i) Distribution

At least 19 wolf packs were known or suspected to be utilizing the Susitna Basin in 1980-1981 (Figure E.3.98). At least 6 and possibly 7 of these packs occur adjacent to the Susitna impoundment.

Individual wolf packs have established territories which, as indicated in Figure E.3.98, overlap little with adjacent packs (ADF&G 1982f). However, because of the large harvest of wolves in this area, packs are periodically eliminated, and areas with no wolves exist for varying periods of time until new packs are formed by animals dispersing from adjacent areas. ADF&G (1982f) provided detailed histories of pack formation, membership changes, and disintegration for 6 packs, beginning as early as 1977. These data indicate that pack territories appear to be more stable than membership (i.e., that a pack is defined by the area it defends rather than its size or individual members). This may be the direct result of the destabilizing influence of extended heavy hunting and trapping and the removal of key individuals from pack structure.

During the summer, activities of packs containing breeding adults are centered on den and rendezvous sites, the latter being above-ground sites where the pups play and are fed from the time they are about 2 months old. Figure E.3.99 shows the locations of known dens and rendezvous sites in the Susitna Basin. Dens are generally but not always roughly centered within a pack's territory, and each is frequently used for more than 1 year. Average distance between 35 dens in the Susitna and adjacent areas was computed to be 28.1 miles (45.3 km) (ADF&G 1982f), a distance that compares well with 24.9 miles (40.2 km) observed in the Brooks Range of Alaska (Stephenson and Johnson 1973).

(ii) Habitat Use

Habitat types used by wolves vary widely (Paradiso and Nowak 1982) and in any particular area are probably determined largely by the habitat of their major prey. In the Susitna Basin, detailed data on habitat use were collected for the Watana pack between April 1980 and November 1981. This pack used a wide variety of habitats but was most frequently encountered in shrub and spruce habitat types (ADF&G 1982f).

Wolf dens in the Susitna area are mostly old red fox dens taken over and dug out by wolves. The majority are located on slightly elevated sandy areas providing good drainage. Entrance holes face predominantly south or east. Both dens and rendezvous sites have been found in a variety of habitats. Overstory trees or shrubs at den sites include spruce, aspen, balsam poplar, paper birch, and willow in densities ranging from 90 percent cover to very sparse (ADF&G 1982f).

- Food Habits

Food habits of wolves in the Susitna area were studied by both direct observation of kills and analysis of scats collected at den and rendezvous sites (ADF&G 1982f). The former method covers all seasons, whereas the latter provides only summer food habits.

During 1980 and 1981, 6 radio-collared wolf packs were observed on 83 kills. Moose comprised 57 percent of the kills, whereas caribou comprised 33 percent. Other prey, such as snowshoe hare, beaver, muskrat, and other small mammals made up the remaining percentage of kills. Calves accounted for 51 percent of the moose kills, and comprised 7 percent of kills of caribou.

Table E.3.116 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, ADF&G (1982f) suspected that the importance of calf moose was probably overemphasized by these data.

Predation rates in the Susitna area have been estimated to average one kill per pack every 5 days (ADF&G 1982f). Rates vary somewhat with pack size (Ballard et al. 1981b) but do not appear to vary seasonally (ADF&G 1982f) as has been suggested for some areas (Peterson 1980).

Studies of wolf food habits in the eastern Susitna Basin and adjacent areas since 1975 have suggested that moose are the single most important food item (Ballard et al. 1981b). Adult moose are taken selectively from August through December, while short and long yearling moose (moose that are a few months younger or older than 1 year) comprise a disproportionate number of January to July kills. Wolves take relatively healthy moose in winter. Ballard et al. (1981b) found that during severe winters all ages of adult moose were taken in proportion to their representation in the population, but in average and mild winters disproportionate numbers of older adults were taken.

Caribou have comprised between 4 and 30 percent of wolf kills from 1975 to 1981. Excluding 1978, when the main body of the Nelchina caribou herd wintered in the Wrangell Mountains and thus was largely unavailable during winter, the importance of caribou in the diet of Susitna Basin wolves appears to have increased. (Wolf diets averaged 18 percent caribou for 1975 through 1977 in comparison to 26 percent 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 in relation to distribution of caribou. Caribou distribution, however, is probably related to herd size (Skoog 1968). The Nelchina herd reached a record low of approximately 7500 in 1972. Since that time, the population has increased to over 20,000. It is suspected that the increase in the caribou population generally has made caribou more available to wolves throughout the eastern Susitna Basin and adjacent areas. If true, this pattern would suggest that if the herd grows even larger, caribou will become more important as wolf prey. Assuming wolf populations in this area increase slightly or remain stable, a larger caribou population may have some positive benefits for moose, in that a larger percentage of the wolf kills may comprise caribou, relieving the moose population of some predation mortality.

- Home Range

Each of the six wolf packs studied by ADF&G (1982f) in the Susitna Basin maintained the same home range during the period that the pack existed as a stable unit. Wolf packs in this area occasionally defend their territories against other wolves, although intrusions into territories often occur when the home pack is not using that portion of the area. Observed pack home ranges varied in size from 232,960 acres (943 km^2) to 621,440 acres (2514 km^2) and averaged 348,800 acres (1412 km^2).

(iii) Population Characteristics

Wolves in the Susitna Basin are heavily hunted and were also subject to an intensive control effort by the Alaska Department of Fish and Game from 1975 to 1978. This control was an attempt to manipulate moose numbers experimentally by reducing predation. Whether the wolf population was at a low level in 1980-1981, when detailed studies related to the Susitna project began, is unknown. The population in the Susitna Basin in 1980-1981 ranged from about 40 in spring after the hunting/ trapping season to about 75 in fall when the pups join the hunting adults (Table E.3.117).

Although there has been much speculation, there is little agreement on the factors that control wolf populations. Van Ballenberghe et al. (1975) believed that pack density, prey abundance, and degree of exploitation varied so much among populations that the combination of factors controlling one population might be quite different from those controlling another. In the Susitna Basin human exploitation is quite clearly the most important factor. The is no bag limit on harvest of wolves in GMU 13 and season is open from August 10 to April 30. In 1981 and 1982, almost half the fall population was removed through legal and illegal winter hunting. Including wolves taken during the wolf control program from 1975 to 1978, the average yearly harvest from the Susitna Basin and areas immediately adjacent (Game Management Units 13A, 13B, and 13E) averaged 38 and ranged from 26 to 68. Additional large numbers of wolves were taken illegally in each year (ADF&G 1982f).

Although there are few specific data, the maintenance of these high levels of harvest suggest high productivity in the population. ADF&G (1982f) does not report average litter size for the packs they studied, but their remarks suggest that 6-8 pups were produced yearly by each pack. High productivity, both in terms of proportion of adult females that whelp and litter size, has been demonstrated in other exploited populations both in Alaska and elsewhere (Rausch 1967, Van Ballenberghe et al. 1975).

The large numbers of pups produced each year results in a large population of young wolves likely to disperse to other areas. ADF&G (1982f) gives numerous examples of radio-collared wolves that moved from one pack to another within the basin; wolves that established new packs in vacant areas; and wolves that left the basin entirely. Dispersal of individuals is often preceded by forays away from the pack home range and may be precipitated by death of most of the other pack members through sport hunting or packing.

(g) Wolverine

The wolverine remains one of the most poorly known of the larger carnivores, and few scientists have attempted to study wolverines in their natural habitat. Van Zyll de Jong (1975) states that the reason for this is that the species is uncommon, highly mobile, and restricted to the more remote and inaccessible parts of the country. Most wolverine studies in North America have reported on the species' breeding biology and other information obtained from carcasses (reviewed by Rausch and Pearson 1972). Recent advances in radio-telemetry have resulted in studies of wolverine movements, habitat use, and home ranges in northwestern Montana (Hornocker and Hash 1981), northwestern Alaska (Magoun 1982), and in the middle Susitna Basin (ADF&G 1982g).

(i) Distribution and Habitat Use

Wolverines occur throughout the Susitna Basin and appear to show little preference for specific habitat types (Figure E.3.100). The lack of use of specific habitats is most likely related to the scavenging lifestyle of this species which dictates seasonally long movements, a relatively large home range, and a solitary existence (Hornocker and Hash 1981). Van Zyll de Jong (1975) states that "the wolverine's niche explains the relative rareness of the species in the community compared to the efficient hunters among carnivores that act as providers [of carrion], and it implies a direct relationship between the biomass and turnover of large herbivore populations and the abundance and distribution of wolverines." The wolverine's propensity for wandering far and wide, which increases its chances of finding widely scattered and immobile food, and its well-developed food-caching behavior are probably also adaptations to the scavenger role (Hornocker and Hash 1981).

Food availability appears to be the primary factor determining movements and home range sizes of wolverines (Hornocker and Hash 1981; ADF&G 1982g). Breeding activity also influences the seasonal movements of males, and to a lesser extent, of females (Hornocker and Hash 1981; Magoun 1982). Temperature may also influence movements; Hornocker and Hash (1981) reported that, during the summer, wolverines of both sexes moved to higher, cooler elevations and traveled less during daylight hours. In the Susitna Basin, ADF&G (1982g) reported that changes in wolverine distribution occurred throughout the year and that food availability probably influenced these shifts. They noted a pronounced movement in spring, summer, and fall to higher elevations where arctic ground squirrels, marmots, and ground-nesting birds were abundant. Food is most available in the spring and summer, and wolverines consume a wide variety of food at that time (see Wilson 1982). Krott (1959) found carrion, small mammals, insects and insect larvae, eggs, and berries in the summer diet. Magoun (1982) found microtines, ground squirrels, marmots, and caribou in the spring and summer diets of wolverine in northwestern Alaska.

Movements to lower elevations during winter are apparently associated with the increased importance of carrion in the diet during the winter months. During winters of moderate-to-deep snow depths, the lower elevations along the Susitna River support high densities of moose (ADF&G 1982a). Also, fewer birds and small mammals are available at higher elevations during the winter months (Kessel et al. 1982a). Winter ground tracking indicated that wolverines were preying upon microtines, red squirrels, ground squirrels, and spruce grouse in addition to carrion (ADF&G 1982g). Both red squirrels and spruce grouse are restricted to forested areas, and other small mammals are also most abundant in coniferous and deciduous forests.

The degree of territorialism exhibited by wolverines in an area appears to be related to the turnover rate of the wolverine population. Magoun (1982) found that female wolverines in an essentially unharvested population occupied exclusive home ranges that were overlapped by those of males. She did not have enough data to determine whether adult male home ranges overlapped. Hornocker and Hash (1981) stated that wolverine home ranges in northwestern Montana overlapped between individuals of the same and opposite sex and claimed that territorial defense was essentially nonexistent. However, they were unable to establish the residency status of individuals in their population. Magoun (1982) reported that females with overlapping home ranges might be mother/daughter combinations, and that young males which have not yet dispersed might be overlapped by resident adult males. The data obtained on wolverines in the Susitna Basin indicate that, except for some overlap between adults and juveniles, individuals of the same sex occupy mutually exclusive home ranges. The overlap of ranges shown in Figure E.3.100 is caused mostly by the mortality of some of these animals during the studies. Hornocker and Hash (1981) suggested that trapping mortality in their study area, while not excessive enough to reduce population size, may have contributed to behavioral instability within the population causing a breakdown in the territorial system. They pointed out that unexploited mountain lion populations showed a highly refined system of territoriality, whereas exploited populations were not territorial at all. Exclusive use of home ranges by same-sex adult wolverines in the Susitna Basin and northwestern Alaska may, therefore, be a reflection of relatively low trapping mortality.

(ii) Population Characteristics

The home range data obtained from the Susitna Basin study and from other studies can be used to estimate the number of wolverines present in the upper and middle basins. Home range sizes of male wolverines will be used in these calculations, since more data are available for males than for females. The average home range size for 5 adult males located at least 5 times was 101,760 acres (413 km^2), ranging from 34,560 to 154,880 acres (141 km^2 to

628 km^2). These ranges were smaller than those reported for males by Magoun (1982) (mean = 172,800 acres [700 km^2]), but similar to the 104,320 acres (422 km^2) value found by Hornocker and Hash (1981).

If we assume that wolverines in the 4,032,640 acre (16,319 km^2) middle and upper basins use all habitat types (including rivers, lakes, rock and ice), and further assume that adult male home ranges are mutually exclusive and contiguous, we arrive at an estimate of 40 adult males in the middle and upper basins. Reported sex ratios of wolverine kits taken from dens and of fetuses do not differ from a 1:1 ratio (Pulliainen 1968; Rausch and Pearson 1972); therefore, an estimated 40 adult females also occur in the area. According to Rausch and Pearson (1972), the effective reproduction of wolverines is 2 kits/litter. Hornocker and Hash (1981) believed that no more than half of the females on their study area were reproductively active in each of the five years of their study, and only 53 percent of mature females trapped in the Susitna basin were reproductively active (ADF&G 1982g). About 40 kits are therefore added to the basin's population each year, resulting in a total summer estimate of 120 wolverines in the basin. This converts to a density of 1 wolverine/ 33,920 acres (1/136 km^2). This compares with other density estimates of 1/233 km^2 in northwestern Alaska (calculated from Magoun 1982); 1/65 km^2 in northwestern Montana (Hornocker and Hash 1981); 1/207 km^2 in British Columbia (Quick 1953), and 1/200 km^2 to 1/500 km^2 in Scandinavia (Krott 1959). There are probably fewer than 120 wolverines in the middle and upper basins, since it is unlikely that wolverines use all areas; and emigration, immigration, and trapping and natural mortality probably result in a smaller population size. Some juveniles also occupy home ranges that do not overlap completely with those of adults.

Trapping is probably the main cause of mortality among wolverines in the Susitna Basin. A total of 27 wolverines was harvested from this area during 1979-1981; 20 during 1979-1980 and 7 during 1980-1981. The low take during 1980-1981 was probably the result of poor weather and snow conditions. Most trapping occurs in the accessible periphery of the area.

4.2 - Baseline Description

(h) Belukha Whale

The belukha whale is a widespread arctic and subarctic circumpolar species that inhabits coastal waters. In Alaskan waters, two discrete stocks, a Cook Inlet-northern Gulf of Alaska stock and a general Bering-Chukchi-Beaufort stock, have been identified based on migration patterns, summer concentration areas, and morphological differentiation (Sergeant and Brodie 1969, Murray and Fay 1979, Gurevich 1980). No evidence exists to indicate interchange between the Cook Inlet stock and the Bering Sea stock, and isolation has been suggested based on morphological differentiation.

(i) Distribution and Habitat Use

In winter, belukhas may be found in some of the ice-free bays in southern Cook Inlet. Some individuals apparently range across the northern Gulf of Alaska; sightings of belukhas have been reported from Shelikof Strait, Kodiak Island, and Yakutat Bay (Fiscus et al. 1976; Calkins and Pitcher 1978; Harrison and Hall 1978; Calkins 1979; and ADF&G unpublished data).

Belukhas aggregate in groups of two to several hundred individuals in spring and summer seasons. These concentrations have been attributed to exploitation of locally concentrated foods, such as anadromous fish (Tarasevich 1960, Sergeant 1962). Belukha concentrations are also apparently associated with polygamous breeding in April and May, with calving (reported to occur in May through August in brackish lagoons) and with the subsequent nursing of neonates (Seaman and Burns 1981).

Most of the Cook Inlet population moves into upper Cook Inlet in spring and remains there through much of the summer. In spring and summer, concentrations develop near mouths of streams and rivers in the northern inlet. The largest concentrations occur annually between the mouths of the Susitna and Beluga rivers, sometimes ascending the rivers for several miles. Various species of smelt and salmon, both out-migrating smelt and returning adults, are the most likely attractants in Cook Inlet rivers. There has also been speculation that the mouth of the Susitna River is a calving and nursing area for belukhas.

Aerial surveys were flown by ADF&G (unpublished data) in upper Cook Inlet between May 17 and August 27, 1982, to identify the timing and magnitude of belukha concentrations. Belukhas were concentrated in the inlet south of the Susitna River mouth from the date of the first survey through late June or early July, with a peak number of 300 animals counted on June 11. As explained below, these counts may be one third to one half the actual numbers present. By July 8, the concentrations appeared to have broken up and only 7 whales were sighted in the Susitna to Beluga River area.

No calves were sighted during these surveys, but ADF&G attributed this to the low visibility in the turbid waters of the upper inlet and indicates that calves were likely to have been present when surveys began on May 17.

(ii) Population Characteristics

Population estimates of the Cook Inlet stock from the mid-1960s indicate 300-1000 belukhas in Cook Inlet, with an estimate of 500 animals (Klinkhart 1966) most accepted. More recent surveys support this estimate (Calkins 1979; Calkins, unpublished data). ADF&G (unpublished data) reported 300 belukhas from direct counts in upper Cook Inlet on June 11, 1982, and indicated that, because the turbid water obscured the observers' vision, 2 to 3 times that many may have been present but could not be observed.

4.2.2 - Furbearers

(a) Beaver

(i) Distribution and Habitat Use

Beavers are common and widely distributed throughout much of North America. They occur throughout the Susitna River drainage, from Cook Inlet upstream along the river, its tributaries, and ponds to elevations above 3281 feet (1000 m) (Gipson et al. 1982). They are herbivorous and eat herbaceous and aquatic vegetation as well as the bark, twigs, and stems of trees and shrubs.

The Susitna River from Devil Canyon to the Delta Islands was surveyed for beaver sign in the summer of 1980 by Gipson et al. (1982). Use of the river by beavers increased progressively downstream from Devil

Canyon (Gipson et al. 1982). An overflight of the river in the summer of 1981 and intensive surveys in 1982 confirmed this observation (Table E.3.118). No beaver lodges, food caches, or dens were observed within the active floodplain between the Tyone River and Devil Canyon, but they do occur on some tributaries and lakes in the middle basin. In summer 1982, Gipson et al. (unpublished data) surveyed the river downstream from Devil Canyon using a river boat, helicopter, and ground surveys to determine beaver habitat preferences, lodge construction materials, and forage plants. Preferred food sources were willow (particularly feltleaf willow), balsam poplar, and paper birch. Alder was the primary material for lodge construction but was rarely found eaten (peeled). Peeled birch, poplar, and willow were also used for construction.

The Susitna River between the Deshka River and Portage Creek was divided into three sections on the basis of river morphology and vegetation characteristics: upper section from Talkeetna to Portage Creek, middle section from Goose Creek to the Talkeetna River, and lower section from the Deshka River to Goose Creek. Each section was divided into linear miles of floodplain parallel to the main channel, and each sample unit was one of the mile sections from the thalweg (the deepest part of the channel) to the active floodplain boundary on one side. Beaver habitat was classified into four categories for analysis as described below. Although described in terms of water type, habitat also included bank characteristics, water sources, and tree and shrub vegetation.

- Main Channel: Consisted of the major river thalweg and associated land masses. Channels were characterized by rocky and eroding banks with high velocity and high volume flows.

- Side Channel: Consisted of channels which split off the main thalweg, yet carried large volumes of water. Representative channels showed rocky banks and silty flow with generally high velocity. Substantial amounts of erosion were often associated with side channels.

- Sloughs: Lower volume and slower flow characterized these channels. Silty banks with established vegetation were characteristic along with reduced erosion. The water source was predominantly the Susitna with some clear-water mixes. A number of sloughs may exist only at normal or high water levels.

- Clear water: This habitat consisted of creeks, river runoff, and seeps which were of non-Susitna or filtered clear water. Slow to moderate flow, silty banks, and established vegetation were characteristic.

In all sections of the river, beaver were found to prefer slow-moving side channels or sloughs, as well as mouths of tributaries (see Table E.3.118). Such sites increase progressively downstream as the river channel becomes more braided. Beaver in the middle and lower sections are reported by residents to use bank lodges which have an underwater entrance and an air vent under a large tree. If this is the case, the "high activity" values in Table E.3.118 for these sections are low, since there is no detectable sign for these types of dens that would have been recorded.

Slough and Sadlier (1977) identified the major components important to beavers as water depth, stability, and flow rate and distance to suitable food species. They found that the variables which correlated best with beaver population densities were low flow, low gradient (low erosion potential), and banks containing a high percentage of food species. Results of the 1982 survey agree with their work as well as the findings of Boyce (1974) and Hakala (1952), who reported that beavers in Alaska favor lakes or slow-moving streams bordered by subclimax stages of shrub and mixed conifer-deciduous forests. The results also agree with a study by Retzer (1955) who found that beavers avoid large rivers with narrow valleys and high velocity flows.

(ii) Population Characteristics

Aerial surveys of food caches in the fall have been shown to be an accurate method of determining the number of active beaver colonies in an area (Hay 1958, Machida 1982). An aerial cache survey conducted by Gipson et al. (unpublished data) in 1982 revealed 14 beaver food caches in the active floodplain of the Susitna River between Portage Creek and Talkeetna (0.26/mile [0.16 caches/km]). Each cache is estimated to support five beavers (Boyce 1974), so the population of that stretch of the river is estimated at 70 beavers. This is a low population density compared to a range of 0.56 - 0.65/mile (0.35-0.40 colonies/km) found elsewhere in Alaska (Boyce 1974), but was expected to be low because of the scarcity of side channels and sloughs with slow-moving water along this reach of the river. Beaver densities would be much higher if beavers in nearby ponds and tributaries were included, but these areas are unlikely to be affected by the project and therefore were not sampled. Population estimates were not possible for the river south of Talkeetna, because high water levels had obscured or destroyed many of the existing caches.

The 1982 survey also included Deadman Creek because of its proximity to the proposed access road. The density of beavers was 0.85/mile (0.53 active lodges/km) along the middle portion of Deadman Creek and was even higher in a marshy section of upper Deadman Creek (Table E.3.119). An estimated 65 beavers currently occupy this creek.

Beaver populations are productive and can withstand moderate trapping pressure. First breeding occurs at age 2 or 3, and annual litters average 3 to 4 young thereafter (Hill 1982). Young beavers disperse during the summer of their third year, sometimes traveling as far as 124 miles (200 km) to set up new lodges (Hill 1982). Trapping for beaver has historically been common along the Susitna River below Devil Canyon, along major tributaries, and around larger lakes like Stephan Lake (Gipson et al. 1982). Beavers in alpine areas have seldom been trapped because of the effort involved. These populations are vulnerable to environmental alteration and/or overtrapping because of their dependence on small, isolated riparian habitats (Gipson et al. 1982).

(b) Muskrat

Muskrats are common and widely distributed throughout most of North America. They occur throughout the Susitna River drainage from Cook Inlet upstream along the river, its tributaries, and ponds to elevations above 3281 feet (1000 m). Muskrats are primarily herbivorous, with a diet that includes pondweed and swamp horsetail (Perry 1982).

The middle Susitna Basin was surveyed for muskrat sign in the early spring of 1980 by Gipson et al. (1982). All lakes within 3 miles (4.8 km) of the Susitna River were surveyed by helicopter, from the confluence with the Oshetna River to

Gold Creek. Muskrat pushups were observed on 27 (26 percent) of the 103 lakes surveyed (Table E.3.120). Most of the lakes and ponds with muskrat sign were above the river valley, between 870 and 2840 feet (265 and 865 m) in elevation. Populations of muskrats were also noted along slow-flowing sections of larger creeks, particularly where lakes drain into streams (Gipson et al. 1982).

A downstream survey of muskrat use of Susitna River habitats conducted by riverboat in the summer of 1980 indicated that muskrat numbers increase with distance from Devil Canyon (Gipson et al. 1982). Suitable slow-water habitat in sloughs and side channels increases in availability downstream from Talkeetna. No sign of muskrat was noted on the river between Devil Canyon and Talkeetna. Between Talkeetna and Montana Creek, sign of muskrat was limited to sloughs and marshy areas near the mouths of feeder streams. Muskrat sign was more commonly observed downstream from Montana Creek where numerous side channels and sloughs occur (Gipson et al. 1982).

Trapping for muskrats has historically been common along the Susitna downstream from Devil Canyon, along major tributaries, including Indian River and Portage Creek, and around larger lakes, such as Stephan Lake. Muskrats in alpine streams and lakes have seldom been trapped because of the effort involved.

(c) River Otter

Information concerning the distribution and abundance of river otters in the middle Susitna Basin was obtained during autumn aerial and winter ground surveys by Gipson et al. (1982) (see Tables E.3.121, E.3.122 and E.3.123, and Figure E.3.101). These data indicate that otters are common along the Susitna, its tributaries to 3937 feet (1200 m) elevation, and around large lakes. This distribution is probably related to the distribution of prey of otters, which includes primarily fish and crustaceans (Ryder 1955, Knudson and Hale 1968, Toweill 1974, Gilbert and Nancekivell 1982).

In November 1980, an unusual concentration of otter tracks was found on the river ice within the proposed impoundment areas (Gipson et al. 1982). The significance of this track concentration is unclear, but it may represent upriver or downriver movements of otters prior to freezeup. It is also possible that the otters were concentrating along the river to feed on grayling, which were migrating out of the tributaries to overwinter in the Susitna.

Some otter trails were also observed in cross-country travel, away from bodies of water. Such tracks have been noted in other areas of south-central Alaska and may represent dispersing sub-adults (Gipson et al. 1982). Local trappers seldom take river otters because they are relatively difficult to trap, and the pelt values have usually not been high enough to justify the effort.

(d) Mink

Mink are locally abundant in the middle basin along the river, its major tributaries to 3937 feet elevation (1200 m), and along lakeshores. Track counts from both air and ground in fall 1980 (Tables E.3.121 and E.3.122) suggest that mink are more abundant in the upper reaches (east of Kosina Creek) of the Watana impoundment area than they are elsewhere (Gipson et al. 1982). Two mink were radio-collared in 1980, but no data were obtained because one animal slipped its collar and the other's radio failed. Food habits of mink vary among areas, depending on prey availability. Small mammals and fish usually form the majority of the diet, but crustaceans and birds may also be eaten (Errington 1954, Wilson 1954, Korschgen 1958). Muskrats may form a major portion of the diet where they are available (Hamilton 1940, Sealander 1943).

(e) Marten

Pine marten are common nocturnal mustelids found in spruce forests throughout interior Alaska. Information presented here is provided by Gipson et al. (1982) from 3 types of data: (1) radio-telemetry studies of home range, habitat use and activity patterns of 14 individuals from fall 1980 to fall 1981; (2) snow-tracking data on habitat use; (3) analysis of food habits from scats; and (4) aerial snow-track survey data on habitat use and relative density.

(i) Distribution

Aerial surveys of the Susitna River flown in November 1980 indicated that marten were present at least as far downstream as Portage Creek and as far upstream as the Tyone River (Table E.3.121) (Gipson et al. 1982). They are locally abundant in the vicinity of the proposed Devil Canyon and Watana impoundments.

Gipson et al. (1982) found that home ranges of adult male marten were mutually exclusive but overlapped those of other sex/age classes. Average home ranges of 10 radio-collared adult males were 1,734 acres (7.02 km^2). Female home ranges averaged 915 acres (3.71 km^2) (n=3), excluding one animal with an unusually shaped home range. Between spring and autumn 1981, some marten home ranges appeared to shift location and vary in size periodically. Marten rarely swim across rivers or large creeks, which often form partial home range boundaries in the study area.

Home range sizes in the Susitna area are midway between the figure of 3,136 acres (12.8 km^2) for 4 marten in Minnesota (Mech and Rogers 1977) and 1,024 acres (4.1 km^2) for 5 marten in the Yukon Territory (Archibald 1980). Differences in home range sizes in different areas and seasons are attributable to variability of food resources (Lensink et al. 1955, Soutiere 1978).

An estimated density of 0.0034 marten per acre (0.847/km^2) was calculated from radiotelemetry data on 10 adult male marten along the Susitna River between Deadman and Watana Creeks (S. Buskirk 1982 pers. comm.). This estimate assumes a 1:1 sex ratio, with male and female territories overlapping and 65 percent juveniles in the population (a figure derived from trapper harvest data in the Yukon Territory by Archibald 1980).

Information from former and present trappers indicates that marten continue to be economically the most important furbearer in the vicinity of the impoundment zones (Gipson et al. 1982).

(iii) Habitat Use

Track counts from a November 1980 aerial survey indicate that marten are most numerous in coniferous and mixed forest and woodland and habitats below 1,000 m (3,281 feet) elevation (Table E.3.121) (Gipson et al. 1982). The highest track counts occurred between Devil Creek and Vee Canyon (Table E.3.121).

Marten resting sites were located below ground in late autumn, winter, and early spring. In summer, when soil temperatures are lower than air temperatures, marten rest above ground. Summer resting sites could not be characterized because of the escape response of marten above ground. Thirty-one of 37 winter resting sites (83 percent) were in red squirrel middens or nests. All were in forest or woodland vegetation types.

- Food Habits

The diet of marten shows some seasonal variation, but microtine rodents are the primary prey at all times of the year in interior Alaska (Lensink et al. 1955). Microtines had an 88.8 percent frequency of occurrence in scats from the middle Susitna Basin (S. Buskirk 1982 pers. comm.) (Table E.3.124). Plant foods, such as bog blueberries, crowberries, mountain cranberries, and rose hips, are consumed most frequently in autumn, and attain an average frequency of occurrence of 23.3 percent. Bird remains were present in 9.6 percent of scats, most frequently in winter, and squirrels occurred in 6.8 percent, most frequently in spring.

(f) Red Fox

Red foxes and their sign have been observed throughout the middle Susitna Basin, including the proposed Devil Canyon and Watana impoundments. During 1980 and 1981, Gipson et al. (1982) employed radio-tracking, snow-tracking, and aerial snow-tracking to determine fox distribution, abundance, and habitat use. Food habits were studied from scat analysis, stomach content analysis, and examination of food remains at dens and on fox trails. Aerial surveys were conducted to locate fox dens, and dens were surveyed periodically throughout summer to determine use.

(i) Habitat Use

Foxes in the middle Susitna Basin appear to prefer relatively high elevation areas near or above the timberline (Gipson et al. 1982). Black spruce flats upstream from Vee Canyon are also commonly used. Some foxes use low elevation tributary deltas during autumn, then shift to alpine zones as snow depth and volume of water flowing over the ice increase. Other foxes remain above timberline year round. Trails in snow indicated that foxes commonly foraged in winter in areas above timberline frequented by large flocks of ptarmigan.

4.2 - Baseline Description

In aerial transects of furbearer tracks in fall 1980, almost twice as many tracks (151 vs. 79) were located south of the river as opposed to the north (Table E.3.125). This is in contrast to the greater number of active dens found on the north side. However, at the upper reaches of the proposed impoundment, fox density was observed to increase markedly and transects 1-11 (see Figure E.3.101 and Table E.3.125) had almost even numbers of tracks on the north and south sides (67 on the north and 51 on the south). All of the north side-south side discrepancy is accounted for in transects 12-14. The south side of the river above Vee Canyon changes from mountainous terrain to open, marshy flats which Gipson et al. (1982) say characterize good fox habitat.

Gipson et al. (1982) report that searches along the Susitna River and lower elevations of tributaries in late winter and early spring 1980 produced no evidence of foxes in these areas. Tracks and other signs were noted on river banks in the following late fall and early winter.

- Denning Habitats

  Nineteen fox dens were located in the middle basin during baseline studies in 1981 (Figure E.3.102) (Gipson et al. 1982). Sixteen dens were located north of the Susitna River with several dens concentrated in the upper Watana Creek and upper Deadman Creek drainages. Gipson et al. (1982) report that several undiscovered dens are likely to exist on the south side of the river, but the aspect, physiography, and vegetation appear more favorable for denning and hunting on the north side.

  Dens are typically situated on an aspect facing south and/or west, and on well-drained prominences up to 16 feet (5 m) above surrounding areas. Dens are also characterized by proximity to a lake of over 10 acres (4 ha) or a creek. Dens were found between 3280 and 3940 feet (1000 and 1200 m) elevation in areas of rolling hills adjacent to mountains. All active dens located were in or near areas of medium-to-high ground squirrel density.

4.2 - Baseline Description

Foxes in this study area remained at den sites into October, much later than in other areas of Alaska (see Gipson et al. 1982) or elsewhere (Sheldon 1950, Storm 1972). Foxes in the Susitna project area appear to use den sites throughout the winter, as evidenced by clearing of snow from at least one entrance of most dens visited by observers during winter months.

- Food Habits

Principal foods of foxes in the middle Susitna Basin were determined by Gipson et al. (1982) through direct observation of foxes, identification of remains at dens and on trails, scat analysis, and stomach analysis of foxes taken by trappers. In spring and summer, diets include arctic ground squirrels, red-backed voles, and singing voles. Ptarmigan are taken throughout the year and are major components of the diet in winter. Muskrats are taken where available and may be relatively important to foxes in the vicinity of large lakes such as Stephan Lake, Clarence Lake, and Deadman Lake. Dispersing young muskrats and muskrats at pushups are especially vulnerable to predation by foxes.

Carrion is also identified as important by Gipson et al. (1982) based on the observations of foxes feeding on a carcass of moose and another of caribou near Watana Camp and on a sheep carcass on the east fork of Watana Creek.

Snowshoe hare are presently scarce in the Susitna study area and are, therefore, unimportant in the diet of foxes there. The scarcity of hares may be responsible in part for the relatively low number of foxes in the area, as well as the seasonal shifts by foxes to higher elevations where ptarmigan are available.

- Home Range

Summer home ranges varied from 4544-8064 acres (18.3 to 32.7 km^2) in the Susitna study area with little difference in home range size between males and females (Gipson et al. 1982). The larger size of home ranges in the Susitna study area compared with studies in midwestern states was attributed by Gipson et al. (1982) to the greater availability of food in the midwest.

(ii) Population Characteristics

Six of 19 dens found in a 432,640 acres (1751 km^2) area in the middle basin in summer 1981 were active (Gipson et al. 1982). Dens were classified according to size and use as described in Table E.3.126; locations are mapped on Figure E.3.102. A seventh den was probably also active, giving a density of one family per 61,440-72,320 acres (250-292 km^2) (a family usually consists of 4-6 foxes). Gipson et al. (1982) report that the most reasonable estimate of density is one family per 20,480 acres (83 km^2) based on the assumption that at least one third of active dens were found in 1981.

Transect data demonstrate a marked increased in number of fox tracks encountered as one progresses upstream from Devil Canyon to the Tyone River. Fur harvest reports of the Alaska Department of Fish and Game indicate that 983 red fox pelts were exported from GMU 13 between 1976 and 1981. Four dealer locations account for 92 percent of the basin harvest: Cantwell, Gakona, Copper Center, and Glenallen. Cantwell, which lies closest to the study area, comprised 11 percent of the total 5-year GMU 13 export. Gipson et al. (1982) indicate that interviews with furdealers and trappers identify the upper Copper River-Solo Hills-Maclaren River area and the Crossman Lake area west of Paxson as the source of most foxes taken. Dean Wilson (personnel communication cited by Gipson et al. 1982) indicated that most of the furs he buys are taken in open, marshy country and that prime fox habitat decreases from the MacLaren River to the Tyone- Oshetna-Susitna areas as flat open plains rise to mountainous alpine terrain. Gipson et al. (1982) conclude that the Susitna project study area supports a low-density fox population relative to other areas in Alaska.

(g) Lynx

The distribution of lynx in the middle basin is very limited at present. Tracks and scats have been found in several areas including the mouth of Goose Creek (probable lynx tracks seen from the air on November 19, 1980, and a dense concentration of scats and tracks found on October 22, 1981); the mouth of Jay Creek (tracks seen on October 30, 1981); and along Goose Creek, 1 mile (1.6 km) from the mouth (tracks seen on November 3, 1981)(Gipson et al. 1982). However, considering the amount of effort involved in aerial and ground furbearer surveys, these track records indicate that few lynx occur in the middle basin.

In the past, lynx were apparently fairly numerous in the canyon country of the Susitna River, being found primarily in the forests along the river (H. McMahan, pers. comm. cited by Gipson et al. 1982). Trappers in the vicinity of the impoundments reported no sightings of lynx or their tracks, and reports from trappers in the Gold Creek area suggest that lynx have been uncommon there in recent years as well (Gipson et al. 1982).

Lynx population levels fluctuate in response to availability of snowshoe hares (Keith 1963), which were uncommon in the Susitna Basin in 1981 (Kessel et al. 1982a). Gipson et al. (1982) reported that historically, the frequency of natural forest fires increased from Portage Creek to the Tyone River, and speculated that snowshoe hare (and lynx) numbers may have been higher in the past. However, Kessel et al. (1982a) note that no fires have occurred in the Susitna Basin in the recent past, and they report that hare numbers appear to be chronically low in the Susitna area. If fire or other habitat change leading to an increase in snowshoe hares occurs, lynx populations will likely also increase. However, for the present, lynx are uncommon in the area.

(h) Coyote

The distribution of the few coyotes occurring in the middle basin is generally limited to those areas downstream from Devil Creek. No coyotes or their tracks were observed by Gipson et al. (1982) during baseline studies in the Susitna area, although several sightings of coyotes in fall 1980 were reported to them. Other sightings of coyotes, or their tracks, have also been reported in the Gold Creek and Canyon areas (H. Larsen 1981 pers. comm.; R. Roullier 1981, pers. comm. cited by Gipson et al. 1982). Coyotes have not been seen or taken by trappers upstream from Devil Creek. The distribution and abundance of coyotes in the Susitna area is probably limited by wolves rather than by habitat, food availability, or trapping pressure. Wolves are usually aggressive toward coyotes within their home range (R. Peterson and J. Woolington 1982 pers. comm.).

4.2 - Baseline Description

(i) Short-tailed Weasel

Short-tailed weasels are locally abundant in the middle basin, and their tracks have been observed in a variety of habitat types at elevations ranging from the banks of the Susitna River to over 4290 feet (1500 m). Transect surveys conducted in November 1980 yielded 746 short-tailed weasel tracks, 328 (44 percent) of which were counted on a single transect near the Tyone River (Table E.3.121). Most of the tracks (489 or 66 percent) were observed in woodland white or black spruce vegetation types; an additional 190 (25 percent) were counted in medium shrub types (Gipson et al. 1982). It appears that short-tailed weasels can meet their food and cover needs in a variety of habitat types. Short-tailed weasels have been taken both deliberately and incidentally by trappers on upper Tsusena Creek, in the Fog Lakes area, and elsewhere in the study area; but they are not a species of major economic importance.

(j) Least Weasel

Least weasels occur at least sparsely throughout the middle basin and may be locally abundant. However, their small size and secretive behavior makes confirmation of their presence difficult. Several sets of tracks believed to be those of least weasels were seen in March 1980 along lower Watana Creek. The carcass of one 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 Site A on October 25, 1981 (Gipson et al. 1982). The pelts of least weasels have practically no commercial value (Svendsen 1982), and, thus, information from trapping returns is rarely available to supplement direct observations.

4.2.3 - Birds

Little was known about the birds of the middle Susitna Basin prior to initiation of baseline studies for the Susitna Hydroelectric Project. Baseline data on breeding birds of the middle basin presented here are primarily those collected and provided by Kessel et al (1982a, Personal communication, and unpublished data), University of Alaska Museum. Data presented are from 3 sources: (1) 12 - 25 acres (10 ha) bird census plots, (2) ground and aerial census of waterbodies, (3) helicopter surveys and ground reconnaissance of raptor nesting habitats, and (4) additional data on species presence and phenology and habitat use were obtained from casual observations of investigators and observations solicited from others working in the region (Kessel et al. 1982a, 1982). These data have been liberally drawn upon to provide much of the following text. However, additional information has been incorporated wherever appropriate.

Locations of census plots are shown in Figure E.3.103. Sites were selected in relatively uniform patches of vegetation that represented each of the major woody avian habitats present in the region (Kessel 1979). The alpine tundra plot was selected to include several of the widespread avian habitats of higher elevations. Each plot was censused 8 times between May 20 and July 3, 1981 (and 8 times between May 24 and July 2, 1982). Methods were modified from the territory census method (International Bird Census Committee 1970).

Locations of censused waterbodies are shown in Figure E.3.104. Ground censuses of 28 waterbodies were conducted between July 8 and 29, 1981. Each waterbody was censused once by observers walking the shoreline or canoeing the edges, or by both methods simultaneously. Aerial surveys to monitor use of waterbodies during migration were conducted by helicopter between September 7 and October 4, 1980; May 3-26, 1981; and September 15 to October 23, 1981. The number of waterbodies surveyed varied each survey; the average was 34. Flights were made at approximately 50 mph (80 km/h) and between 100 and 250 feet (30 and 75 m) altitude. When flocks were encountered, the helicopter circled widely and slowly for an accurate count and identification. On lakes, the helicopter followed the shoreline for the survey; a single pass was made over smaller waterbodies. Large lakes were surveyed in sections.

Raptor surveys were designed specifically for cliff-nesters (especially golden eagles, gyrfalcons and peregrine falcons) and large tree-nesters (especially bald eagles). Information on other species was obtained incidental to these surveys and during ground-based plot surveys and waterbody surveys.

Raptor surveys were conducted in the middle basin by helicopter on July 6, 1980 and May 16 and 17, 1981 (Kessel et al. 1982a). All cliff nesting habitat and stands of large white spruce and cottonwood within approximately 3 miles (5 km) of the Susitna River and its tributaries from Portage Creek (1980) and the Indian River (1981) to the mouth of the Tyone River were surveyed. The proposed access routes were surveyed on July 3 and 5, 1981. During surveys, the helicopter moved slowly past cliff faces at approximately 30-40 m distance until the face was considered adequately scanned. In 1980 and 1981, active nests were visited from the ground between May 20 and July 13, 1981. In addition, all potential appearing peregrine falcon nesting habitat (e.g., especially partially vegetated cliffs) was examined by helicopter and on foot in June 1981.

4.2 - Baseline Description

A total of 135 species of birds were recorded in the middle basin. Their relative abundances (see Appendix 3.E) were largely a function of habitat availability. The most abundant species in the project area are common redpoll, savannah sparrow, whitecrowned sparrow, Lapland longspur, and tree sparrow.

Of the 135 species, 15 are ranked as rare in the middle and upper basin on the basis of current information: 4 raptors (osprey, American kestrel, snowy owl, boreal owl); 3 species of ducks (gadwall, blue-winged teal, ring-necked duck); 4 shorebirds (upland sandpiper, turnstone spp., surfbird, sanderling); 3 small land birds (black-backed three-toed woodpecker, western wood pewee, yellow warbler); and ruffed grouse. Most of these species were rare because they were either at the periphery of their geographic ranges or were limited by a lack of appropriate habitat. All 15 species are represented by larger populations in other portions of Alaska.

Baseline data on distribution, abundance, and habitat use of bird populations in the lower Susitna floodplain were collected by the University of Alaska Museum (Kessel et al. 1982b). Three types of avian surveys were conducted between Devil Canyon and Cook Inlet: (1) spring aerial surveys of waterbirds in 1981 and 1982; (2) a ground survey of all bird species in early summer 1982; and (3) an aerial survey for bald eagle nests in summer 1982.

Spring aerial surveys were made on May 7, 1981, and May 10, 21, and 28, 1982. Flights were made with 2 observers and a pilot by fixed-wing airplane or helicopter at an altitude of 100-200 feet (30-60 m) between 60-100 mph (95-160 km/hr). Flight patterns varied with river morphology to obtain the most complete count possible. In wider, braided sections, and in the delta, an S-pattern between the outermost banks was followed. Where the main channel was split, each portion of the channel was surveyed separately. Single, unbraided channels were surveyed with a direct flight pattern.

The ground survey was conducted between Curry and the river mouth from June 10-21, 1982. Extensive, uniform patches of each of the major terrestrial habitats, as sighted from the river, were surveyed each morning on foot.

Surveys for nesting bald eagles were conducted in the lower Susitna River floodplain in April 1980 by the US Fish and Wildlife Service, in late June 1981 by TES and on July 1, 1982 by the University of Alaska Museum (Kessel et al. 1982b). Three observers and a pilot flew an S-pattern searching for mature/decadent cottonwood forests, which is favored bald eagle nesting habitat along the lower river. Nesting habitat was thoroughly searched from the air and an attempt was made to locate all previously recorded nests. Additional nests were located during waterbird and ground surveys.

At least 82 bird species were recorded along the lower Susitna floodplain in June 1982 (see Appendix 3.F).

(a) Raptors and Raven

Definitions for raptor "nesting locations" and "nest sites" are given in Appendix 3.I.

A total of 10 raptor species were recorded upstream from Devil Canyon. Kessel et al. (1982a) recorded 10 raptor species upstream from Devil Canyon. Five of these species (six including the common raven, a functional raptor that often provides nests for some raptor species) are known to nest in the area, and at least two additional species probably breed there (Appendix 3.E). The presence of Broad Pass to the west and a pass to the east containing the Richardson Highway, both commonly used by a variety of migrating raptors (H. Springer, pers. comm., D. Roseneau 1982 pers. comm.), and the absence of comparable passes in the immediate project area suggest that any migratory movements of raptors in the project area would likely be comprised primarily of local breeders.

A total of 53 raptor/raven nesting locations have been reported from the middle basin (White 1974; Kessel et al. 1982a; B. Kessel 1982 pers. comm.; see Table E.3.127). At least two of these locations (GE-6 and GE-12) do not appear to exist and probably represent two of the remaining 51 locations (see Table E.3.127). Active nesting locations in 1980 included 6 golden eagle, 4 bald eagle, 1 common raven, and 1 nesting location of an unidentified species (probably gyrfalcon). Active nesting locations in 1981 included 6 golden eagle, 5 bald eagle, 1 gyrfalcon, 2 goshawk (discovered during ground-based plot search), and 4 common raven. One additional active golden eagle nesting location was discovered during the course of other work in 1982. Nesting locations that were not active in 1980 and 1981 presumably functioned either as alternates or, in some cases, may be used by additional pairs in years when population levels may be higher. Table E.3.128 shows the general breeding phendogy of golden eagles, bald eagles, gyrfalcons and ravens in Alaska. These schedules are applicable to the middle basin.

In 1974, White (1974) found 14 active nesting locations within the same area of the middle Susitna Basin:

2 gyrfalcon, 3 bald eagle, 9 common raven. He also reported a single gyrfalcon at one additional known nesting location (GYR-1; see Tble E.3.127) and observed 2 single peregrine falcons that did not apear to be nesting [see Section 4.2.3(a)(iv)]. White (1974) also reported an addition 13 inactive nesting locations, ascribing 7 to ravens, 3 to golden eagles, 2 to bald eagles, and 1 to goshawks. The apparent change in number of pairs of golden eagles and ravens present in th middle basin between 1974 and 1980 - 1981 may be the result of a combination of several factors, including differences between observers and survey intensity, and natural variations in breeding population levels as a result of spring nesting conditions or changes in prey availability and vulnerability (Kessel et al. 1982a, D. Roseneau 1982 pers. comm.).

No specific data on migratory movements of raptors were collected in the middle basin. However, the presence of Bread Pass to the west and the Richardson Highway pass to the east, both commonly used by a variety of migrating raptors and other birds (B. Kessel 1982 pers. comm., H. Springer 1982 pers. comm., D. Roseneau 1982 pers. comm.), and the absence of comparable passes in the immediate project area, suggest that migratory movements of raptors in the project area would likely be comprised of local breeders.

Distribution, abundance, and food habits are discussed below for each species. Although no data were collected on food habits of raptors in the Susitna Basin, they are unlikely to differ greatly from raptors in similar situations in other parts of the state.

(i) Golden Eagle

Estimates of breeding populations of golden eagles in south-central Alaska, including the Alaska Range, are not available. However, this raptor nests at low densities throughout most of the state, including the arctic slope, and nesting occurs almost exclusively on cliffs (Roseneau et al. 1981). Golden eagles regularly build and maintain a number of simultaneous nests, often at locations several kilometres apart, which are used as alternates in different years (Brown and Amadon 1968, McGahn 1970, Roseneau et al. 1981).

The abundance of golden eagles in the central Alaska range is likely to be lower than that found in the middle Susitna basin. In most of the Alaska Range, cliff-nesting locations for raptors tend to be widely dispersed (Bente 1981, P. Bente 1982 pers. comm., D. Roseneau 1982 pers. comm.). However, if nesting cliffs are available, pairs of golden eagles may nest relatively close to one another. Murie (1944) found golden eagles nesting as close as 1.0 and 1.5 miles (1.6 and 2.4 km) apart in Denali National Park in 1941 and 1939, respectively.

The abundance of active golden eagle nesting locations present in the middle basin in 1980 and 1981 (one pair per 9.18 miles [14.8 km] of river) (Kessel et al. 1982a) was similar to that found along the Brooks Range portion of the Dalton Highway in 1979 (one active nest per 9.73 miles [15.7 km]) (Roseneau and Bente 1979). The latter abundance appears to be one of the highest reported in Alaska. White et al. (1977) suggested that local populations of golden eagles may increase during years of high snowshoe hare populations; however, hares are relatively scarce in the middle basin in 1980 and 1981 (Kessel et al. 1982a). Murie (1944) noted that arctic ground squirrels were a major prey of golden eagles in Denali National Park in 1939-1941, and these rodents were abundant in the middle basin area during the study.

Golden eagles are opportunistic hunters. Diets vary from region to region according to prey availability and vulnerability. When available, mammals are an important component of their diet (up to 70-90 percent by weight), but birds and carrion are also often important. Nonbreeding of golden eagles occurs in some years, and there is some evidence to suggest that prey availability may influence breeding success (Brown and Amadon 1968).

In Alaska, there are few published reports of prey items found at golden eagle nests. Common items have included ground squirrels, marmots, snowshoe hares, ptarmigan, ducks, and other waterfowl (D. Roseneau 1982 pers. comm.)

Occasionally, both arctic and red foxes are taken. One pair on the Seward Peninsula took as many as 5 - 6 red foxes during the summer, and the fledgling from that nest attacked a red fox about 2 weeks after leaving the nest (D. Roseneau 1982 pers. comm.).

Pairs nesting along sea coasts also take a variety of seabirds (both alive and as carrion), including young gulls and murres (D. Roseneau 1982 pers. comm.).

Carrion, often in the form of large game animals, may be particularly important during the early spring and the fall. Carrion also appears to be very important to sub-adult golden eagles. Large numbers of sub-adults frequent the calving and post-calving grounds of caribou herds. Up to six sub-adults have been found feeding at one time on wolf-killed and bear-killed caribou, and sub-adults occasionally kill caribou calves (Roseneau and Curabole 1976, Roseneau et al. 1981).

(ii) Bald Eagle

In Alaska, the majority of bald eagles nest coastally in southeast, southcentral and southwest Alaska; these populations may exceed several thousand pairs. North and west of the Alaska Range, numbers decline markedly and most nesting is associated with wetlands in portion of the Yukon (including the Tanaa) and Kuskokwim River drainages (see Roseneau et al. 1981). In total, surveys for nesting bald eagles in the lower Susitna floodplain discovered 38 nest sites, some of which undoubtedly represent alternate nest sites or alternate nesting locations (see Table E.3.129). In 1982, the year for which data are the most complete, only 14 of the 24 nest sites reported in 1980-81 were relocated, but 14 new nest sites were found. A few nesting locations and nest sites found in 1980 and 1981 may no longer exist as a result of blowdown, bank erosion or beaver activity (see Roseneau and Bente 1981). Of the 28 total known nest sites reported in 1982, 17 were active and 11 were inactive. Similar proportions of active versus inactive nesting locations and nest sites have been found along the Tanana River (Roseneau and Bente 1981). The amount and suitability of bald eagle nesting habitat and the number of nesting bald eagles increased markedly downstream from Indian River (see Table E.3.129). Most of the bald eagle nesting locations were concentrated in three sections of the floodplain: (1) between Talkeetna and the Parks Highway Bridge; (2) between Kashwitna Lake and the mouth of the Yentna River; and (3) from Bell Island to the mouth of the Susitna River (Kessel et al. 1982b). The number of bald eagle nests and nesting pairs per river mile along the lower Susitna River floodplain is comparable to that found on the Tanana River (D. Roseneau 1982 pers. comm.).

Bald eagles are opportunistic in their feeding habits, and diets vary from region to region according to the availabiltiy and vulnerability of prey species. Although they take a variety of live prey, bald eagles often rely heavily on local sources of carrion, may be attracted to dumps, and may pirate prey from other raptors, particularly osprey (Brown and Amadon 1968). Fish and birds are both important components of their diet.

In Alaska, bald eagles often rely on dead or dying salmon when they are available, and take a variety of other species of fish in shallow water or as carrion along shorelines. Waterfowl and seabirds (alcids, anatids and larids) also figure prominently in their diet, particularly in some coastal regions (e.g., the Aleutian Islands). Ritchie (1982) found fish and avian prey to have nearly equal frequency of occurrence (43.8 and 43.7 percent, respectively) in remains at nests along the Tanana River, Alaska, whereas mammal remains occurred in 12.6 percent of nests. Remains of Anas spp. (mostly mallard) constituted 17 of 28 occurrences of avian prey. Dead, dying, or injured birds are often taken from the water surface, but eagles are also quite capable of surprising and taking uninjured waterfowl and seabirds from the water surface or in the air. Even geese may be occasionally taken in flight (Brown and Amadon 1968), and sandhill cranes and swans have also been taken (D. Herter 1982 pers. comm. and A. Springer 1982 pers. comm.).

Diets of bald eagles nesting along the Susitna River are probably similar to diets of eagles nesting along the Tanana River. Salmon are undoubtedly important to many pairs in late summer and fall. Earlier in the year, other fish species (particularly whitefish, suckers and grayling) and waterbirds (especially waterfowl) constitute the bulk of their diet. Snowshoe hares and muskrats may also be taken on occasion.

(iii) Gyrfalcon

Gyrfalcons are not abundant in southcentral and central Alaska, but they regularly nest throughout the Alaska Range. Cade (1960) estimated the total Alaska population at only about 200-300 pairs. Roseneau et al. (1981) considered that estimate too low, but doubted that the population exceeded 500 pairs.

4.2 - Baseline Description

Numbers of nesting gyrfalcons may vary considerably between years (Cade 1960, Roseneau 1972, Swartz et al. 1975) but variation may be less over larger regions (Roseneau 1972). The majority of the Alaskan population is found in northern and western Alaska (Roseneau 1972, Roseneau et al. 1981), and gyrfalcons there tend to exhibit relatively low site fidelity from year to year (Cade 1960 and Roseneau 1972). However, in the Alaska Range, where suitable nesting cliffs are fewer more widely dispersed, most sites appear to be used more regularly (Bente 1981).

Gyrfalcons are year-around residents of the arctic and subarctic and are also opportunistic hunters. During the summer their diets vary according to prey availability and vulnerability (Roseneau 1972), but they typically rely on only a few principal prey species for the bulk of their food.

The principal summer prey species include ptarmigan (often 70-90 percent by weight of their diet), arctic ground squirrels, and, in some regions, long- tailed jaegers (White and Cade 1971; Roseneau 1972). Migratory birds typically constitute no more than 15-20 percent by weight of their summer diet. In some regions of interior Alaska (e.g., the Alaska Range), ground squirrels surpass ptarmigan in importance (Cade 1960 and Roseneau 1972). In the winter, gyrfalcons are almost solely dependent on ptarmigan (Platt 1976 and Walker 1977), although in some high arctic regions, arctic hares are also important winter prey. The year-round reliance on ptarmigan and the high utilization of small mammals in the summer are important factors that have helped gyrfalcons to avoid serious biocide contamination and thus maintain healthy, non-endangered populations in the arctic.

Despite the reliance on a few principal prey species, gyrfalcons are capable of shifting to other food sources during the breeding season if the availability of a few prey species changes dramatically-- provided that other prey species are present (White and Cade 1971; Roseneau 1972). It has also been suggested that gyrfalcons may not breed in some years when prey availability is low.

(iv) Peregrine Falcon

Peregrine falcons are distributed worldwide. Peregrines are specialists in avian prey and prey weights range from 50 g or less to over 600 g. In Alaska, the 2 endangered races, Falco peregrinus anatum and F.p.sundrius, rely on a broad prey base consisting of a variety of shorebirds, waterfowl, passerines and occassional small mammals (Cade 1960, Roseneau et al. 1981). In contrast to gyrfalcons, peregrines are diverse in their feeding habits, concentrating more on categories of prey, such as shorebirds, than on individual species. Their high use of migratory prey (especially shorebirds) on northern breeding grounds and on wintering grounds as far south as 30°S in South America has contributed to their endangered status as a result of biocide contamination. Recently, pollutant residues (biocides) have tended to decline in peregrine tissue (A. Springer, unpublished data). Since the late 1970's, in most of Alask and in some other parts of North America, numbers andproductivity of both endangered races have increased (USFWS unpublished data).

There were no confirmed sightings of peregrine falcons in the middle Susitna BAsin during 1980, 1981, or 1982, despite the substantial number of man-hours spent on ornithological field work and on raptor surveys (Kessel et al. 1982a; B. Kessel 1982 pers. comm.). White (1974) saw two individual peregrines during a June 10-15, 1974, survey; however, he found no sign of nesting. One of the birds 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 (1974) stated that the Yenta-Chulitna-Susitna-Matanuska drainage basin "seemingly represents a 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."

The Susitna River drainage does not provide habitat typical of or comparable to any important areas of peregrine nesting habitat in the boreal zone of Alaska (e.g., upper Porcupine, upper Yukon-Charley, middle Yukon, lower Yukon, upper Tanana and Kuskokwim river drainages). Key elements of the exisitng habitat in the Susitna River drainage, in addition to the surveys conducted for them, provide reasonable evidence that peregrines do not presently nest in the project area and that biologically significant numbers of them are unlikely to occur there naturally in the future with or without project development.

(v) Other Raptors

No breeding records for owls were reported in the middle basin by Kessel et al. (1982a). Three of the five species of owls (great horned owl, hawk owl, and boreal owl) that have been recorded in the middle basin are year-round residents and probable breeders in mixed and coniferous forests (Appendix 3.E). The short-eared owl occupies open habitats in small numbers in summer, and a few may breed in the region. Snowy owls, occasional migrants, are rare in the middle basin.

Only single records of two species of owls (great horned owl short-eared owl) were obtained along the lower Susitna River during the spring surveys (Appendix 3.F). Great horned owls are likely residents and breeders, especially in mature cottonwood stands along the river and sloughs.

Suitable nesting habitat for goshawks and great-horned owls consists primarily of occasional mature paper birch and paper birch-white spruce stands, which are most commonly found downstream from Devil Canyon (D. Roseneau 1982 pers. comm.). Some nesting habitat for other tree-nesting species (e.g., red-tailed hawks, American kestrels, sharp-shinned hawks, boreal owls, and hawk owls) and ground-nesting species (e.g., merlins, northern harriers, and short-eared owls) also occurs in the Susitna Basin, but no concentrated areas of nesting habitat are known or expected to occur.

The diet of owls and smaller raptors consists mainly of small rodents and small birds. Northern harriers feed on either small rodents or small birds in open terrain. American kestrels feed primarily on insects, small mammals, and occasionally small birds. Owls (great-horned owl, short-eared owl, hawk owl), and boreal owl) are generally specialists on small mammal prey, though great-horned owls may also take birds. Sharp-shinned hawks and merlins are specialists on small avian prey. Goshawks and red-tailed hawks rely on a combination of small mammal and avian prey.

(b) Waterfowl and Other Large Waterbirds

The middle basin and the lower Susitna River floodplain above the delta do not support large concentrations of waterfowl or other waterbirds during either migration or the breeding season (Kessel et al. 1982a, 1982b). Although low, avian use of discrete waterbodies and waterbody groups in the middle basin varied considerably. An analysis of the relative importance of discrete wetland areas is included to identify potentially important areas.

The species composition of waterfowl in the middle basin showed some differences from that of central Alaska as a whole, in part reflecting the subalpine nature of much of the study area (Kessel et al. 1982a). Oldsquaw and black scoter were the most productive of the waterfowl in 1981 (Table E.3.130). 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). The pintail, one of the most numerous ducks in central Alaska, occurred in relatively small numbers in the study area, in spite of the fact that both 1980 and 1981 were high population years for pintails in Alaska because of severe drought in the Canadian prairie provinces (King and Conant 1980, Conant and King 1981).

(i) Migration - Middle Basin

The middle Susitna 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. Corps of Engineers 1977) (Kessel et al. 1982a). A relatively small number of individuals were seen during three surveys in spring 1981 and six and five surveys in fall 1980 and 1981, respectively (Tables E.3.131, E.3.132 and E.3.133).

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. Pintails were common during spring migration but uncommon in fall. Few geese or cranes were seen at either season (Kessel et al. 1982a).

The middle Susitna Basin was less important to migratory waterfowl in spring than fall (Kessel et al. 1982a). Because ice breakup does not regularly occur until mid-May on many lakes in the middle basin little open water was available to early migrating waterbirds, such as the dabbling ducks and common goldeneye. Early migrants used the Susitna River itself and the thawed edges of lakes. Use of the middle basin's water bodies increased toward the end of May, concurrent with the availability of more open water and the influx of the later arriving loons, grebes, scaup, oldsquaw, scoters, and mergansers (Kessel et al. 1982a).

The pattern of fall movement in the middle basin was similar to that known for the rest of central Alaska (Kessel et al. 1982a). Peak numbers of American wigeon, pintail, and green-winged teal occured during the first half of September; loons, grebes, and scaup during the second and third weeks of September; and mallards, scoters, buffleheads, and goldeneyes, from the last third of September to mid-October. Trumpeter and whistling swan migration occured between the last week of September and the end of October (Kessel et al. 1982a).

(ii) Summer Use of Waterbodies - Middle Basin

The wetlands of the middle basin supported relatively few waterbirds during the summer. An average density of only 0.09 adult loons, grebes, ducks, gulls, and terns/acre of wetlands ($22.5/km^2$) and 0.01 broods/acre of wetlands ($2.9/km^2$) were found on 28 intensively surveyed water bodies in summer 1981 (Table E.3.130). By comparison, a census of 13 waterbodies in the upper Tanana River valley, similar in size class distribution to those surveyed in the middle basin, had average densities of 0.74 adult loons, grebes, ducks, gulls, and terns/acre of wet- lands ($183.0/km^2$) in 1977 and 0.45 adults/acre ($110.5/km^2$) in 1979 (Spindler et al. 1981 cited by Kessel et al. 1982a). Even when gulls and terns are excluded, the density of broods in the Tanana River Valley was markedly higher, at 0.03/acre ($6.2/km^2$) than in the middle Susitna basin. Productivity in the eastern portion of the upper Tanana River valley study area in 1979 was 30-40 percent lower than historical levels typical of Minto Lakes, Tetlin Lakes, and portions of the Yukon Flats are considered among the most productive wetlands in Alaska (J. G. King, U. S. Fish and Wildlife Service, Perssonal communications cited by Kessel et al. 1982a). Thus, the waterbodies of the middle basin appear to support a relatively impoverished population of waterfowl during the summer (Kessel et al. 1982a).

As discussed earlier, the species composition of waterfowl reflects the subalpine nature of the study area with oldsquaw and black scoter (tundra nesters) being the most productive species. Trumpter swans also breed commonly on the eastern end of the study area, from the vicinity of Oshetna River to at least the MacLaren River. On an informal flight over ponds of this area on August 4, 1981, Kessel et al. (1982a) recorded 19 observations of trumpeter swans. Forty adult birds were seen, including 9 pairs with broods (28 cygnets). This area is on the western edge of habitat used by the Talkeetna Basin trumpeter swan population which has more than doubled in the past 5 years (King and Conant 1981).

(iii) Relative Importance of WaterBodies - Middle Basin

Kessel et al. (1982a) calculated relative importance values (I.V.) for each lake surveyed, which combined 3 commonly used measures of habitat quality: number of birds, density, and species richness. The I.V. values are an index to the relative importance of each waterbody included in a particular computation of the index, and are patterned on concepts presented by Curtis and McIntosh (1951). The I.V. for each waterbody was calculated each season as the sum of 3 ratios: (1) the mean number of birds per census for the water body divided by the sum of the means per census for all waterbodies censused; (2) the mean density of birds per census on the waterbody divided by the sum of the means per census for all waterbodies censused; and (3) the mean number of species per census for the waterbody divided by the sum of means on all waterbodies. Figures E.3.105 and E.3.106 compare relative I.V. ratings for all lakes surveyed in fall 1980 and spring 1981 respectively. Seasonal population statistics are listed in Table E.3.134 for the lakes that had the highest scores. The following discussions of individual waterbodies are based on Kessel et al. (1982a).

Stephan and Murder Lakes were among the top three waterbodies in I.V. for all seasons. Stephan Lake received twice as much use in fall as in spring, and supported high numbers of species and number of birds. Murder Lake consistently supported high densities. These lakes assumed additional importance in early spring and late fall because of ice conditions. Murder Lake, which reportedly has some open water all winter, provided some of the first open water for early spring migrants, as did the inlet of Stephan Lake; green-winged teal, mallards, and pintails were using this open water on May 3, 1981. Likewise, these lakes provided the last open water in fall and were used by the late migrants. Swans used these lakes during October, as other lakes in the region became ice-covered. Between 9 and 11 trumpeter swans frequented Murder Lake between October 10-18, 1981 (J. Ireland 1982 Personal communication cited by Kessel et al. 1982a); 11 to 22 unidentified swans were on Stephan Lake from October 9-23, 1981; and 120 swans were there on October 10, 1980.

WB 131, near the mouth of the MacLaren River, consistently supported high levels of waterfowl abundance, density, and species richness. Its I.V. in spring was lessened by the fact that it was still frozen during the first two spring surveys. Because it was far from the proposed construction sites, it was not censused for breeding birds, but a flight over the lake on August 4, 1981, revealed a flock of some 100 molting ducks, mostly scaup, as well as a pair of trumpeter swans. This and WB 134 were the only duck-molting lakes found in the basin. A flock of 22 to 42 trumpeter swans congregated to feed on this lake throughout the first half of September 1980.

WB 140, east of the Oshetna River, had the highest I.V. of 28 waterbodies censused during the breeding season. Not only did it have a high species richness (11 species), but it also supported a large number of birds and had an above-average density. It was also of above-average importance during migration, even though it thawed later and froze earlier than most other lakes.

Clarence Lake had the fourth highest I.V. during spring and fall migration, but ws less important during the summer. It had a relatively high species richness during all seasons, being used by both diving and dabbling ducks during migration, but primarily by divers in summer.

Watana Lake was used in fall, especially in 1980, by migrant scaup, goldeneyes, and mergansers during the last half of September. Otherwise, it was of little importance to birds.

Pistol Lake in the lower Deadman Creek area had a relatively high I.V. in spring because of the number and diversity of birds it contained after it began to thaw toward the end of the first week of May. However, this relatively large lake was only of average importance during summer, and was little used in fall.

The southernmost Fog Lake supported high levels of abundance and species richness during all seasons. It received less use in spring than during other seasons, probably because ice cover was still extensive as late as May 17, 1981. On this date, ducks were heavily concentrated in the open water at the inlet end of the lake. This lake and WB 140 had the highest species richness (11 species) during summer.

WB 032, a small lake at the west end of the Fog Lakes, supported a high density of birds in summer and showed high productivity (at least 4 broods of horned grebe and 2 of American wigeon seen on July 28, 1981). It was not monitored during migration.

Swimming Bear Lake, an alpine lake, received its primary use during summer. After it thawed in late May, it was occupied by at least 5 species of waterbirds (scaup, oldsquaw, scoter, mew gull, and arctic tern), 3 of which were observed with broods on July 29, 1981. Flocks of scaup and white-winged scoters were seen on the lake during the last half of September 1981.

None of the waterbodies in the middle basin had importance values as high as those calculated for some of the better wetland sites of eastern interior Alaska from data obtained during fall 1980 by Ritchie and Hawkings (1981) (Figure E.3.106) and during spring 1980 by Ritchie (1980) (Figure E.3.105).

(iv) Lower Basin

The lower Susitna River above the delta appears to be little used by waterbirds. Few birds were seen during spring aerial surveys in either 1981 or 1982 (Table E.3.135), or during the June 1982 ground surveys (see Appendix EF). Few birds have also been seen on US Fish and Wildlife surveys (see King and Conant 1981). Overall, swans, white-fronted goose, scaup spp., common merganser and merganser spp. were the most abundant species seen. Numbers were highest in the last 37 km of the river between the mouth of Yentna River and Cook Inlet.

Ice on the lower river apparently broke a week or more later in 1982 than in 1981. During the May 7, 1981, survey, the river above Talkeetna was breaking up and carrying a heavy load of ice chunks; whereas on May 10, 1982, this section of river was still almost entirely frozen. Since spring migration of dabbling ducks in central Alaska was only 2 to 3 days later in 1982 than in 1981 (Kessel, unpublished data), the main spring movement had passed through the Susitna region in 1982 before water became available in the river above Talkeetna.

In addition to early season ice above Talkeetna, the main reasons for the low use of the lower river appear to be its rapid flow and heavy silt load (Kessel et al. 1982b). These factors limit the development of aquatic plants and associated invertebrates, the main diet of most waterbirds, and make food invisible, except at shallow edges or in sloughs (Kessel et al. 1982b). Corroborating this assumption is the fact that the most numerous ducks on the river were fish-eating mergansers (Kessel et al. 1982b).

(c) Other Birds

(i) Shorebirds and Larids

Seven of the 19 species of shorebirds that occur in the middle basin are transients that occur only during migration (Appendix 3.E). An additional six species nest in alpine tundra habitats that will be little affected by the Susitna development. The six species that will be most affected (semipalmated plover, common snipe, spotted sandpiper, solitary sandpiper, and greater yellowlegs) nest on alluvial bars along the river edge or in lower elevation woodlands and meadows. No shorebirds overwinter in the Susitna region.

Five species of larids occurred in the middle basin in 1980 and 1981 (Appendix 3.E) (Kessel et al. 1982a). Two are confirmed breeders in the area: mew gull and Bonaparte's gull. Mew gulls were the only common larid species in the middle basin (Kessel et al. 1982a), breeding around lakes and rivers. Arctic terns and long-tailed jaegers were fairly common and undoubtedly bred in the area (Kessel et al. 1982a). Herring gulls were uncommon summer visitors (Kessel et al. 1982a).

Seven species of shorebirds were seen along the lower Susitna River during a June ground survey in 1982 by Kessel et al. (1982b) (Appendix 3.F). Spotted sandpipers were common breeders along shores of the main river as well as along its sloughs and feeder creeks; solitary sandpipers were also fairly common along the river. Semipalmated plovers were uncommon breeders on alluvia, and greater yellowlegs were uncommon probable breeders along the river. Winnowing common snipe were recorded at numerous locations. Only one migrant whimbrel was observed on an alluvial island below Talkeetna, and two female northern phalaropes were also seen on the river.

Six species of larids were recorded in the spring 1982 survey downstream from Talkeetna (Kessel et al. 1982b). Herring gulls were most common with at least 7 breeding colonies in the lower basin; the largest colony containing approximately 1300 birds (Kessel et al. 1982b). Arctic terns and mew gulls were fairly common breeders on river bars in isolated pairs and small groups. Bonaparte's gulls were fairly common and probable nesters in spruce woodlands adjacent to the river. Parasitic jaegers and black-legged kittiwakes were also recorded in the lower reaches of the river. Neither species breeds in the area (parasitic jaegers breed in northwest and northern coastal Alaska, and the nearest black-legged kittiwake breeding colony is located at Chisik Island in Lower Cook Inlet).

(ii) Grouse and Ptarmigan

Spruce grouse are year-round residents of mixed and coniferous forests in the middle Susitna Basin. Their status was given as fairly common by Kessel et al. (1982a) who reported a maximum density of 1.0 territories/10 ha in white spruce-paper birch forest in 1981 (Table E.3.136). Ruffed grouse were reported as a rare visitant by Kessel et al (1982a). Willow, rock, and white-tailed ptarmigan were all recorded as breeders in the middle basin. Willow ptarmigan were common in low shrub thickets and attained a maximum breeding density of 0.5 territories/10 ha in dwarf-low birch shrub (Table E.3.136) (Kessel et al. 1982a). Rock ptarmigan are also common in dwarf and low shrub at high elevations and in blockfields and also attained maximum breeding densities in dwarf-low birch shrub (Table E.3.136) (Kessel et al. 1982a). White-tailed ptarmigan were uncommon in dwarf shrub mat and blockfields, and are found at generally higher elevations than other ptarmigan, although attitudinal ranges may overlap considerably with rock ptarmigan (Kessel et al. 1982a).

Grouse and ptarmigan were not recorded along the lower Susitna River (Kessel et al. 1982b). However, spruce grouse are likely residents of adjacent forest habitats, and a few willow ptarmigan may migrate to riparian habitats in some winters.

(iv) Woodpeckers and Passerines

In terms of numbers, woodpeckers and passerines comprise by far the greatest proportion of the birds inhabiting the middle Susitna Basin. Fifty-seven species have been recorded, and nine (possibly 10) of these are year-round residents (Appendix 3.E) All of the woodpeckers and a large proportion of the passerines are forest species, but passerines are found in all vegetated habitats, from closed forest through shrublands to alpine tundra. Breeding densities in 1981 and 1982 of these terrestrial species are given in Tables E.3.136 and E.3.137, and are discussed in more detail below.

The four species of swallow and the dipper are closely associate with aquatic habitats, and they were not adequately represented in censuses of terrestrial habitats. Bank swallows and cliff swallows nest colonially, the former in cutbanks and the latter in areas of cliffs and in abandoned cabins. Tree swallows and violet-green swallows are not colonial and nest in a variety of habitats. Swallows capture food while flying over open expanses and often over lakes and rivers, if they are present. The dipper is a bird of clear, fast flowing streams. It forages year-round in shallow sections of streams and nests along streambanks and under bridges. Dippers are uncommon in the middle basin, but a few birds occur in each of the major creeks that drain into the Susitna River as well as along the middle and upper Susitna itself (B. Kessel 1982 pers. comm.).

Thirty-nine species of woodpeckers and passerines were recorded along the lower Susitna River during the spring surveys. Six (possibly seven) are year-round residents (Appendix 3.F). Relative abundance of some species are discussed below.

(v) Middle Basin Bird Communities

Breeding populations of terrestrial birds in the middle basin were studied in 1981 (Kessel et al. 1982a) and in 1982 (Kessel, unpublished tables) by means of plot censuses. The number of territories of each species on the census plots in the two years is shown in Table E.3.136 and E.3.137. Breeding bird densities in 1981 and 1982 are compared in Table E.3.138.

Table E.3.139 lists the avian habitats (as described by Kessel 1979) represented in the 10 ha census plots and their approximate equivalents in Viereck and Dyrness (1980) vegetation types. Kessel et al. (1982a) caution against the use of Viereck and Dyrness types as avian habitat types because of: (1) a failure to differentiate between habitats of medium and tall shrub avian communities; and (2) a failure to restrict coniferous and deciduous forest types to exclusively (≥90 percent) coniferous or deciduous canopy coverage.

Density of breeding birds were substantially lower in most habitats in 1981 and 1982 (Table E.3.138). Kessel (1983 pers. comm.) believes that the 1981 densities were probably closer to normal and that 1982 densities were abnormally low, probably the lowest since 1964. The low 1982 densities are attributed by Kessel (1983 pers. comm.) to extremely late environmental conditions relative to spring arrival dates of migrants in 1982. At the suggestion of the investigators (B. Kessel 1983 pers. comm.) the 1981 data is used in all analyses rather than a simple average of the 2 years.

Generally, the forest and woodland habitats supported higher densities of birds than the shrub communities. Highest densities found in forests were at a cottonwood forest plot near Sherman, which supported 1.7 bird territories/acre (60.9/10 ha). The lowest densities in forest habitats were in the white spruce forest plot at the mouth of Kosina Creek (0.6 territories/acre [15.7 territories/10 ha]). Of the shrub habitats, low-medium willow shrub had the highest densities (1.8 territories/acre [45.4 territories/10 ha]) and alpine tundra the lowest (0.2 territories/acre [4.8 territories/10 ha]). Although alpine tundra had the lowest bird usage, these types supported some bird species generally not found in other habitats, such as white-tailed ptarmigan, horned lark, wheatear, water pipit, gray-crowned rosy finch, and snow bunting.

Bird densities in habitats of the middle basin are similar to those in the upper Tanana River Valley (Spindler and Kessel 1980). In both regions, coniferous forests were low-density habitats relative to other forest types. Deciduous and mixed forests, and shrubby woodlands in both regions supported intermediate densities, and low shrub habitat support low densities. Such differences in occupancy levels are affected by a number of factors, including in Interior Alaska, habitat structural complexity and primary productivity (Spindler and Kessel 1980). Tall shrub habitats in interior Alaska support the highest avian densities (Spindler and Kessel 1980). Kessel et al. (1982a) attributed the lower densities in their Susitna tall alder shrub study plot to species composition of the shrub community. They contrasted the average to above-average productivity (Spindler and Kessel 1980) of the willow, thinleaf alder (Alnus tenuifolia) and balsam poplar which dominated the Tanana valley tall shrub plot with the relatively low productivity of American green alder (Alnus crispa) (Spindler and Kessel 1980) which dominated in the middle Susitna Basin plot.

Kessel et al. (1982a) calculated Shannon-Weaver diversity indices (H') for each census plot (Table E.3.138). Diversity values are sometimes used as indicators of habitat quality. Values of H' ranged from 0.91 for the dwarf-low birch shrub plot in 1982 to 2.55 in the closed balsam poplar forest plot in 1981. With the exceptions of the white spruce forest plot in both years and white spruce woodland in 1982, all plots in forest habitats obtained indices >2.0. The tall alder shrub plot diversity index values were 2.05 in 1981 and 2.02 in 1982, while values in all other shrub and tundra habitats were all <2.0. The 3 greatest diversity values in both years were obtained in the balsam poplar forest, white spruce-paper birch forest, and black spruce woodland plots (Table E.3.138). The 1982 values on these more diverse plots were substantially lower than 1981 index values, the result of both reduced densities and reduced numbers of species. Habitats obtaining high values of H' are characterized by large numbers of species and large numbers of individuals of each species.

Each avian habitat type (as defined by Kessel 1979) in the middle basin supports a moderately distinct bird species association, as indicated in Table E.3.140.

(vi) Lower Susitna River Floodplain Bird Communities

Information on the relative abundance and habitat use of terrestrial birds in the lower Susitna River floodplain was obtained during a ground survey conducted in June 1982 by the University of Alaska Museum (Kessel et al. 1982b). Abundance was determined by counts of singing birds in each habitat type. Total time spent in each of 10 habitats varied between 30 and 352 minutes; data are presented as birds per 100 minutes of survey in Table E.3.141.

Generally, following ecological tenets, both abundance and species richness increased progressively from the early to late vegetation successional stages (Table E.3.141) (Kessel et al. 1982b).

Species composition of the early successional stages was dominated by waterbirds, such as plovers, sandpipers, gulls, and terns. The only regular land bird was the white-crowned sparrow, which was common in medium-height shrub at the late stages of early succession (Kessel et al. 1982b).

Species composition and abundance in the tall shrub and forest habitats of the lower Susitna River floodplain followed known patterns of habitat selection in central Alaska, except in the cottonwood forests. Several bird species normally associated with tall shrub communities (i.e., gray-cheeked thrush, blackpoll warbler, northern water-thrush and fox sparrow) were found to select nesting territories within riparian cottonwood forests, probably because these forests have a well-developed, tall shrub understory (Kessel et al. 1982b).

A profound effect of silt ground cover on avian abundance was also noted along the lower floodplain. Forest and tall shrub stands with a heavy ground cover of recently deposited silt were essentially devoid of birdlife. Earlier studies (Spindler and Kessel 1980; Kessel et al., unpublished data) have suggested that there is little preference by most terrestrial birds for specific taxa of plant ground cover, but apparently some kind of vegetative cover is necessary--undoubtedly because of its role in providing food resources (Kessel et al. 1982b).

4.2.4 - Non-Game (Small) Mammals

Non-game (small) mammals of the project area include shrews, voles, lemmings, red squirrels, ground squirrels, marmots, pikas, snowshoe hares, and porcupines. Small mammals, by the nature of their size and visibility, are not high profile species. However, they are important ecological components of most northern ecosystems. Small rodents have been shown to be important in nutrient cycling; soil aeration; dispersal of seeds, mycorhizae and spores; control of insect pests; and as the primary or secondary prey of many carnivores (Grodzinski and Wunder 1975).

Kessel et al.'s (1982a) studies of small mammals were restricted to an area ranging 9.3 miles (15 km) to either side of the Susitna River, extending from the Maclaren River on the east to near Sherman on the west (approximately 6.2 miles (10 km) south of Gold Creek). Within this area, 49 trapline transects were established and operated in the falls of 1980-1982 and spring of 1981. Sites for the transects were selected to represent as broad a spectrum as possible of the various vegetation types in the region. Details on sampling techniques are provided in Kessel et al. (1982a). Information on small mammals was also obtained by opportunistic observations.

(a) Species Composition and Relative Abundance

During the study period, 16 species of small mammals were trapped and/or observed in the middle basin (Appendix 3.G) (Kessel et al. 1982a). In addition, there was evidence of two other species occurring in the region: bats (two separate sightings of what were probably the little brown bat) and water shrews (tracks of a small mammal between ice openings on Watana Creek). The distribution of small mammals documented in the middle basin is similar to known distributions in the literature. However, the occurrence of arctic shrews in the study area constitutes a minor range extension; the closest previous record was from Denali National Park (Murie 1962).

The one spring and three fall trapline surveys involved a total of 23,061 trap nights of effort (Table E.3.142).

4.2 - Baseline Description

Totals of 950, 138, 2190, and 447 small mammal specimens were captured during the fall of 1980, spring of 1981, fall of 1981, and fall of 1982, respectively. A total of 1977 microtine rodents (6 species) and 1748 shrews (4 species) was captured. Northern red-backed voles and masked shrews were the two most abundant species of small mammals, constituting 74 percent of the total captures. A total of 1458 northern red-backed voles and 1289 masked shrews was captured during the 1980-82 studies. Other shrews captured were arctic shrews (303 specimens), dusky shrews (146), and pygmy shrews (10). Captures of microtines included 224 tundra voles, 103 meadow voles, 148 singing voles, 29 brown lemmings, and 15 northern bog lemmings (Table E.3.142).

Capture results illustrate the large population fluctuations that can be observed within and between years (Table E.3.142). The fall 1980, spring 1981, and fall 1981 sequence demonstrates the typical annual cycle of most short-lived multiparous small mammals. In such species, summer reproduction results in high population levels by fall, and winter attrition reduces the population to animals born late in the previous summer or fall. Superimposed on this annual cycle are yearly fluctuations in abundance demonstrated by the fall data for the 3 successive years. The most common microtines, northern red-backed voles, meadow voles and tundra voles, were most abundant in fall 1981, as was the most common shrew,the masked shrew. All of these species exhibited very low fall populations in 1982. Fall 1982 capture rates were low for all species except singing voles, brown lemmings, and bog lemmings, throughout the study period. Northern red-backed voles were the most frequently captured microtine in all periods. Masked shrews were the most frequently captured shrew in all periods, in spite of their dramatic decline in abundance in 1982.

Six other species of small mammals were not trapped but were observed in the study area by Kessel et al. (1982a): arctic ground squirrel, hoary marmot, collared pika, red squirrel, porcupine, and snowshoe hare. Although no quantitative estimates of abundance were obtained for these species, limited information on distribution was collected and is reported below from Kessel et al. (1982a).

The arctic ground squirrel is a common and ecologically important mammal of the region. The largest numbers were observed on the drier slopes, knolls, and ridges above tree-line; only small numbers were observed at lower elevations. General observations indicate that the Susitna study area supports a relatively high and stable population of ground squirrels, probably comparable to densities reported elsewhere in the state (Kessel et al. 1982a). For example, in the Talkeetna Mountains to the south, Hock and Cottini (1966) removed 27 squirrels in one day from 0.12/acres (0.05 ha) (22 squirrels/acre, 54/ha) with little apparent decrease in numbers; the squirrel population in this area remained high throughout 4 years of study. In the eastern Brooks Range, Bee and Hall (1956) counted 175 ground squirrels along a 0.62 miles (1-km) ridge, and 70 squirrels on approximately 3.7 acres (1.5 ha) of hillside (nearly 19 squirrels/acre, 47/ha).

Hoary marmots were locally common residents of the alpine zone. Scattered colonies were found above treeline. None were seen within the proposed impoundment areas. Collared pika is another locally common alpine species, found on talus slopes at higher elevations. No pikas were seen below treeline. Densities of pikas in Denali National Park during 1962 varied from 2/acre (5/ha) in large rock slides, to 10 acre (25 ha) on small, isolated rock piles (Broadbooks 1965).

Red squirrels, porcupines, and snowshoe hares were generally confined to the forested areas of the basin. Red squirrels were present in coniferous forests throughout the area, but were most numerous in the mature spruce stands that occur along the larger creeks such as Watana and Tsusena Creeks. Porcupines are uncommon in the study area; a few individuals were sighted during the summer of 1980, and 3 to 4 sets of tracks were seen during the winter of 1980.

Snowshoe hares, a major source of food for predators over much of central Alaska, were generally restricted to areas east of Watana Creek. Localized "pockets" occurred primarily in the vicinities of Jay Creek, Goose Creek, and the lower Oshetna River. Snowshoe hare populations undergo 8- to 12-year cycles of abundance (Keith and Windberg 1978); peak densities may be as high as 15.6 hares/acre (38.6/ha) whereas densities may drop to as low as 0.05 hares/acre (0.12/ha) during population lows (Green and Evans 1940). Long-term information in overall hare abundance, provided by several local residents, indicated that the recent low number of hares is a chronic situation and not just a low phase of the population cycle.

(b) Habitat Use

The following analysis of habitat use draws heavily from Kessel et al. (1982a).

4.2 - Baseline Description

(i) Shrews and Voles

Forty-two trapping sites were organized by Kessel et al. (1982a) into floristically similar groups using a cluster analysis of frequency counts of 81 plant taxa from the vicinity of the sample sites (Figure E.3.107). The clustered subgroups roughly correspond to the following vegetation types from Viereck and Dyrness (1980): sedge-grass and shrub tundra, sedge-grass and low willow shrub, herbaceous-mixed low shrub meadow, open white spruce forest, woodland spruce, black spruce bog (some low birch shrub sites were included in this group), paper birch-white spruce forest, cottonwood forest, tall alder shrub, and tall grass meadow. The number of captures of each small mammal species relative to these vegetation types is shown in Figure E.3.108.

Shrews and red-backed voles in the middle basin displayed a relatively broad and uniform distribution pattern across habitats (Figure E.3.108). Masked shrews, the numerically dominant shrew species, occurred at all trapping sites. They were most numerous in deciduous forest (particularly cottonwood), grassland, and tall shrub sites. Arctic shrews occurred at 29 trapline sites, with peaks of abundance on the drier, nonforested sites, particularly grassland (at low elevations) and low shrub (above treeline). Dusky shrews were thinly distributed across the vegetation types of the study area. Although dusky shrews were captured at 23 sites, no particular preferences were apparent; however, none were captured in the wettest sites. The capture of three pygmy shrews in cottonwood forest, one in white spruce forest, and one in grassland during fall 1981 and the capture of five specimens in open spruce forest and one in cottonwood forest during fall 1980 suggest a restriction of this species to forest habitats. Northern red-backed voles, the dominant microtine of the region, occurred on all but five trapline sites. Northern red-backed voles were moderately to very abundant in most forest and shrub types. The greatest numbers were recorded in open and woodland spruce and cottonwood forest sites. In contrast, herbaceous meadows, particularly wet meadows and paper birch forest, supported low numbers of this species.

In contrast to the more general habitat occupancy patterns of most shrews and red-backed voles, the 3

Microtus species displayed stronger habitat specificity, as evidenced by their general restriction to open, nonforested sites (Figure E.3.108). Singing voles were captured on only 10 trapline transects. They were most abundant in open, low willow-birch shrub on relatively dry soils but were also found in herbaceous tundra and mat and cushion tundra above treeline. Tundra voles and meadow voles occurred primarily in sedge and grass-forb meadows and bogs. Tundra voles were captured on 22 sites (primarily grass- forb,. but also sedge-grass), compared to 10 sites for meadow voles (primarily wet sedge-grass). Small numbers of brown lemmings were captured on 11 sites at or above treeline, usually in wet herbaceous and low shrub situations. Two bog lemmings were taken at lower elevations in mesic sedge-grass/low shrub meadow, one in grass meadow and one near a seepage in white spruce forest.

To summarize the differences in habitat use among the various species of small mammals, a standardized habitat niche breadth measure was calculated for each species captured during fall 1981 (Table E.3.143). The ubiquitous masked shrews and red-backed voles had the broadest habitat niche breadth, followed closely by dusky shrews and arctic shrews. Microtus species, particularly singing voles, had the narrowest habitat niche breadths, along with the rare or uncommon pygmy shrews, bog lemmings, and brown lemmings.

Small mammal community structures, especially as they relate to species dominance and habitat breadth, are highly correlated with population levels and species interactions. Because most northern microtine populations undergo extreme fluctuations in density (Krebs and Myers 1974), strict ecological boundaries are difficult to delineate. A small mammal population sampled during the peak phase of a population cycle may occupy a greater range of habitats than during a population low. Interspecific competition for space may also vary with density. For example, Kessel et al. (1982a) found that open herbaceous-dominant habitats left vacant by declining Microtus populations were quickly colonized and dominated by the northern red-backed vole, suggesting that Microtus species were able to exclude northern red-backed voles from some habitats.

Northern bog lemmings and brown lemmings were uncommon members of the small mammal community in the Susitna Basin. Bog lemmings are generally uncommon throughout their range, and little is known of their ecological requirements (Banfield 1974, West 1979, MacDonald 1980). In other areas of the state, small numbers have been taken primarily in shrub bogs and marshes (Osgood 1900, Dice 1921, West 1979, MacDonald 1980)--not unlike the few sites where they occurred during this study. Their diet is apparently restricted to sedges, grasses, some forbs (Cowan and Guiguet 1956), and mosses (West 1979).

Although the high country of the middle basin has an apparent abundance of suitable brown lemming habitat, only small, scattered numbers were captured during the 1980-81 study. However, they have been found in fairly large numbers in other montane areas of central Alaska (R. L. Rausch, Personal communication cited by Kessel et al. 1982a). The low numbers in the Susitna area may be caused by a failure to sample the right habitats, or, more likely, to sampling during a period of low population levels. Brown lemmings are usually associated with wet sedge-grass tundra above treeline, but also are found locally at lower elevations in spruce bogs and wet meadows (Buckley and Libby 1957 and Banfield 1974). This species is almost completely dependent on a diet of sedges and grasses (Guthrie 1968), although mosses may be important at times (West 1979).

(ii) Other Species

Arctic ground squirrels inhabit herbaceous tundra and open shrub habitats above treeline (Kessel et al. 1982a). At lower elevations they also colonize riverbanks, lakeshores, moraines, eskers, road sidings, and other disturbed sites with subclimax vegetation (Guthrie 1968, Banfield 1974, Kessel et al. 1982a). Kessel et al.'s (1982a) observations corroborate Bee and Hall's (1956) conclusion for the Brooks Range that the optimum conditions for ground squirrel colonies are:

- Loose permafrost-free soils on well-drained slopes;
- Vantage points from which the surrounding terrain can be observed; and
- Bare soil surrounded by vegetation in an early xerosere stage of succession.

Carl (1962) found that ground squirrels avoided sites where tall vegetation (greater than 8 inches [>20 cm]) impaired vision. The effects of squirrel activity--e.g., burrowing, mound building, feeding, feces deposition--within areas of established colonies tend to maintain vegetation at an early successional stage (Carl 1962 and Youngman 1975).

During the snow-free months, ground squirrels provide an abundant, reliable food source for a number of mammalian and avian predators (Carl 1962, Murie 1962, Bente 1981, Olendorff 1976). At High Lake in 1981 the first ground squirrel emerged from hibernation the third week of April; the latest date in 1981 on which ground squirrels were seen was October 4 (E. Powell, Personal communication cited by Kessel et al. 1982a). These emergence and entrance dates are essentially the same as those reported by Hock (1960) and Hock and Cottini (1966) in the Talkeetna Mountains near Anchorage, and by Carl (1962) at Ogotoruk Creek, northwestern Alaska.

Hoary marmots and pikas are generally restricted to tundra/talus habitats at high elevations (Hoffman et al. 1979 and Kessel et al. 1982a). Both are ecotone species: their homes and shelters are in one habitat (rocks of various size and shape) and their food in another (herbaceous tundra types) (Broadbooks 1965). Hock and Cottini (1966) suggested that a portion of their marmot population underwent seasonal shifts in altitude, moving down from high rocky slopes in fall to sites having better conditions for winter denning and having an available food supply in early spring. An opposite seasonal movement apparently occurs in some Montana hoary marmot colonies (Barash 1974). The only suggestion of fall movement in the middle basin was the observation of several marmot trails and a single marmot traversing the 3500-foot-high (1067-m-high valley near Swimming Bear Lake (WB 150) in about 3 inches (8 cm) of snow on October 10, 1980 (T. Hobgood, Personal communication cited by Kessel et al. 1982a). Marmots hibernate longer than ground squirrels; in the Talkeetna Mountains near Anchorage, marmots emerge from hibernation during the first third of May and begin entering hibernacula in early September (Hock and Cottini 1966). Pikas are active throughout the year (Sheldon 1930, Broadbooks 1965, Hock and Cottini 1966) and store large quantities of dried plant material in late summer for use during the winter months.

4.2 - Baseline Description

The arboreal red squirrel occupies a variety of forest habitats, but prefers mature coniferous forest (Cowan and Guiguet 1956). White spruce forest is generally considered the optimal habitat in interior Alaska (Nodler 1973). Red squirrels feed primarily on the seeds of spruce, particularly white spruce, but supplement their diet with fungi, fruits, and even the buds of spruce and aspen (Smith 1967 and Nodler 1973). They store large quantities of spruce cones and mushrooms in middens for winter use (Murie 1927 and Streubel 1968). Buskirk (Personal communication cited by Kessel et al. 1982a) noted that red squirrel middens in the middle basin in fall 1981 appeared to be composed only of mushrooms and spruce buds. A massive cone crop failure caused by an area-wide epidemic of white spruce needle rust (*Chrysomyxa ledicola*) during 1980 (J. H. McBeath, Personal communication cited by Kessel et al. 1982a) may explain why squirrels were storing such low- quality food as spruce buds (Smith 1967). Smith (1967) reported a 67-percent drop in a red squirrel population following the second year of a two-year cone crop failure in white spruce forest and suggested that the squirrels had emigrated into surrounding black spruce stands. Repeated cone crop failures could have similar effects on red squirrels in the middle basin (Kessel et al. 1982a).

In interior Alaska, Wolff (1977) found that snowshoe hare habitat preference depended on population density; during population lows, hares were restricted to dense black spruce forest and willow-alder thickets, but during highs they used a wider variety of vegetation types, including recently burned areas with minimal cover. He concluded that a patchy environment of recently burned sites with inclusions of unburned spruce was the preferred hare habitat. The chronic scarcity of snowshoe hares in the middle basin is probably related to a scarcity of suitable habitat (Kessel et al. 1982a). Recent burns and riparian shrub thickets are noticeably absent from this area (Kessel et al. 1982a).

4.3 Impacts

Five classes of impacts to terrestrial vertebrates are anticipated to result from the Susitna Hydroelectric Project: (1) permanent habitat loss, including flooding of habitat and covering with gravel pads or roads; (2) temporary habitat loss and habitat alteration resulting from reclaimed and revegetated areas such as borrow areas, temporary rights of way, transmission corridors, and from alteration of climate and hydrology; (3) barriers, impediments, and hazards to movement; (4) disturbance associated with project construction and operation; and (5) increased human access not directly related to project activities. The acceleration of secondary development in the basin is an indirect impact which can be neither predicted nor controlled by the Alaska Power Authority and is therefore excluded from this discussion. Specific impact issues associated with each class of impact are enumerated in separate tables and discussed in the following sections for each big game and furbearer species.

Permanent loss of specific vegetation types is shown in Tables E.3.82 and E.3.83 for the Watana and Devil Canyon facilities. Approximate time schedule and areas affected are shown in Table E.3.144 for permanent habitat loss, temporary habitat loss, and habitat alteration. Habitats altered by the transmission corridor and access roads are described in Tables E.3.84, E.3.85, and E.3.86. Impacts resulting from increased human access have already begun and will continue throughout the life of the project.

4.3.1 - Watana Development

(a) Moose

Moose are common in the Susitna River valley and are one of the most important wildlife species that will be affected by the Watana project. Activities associated with the construction of the Watana project will affect moose mostly in areas adjacent to and within the dam and impoundment area. Activities associated with the filling and operational phases will affect moose in both the middle and lower Susitna basins. The construction and operation of the Devil Canyon dam, access routes to the development sites, and transmission lines also will affect moose in the Sustina Basin; impacts resulting from these activities are discussed in Section 4.3.2, 4.3.3 and 4.3.4. Although the Watana project may benefit moose in some areas of the Susitna Basin, detrimental effects of the project will likely result in a decline in the number of moose and altered distributions of this species throughout the basin. Because both migratory and resident populations of moose utilize areas in the immediate vicinity of the proposed impoundment area (ADF&G 1982a), impacts associated with each phase of the project could influence moose populations in other drainages removed from the Susitna Basin.

4.3 - Impacts - Watana Moose

In this discussion, impacts of the Susitna project on moose will be assessed by estimating the extent (temporal and spatial) to which carrying capacity for moose is reduced within the basin, and by the effect on population regulatory mechanisms (Figure E.3.109). The effects of developments that reduce carrying capacity or productivity of moose populations for more than 10 years will be considered as severe impacts. Moderate impacts may affect either a large proportion of the moose population for a short period (less than 5 years) or a smaller proportion of the population for long periods. Minor impacts will include very short term (less than 1 year) effects. A summary of anticipated and hypothesized impacts to moose appears in Table E.3.145.

The direct impacts that will most severely affect moose populations in the middle Susitna Basin are, in order of decreasing severity: permanent loss of habitat, blockage of seasonal migration routes, disturbance by machines and humans, hazards associated with the drawdown zone, and alteration of habitat. Moose in the lower basin will be affected mostly by alteration of habitat. The major indirect impact of the Watana development will be the provision of access to a previously remote area and a substantial increase in hunting pressure with subsequent increases in moose mortality.

ADF&G (1982a) estimated that about 2400 moose would have home ranges that overlap a 5-mile (8-km) zone surrounding the impoundment area. The distance of 5 miles (8 km) was derived by ADF&G (1982a) as 1/3 of the average moose home range length and assumed that moose within this distance would experience severe impacts. This estimate of 2400 moose was based on 162 radio-collared moose from an estimated regional population of 4500 (total estimate for the upper and middle Susitna basins). This estimate (2400 moose severely affected) is biased by nonrandom sampling and is undoubtedly high (see ADF&G 1982a for a discussion). However, it does provide a rough estimate of the number of moose that may be affected by the project in the middle basin without mitigation. The winter carrying capacity of the impoundment zone and areas lost to adjacent project facilities was estimated to be 300 resident moose for 180 days (see Section 4.2.1[a]). This value is being refined to account for movements of moose into and out of the area, and to better estimate moose food requirements using simulation modeling of moose bioenergetics.

The eventual fate of the moose having home ranges that overlap the 5 miles (8-km) zone around the Watana and Devil Canyon projects is unknown; some would successfully disperse to other parts of the Susitna basin or to adjacent drainages; some would adapt to disturbances and remain in the immediate vicinity of the impoundment until filling; and some would die as an indirect or direct result of the development. Ongoing studies will greatly refine this assessment.

(i) Construction

Construction of the Watana dam will involve intense construction activities at the actual damsite, establishment of temporary camps and a permanent townsite, removal of forest cover in most parts of the impoundment, and the excavation and transportation of borrow material. The major impacts on moose during construction will be habitat loss or alteration, disturbance, interference with seasonal movements, and mortality associated with construction activities and hunting.

- Habitat Loss

Clearing of the impoundment area, townsite, local transportation corridors, and operational areas will result in the permanent loss of some high quality habitat for moose in the middle Susitna Basin. (High quality habitats are those areas supporting relatively high browse production and having snow depths less than the regional average, areas where spring snowmelt occurs earliest, and/or areas used for calving.) Campsites, borrow pits, and construction access roads will temporarily alienate smaller areas of habitat from moose use (Tables E.3.143 and 144). There is no question that moose will be affected by this loss of habitat: browse availability will be reduced; winter range, calving areas, and breeding areas will be lost; movements may be altered as a result of behavioral or physical barriers; animals will be more vulnerable to predation and hunting (as a result of the loss of cover); and repeated human and mechanical disturbances may preclude use of some areas by moose. Accidental fires may also temporarily eliminate moose habitat, although in the long term would provide additional areas of high quality browse to moose.

Clearing of the impoundment area will remove a wide range of riparian, deciduous forest, coniferous forest, and muskeg communities which are important to moose during all or part of the year. Although moose may feed on the leaves of felled deciduous trees and some areas may develop sparse successional growth prior to flooding, inundation will eventually permanently destroy these habitats. The distribution and occurrence of major plant communities in the Watana watershed are discussed in Section 3.2.1. The regional availability of forest cover types and their seasonal use by moose are shown in Table E.3.146.

. Winter Use

There is a general consensus that moose populations in North America are ultimately limited by the availability and quality of winter range (Coady 1982). High quality winter range of moose is characterized by (1) abundant trees and shrubs that are most preferred by moose as winter browse; (2) consistently low snow depths in relation to surrounding areas, and (3) good interspersion of young seral growth (for foraging) and older aged forest stands (for cover) (LeResche et al. 1974, Peek 1974). The nutritional quality of browse (e.g., amounts of crude protein, fats, and carbohydrates; digestibility; total calories) also is important in determining the quality of winter range (Oldemeyer 1974). Other factors such as predation, hunting mortality, disease, and weather may reduce moose populations below the carrying capacity of the range (Figure E.3.109).

Although the quality and quantity of winter range are likely the limiting determinant for carrying capacity of moose, they are critical to moose survival only during severe winters. Winter severity, particularly snow depth, strongly influences the use of winter browse by moose (Coady 1974, LeResche et al. 1974). During mild winters, when snow depths are low throughout much of the range, few moose may utilize critical winter ranges. During severe winters, however, deep snows may force high numbers of moose to overwinter in limited areas. The limiting effect of critical winter range may thus be evident only during periods of severe winter conditions.

Although not observed during current moose studies in the middle Susitna Basin (ADF&G 1982a), earlier studies of moose in the basin (USFWSF 1975, Ballard and Taylor 1980) suggest that during severe winters with heavy snowfall, moose move from upland shrublands to mixed spruce deciduous woodlands at lower elevations. The

4.3 - Impacts - Watana Moose

Watana impoundment area includes several large areas of river valley bottomland that are probably critical to survival of some moose during severe winters. Mild winters with limited snow cover during 1980 and 1981 are thought to have resulted in the use of upland areas by moose in the Susitna Basin and their absence from lower elevation sites. A census of the Watana impoundment on March 25, 1982 (a time when most moose that used the impoundment area in that year would be found there) determined that 260 moose were present in the Watana impoundment area (ADF&G unpublished data).

Because low elevation riparian shrub, deciduous forest, coniferous forest, and muskeg habitats will not be available in areas adjacent to the impoundment, the removal of these habitats by initial clearing activities and later flooding will deprive moose of a large area of high quality winter range. Assuming that bottomland browse resources throughout the middle Susitna Basin are fully utilized by moose in severe winters, clearing and flooding of the impoundment will force moose to depend on and likely over-utilize the remaining winter range. Moose which never use the impoundment area will also be affected by over-utilization of these adjacent areas. Increased mortality would be expected caused by starvation and increased predation, whereas natality may decrease because of the poor physical condition of moose.

- <u>Spring Use</u>

During recent moose studies (ADF&G 1982a), many (no numbers available) of the radio-tagged animals moved to lower elevation habitats adjacent to the Susitna River during late spring. It is believed that these movements are related to the earlier snowmelt and emergence of new plant growth in low elevation sites (ADF&G 1982a). Because moose typically have a negative energy balance during winter and are in poor physiological condition by late spring (Gasaway and Coady 1974), the availability of new plant growth may be critical to survival. During the spring, parturient cow moose commonly use low elevation sites along the middle Susitna valley, presumably to calve (no numbers given in ADF&G 1982a). The availability of new plant growth and suitable shrub cover in these low elevation sites is thought to be important to the survival of both the cow and her calf. Bull moose and cow moose without calves also utilize the low elevation habitats during the spring (ADF&G 1982a).

Clearing and flooding of bottomland areas would reduce availability of lower elevation sites where spring snowmelt and plant emergence appears to be more rapid. Because micro- climatic changes resulting from the impoundment are suggested to delay spring green-up by 5-15 days (McKendrick et al. 1982) and because habitats which will remain available around the impoundment area are at higher elevations, moose may be deprived of a large area of early spring habitat. This impact would be most severe following winters with deep snowfalls when moose may be highly dependent on the availability of these spring foraging areas.

ADF&G (1982a) suggest that concentrations of calving moose occur in the impoundment area and that these may represent traditional calving sites (no unequivocal data are provided, see ADF&G 1982a). Although it has not been shown that moose use traditional calving areas (as do several other species of ungulates), studies by Markgren (1969) and Stringham (1974) suggest that a calving location may be used repeatedly by an individual cow. Predation moose calves by brown bears is a major mortality factor of moose during the spring and summer (Ballard et al. 1980), and displacement of parturient cow moose from their habitual calving areas by clearing activity may increase the vulnerability of their calves to predation.

- <u>Summer and Fall Use</u>

Because most moose in the middle Susitna Basin commonly move to upland shrub habitats during summer and fall, loss of bottomland communities will not have serious effects on summer and fall habitat use. However, some sedentary (or non-migratory) moose remain in the valley bottoms throughout the year and these individuals would be displaced from their summer and fall range.

4.3 - Impacts - Watana Moose

- Disturbance

During construction of the Watana dam and clearing of the impoundment area, human and mechanical disturbance will likely limit the use of several development areas by moose and could result in alterations in feeding behavior. Because undisturbed ungulates spend much of their active period searching for and consuming food (Hudson 1977), disruption of daily activities can reduce feeding activity to the point where an individual derives less energy from the resources consumed than it expends (Geist 1975). Ungulate energy balances are most delicate during the winter (Dorrance et al. 1975, Moen 1976). Therefore, disturbances are likely to have the most severe impacts on ungulates during this season. An assessment of the effects of disturbances on the energy balance of moose in the middle Susitna Basin and subsequent effects on productivity is not possible on the basis of current information, but will become feasible using the modeling approach being developed (see Section 4.3.1(a)(iii).

Although repeated human and mechanical disturbances could result in an alteration of activity budgets with consequent impacts on growth, survival, and production, a more serious immediate impact is the alienation of some portions of the range as a result of possible avoidance of human activity areas. Prolonged avoidance would result in an effective loss of habitat, and animals may concentrate in limited areas of prime range or subsist on marginal range. Either scenario could result in over-browsing and a reduction in carrying capacity with eventual population declines (Sopuck et al. 1979).

Moose appear to be more tolerant of disturbances than most ungulates (Tracy 1977), particularly if disturbances are predictable, neutral stimuli such as moving vehicles (Kucera 1976, Schultz and Bailey 1978). Cow-calf pairs generally respond to disturbance more strongly than bulls and cows without calves (Tracy 1977). If moose are not directly approached by humans or machines, they appear to tolerate even moderate and high activity levels. For example, repeated aerial surveys of moose in the vicinity of the Revelstoke Hydroeletric Project in British Columbia over a five-year period that spanned preconstruction and construction phases indicated that moose numbers had not changed despite frequent blasting and heavy industrial activity (R. Bonar 1982 Personal Communication). Observations of moose, including cows and calves, in close proximity to active oil sands extraction plants in northern Alberta despite frequent mechanical disturbances and blasting, support this observation (J. Green 1982 Personal Communication). However, toleration of such activities by moose appears to occur only in the absence of high levels of human harassment and hunting. Moose can be expected to avoid human activity areas if harassment and/or hunting commonly occur.

Assuming that the Watana dam construction site and associated facilities are restricted to as small an area as possible and that hunting from project facilities and harassment is prohibited, moose would probably continue to utilize forested areas near these sites. (Hunting has been prohibited within a 10-mile corridor containing the Trans-Alaska pipeline and can be regulated by the Alaska Board of Game. Harassment is prohibited by state law and can be minimized by adequate enforcement.) If hunting from project facilities and access routes is permitted, moose will avoid the major activity centers, resulting in an additional loss of habitat beyond that associated with only the impoundment and discrete construction areas.

Because the clearing of the impoundment will involve noisy and unpredictable disturbances, moose will probably avoid the areas of active clearing. This and additional loss of habitat resulting from a lack of cover in cleared sites will gradually increase the intensity of use of browse in areas outside the impoundment area during the three-to-four-year clearing program. The concentration of moose in these areas will increase intraspecific competition for food and space. If the populations in these adjacent areas are at or near carrying capacity, mortality of moose as a result of starvation and predation may increase, natality may decrease, and carrying capacity and population productivity will gradually decline.

Aircraft enroute to or from the Watana airstrip may cause minor disturbances to moose. In general, most aircraft are expected to maintain high altitudes except during landing and take-off, and will not be a major disturbance stimulus. Frequent, low-altitude flights by fixed-wing aircraft or helicopters may elicit panic responses in moose. Because the intensity of reactions to aircraft by ungulates is influenced by such factors as the time of year; distance of the aircraft from the animals; group size; sex and age composition; type of aircraft; activity of the animals; and the type of terrain (Sopuck et al. 1979), it is difficult to generalize potential impacts on moose of repeated aircraft disturbance. The use of wooded areas on or in the immediate vicinity of several international airports in Canada suggests that if moose are not harassed, they will habituate even to frequent low altitude overflights (Green 1981).

- <u>Interference With Seasonal Movements</u>

  Clearing of the impoundment area will not physically obstruct river crossings or seasonal movements but may interfere with these movements through avoidance of active clearing operations or the expansive clear-cut areas. Increased visual exposure to predators and hunters may inhibit moose from crossing these cleared areas. Several studies have documented avoidance of large clear-cut areas by moose (Hamilton and Drysdale 1975, Parker and Morton 1978, Tomm 1978); in general, moose appear reluctant to enter areas where they would be far (i.e., more than (163-218 yards) 150-200 m from forest cover. Following filling, the Watana impoundment will constitute a greater obstacle to seasonal movements of moose than did the river. A more detailed discussion of the effects of the Watana development on seasonal movements is discussed below under Filling and Operation.

- <u>Mortality</u>

  An unpredictable number of moose may be killed as a result of collisions with vehicles or other accidents associated with construction activities. Mortality to predators may also increase if impoundment clearing facilitates hunting by wolves. The effect of these mortalities on moose populations is likely to be minor. The most serious mortality factor associated with the construction of the Watana dam will be the increase in hunting associated with the influx of people into a previously remote area. Effects of increased hunting on moose are described more fully in Section 4.3.3(a).

(ii) Filling and Operation

During the filling and operation phases of the watana development, the major impacts to moose will be permanent loss of habitat, alteration of habitats upstream and downstream from the damsite, blockage of movements, disturbance, and increased accidents and hunting mortality.

- Permanent Loss of Habitat

As flooding of the impoundment area proceeds, a variety of bottomland and low elevation habitats along the Susitna River will be permanently lost. As discussed above for the construction phase of the project, clearing of the impoundment area will have already resulted in a substantial reduction of the value of these areas to moose. By the time these areas are flooded, few or no moose may be utilizing these areas. However, the impoundment will permanently alienate the area from moose use. The consequences of the loss of these low elevation areas have been discussed in the previous section.

As a result of the habitat loss, moose will be forced into adjacent areas. Although it is not possible to predict the distances moose will disperse from the impoundment area, it is clear that densities in adjacent areas will increase during the clearing and filling of the impoundment. Hunting guides in the vicinity of the W.A.C. Bennett dam in northern British Columbia reported an increased harvest of moose in areas near the impoundment for a few years following flooding (K. Child 1982 Personal Communication). Increased moose densities could result in a decline in habitat quality in adjacent areas. If overutilization of food resources, particularly winter browse (generally conceded to be a major limiting factor in moose populations) occurs, increased mortality and decreased productivity can be anticipated.

During the operation of the Watana dam, a maximum drawdown of 95 feet (29 m) will create an unvegetated shoreline zone that, in the Watana Creek area, may be over 0.67 miles (1 km) wide. The impoundment level will be at its highest in August and September, and will generally decline between

October and August. Although a few herbs and forbs may become established during early summer, most of the area will remain a bare mud slope. Fine material will gradually move downslope so that much of the upper drawdown zone will eventually be composed of coarser material. Except during crossings of the reservoir, it is unlikely that moose will utilize the drawdown area. Hazards of the drawdown area to moose movements are discussed below.

- <u>Alteration of Habitats</u>

The Watana Project will result in the alteration of plant communities in both the upstream and downstream Susitna Basins (Section 3.3). These alterations will affect moose use of existing habitats and may have some effects on the long-term productivity of populations.

. <u>Upper Susitna Basin</u>

Based on analyses of home ranges and seasonal movements (ADF&G 1982a), radio-collared moose commonly utilize lower elevation habitats in close proximity to the future impoundments. Vegetation in the areas immediately adjacent to the impoundment may be altered as a result of several mechanisms such as minor changes in seasonal temperatures, wind direction and speed, and ice fog preventing direct sunlight from reaching the ground (see Section 3.3).

If the proposed reservoirs decrease either spring daytime temperatures (Baxter and Glaude 1980) or insolation, the spring green-up period may be delayed. This phenomenon is complicated by the fact that some plants use photoperiod rather than temperature to trigger early spring growth (see Section 3.3.1). If snow depths along the impoundment shoreline increase, plant green-up may be delayed. Some parturient cow moose, as well as male and young moose, were apparently observed to move to lower elevation areas of the Susitna River during the early spring, presumably to utilize the early emerging vegetation (ADF&G 1982a, no actual numbers available). Assuming that the timing of the spring green-up is important to the condition of parturient cows and the survival of their calves, any delay in green-up may reduce the survival of the calves. If moose are forced to utilize higher elevation areas where green-up is later (in comparison to low elevation sites), a reservoir-mediated delay in green-up would further aggravate problems of nutritional stress during the spring period.

Erosion of the impoundment shore will likely occur during the period of maximum fill until the new banks become stabilized. In particular, permafrost slumping along the south shore of the impoundment may eliminate large areas of habitat along the shore, although most of the unstable areas are steep slopes of little value as moose habitat. Areas of successional vegetation, favorable to moose, may develop on some of the resulting more gently sloping areas along the shores of the reservoir.

. Lower Susitna Basin

Changes in the flow regime will alter the availability and local distribution of important moose habitat in the lower Susitna Basin. The extent of vegetation changes will vary considerably along the lower reaches of the Susitna River because of the diluting effect of tributaries as well as changing channel morphology (see Section 3.3.1). Differences between pre- and post-project flow regimes will be greatest upstream from Talkeetna; change in the frequency and duration of flooding, ice scouring events, and shifting of bed materials will be less noticeable as one progresses downstream.

The alteration of moose habitat in the reach between Watana and Talkeetna can be better predicted than for areas further downstream. Between Watana and Devil Canyon, the river is contained by bedrock outcrops and steep canyon sides; early successional vegetation favored by moose occurs mostly on islands and along a narrow band adjacent to the main channel. The lower summer flows and lack of ice scouring will result in the colonization of a narrow band by new vegetation and the succession of some areas now subject to vegetative recession to climax forest. Although moose habitat will be improved for 10 - 20 years, the lack of flooding and ice scouring events will eventually result in the decreased availability of good moose habitat along this river reach.

In addition, preferred moose browse may become unavailable in winter because of blockage of movements by open water areas, and heavy frosting of vegetation along this open water reach. The icing effect is likely to be heaviest within the steep canyon as it is downstream from the Peace Canyon dam in British Columbia (where the climate and topography is similar) (Movold 1982 Personal Communication). In most areas, icing is unlikely to reduce browse availability, but it will increase the energy requirements of moose which consume large quantities of ice.

During operation, the area in the Devil Canyon-Talkeetna reach supporting early successional plant communities will be regulated by flow discharge from Watana at freezeup (see Section 3.3.1). Higher post-project winter flows will initially cause a widening of the unvegetated floodplain, including a decrease in the size of islands. If flows at freezeup are kept constant each year, little browse would be available to moose at any time of the year. However, flows at breakup are varied to meet energy demand or a reservoir level rule curve, the early successional stands will appear as plants colonize the scoured areas above the winter ice stage.

Female moose in the area north of Talkeetna appeared to move to and use riparian habitats and river islands during the calving period (ADF&G 1982b). Islands appeared to be particularly good calving areas, perhaps as a result of lower numbers of predators (Stringham 1974). Stable winter flow release will cause a decrease in the amount of early-successional vegetation in this reach, thereby degrading calving habitat. Most river islands will decrease in size, thus providing fewer areas for calving. If any islands become connected to the river banks, their value as calving areas will be further decreased.

The effects of the project on the quantity and quality of moose browse downstream from Talkeetna will be less than those between Devil Canyon and

Talkeetna, but because the number of moose using the river increases as one moves downstream, smal small effects on vegetation could result in relatively greater effects on moose. In winters of deep snowfall (such as in 1982-83), the amount of browse available above the snow surface probably limits the moose population, and in these winters, a decrease inavailability of brouse can be translated to a proportional change in the moose population supported along the river. In most winters, however, the amount of riparian vegetation does not limit the population (Section 4.2.1[a]), and changes in browse availabiity would be less important.

As discussed in Section 3.3.1(a), the area colonized by early- and mid-successional vegetation will vary considerably during the license period depending on the timing of peak floods of the various tributaries and river stage at freezeup. Additional research is in progress to improve the ability to predict future trends in the quantity and quality of moose browse based on an understanding of bank erosion processes, the importance of ice scouring in vegetative recession, and colonization rates on different substrate types.

- Blockage of Movements

Studies of seasonal movements of moose in the middle basin have identified several sites along the river where moose crossings tended to be concentrated (ADF&G 1982a). Depending on the time of year, moose attempting to cross the impoundment would encounter open water or uncertain ice conditions. Drifted snow near the southeast end of the impoundment could physically prevent moose from crossing the impoundment at that location. Because all of the recorded moose crossings of the Susitna River during 1980-81 occurred during May to November, moose will most commonly encounter open-water conditions. In addition, these animals would have to descend over mud flats or ice blocks within the drawdown area. Percentage slopes of the drawdown area in the Watana impoundment will range from less than 5 percent to as high as 115 percent (Hanscom and Osterkamp 1980). As a result of both the physical and visual barrier effects of the impoundment, it is likely that some moose movements will be blocked by the impoundment.

4.3 - Impacts - Watana Moose

Moose in British Columbia apparently do not seem to cross the open river area below dams in winter (Harper 1982 Personal Communication). The stretch of open river between Watana and Devil Canyon during winter will interfere with moose crossings during that season.

Moose in Alaska are adapted to and are dependent on seral habitats in at least a portion of their seasonal range (LeResche et al. 1974). With the exception of riparian zones, which are seral communities with predictable locations, most successional communities are products of random events such as forest fires, slides, or storms. To utilize new successional areas, moose must maintain some degree of flexibility in their seasonal and regional movement patterns. It is probable then that surviving moose in the vicinity of the impoundment will alter seasonal movements and crossings to maximize use of the remaining browse and forage supplies.

Blockage of seasonal movements, particularly to winter ranges or to calving areas, could severely affect moose populations if no alternative ranges are available. Moose distributions during 1980 suggested that relatively high concentrations of moose overwintered on both sides of the proposed impoundment. Locations of moose during the calving period similarly suggested that although moose were located more often to the north of the impoundment, animals probably calved on both sides of the impoundment. Relocations of moose during 1981-82 suggest that, although some moose cross the Susitna River to winter or calve, suitable habitat for calving and wintering are available on both sides of the valley. However, there is one report that moose have been known to starve to death in a traditional foraging area, even though adequate habitat was present nearby (W. Ballard 1982 Personal Communication).

Additional information on the availability of critical winter range and calving habitats following flooding is being obtained to more accurately assess the impacts of interference with seasonal movements.

- Disturbance

Mechanical and human disturbance should decline in the impoundment and construction areas once the Watana dam is operational. Public access will continue to increase levels of disturbance, though at a level lower than during construction. Helicopter and boat trips to the Jay Creek mineral lick by project personnel and recreationists would have an insignificant effect on moose. If animals are not directly harassed, disturbances during the filling and operation stages, with the exception of hunting, will at most have a slight effect on moose distributions.

- Mortality

During the filling and operational phases of the Watana project, hunting mortality of moose may be much greater than current levels. Construction workers may hunt, and improved access will permit hunters to reach many more areas within the Susitna Basin. Hunting pressure will likely increase rapidly during the first five to ten years of the project, and increased harvest of moose is expected. Hunting will prevent over-brousing of remaining range by removing displaced animals (assuming adjacent areas would be over-utilized as a result of moose dispersal from the impoundment area).

Mortality of moose may result from animals being injured on ice shelves, falling through the ice after the water level has been drawn down (Harper 1982 Personal Communication), or from animals becoming mired in the drawdown area. Moose have also become trapped and drowned in floating debris within impoundments (Child 1982 Personal Communication). Floating ice during breakup may cause similar increases in crossing mortality. The number of moose accidentally killed each year as a result of the impoundment hazards, based on experience from impoundments in British Columbia (Bonar, Harper, Childs 1982 Personal Communication) is unlikely to exceed one percent of the moose population occurring within five miles of the impoundment. However, highway and railroad kills associated with the project may be substantial (see Section 4.3.3[a]).

The impoundment will also affect predation rates on moose. The ratio of brown bear to moose may increase in the early years of filling and operation. Bears may also kill more moose to compensate for the loss of vegetation in spring. The drawdown zone and ice conditions may facilitate hunting of moose by wolves. If a severe winter occurs during or just after filling, the moose population may suffer high winter mortality, reducing its ability to sustain high levels of predation. These factors could allow predation to drive the moose population to low levels, with slow recovery because of sustained predation levels.

(iii) Quantification of Project Effects

The loss or alteration of moose habitat in the middle basin during both winter and summer has been identified as the major impact of the project on moose. The population-based studies conducted to date indicate the magnitude of use of areas by the existing populations during the study, but do not allow a quantitative assessment of the potential of the habitat to support moose under varying environmental conditions. To estimate moose carrying capacity in the Susitna project area, a moose bioenergetics model is being developed. This habitat-based assessment, in combination with the population-based assessment currently underway, should provide a strong basis for impact prediction and mitigation planning.

Carrying capacity models based upon the nutrient requirements of the animal and the capacity of the range to supply these necessary nutrients have recently been developed (Moen 1973, Wallmo et al. 1977, Mautz 1978). The nutritional interfaces between the animal and range are forage selection, ingestion, and digestion. Forage quality can be assessed by measuring available nitrogen and energy. Other nutritional entities are requisite to the health of wild ungulates, but they are seldom the limiting factor. A simulation model of ruminant energy and nitrogen balance developed by D. M. Swift (1983) and Swift et al. (1981) has been adapted to moose (Regelin et al. 1981) Schwartz and Franzmann 1981b). This model predicts rates of daily forage intake and changes in body weight and composition of an individual moose based upon the composition and quality of ingested forage. The basic research necessary to adapt the model to moose was conducted at the Moose Research Center near Soldotna, Alaska, during the past five years. Required information to adapt the model to moose included moose energy and protein requirements, digestive capacity, rumen turnover time, rate of passage, and partitioning of energy from gross energy intake to net energy available for production (Regelin 1982 Personal Communication).

The model estimates daily energy and nitrogen requirements for non-reproducing moose. Based on daily diet digestibility and nitrogen concentration, the model predicts total voluntary intake; rates of digestion and passage; partitioning of energy and nitrogen to maintenance, growth and fattening; changes in lean body mass and adipose reserves; and returns of energy and nitrogen to the ecosystem (Swift et al. 1983). Specific information on the range nutrient supply must be collected from each area where carrying capacity is to be predicted. The data needs are the amount of available forage, quality of the forage, and food habits of moose. The data are first used in the ruminant sub-model to predict daily intake rates. A separate model then estimates the potential carrying capacity of the area. The total amount of digestible energy and crude protein available to moose is calculated. The carrying capacity is determined by dividing the daily requirements for digestible energy and crude protein into the total amount available. Separate estimates are made, based upon crude protein and digestible energy. Carrying capacity can be expressed as the number of moose days of use or the number of moose, and can be predicted for summer or winter periods.

The ruminant sub-model has been adapted to moose and produces realistic outputs; however, the model has not been validated under field conditions. There are currently plans to validate the model using moose within four 1- mi^2 pens at the Kenai Moose Range. Potential carrying capacity will be predicted in each enclosure, and each will be stocked with moose at different densities. The moose will be weighed periodically to determine if the sub-model correctly predicts changes in body weight.

Specific data needed to quantify the carrying capacity of moose within the middle basin are listed below (Regelin 1982 Personal Communication):

- Detailed vegetation maps of the Watana impoundment area and middle basin. The areal extent of each vegetation type must be calculated and the spatial distribution of each type must be determined.

- Standing crop biomass of moose forage within each vegetation type must be determined through appropriate sampling methods.

- Food habits of moose during October, February, May, and July need to be determined. Fresh fecal pellets should be collected at each season and analyzed by the microhistological technique to determine food habits.

- Seasonal nutritional quality of moose forage needs to be measured. Important forage species (4-6 species) should be collected during October, February, May and July. Only plant parts eaten should be collected from several locations within the area. Samples should be ground in a Wiley mill and analyzed for N content and in vitro digestibility. Moose rumen fluid should be utilized in the in vitro digestion process.

Nonhabitat related impacts such as increased predation or crossing mortality will also be assessed through the use of simulation modeling. Various levels of predation or other mortality will be input to the model now being developed to assess the resulting long-term effect on the population. Preliminary outputs from these analyses will be available in 1983, but the combined effects of habitat loss and alteration and various direct mortality factors will not be available until 1986.

(b) Caribou

Anticipated and hypothesized impacts to caribou are summarized in Table E.3.147. Alaska's Nelchina caribou herd is an invaluable wildlife resource and may be subject to serious impacts as a result of the Watana project. In particular, concerns have focused on the position of the impoundment in a migratory corridor. Direct impacts here treated include blockage of migratory routes, hazards associated with impoundment crossings, disturbance, and loss of habitat. Increased access will be a major indirect impact.

4.3 - Impacts - Watana Caribou

(i) Construction

Construction activities in the immediate vicinity of the Watana dam are unlikely to greatly affect caribou of the Nelchina herd.

The construction site will remove much less than one percent of infrequently used habitat. Although some caribou may encounter and avoid areas of intensive human activity, this should not result in any population effects. Proposed borrow sites also cover less than one tenth of one percent of caribou habitat and are temporary facilities. Borrow sites A, D, and F are more likely to be frequented by caribou than are the other potential borrow sites. Most use of these areas is attributable to summer use by bulls, and it is unlikely that the cow/calf segment of the main Nelchina herd will come close to the borrow sites during annual movements. Although bull caribou appear to be less sensitive to human activity and disturbance than other portions of the herd, they may still avoid the areas during active mining to a limited extent. As a result, the borrow sites will represent an inconsequential loss of summer bull habitat. Caribou may avoid the construction camps and permanent villages, but again these areas remove a relatively small area of infrequently used habitat.

Aircraft traffic will increase considerably in the middle basin as a result of the project. The degree of response of caribou to aircraft disturbance depends on many factors, including: aircraft type, altitude and horizontal distance from the animals, season, group size and composition, previous activity, herd experience and habitat type. There is some evidence that aircraft disturbance could result directly in the death of young animals (DeVos 1960, Miller and Broughton 1973). However, no unequivocal evidence of this for wild animals is available, and except for intentional harassment of animals by aircraft or low-altitude flights causing groups of animals to stampede, the main concern of aircraft harassment is related to its energetic effects. Caribou and other large mammals often react to a low-flying aircraft by running. The energetic cost of running in caribou can be 8 to 20 times the basal metabolism (Geist 1975), and there is some evidence that the energy costs to animals that show no overt response at all to disturbance are nevertheless increased (e.g., MacArthur et al. 1979).

Most studies have found that fixed-wing aircraft are less disturbing than helicopters, other factors being equal (Klein 1974, McCourt et al. 1974, Surrendi and DeBock 1976, Fischer et al. 1977, Miller and Gunn 1979), although horizontal and vertical (altitude) distances have not always been distinguished. Shank (1979) generalized results of all these studies and suggested that response levels decreased rapidly with increasing distance from the aircraft up to distances of about 250 feet (80 m). Beyond 250 feet (80 m), response levels decreased more slowly, and there was great variability in the level of response at particular altitudes. The results of both Fischer et al. (1977) and Miller and Gunn (1979) suggest that response levels decrease with increasing horizontal distance in a much more regular manner than the decrease in response with decreasing vertical distance.

From the various studies that have been conducted on large mammals, and by extrapolating from the domestic reindeer literature (Zhigunov 1968, Klein 1971), it is evident that very high levels of disturbance from low-flying aircraft could affect the productivity of caribou; however, if pilots maintain an altitude of at least 1000 feet (300 m) above sound level whenever possible 2000 feet (600 m) agl over the calving grounds during April-July), there is little evidence to suggest that caribou would be seriously affected by aircraft associated with project construction and operation.

(ii) Filling and Operation

The area to be flooded by both the Watana and Devil Canyon impoundments represents much less than one percent of the Nelchina herd's range (ADF&G 1982c). Skoog (1968) considered the middle Susitna bottomland to be low quality grazing habitat, but noted its importance to migrating animals at several times of the year. The loss of caribou habitat as a result of inundation will, therefore, not be of major consequence to the herd, and by itself should not cause any change in herd size, productivity, or distribution patterns.

Information collected on the movements of the Nelchina caribou herd since 1947 indicate that the proposed Watana impoundment would intersect a major caribou migration route. This has led to concerns that the impoundment and other project facilities might serve as barriers to caribou movements, cause a decrease in use of portions of the range, increase the mortality rate, and tend to isolate one or more subherds having separate calving grounds. Many secondary impacts, whose probability would be even more difficult to predict, would follow, including increases in predator populations which would further increase mortality, decreases in the birth rate and in calf survival, and decreased potential carrying capacity because of alienation from use of some portions of the range.

However, large movements of caribou across either of the proposed impoundment areas have been reported only once since 1973 (skoog 1968, ADF&G 1982c). Hemming (1971) reported that, as the herd increased in size between 1947 and 1962, shifts in range use and seasonal splitting both increased in frequency, and the herd expanded its range. Conversely, as numbers decreased after 1962, the area occupied by the herd contracted toward the traditional calving area in the Talkeetna Mountains.

It thus appears that there is a close relationship between herd size and the potential for adverse impacts caused by the Susitna Hydroelectric Project. As the herd increases, large movements of caribou across the Watana impoundment and Denali to Watana access road will likely recur. However, major movements across these facilities are not expected under the current Nelchina caribou management plan (ADF&G 1976), which includes a management guideline to harvest the annual increment after the herd reaches 20,000 adult caribou. Herd movements during the construction phase are not likely to differ greatly from those observed during the past five years, since herd size is not likely to exceed 30,000 caribou before 1990.

It is not possible to determine to what extent, if any, portions of the historically used range would become alienated from regular use by the impoundment. It is possible that isolated subherds with separate calving grounds would regularly utilize those portions of the range. It is also possible that no decrease in use will be detected (although mortalities related to impoundment crossing will occur). If portions of the range are alienated from regular use, the project will result in a decrease in the ability of the range to support population levels which have occurred in the past. Although current management plans call for maintenance of the herd at 20,000 adults, the option to allow a substantial increase may be foreclosed by development. Again, it is not possible to determine the value of this hypothetical upper limit at the present time or how much it may be reduced by the project.

Even at current herd size, the Watana reservoir will interfere with the migration of caribou between portions of the herd's range and may increase mortality during migration as a result of hazards created by the impoundment. Although the large movements of caribou recorded in the past across the proposed Watana impoundment area have not occurred in recent years, the area is still used by many caribou as a travel route. Nine crossings of the proposed impoundment by six radio-collared caribou were documented during studies in 1980 and 1981, and other caribou apparently walked along the river ice between the Tyone and Oshetna Rivers area to Kosina Creek and Watana Lake, where they then moved into the Talkeetna Mountain foothills.

Crossings of the impoundment in 1980 and 1981 occurred mostly between April 10 and May 31, and between August 1 and September 30 (ADF&G 1982c). About 10 percent of the main herd crossed the river during October 1982 (Pitcher 1982 Personal Communication). 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 95 feet (29 m) lower than when it is full in October. The gradual winter drawdown will result in the formation of ice blocks grounded on the shore. Where the slopes of the shoreline are gradual, such as along the Watana Creek drainage, the blocks will be wide and flat and more easily traversed. Where the banks are steeper, the ice 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. It is possible that some caribou may be killed or seriously injured when crossing.

During the ice-covered reservoir period, the prevailing northeast winds will tend to sweep the reservoir clear of snow or at least will maintain a smooth, flat surface. Drifting snow is thus expected to accumulate near the southwest end of the reservoir.

proceeding to the least likely reaction (Banfield 1982 Personal Communication; Roseneau 1982 Personal Communication). In any particular year, all four responses will likely be exhibited by varying proportions of the herd.

- The caribou will manage to cross the impoundment safely in the Watana and Kosina creek areas.

- The caribou will travel eastward and cross the Susitna River in the vicinity of the Oshetna and Tyone rivers on ice-covered flats.

- The caribou will make hazardous crossings with increased mortality.

- The caribou will refuse to cross the impoundment and reverse direction.

The Watana impoundment should not cause any substantial caribou mortality during the summer and fall open-water period, but it may greatly influence the movements of some caribou during that time. Caribou are excellent swimmers, but large lakes and swift rivers can change the direction or timing of movements. Skoog (1968) reported that "even though caribou are excellent swimmers and generally take readily to the water, frequently I have noted how a movement will change direction upon encountering a large lake or river and will parallel the waterway rather than cross it." Banfield and Jakimchuk (1980) ADF&G 1982c) state that "caribou prefer to avoid open water," and that large lakes are often crossed at narrow points or where islands provide interim stopping points. It thus seems likely that caribou approaching the reservoir in the Watana Creek vicinity, for example, might parallel the shore to an area where the impoundment is narrower.

(c) Dall Sheep

Anticipated and hytopthesized impacts to Dall sheep are summarized in Table E.3.148. The most serious impacts to Dall sheep include disturbance and harassment and the inundation of portions of a mineral lick. Disturbance of sheep at the lick is a major potential impact.

(i) Construction

4.3 - Impacts - Watana Dall Sheep

The three Dall sheep populations identified in the Susitna Basin are most likely to be affected by the project through disturbance (i.e., aircraft traffic, construction noise, presence of workers), habitat loss, and increased access by hunters. Each of the populations will be affected to a different degree as a result of their distribution in relation to project facilities.

The Mount Watana population does not usually occur near the impoundments, access roads, or borrow areas at any time of the year, and is likely to be affected only by low-flying aircraft crossing between the Susitna and Talkeetna river drainages. Disturbance from low-flying aircraft is also of concern with the Portage-Tsusena Creek population. The Watana Hills population will be most affected by the project because of the partial inundation of a major mineral lick on Jay Creek used by this population. As will be discussed, the frequent disturbance of sheep at the lick by project personnel and recreationists is expected to be a more immediate and serious impact than will the eventual partial inundation of the lick.

The impact of intensified human activity on Dall sheep populations is not completely understood, but some general predictions can be made. If an animal is excessively aroused, as from human disturbance, the added cost of excitement or activity may interfere with health, growth, and reproductive fitness (Geist 1975). Ewes with lambs are particularly sensitive to disturbances (Smith 1954, Jones et al. 1963). Recent studies of free-ranging ungulates have found that the heart rate of an individual is a sensitive indicator of arousal, the first stage of an alarm reaction to stress (Ward et al. 1976; MacArthur et al. 1979, 1982). These and other investigators have demonstrated consistent heart rate responses to disturbing visual or auditory stimuli, often in the absence of overt behavioral reactions. MacArthur et al. (1982) reported on the heart rate response of an unhunted population of mountain sheep (*Ovis canadensis*) to aircraft and vehicle traffic. No heart rate responses were associated with helicopter or fixed-wing aircraft at distances exceeding 1300 feet (400 m) from sheep. They found that direct overflights at 100-275 feet (90-250 m) by helicopters caused sheep to run for 2-15 seconds and elicited a

2-3.5 x increase in heart rate. In Alaska, six studies have included observations on the response of Dall sheep to aircraft disturbances (Andersen 1971, Linderman 1972, Nichols 1972, Price 1972, Lenarz 1974, and Summerfield 1974), although only one of these (Lenarz 1974) presented quantitative data. Helicopters usually evoked a greater response from sheep than did fixed-wing aircraft. This is possibly because helicopters fly slower and closer to the sheep and are generally more noisiest (especially "rotor popping") (Andersen 1971, Linderman 1972, Price 1972). No studies have been conducted to determine the responses of mountain sheep to aircraft flying at different altitudes, as have been conducted with caribou and muskoxen. The reaction of Dall sheep to low-flying aircraft is highly variable (Linderman 1972 and Price 1972), although Linderman found that sheep always reacted nervously and assumed the alarm posture (Geist 1971b) until the disturbance had passed. Lenarz (1974) found that "ewes" (including young rams not discernible from females) reacted more strongly to helicopters than did rams. Andersen (1971) and Price (1972) found that sheep were more easily disturbed by aircraft when congregated at mineral licks, which are usually located lower on slopes away from escape cover.

The Watana Hills sheep population will be most affected by the project because of the location of a major mineral lick on Jay Creek. The area used by sheep is a steep bluff extending from the creek bottom at 200 feet (610 m) to the rim at 2450 feet (747 m). A ridge on the east side of the creek 2252 feet (692 m) elevation) is also used. Approximately 42 percent of the lick surface area will be inundated each year when the Watana impoundment is at its maximum level 2190 feet (668 m) (668 m). However, during the months of maximum lick use (May and June), the reservoir level will be approximately 2093 feet (636 m) (May 1) and 2100 feet (638 m) (June 1), and thus only about 22 percent of the lick will be under water. Sheep appear to use the lower half of the lick more frequently than the upper half (ADF&G 1982d, no quantitative data provided) and, therefore, these percentages may underestimate the amount of soil that will be inundated. Most licks are created and/or maintained by water action along creeks or lakes, and it is unlikely that sheep will discontinue use of the lick because of partial inundation. Erosion caused by the reservoir may enhance the lick by exposing new soil, but may also leach important ions from the soil. Of greater immediate consequence than the decrease in surface area of the lick is the disturbance of sheep using the lick. Frequent visits to the lick (mostly with helicopters) by researchers, other project personnel, and visitors touring the project area have undoubtedly affected the sheep using the lick. The lick is far removed from adequate escape habitat, and these frequent helicopter trips into Jay Creek for purposes of viewing the lick could result in its abandonment if continued. Recreationists accessing the area by boat after the impoundment has filled could have a similar effect.

The consequences to the Watana Hills sheep population if the Jay Creek lick is abandoned for any reason are unclear. Several other mineral licks have been identified within the range of this population, but because sheep have a demonstrated high fidelity to specific licks, it is uncertain whether these alternative licks would replace Jay Creek. Many researchers have conducted chemical analyses of mineral lick soils in an attempt to explain why sheep visit licks, but the results have been conflicting or inconclusive. Contamination of samples from urine, feces, and/or muddy water have been cited as potential sources of error in these analyses. Many studies have found that sodium is relatively abundant in lick soils and is selectively sought by ungulates (see Stockstad et al. 1953 and Tankersley 1981). Plants other than halophytic species absorb only a small percentage of the sodium present in the soil, and it is therefore possible that forage species are unable to supply the quantity of sodium needed by big game (Stockstad et al. 1953). Heimer (1973) found that soil samples from high use sites within a mineral lick contained large quantities of clay minerals called zeolites which contain biologically available cations of sodium, potassium, calcium, and magnesium.

(d) Brown Bear

Anticipated and hypothesized impacts to brown bears are summarized in Table E.3.149. Probable factors regulating brown bear populations in the Susitna Basin and actions that might affect populations are illustrated in Figure E.3.110.

4.3 - Impacts - Watana

Brown bear-human conflicts are a major concern of development project planners in the north and are treated in this section. Other impacts include spring habitat loss, disturbance, and impediments to movement. Indirect impacts associated with increased access are likely to be serious.

(i) Construction

The two major impacts of the project on brown bears during the construction phase will be the loss of spring feeding areas during and after clearing, and direct mortality of bears resulting from bear/human conflicts at camps, construction sites, and bear concentration areas. Unregulated hunting by construction workers would also have a major impact on brown bears during this period.

Several food sources have been identified that appear to be seasonally important to brown bears in the Susitna Basin. These include spawning salmon in July and August at Prairie Creek, early spring herbaceous growth and overwintering berries along the lower slopes near the river bottom, widely scattered berry patches on the benches above the river, carrion and moose calves near the river and its tributaries, and vegetation along tributaries such as Deadman Creek. Some bears may avoid areas of intensive human activity, thus affecting their movements between these widely scattered food sources. However, because brown bears range widely and frequent open habitats, it is unlikely that the intensive human activities near the damsite and borrow sites, or the presence of a cleared impoundment area in the last year or two of the construction phase, would prevent bears from reaching food sources outside the intensively used construction area.

The greatest impact on food sources during the first few years of the construction period will occur near the damsite, where facilities and human activities will be concentrated. A much greater reduction in spring food availability will occur during and after impoundment clearing. The availability of early spring foods to brown bears will be reduced both as a result of direct habitat removal near the construction sites, and by alterations of bear movements along the river. Because the food requirements of brown bears are so poorly understood, it is not possible to equate losses in food supplies to losses in number of bears. It is thought that the riparian areas are most important to bears in early spring, just after they emerge from dens. Snowmelt occurs sooner in these areas (particularly on south-facing slopes), making overwintering berries and green growth available to bears when they have low energy reserves. Moose calving is also concentrated in riparian areas, and brown bears have been shown to be effective predators of both adult and young moose (Ballard et al. 1980).

The loss of early spring feeding areas near the construction site will probably not affect the population size or productivity of brown bears during the short construction period. Reservoir clearing activities will cause a reduction in carrying capacity, but it is doubtful that this alone would cause measurable population effects in the one or two years of the construction phase when clearing occurs. Brown bears eat sparingly for several weeks after emerging from dens during a transition stage from hibernation to normal activity (Craighead and Mitchell 1982). As food becomes increasingly available, the bears' food consumption increases. Craighead and Mitchell (1982) reported that bears in Yellowstone Park during April and May continued to utilize body fat stored the previous fall, and that weight gains were not noticeable until late July and August. Berry production appears to be highest on the benches above the river (above the impoundment level) where snowmelt occurs 1-3 weeks later than on the south-facing slopes below 2200 feet. If bears are able to subsist on fat reserves for these few weeks, a more abundant food supply will become available.

Craighead and Mitchell (1982) also reported that although brown bears feeding primarily on green vegetation in spring failed to gain weight, those securing high-protein food such as carcasses, the young of big game species, or garbage maintained or increased their weight. This suggests that a decrease in ungulate populations may have as great an affect on bear condition in the spring as would a decrease in the availability of green vegetation. If project personnel are not allowed to hunt, the effects of the project on moose during the construction phase are expected to be mostly distributional (as opposed to changes in population size), and no changes in caribou numbers are expected. Thus, it is unlikely that noticeable changes in the number of brown bears as a result of altered spring food availability will occur during the construction period. During the filling and operation phases, however, the loss of spring feeding areas will have a major impact on brown bears.

Brown bears have one of the lowest reproductive rates of any land mammal in North America (Bunnell and Tait 1978). This, coupled with the low densities of brown bears in most parts of their range, makes the impact of sustained high levels of mortality particularly severe (Craighead et al. 1974). Typically, causes of direct bear mortalities during construction of projects in their range include killings in "defense of life and property", control kills of nuisance animals by appointed agency or project personnel (Cole 1971); accidental deaths of bears during attempts to frighten or trap and transplant animals; and increased hunting and poaching pressure resulting from improved access and higher numbers of people (Rogers et al. 1976, Nagy and Russell 1978, JFWAT files). Accidental deaths of bears from blasting or destruction of dens also occur but are less common (JFWAT files).

Human activities related to the Trans-Alaska pipeline project (TAPS) resulted in a minimum of 11 brown bear and 30 black bear deaths (JFWAT files). One of the most serious problems encountered during TAPS construction resulted from the attraction of bears to areas of human activity. Bears quickly discover and utilize improperly handled food and garbage at camps, worksites, or dumps (Barnes and Bray 1967, Craighead and Craighead 1972a, Meagher and Phillips 1980). The effects of bears' concentrating at artificial food sources such as dumps are not clearly understood, but there is some evidence that higher cub mortality from predation by adults and higher disease and parasite loads may result when bears are concentrated (Cole 1971). Brown bears from hunted populations such as that in the Susitna Basin are less likely to be attracted to camps and dumps than are those in unhunted populations, but some brown bears can still be expected to frequent these areas.

Human activity in bear habitat poses problems for people and thus for bears. Fatal attacks by bears occasionally occur when artificial food sources attract habituated bears to sites of human activity (Craighead and Craighead 1972a, Hamer 1974, Herrero 1976). Females with cubs, very old bears, and habituated bears pose the most serious threats (McArthur 1969). Besides serious maulings, minor injuries such as bites and scratches frequently result from attempts to feed bears (Eager and Pelton 1980). Extremely serious bear/human conflicts occurred during the TAPS project (JFWAT files).

There are several specific areas and seasons where human/bear conflicts might occur. Areas where bears congregate to feed on salmon in late summer are likely to be attractive to project personnel as fishing sites. Brown bears tend to concentrate near the river to feed on vegetation during early spring, soon after emerging from dens; thus, bear/human encounters near the construction site and borrow sites may be frequent at that time. The proposed camp is likely to be frequented by bears if proper food storage and disposal methods are not implemented. Also, the camp is located in prime berry habitat used by bears in late summer and early fall. The ongoing bear studies will provide the information needed to further identify such bear concentration areas.

Bears are reported as one of the large mammals more sensitive to aircraft disturbance (Klein 1974, McCourt et al. 1974). The reactions of bears to aircraft have been recorded in several studies (Quimby 1974, Ruttan 1974, Harding 1976); there is much individual variation in their reactions, probably related in part to previous experience (Linderman 1974, Pearson 1975, Harding and Nagy 1977). Bears seem to react more strongly to helicopters than to fixed-wing aircraft (Quimby 1974, Harding and Nagy 1977). Low-flying aircraft near feeding sites could affect the productivity of brown bears if disturbance is frequent enough.

The impacts of the project on brown bears downstream from the Watana dam will be limited mostly to aircraft disturbance and increased hunting, since downstream flows will not be altered until the filling phase. No measurable changes in the number of moose or other important prey species are expected, although there may be some noticeable shifts in the distribution of prey species away from the construction sites. Fish and mammal populations downstream from the Devil Canyon site would be affected primarily by increased fishing and hunting pressure, and no impact on brown bears should result given the current hunting and fishing regulations.

(ii) Filling and Operation

The loss of habitat as a result of the impoundment clearing and filling and the partial avoidance of project facilities will have the greatest impact on brown bears during the filling and operation phases. Indirect effects of decreased moose populations and increased hunting by people will also have measurable effects on brown bears. There is also some potential for the impoundment to interfere with bear movements, particularly during the spring.

The impoundment will affect the brown bear population primarily through decreased availability of moose, berries and green vegetation. Although the loss of early spring feeding areas near the damsite during the construction period is not likely to measurably affect the population, the loss resulting from impoundment of the river will decrease carrying capacity. Brown bears must build up large fat reserves during the six-month period that they are out of dens to sustain them through the winter and early spring. Following the 1981 berry crop failure, Miller (1982 Personal communication) reported that two of the four females expected to have cubs in 1982 did not, suggesting that the poor nutritional condition of females in the fall may have caused a lower productivity the following year. Pelton (1982) reported for black bears that years of poor berry or acorn production can result in delayed first estrus, decreased litter sizes, and increased incidence of barren females. In addition, overwintering berries appear to be a particularly important spring food for some bears. Yearlings, which emerge from dens in poor condition and suffer higher rates of mortality than other age classes, may be particularly sensitive to loss of overwintering berries as a spring food source. The permanent loss of habitat and early spring foods in the impoundment area will therefore cause a decrease in the carrying capacity of the project area for brown bears. The decrease in the number of moose available to bears, in combination with the loss of berries and other vegetation and any alteration of plant phenology in the impoundment zone, will cause an even greater reduction in the carrying capacity of the area.

The impoundment is not expected to be an absolute barrier to brown bear movements, except possibly during the spring. Some interference with movements between food sources will occur, but the number of bears affected and the consequnces in terms of productivity or survival cannot be predicted. Brown bears usually emerge from dens in April, and most have entered new dens by the end of October. Thus, the reservoir will be ice-free during most of the time bears are out of their dens. Brown bears commonly swim long distances in the ocean to offshore islands (Miller and Ballard 1982, Roseneau 1982 Personal communication), and the open water in the reservoir should not physically obstruct crossings. The ice on the reservoir is expected to begin melting in early March, and the reservoir should be ice-free by late May to early June (Bredthauer and Drage 1982). During April and May, bears attempting to cross the reservoir will be confronted with ice shelves and blocks, wide mudflats, and thin and broken ice conditions. There will also be open-water conditions near the intake structures and downstream from the dam. It is not known whether one or more of these factors might deter bear crossings, but these spring conditions would be more likely to affect movements than would the open water later in the summer.

Indirect impacts on brown bears downstream from Watana will result from reduced populations of moose and salmon and from increased hunting along the transmission corridor. Moose and salmon studies are being conducted along the lower river in an attempt to quantify project impacts. The carrying capacity of the areas adjacent to the river will decrease if salmon and moose populations are substantially reduced.

Hunting pressure on brown bears will probably increase in the upper Susitna basin because of the improved access afforded by the reservoir and access road. Also, many of the workers who helped to construct the dam may return to the area to hunt. This increased hunting pressure will likely result in lower bear densities and a younger age structure in the brown bear population (ADF&G 1982e).

(e) Black Bears

Anticipated and hypothesized impacts to black bears are summarized in Table E.3.150. A large proportion of the acceptable black bear habitat in the middle basin will be eliminated. Disturbance will also be a serious impact, as will black bear/human conflicts.

(i) Construction

The long-term impact of the Watana development on black bears will be much greater than that for brown bears, since the impoundment and other project facilities will remove a large proportion of acceptable black bear habitat in the Watana area. However, habitat loss may not be the most serious impact on black bears during the first few years of the construction period, when attraction to artificial food sources, disturbance of bears at denning and feeding sites, and increased levels of hunting are more likely to have serious effects (see Figure E.3.111).

Black bears in the vicinity of the proposed Watana impoundment are restricted to a band of conifer forest adjacent to the river. Between Watana Creek and the Tyone Rivers, this band of forest becomes increasingly constricted. The construction site, borrow sites, camp, airport, and other facilities will remove a large proportion of the black bear habitat, thus concentrating the bears into the limited remaining areas. Black bears are more likely to frequent the camp and construction sites than are brown bears, and this will cause problems for both people and bears (see 4.3.1[d]). Deliberate feeding of bears by project personnel at construction sites will intensify the problem.

Borrow sites D and F are located in the tablelands and are used by black bears foraging for berries in late summer (ADF&G 1982e). Bears will be affected both by the direct removal of this rich food source and by a greater likelihood of contact with humans, which could lead to some bear mortalities. The other borrow sites are in forested areas used by black bears throughout the year, and the mining of construction materials from these sites will cause a reduction in the availability of denning sites and feeding areas.

Black bears in the Susitna Basin typically den at elevations below 3,000 feet, and 9 of the 13 known black bear den sites in the Watana impoundment area will eventually be flooded. Assuming that other dens occur above or below the impoundment level in the same ratio, 69 percent of the black bear denning habitat in the Watana impoundment vicinity will be lost. Since dens are concentrated near the river where human activity will be greatest, there is also the potential for disturbance to cause den abandonment or to make some denning areas unacceptable. Many of the dens sites were reused by the same or a different bear, which may indicate a scarcity of acceptable sites. Human activity on the ground and low-flying aircraft can both cause den abandonment. As discussed for brown bear, den abandonment in winter when the ground is frozen may result in a bear's death.

Because black bears will be concentrated near the river and may have increased movements while searching for food, any increase in hunting pressure during the construction period could have a substantial effect on the population. If black bears do increase their movements away from forested areas, as they do during berry crop failures (ADF&G 1982e), there is also a potential for increased mortality caused by encounters with brown bears.

(ii) Filling and Operation

Black bears will be affected in several ways during the clearing of the impoundment area and initial filling period. The loss of feeding areas, disturbance at den sites, and increased contacts with people will all result in severe habitat degradation within and adjacent to the impoundment area. Bears occurring in the impoundment area will likely increase their movements away from the river, thus increasing contacts with brown bears and hunters. There is little likelihood of bears being drowned while in their dens during reservoir filling, since winter flows into the reservoir will be very low, and most of this flow will be released downstream.

After filling, it is unlikely that a viable resident black bear population will exist upstream from Watana Creek. Transient bears may use areas adjacent to the impoundment, and a few bears may reside there year-round. However, the lack of denning areas and adequate forest stands near the remaining food supplies will severely limit the resident population. These bears will also be quite susceptible to hunting along the reservoir margin. Many bears residing downstream from Tsusena Creek made movements in 1980-82 upstream to feed on berries, and the road and other permanent facilities may interfere with these movements. Other long-term impacts are likely to be similar to those for brown bears (see 4.3.1(d)). Black bears, like brown bears, are able to swim long distances, and the open water in the impoundment should not be an absolute barrier to their movements. Some effects on bear movements, however, can be expected. Since black bears in the Watana watershed will be subject to serious habitat loss, the cumulative impacts to vegettion and prey populations are likely to be of greater importance than for brown bear.

Downstream effects of the Watana development on black bears are likely to be much less severe. Impacts on salmon spawning areas, aircraft disturbance, and increased hunting will probably have the greatest effect on the population. The expected successional changes in vegetation are not likely to have a noticeable effect on the population, nor will any open water areas during winter, since bears will be in dens at that time. The importance of salmon to downstream bears is unknown, but several bears from the middle basin moved downstream to feed on salmon during a berry crop failure, and bears are commonly seen along spawning sloughs in late summer (ADF&G 1982e). Twenty percent of the salmon radio-tagged during studies downstream were eaten by bears (Miller 1982 Personal communication). However, bear scats found along salmon streams comprise mostly berries, and thus the importance of salmon to these bears is uncertain. Bear studies downstream from Devil Canyon will be intensified in 1983, and consequently, the food habits of downstream bears will be better defined at that time.

(f) Wolf

Anticipated and hypothesized impacts to wolves are summarized in Table E.3.151. Wolves may be affected by construction and operation of the Watana development by some loss of den and rendezvous sites, by disturbance, by increased hunting (see Section 4.3.5), and indirectly, by loss of food sources. The Watana pack in particular may be seriously affected by the loss of habitat for the major prey species - moose, within their territory.

No known dens or rendezvous sites will be flooded or destroyed by the present construction zone plans. Some den and rendezvous sites that have not been located may be destroyed, but because potential sites are relatively abundant in the Susitna Basin (ADF&G 1982f), this would not have a serious effect on wolf populations.

Under most circumstances, wolves readily habituate to man-made disturbance (Van Ballenberghe et al. 1975, Milke 1977). The major exceptions to this are disturbances at den sites in spring. During Susitna baseline studies (ADF&G 1982f), human disturbance at three den sites caused early abandonment of all three, the adults moving the pups to new locations. In these cases, the pups were probably a month old and no pup mortality was noted. ADF&G (1982f) speculated that younger pups might be more likely to die if moved from the whelping den prematurely. Abandonment of dens after disturbance has also been noted in other areas of Alaska and in Canada (Carbyn 1974, Chapman 1977). Aside from disturbance at dens, disturbance alone is unlikely to cause noticeable changes in the distribution of wolves or home range use of individual packs.

A serious impact of increased interactions between humans and canids (wolves and foxes) is the threat of exposure to rabies. That wolves (and bears and foxes) do habituate to the presence of humans was demonstrated by problems encountered during the construction of the Trans-Alaska Pipeline (Milke 1977). Wolves were fed deliberately and were allowed to scavenge on unburned garbage at construction sites and camps. As a result, many animals became severe nuisances and were killed. In addition, instances of workers being bitten and requiring hospitalization and occasionally rabies vaccine occurred.

Loss of food sources through development impacts on prey species will be another impact of the Watana development on wolves. Wolves in the middle Susitna Basin prey primarily on moose and to a lesser extent on caribou. Caribou population levels are not likely to be seriously affected by the Watana development, but moose populations will be reduced. The extent to which this reduction actually affects wolves depends on the extent to which wolf populations are limited by food availability rather than by human exploitation, and on the distribution of the reduction in prey availability relative to territories of individual packs.

Van Ballenberghe et al. (1975) reviewed the available literature on factors controlling wolf populations. They believed that while social factors such as territoriality and stress were the ultimate factors controlling population levels, an abundant food source lowered the threshold for action of social factors. They suggest that food is the main factor permitting the development of dense wolf populations (Figure E.3.112).

There are few data to indicate wolf population trends in relation to population trends of moose and caribou in the Susitna Basin. However, the consistently high harvest of wolves through the 1970s (Section 4.2.1[f]) suggests that the low caribou population and declining moose population in the early 1970s (Section 4.2.1 (a) and (b)) did not cause a substantial reduction in wolf numbers.

Wolf population levels are currently controlled by exploitation rates. Close to half the middle basin wolf population is removed each year by legal and illegal hunting (Section 4.2.1 [f]). In the likely event that this situation continues, the reduction in the moose population as a result of the project should have little effect on the regional wolf population. Only if the harvest level is greatly reduced through better enforcement and/or altered management practices, will the density of moose and caribou become the major factor controlling the wolf population.

On the other hand, the Watana pack will be seriously affected by inundation. As a result of habitat loss, reductions in the moose population, and disturbance near den and rendezvous sites, it can be assumed that this pack of up to 14 wolves will be eliminated. If prey densities become the major factor controlling wolf populations, reduced moose numbers and altered caribou movements would affect the potential carrying capacity of the area and cause measurable changes in the productivity and territory size of as many as 10 other packs. Several wolf packs will also experience positive impacts because of improved hunting conditions along the impoundment shoreline, lower brown bear numbers, and altered distributions of moose and caribou.

Displacement of prey animals from the reservoir area may result in a temporary increase in wolf density in adjacent areas. However, the loss of habitat from the impoundment may cause adjustment of territory boundaries with neighboring packs, and a decrease in both wolf and moose density from temporarily higher levels would ensue.

(g) Wolverine

Anticipated and hypothesized impacts to wolverine are summarized in Table E.3.152. The Susitna Hydroelectric Project will have both positive and negative effects on the wolverine population in the middle basin. Wolverines will be most affected by changes in winter food availability and by higher trapping mortality resulting from improved access and a larger human population in the area. Other factors such as a localized avoidance of camps and roads, disturbance from aircraft and construction activities, and habitat loss caused by the impoundments and other project facilities are not likely to greatly affect the number or productivity of wolverines in the Susitna Basin. Loss of den sites is not likely to be a problem since wolverines den in a variety of habitats, generally on the surface of the ground under snow. Downstream from Devil Canyon, wolverines are likely to be measurably affected only by any increase in trapping pressure resulting from the project. Each of these factors will be discussed in greater detail in the following sections.

The area in northwestern Montana studied by Hornocker and Hash (1981) contained a large reservoir 32.2 miles (48 km) long and up to 4.4 miles (6.5 km) wide, and thus some data are available on wolverine movements and ranges in relation to a large impoundment. They reported that "the size and shape of ranges were not affected by rivers, reservoirs, highways or major mountain ranges." Magoun (1982) stated that, although topographic features were not physical barriers to wolverine movements, they did appear to influence the shape of home ranges to some extent. Rivers, ridges, drainage divides, and well-defined breaks in habitat types often coincided with home range boundaries in her study area. Male home ranges appeared to be less affected by topographical features than did female ranges. Some home range boundaries in the middle Susitna Basin coincide with topographical features (see Figure E.3.98), but no clear relationship between the major features and most home range boundaries is evident. It is possible that the Watana impoundment might serve to separate home ranges once it is in operation.

Based on the estimate of about one wolverine per 40,320 acres (163 km^2) derived in Section 4.2.1(g), the direct loss of over 50,900 acres (206 km^2) caused by the impoundments, access roads, camps, and other project features would lower the carrying capacity by about two wolverines. However, winter food supplies are usually greater at the lower elevations most affected by the project facilities. Changes in the availability of winter food may affect wolverine movements, densities, and productivity; and therefore, it is important to consider these changes in some detail.

The Watana impoundment will cause a decrease in winter food availability. Because a relatively high proportion of the forested area will be inundated, there will be a substantial decrease in the availability of small mammals and grouse used by a few wolverines during winter. The size of the moose population in the vicinity of the Watana impoundment will decrease during the license period, but there may be an increase in the number of ungulate carcasses available to wolverine. Some mortality of both moose and caribou is expected from floating debris, thin ice conditions, and large mud flats in the drawdown zone; and predation by wolves and brown bears may increase along the shores of the impoundment. Higher winter mortality of moose near the impoundment is also expected during winters of moderate to deep snow. It is not clear whether the more rapid turnover of the moose population in the middle basin will offset the lower density of moose and small mammals. The effects of improved access from the roads and impoundment on wolverine, including increased trapping mortality and human presence, is discussed in Section 4.3.3(g).

(h) Belukha Whale

The majority of the Cook Inlet population of belukha whales appears to concentrate near the mouth of the Susitna River during the calving period. Studies were undertaken in 1982 to address the concern that project-related changes in water temperatures or anadromous fish runs at this critical period might interfere with calving success. For example, Seargent (1973, cited in ADF&G, unpublished report on 1982 Phase 1 Report) attributed the elimination of calving by belukhas in the St. Lawrence River to hydroelectric development on the Manicougan and Outardes rivers and subsequent alterations in water temperatures.

Although water temperatures released from the dams will be 0-7°F (0-4°C) warmer than natural temperatures, the dilution effect of other rivers and temperature exchange of the river with the air and ground will result in no post-project difference in water temperatures at the mouth of the river during May and June. Only 7,650 cfs of the 55,930 cfs post-project inflow into Cook Inlet in May will be from the

Susitna River (both dams operating). In June, only 8,150 of 105,702 cfs will be contributed by the Susitna. Thus, the dilution factor of other water sources and 151 river miles of temperature exchange with the environment will result in similar pre- and post-project water temperatures at the mouth of the river during calving.

Belukhas are thought to feed on the large runs of anadromous eulachon (a major run occurred between June 1-9, 1982) and on adult and out-migrating salmon. Eulachon are thought to spawn in the lower mainstem and in the lower tributaries of the river (McPhail and Lindsey 1970:198), and the project should have no effect on the number of eulachons available to belukhas. However, eulachon investigations are currently being conducted in the Susitna River to verify this prediction. If all salmon spawning habitat in the sloughs upstream from Talkeetna were lost, about 5-8 percent of the salmon available to belukhas would be unavailable. Given this small potential decrease in food supply, the necessity of applying a correction factor of 2 or 3 times the number of belukhas counted during surveys (because of silty waters and submerged whales), and the fact that it cannot even be determined whether calves are present during surveys, it is extremely unlikely that any measurable decrease in the belukha population would occur as a result of the project.

(i) Beaver

The beaver population along the Susitna River is likely to increase during the license period as a result of the Watana development. Beneficial effects will occur mostly downstream from the dam as a result of regulated flows. Anticipated impacts to beaver are summarized in Table E.3.153.

(i) Construction

No active beaver lodges have been located during surveys of the impoundment area, borrow sites, camp sites, airport location, or damsite (Gipson et al. 1982), and, therefore, beaver should not be affected by construction and clearing activities at these sites.

(ii) Filling and Operation

No beavers are known to reside in the impoundment area, and therefore, the flooding of this area will not affect this furbearer species. The reservoir will be of little value to beavers after filling because of the annual drawdown. A few beavers, however, may persist in using the reservoir area. Each year for the past 12 years, beavers have attempted to build lodges and food caches on Williston Lake in British Columbia, which has an annual drawdown of about 50 ft (15 m) (Bonar 1982 Personal communication). One innovative colony there has built its lodge on a raft of floating logs, which moves up and down with the water level; whereas another colony has a series of burrows extending down to the minimum drawdown level.

During filling, the river is to be passed directly through the dam during the winter months, and thus, the only effect of the dam on downstream flows will be during summer. During the operation phase, downstream flows will be higher than present in the winter, but lower in summer.

No beavers currently occur in the river reach between Watana and Devil Canyon, and the estimated 70 beavers between Devil Canyon and Talkeetna were found mostly in side channels, sloughs, and clearwater areas (Section 4.2.2[a]). Although swift currents in the main channel probably contribute to these low densities, the greatly fluctuating water levels, ice scouring events, and low abundance of early successional vegetation are probably the major limiting factors (Figure E.3.113). Another limiting factor is the depth of water beneath the ice in winter. Beavers require at least 1.5 ft (0.5 m) of open water under the ice for access to food caches and lodge entrances (Scott 1940, Hakala 1952). Since winter water depths are now much less than those in summer, the winter flows determine which areas are suitable for year-round occupation by beavers.

Any site currently occupied by beavers should still be available post-project, since winter flows will be higher than at present. In addition, many areas now subject to freeze-out will also be available for colonization by beaver. The increased availability of early-successional vegetation, reduced ice-scouring, lack of an ice cover in the Watana-Devil Canyon reach, more stable year-round flows, and lack of floods which destroy food caches and other beaver structures will all result in improved downstream habitat for beaver. Beaver habitat south of Talkeetna may also be enhanced as a result of the increased occurrence of favored food plants, but the more unstable water levels resulting from increased contributions from other rivers and tributaries will dampen this effect.

If construction camp personnel and their families are allowed to trap in the area, beaver populations will be affected both along the Susitna River itself and in the lakes and creeks on either side of the river.

(j) Muskrat

Anticipated impacts on muskrat are summarized in Table E.3.153. Muskrats will be affected primarily as a result of improved access for trappers. Some habitat loss within the borrow sites and impoundment zone will also occur; however, muskrats may benefit from additional beaver ponds downstream from the project (Section 4.3.1[i]). With the exception of trapping mortality, the net impact on the muskrat population should be negligible.

Of the 103 lakes surveyed for muskrat sign in spring 1980, 17 occurred within borrow sites D or E or the impoundment zone (Table E.3.154); only 5 of these lakes had muskrat pushups (Gipson et al. 1982). A total of 13 pushups were observed on these 5 lakes, but the number of muskrats this represents is unknown (pushups are temporary structures, and one muskrat can create many of these during a winter). A likely estimate of the number of muskrat to be lost as a result of this habitat loss is 5 to 10 animals. Improved downstream habitat will compensate for this loss.

Muskrats are extremely susceptible to water level fluctuations (Bellrose and Brown 1941), and usually find braided rivers poor habitat because of lack of forage and burrow sites (Brooks and Dodge 1981). As such, there is little potential muskrat habitat in the active floodplain downstream from the Watana damsite. Many muskrat probably occupy beaver colony sites (Curatolo et al. 1981) along the Susitna River that are outside the active floodplain. Below Montana Creek good muskrat habitat occurs in old channels now functioning as clear-water seeps which will not be affected by the project (Bredthauer and Drage 1982).

If construction camp personnel and their families are allowed to trap in the area, muskrat populations throughout the lakes lying on either side of the Susitna River could be seriously affected. Gipson et al. (1982) found muskrat sign in these lakes and noted their vulnerability to trapping.

(k) Mink and Otter

(i) Upstream Effects

Anticipated and hypothesized impacts to mink and otter are summarized in Table E.3.155. Because mink and otter are moderately abundant in the middle Susitna Basin (see Section 4.2.2 [c,d]) and are dependent on aquatic and semi- aquatic habitats along the Susitna River and its tributaries, construction and operation of the Watana dam may have substantial impacts on these species. The most important effects include loss of habitat, reduction of food supplies, increased disturbance, and barriers to movement.

Clearing and flooding of the impoundment will eliminate a substantial proportion of good quality otter and mink habitat. High quality habitat for these semi-aquatic furbearers is generally characterized by moderate-to-slow-flowing streams and rivers with well-wooded banks. Ponds with abundant food, deep and stable water conditions, and an irregular shoreline also appear to be good habitats (Hodgdon and Hunt 1953, Knudsen 1962, Barber et al. 1975). Because the impoundment will result in a large drawdown zone, it is unlikely that the reservoir will be heavily utilized by mink or otter. Small declines in water levels (e.g., less than 3.3 feet [1 m]) may actually benefit mink during the winter by creating air spaces under the ice that would allow them to hunt more easily (Errington 1943, Harbo 1958). However, the large drawdown area of the Watana dam will probably be detrimental to otter and mink; it will isolate their bank dens from the reservoir during the winter and will probably reduce prey availability.

The extent to which otter and mink habitat will be reduced and the effects on local populations are difficult to assess. The impoundment will flood approximately 53 miles (85 km) of the mainstream Susitna River. In addition, portions of a number of tributaries will be inundated by the impoundment; these include Deadman Creek (2.3 miles of stream will be inundated at maximum fill [3.7 km]), Kosina Creek (4.2 miles, 6.8 km), Jay Creek (3.2 miles, 5 km), Goose Creek (1.2 miles, 1.9 km), and the Oshetna River (2.0 miles, 3.2 km). The lower reach of Tsusena Creek will be disturbed by gravel removal.

It is not known what these losses represent in terms of a proportionate reduction of available mink and otter habitat.

Clearing and flooding of the impoundment area will reduce prey availability for otter and mink. Clearing of forest cover will reduce the availability of some mink prey such as small mammals and waterfowl. Effects of erosion and consequent siltation, as well as effects of dust that are associated with clearing may also reduce the availability of fish and crustaceans. Flooding of the reservoir will probably result in further reductions in prey availability; crustacean distributions and productivity will probably be altered by the drawdown zone; and the species composition, abundance, and distribution of fish will change. In addition, because the reservoir will greatly expand the amount of aquatic habitat, fish will be less concentrated than they are at present and more difficult for otters and mink to capture. The net result of these changes, in addition to the change of shoreline habitats, will be an avoidance of the reservoirs by mink and otter. The effects on productivity associated with these dietary changes are unknown.

Clearing of the reservoir site and construction activities, particularly in close proximity to streams and rivers, may disturb mink and otter and may result in interference with daily activities or, in extreme cases, an avoidance of the area. Densities of the European otter (Lutra lutra), a species closely related to river otter, along the River Terre in England appear to be inversely related to the amount of human disturbance (recreational fisherman) and the amount of clearing of woodland cover along the river banks (MacDonald et al. 1978). Because recreational use of the upper reaches of streams along the north side of the impoundment will probably increase during construction and operation, and because the upper reaches of these streams may represent a moderate proportion of the remaining high quality habitat for semi-aquatic furbearers, disturbance effects on mink and otter could be important.

(ii) Downstream Effects

Alteration of the river hydrology and vegetation communities as a result of the Watana dam has already been discussed (Section 3.3.1). Both of these fur-bearers commonly concentrate in open water stretches of rivers and streams in winter (Barber et al. 1975), and therefore, the reach of permanently open water downstream from the Watana dam may benefit small numbers of mink and otter. Major impacts on these species are not expected downstream from the dam.

(1) Coyote and Red Fox

Coyotes occur in the Watana development area, but they are so uncommon that development activities are unlikely to have a quantifiable effect on them.

Coyotes do not appear to avoid areas of human activity; however, no studies have specifically evaluated the effects of human disturbance on this species. Ferris et al. (1978) demonstrated a significant preference of coyotes (based on winter track count surveys) for an area within 656 feet (200 m) of a section of an interstate highway in Maine relative to an area 656-1312 feet (200-400 m) from the highway. Track surveys also indicated that coyotes occasionally used the right-of-way as a hunting or travel route. Penner (1976) similarly concluded that coyotes preferred large cleared areas and avoided undisturbed habitats within an oil sands development area in northwestern Alberta.

Coyotes are likely to exhibit a significant increase in population level in the development area only if wolves are eliminated. Wolves will exclude coyotes from their ranges through physical aggression when encountered. Only when wolf numbers are extremely low and packs are eliminated will resident wolves allow expansion of coyotes into their territories. If wolves are locally exterminated and excluded from portions of their territories near the development, coyotes may colonize localized areas in low numbers.

Anticipated impacts on red foxes are summarized in Table E.3.156. The major impact on red foxes will probably result from trapping by construction workers and killing of nuisance animals at camps and construction sites. Habitat loss from flooding of the impoundment will not have a great impact on foxes, since most individuals apparently utilize areas above the high water line of the impoundment (2140 ft, 666 m elevation) during winter seasons when food availability is most limited, and areas to the east of the impoundment on the Lake Louise flats. Fox dens typically occur at elevations of 3280-3937 feet (1000 m to 1200 m) and no foxes or fox sign were found along the Susitna River or the lower reaches of its tributaries in late winter or spring during baseline studies (Gipson et al. 1982). Foxes did occur along the Susitna at other seasons. An abundance of arian and small mammal prey would be available for foxes during summer and fall, and loss of habitat along the river would probably have negligible or minor effects.

Red fox similarly do not appear to avoid areas of frequent human activity. Observations of red fox and the location of den sites in relation to the main road in Denali National Park showed that red foxes did not avoid areas of frequent human use and that in some cases would habituate to human disturbances (Tracy 1977). Red foxes in Gatineau Park, Quebec, appeared to commonly use areas in the immediate vicinity of human disturbance and showed little avoidance of areas frequented by snowmobilers (Neumann and Merriam 1972).

Foxes away from den sites habituate to human activity so readily that they can become a nuisance at construction and campsites if they are fed or allowed to feed on garbage (Milke 1977). The presence of scavenging foxes frequently leads to workers being bitten and occasionally needing hospitalization for rabies vaccine (Milke 1977). It also often leads to the destruction of the foxes.

Although the fox population in the Susitna Basin is small (Section 4.2.2[f]), it is apparently a source of juveniles that disperse to adjacent areas (Gipson et al. 1982). An increased take of foxes from currently low levels is expected because of improved access and residency of construction personnel and may eliminate this source of dispersing individuals.

(m) Other Furbearers

This group includes species that occur primarily in forested habitats--marten, lynx, short-tailed weasel and least weasel. Anticipated impacts are summarized in Table E.3.157. Impacts on marten are discussed in greatest detail. As mentioned previously (Section 4.2.2[c]), marten have historically been and continue to be economically the most important furbearer in the vicinity of the impoundment zones. Lynx are very uncommon in the middle Susitna Basin. Weasels are probably quite common, but there is little specific information on their abundance and distribution in the basin.

4.3 - Impacts - Watana

All of these species will suffer primarily as a result of the loss of forested habitats to the impoundment, borrow sites, and other project facilities. Probable factors regulating marten populations in the Susitna Basin and actions that might affect populations are illustrated in Figure E.3.114. Gipson et al. (1982) have estimated the number of marten in the winter population directly impacted by loss of habitat in the Watana and Devil Canyon developments through a model based on the following data and assumptions:

- Adult male marten home ranges are mutually exclusive and adjoin one another so that all marten habitat in the impounded area is inhabited (trapping likely affects this assumption);

- Marten habitat is defined as forest, and marten are restricted to this habitat type;

- A 1:1 sex ratio exists in all age classes of the population;

- 65 percent of the population are juveniles (less than 1 year old) (R. Archibald 1982, Personal communication, cited by Gipson et al. 1982), and juveniles appear in the harvest in proportion to their number in the population; and

- The mean home range size of male marten is 1685 acres (682 ha) (Gipson et al. 1982).

This model gives an estimated density for all age/sex groups of 0.0034 marten per acre (0.0085 per ha). Using a figure of 11,798 ha of forest habitat lost to impoundment areas, borrow sites, construction sites, and camps, habitat supporting 100 marten (3.4 percent of the Susitna watershed upstream from Gold Creek) would be lost.

P. Gipson (1982 Personal communication) attempted an independent population estimate in July 1982 near Watana Creek using a mark-recapture technique. A 6.8-miles (11-km) trapline with trap spacing of 1312 feet (400 m) on either side of Watana Creek captured no marten in 252 trap nights. The minimum expected catch was ten, based on densities of 0.003 marten per acre (0.008/ha) and assuming all marten within 1640 feet (500 m) of the trapline were captured. This result suggests that fewer marten than calculated above may actually exist in the impoundment areas, and that fewer marten would be affected.

There are obvious difficulties with the model. Perhaps the most serious is that marten densities and home ranges vary among different forest types, being most common in dense, mature coniferous forest (deVos 1952, Douglass et al. 1976, Koehler and Hornocker 1977). If only closed forest habitat were used in the calculations (eliminating woodland and open forest types), habitat supporting 26 marten (7.5 percent) would be eliminated from that currently supporting 347 marten.

Clearing of forested areas at construction sites and borrow areas and the associated human disturbances may affect marten home range size and distribution. However, these types of changes will be most extensive in areas affected by the access route and transmission line and are discussed in Sections 4.3.3 and 4.3.4.

Lynx are uncommon in the Susitna Basin, probably because their major prey, snowshoe hares, have been historically uncommon. Habitat loss will probably eliminate the few lynx occurring near the impoundment.

Numbers of short-tailed and least weasels may also be reduced through habitat loss. Based on the amount of area affected, less than 5 percent of their population will be lost.

Construction activities and human disturbance could result in avoidance of the construction zone by furbearers. No information is available for lynx and weasels. Evidence exists that marten are tolerant of moderate levels of disturbance in areas adjacent to logging operations (Clark and Cambell 1977, Soutiere 1978, Steventon and Major 1982).

(n) Raptors and Ravens

General types of potential impacts to raptors that occur with development are summarized in Table E.3.158. The construction and operation of the Watana dam will affect raptors through a number of mechanisms (Table E.3.159), the most important of which are habitat loss and disturbance. Habitat loss includes the flooding of suitable nesting cliffs, removal of trees used for nesting and perching, and a loss of hunting areas. Many of the tree and cliff nests within the impoundment area may be abandoned during the construction phase as a result of disturbance, and several nest sites immediately adjacent to the access road or borrow sites may also be abandoned.

(i) Habitat Loss

- Nesting Habitat

Nesting locations for most cliff and tree-nesting raptors are defined as a cliff or stand of trees which may contain one or more nest sites. A pair of raptors uses only one nesting location in a given breeding season. However, a pair may have one or more alternative nesting locations. Nest sites are defined as the actual nests or ledges on cliffs, or the actual nests in trees used by a pair of raptors. A pair uses only one nest site in a given breeding season, but may have one or more alternate nest sites at a nesting location.

The distribution, quantity, and quality of nesting locations and nest sites clearly limits the numbers and nest success of most raptors, including both cliff-nesting and tree-nesting species (Newton 1979). Cliff-nesters are especially limited by availability of nesting locations and nest sites in many regions because suitable nesting cliffs (i.e., those meeting the specific nesting requirements of a species) are fixed geologic features whose presence or absence are a result of geologic events which are bound in geologic time. In contrast, tree-nesters rely on vegetative features for nesting locations and nest sites. Succession and growth of vegetation is on-going and occurs relatively rapidly in contrast to formation of cliffs, and therefore, tree-nesting locations and nest sites are both lost and replaced in much shorter periods of time. However, for some tree-nesting species (e.g., bald eagles) the times required for replacement may represent several generations of birds, especially at northern latitudes. Because raptors are one of the few groups of birds whose distribution (within each species' breeding range), numbers, and even nesting success are clearly limited by the distribution, quantity, and quality of nesting locations and nest sites, mitigation measures which provide compensatory nesting locations and nest sites can be particularly effective (see Appendix 3.I).

There is no reason to doubt that most raptors in the Alaska Range are considerably more limited by nesting locations and nest sites than by other parameters such as food. Loss of nesting locations and nest sites will almost certainly be the single most important adverse impact of Susitna development to raptors in the Susitna River drainage. However, a distinction can be made between the prominent cliff-nesters (i.e., golden eagles, gyrfalcons) and the prominent tree-nesters (i.e., bald eagles, goshawks) that serves to help identify the relative degrees to which the Susitna Hydroelectric project will impact populations of these two groups of raptors within the Susitna River drainage.

For golden eagles and gyrfalcons (cliff-nesters), most of the suitable nesting locations available in the Susitna drainage are clearly concentrated in the middle basin along the river and along the lower reaches of its tributaries between Vee Canyon and Devil Canyon. Despite the quantity of this habitat, gyrfalcons are apparently not especially locally numerous. The paucity of gyrfalcons, but the presence of a relatively larger number of golden eagles is likely a result in large part of geography--the area is near the southern limit of the gyrfalcons' breeding range in south-central Alaska, but well within the breeding range of golden eagles. In contrast to the quantity and quality of cliff-nesting habitat concentrated along the Susitna River between Vee and Devil canyons, the occurrence of suitable nesting locations for golden eagles is much lower throughout the remainder of the middle and upper Susitna basins (Bente 1982 Personal communication, Roseneau 1982 Personal communication). Furthermore, the density of suitable nesting locations for golden eagles is probably relatively low throughout much of the remainder of the Alaska Range (Bente 1981), and regional topography further suggests that concentrations of cliff-nesting habitat similar to that found along the Susitna River in its middle basin are at best uncommon. As a consequence, direct losses of cliff-nesting locations in the middle basin as a result of construction of the Susitna Hydroelectric project are judged to be reasonably significant to the golden eagle population inhabiting the Susitna River drainage.

In the case of bald eagles and goshawks (tree-nesters), the majority of appropriate nesting habitat containing suitable nesting locations and nest sites clearly lies downstream of Devil Canyon. Upstream of Devil Canyon in the middle basin appropriate nesting habitat for both species is sparse. Farther upstream in the upper basin appropriate nesting habitat becomes nearly non-existent. Pairs of both species that nest throughout the Susitna River drainage upstream of Devil Canyon are clearly members of much larger downstream populations inhabiting the considerably greater amounts of appropriate nesting habitat found there. As a consequence, direct losses of bald eagle and goshawk nesting locations in the middle basin, as a result of construction of the Susitna Hydroelectric project, are judged to be of reasonably minor consequence to populations of those species.

Specific losses of known nesting locations of both cliff-nesting and tree-nesting raptors and ravens are discussed in greater detail below. The reader is reminded that numbers and percentages given below represent known losses within the local vicinity of the Susitna Hydroelectric project, and they should not be interpreted to necessarily represent the degree to which total Susitna River drainage populations or regional populations of these species are affected by the project.

Eighteen of 41 (44 percent) of the known raptor and raven cliff-nesting locations and 4 of 10 (40 percent) of the known raptor tree-nesting locations in the general vicinity of the proposed project will be lost as a result of the Watana development (Tables E.3.160 and E.3.161). These include known nesting locations for the following raptors: golden eagles, bald eagles, gyrfalcons, goshawks, and ravens.

At least 6 (38 percent) of the 16 total known golden eagle nesting locations in the general vicinity of the project area will be directly lost to construction and filling of the Watana reservoir. Five of those 6 nesting locations will be inundated, whereas one may be lost during material excavation operations at Borrow Site E (Figure E.3.115, Tables E.3.160, E.3.161, and E.3.162).

Cliff-nesting habitat for golden eagles will become severely limited upstream from the Watana damsite once the impoundment is full. Loss of cliffs upstream from the Watana damsite may increase the importance of cliffs farther downstream in Devil Canyon, along Fog Creek, Tsusena Creek, and other streams draining into the Watana to Devil Canyon reach. However, airspace is restricted in much of Devil Canyon, many of the cliff areas appear to be exposed to higher levels of moisture, and existing cliffs may lack suitable ledges on which golden eagles could construct nests.

Golden eagles often have several alternative nesting locations, some perhaps 4-5 miles (6-8 km) apart (McGahn 1968, Roseneau et al. 1981), and thus the 6 nests lost to the project do not represent 6 pairs of eagles. The middle Susitna River basin population of golden eagles will probably be reduced by 3-5 pairs as a result of the construction and filling of the Watana reservoir because of (1) losses of 38 percent of the well-established golden eagle nesting locations along the river; (2) concomitant losses of most of the other potential cliff nesting habitat upstream from the Watana damsite; and (3) a suspected scarcity of alternate nesting locations throughout much of the remainder of the middle basin.

Four of 8 (50 percent) known bald eagle nesting locations in the general vicinity of the project area will be lost to clearing and filling of the reservoir (see Figure E.3.115, Tables E.3.160, E.3.161, and E.3.162). Three of these locations are tree-nests and one is the sole cliff-nesting location known to be used by bald eagles in the Susitna River drainage. (Bald eagle cliff-nesting locations are relatively rare throughout Alaska north of the Alaska Peninsula--for instance, in the entire Tanana River drainage where over 40 nesting locations are known [Roseneau et al. 1981], only one nesting location is on a cliff.) Furthermore, almost all suitable white spruce and balsam poplar trees in the general vicinity of Watana are located within the impoundment area on tributary deltas and islands. Construction and filling of Watana will likely limit bald eagles to one or two available nesting locations along the Susitna River upstream from the impoundment and one or two potential locations along the lower Oshetna River. This may increase the importance of other potential nesting habitat downstream from the Watana damsite, including balsam poplar stands along Portage Creek and white spruce and balsam poplar near Stephan Lake and along Prairie Creek. In any event, it appears unlikely that habitat loss as a result of construction and filling of the Watana reservoir will have more than a local effect on the Susitna River bald eagle population, the majority of which inhabits the area downstream from Indian River (see Section 4.2.3[a]).

No known gyrfalcon nesting locations will be directly lost as a result of the Watana project. However, gyrfalcons often use nests constructed by other cliff-nesting species, including ravens and golden eagles (Cade 1960, White and Cade 1971, Roseneau 1972), and some of the golden eagle and raven nesting locations lost as a result of inundation or gravel mining may represent past or future locations used by gyrfalcons. In south-central Alaska and the Alaska Range, where nesting densities are low (Roseneau 1972, Bente 1981, Roseneau et al. 1981), use of other species' nests by gyrfalcons is less prevalent than in northern and western regions of the state where the majority of the Alaska gyrfalcon population breeds and winters (see Roseneau et al. 1981). It is therefore unlikely that habitat loss as a result of construction and filling of the Watana reservoir will have more than minimal effect on the middle Susitna River gyrfalcon population.

One of three (33 percent) known goshawk nesting locations in the middle basin will be lost to clearing and filling of the Watana reservoir (Figure E.3.115, Tables E.3.160, E.3.161 and E.3.162). This nest location is the only one discovered to date upstream from the Watana damsite, beyond which typical goshawk nesting habitat becomes very scarce (Roseneau 1982 Personal communication).

Eleven of 21 (52 percent) previously used raven nesting locations in the middle basin will be lost as a result of construction and filling of the Watana reservoir (Figure E.3.115, Tables E.3.160, E.3.161 and E.3.162). Ten will be lost by inundation, and one additional nest (R-4) may be inundated at times of maximum flood stage (see Figure E.3.115) or be so close to maximum operating water level as to be unusable.

Although a considerable number of raven nesting locations and cliff habitat will be lost, the consequences of this loss to ravens will be minor in comparison to those for other cliff-nesting species (particularly golden eagles). Ravens commonly nest in a wide variety of situations in Alaska, including man-made structures (Roseneau et al. 1981). Tree-nesting in balsam poplar, aspen, and white spruce is common, and ravens consistently nest on small cliffs that are often unsuitable for raptors (Roseneau 1982 Personal communication). Construction and filling of Watana without development of Devil Canyon is likely to result in increased use of cliffs along Devil Canyon and trees along the river and tributaries downstream from the Watana damsite rather than a reduction in the middle basin raven population.

- Hunting and Perching Habitat

  In addition to loss of nesting habitat, it is anticipated that some loss of perching and hunting habitat for raptors will occur as a result of construction and filling of the Watana reservoir. Perching habitat will be lost primarily as a result of inundation of cliffs (see Table E.3.159) and the clearing of trees prior to reservoir inundation.

  Most of these losses will occur concomitantly with losses of nesting habitat. Losses of perches, whether by inundation (cliffs and trees), materials excavation (cliffs and trees), clearing (trees) or blowdown (trees), are considered of minor consequence relative to losses of nesting locations. Man-made structures, especially transmission towers and smaller power poles, will also compensate in part for losses of perching habitat, because raptors commonly use such structures as perches to hunt from.

  Loss of hunting habitat is more difficult to determine. No data were collected in the middle basin to determine raptor hunting ranges and foraging areas; however, losses of hunting habitat are almost certainly to be of minor consequence, relative to losses of nesting habitat. Most raptors are limited by availability of nesting locations and nest sites, not food (Newton 1979). Furthermore, raptor "hunting habitat" and productive areas of prey habitat, including riparian zones and wetlands, are not necessarily equivalent.

  Habitats such as riparian areas and wetlands are, of course, important because they tend to produce and concentrate prey species. However, areas that produce prey usually provide escape cover for the prey species that inhabit them. Some of the most important hunting habitat for many raptors is often overlooked because of confusion regarding nesting location, nest-site limitations vs. food limitation, and because "hunting habitat" is commonly assumed to be equivalent to areas of rich prey production. Some of the most important hunting habitat for many raptors consists of the three dimensional "gulf" of air over rivers, lakes, unvegetated or little vegetated terrain, or over forested valley floors in mountainous terrain.

Peregrine falcons provide an excellent example. Peregrines hunt and capture much of their avian prey over water in front of and to the sides of their river cliff-nesting locations as wetland, forest, and shrubland birds attempt to cross it. Thus, some of the very best peregrine nesting and hunting habitat in the boreal zone is found only along larger rivers (e.g., Yukon, Tanana), regardless of varying and diverse prey habitats and despite the fact that similar cliffs may be present along narrow side tributaries.

For other species of raptors forest clearings, open meadows and open mat-cushion tundra serve in a similar fashion as important hunting habitat. Most raptors, and especially the larger species, have the capability to range relatively long distances from their nesting locations to hunt. Thus, loss of hunting habitat as a result of construction and operation of the Susitna Hydroelectric Project is unlikely to be of major consequence to most raptors inhabiting the Susitna drainage. Loss of hunting habitat will be compensated for in part by the creation of the long, relatively narrow impoundment over which potential prey species will pass. It is also unlikely that loss of any prey production habitat in the impoundment zone will be of a scale that will be of major consequence to most raptors inhabiting the middle and upper Susitna basins.

The general degree of impact may be inferred from the data presented in Section 4.2.3(a); and additional information on hunting habitats of three of the prominent species found in the middle basin given below.

.Golden Eagles

Golden eagles probably hunt throughout the middle and upper basins. However, they may avoid heavily treed areas, concentrating their effort above and outside of the impoundment area rather than in it. A tendency to hunt over open treeless areas, coupled with their varied diet that includes several upland species, suggests that the loss of hunting habitat caused by the project will have minor effects on golden eagles.

.Bald Eagles

Bald eagles may hunt throughout the middle basin; however, they tend to spend greater amounts of time at lower elevations near water bodies than golden eagles. Losses of hunting habitat to bald eagles nesting in the middle basin may therefore be greater than losses to golden eagles. However, some attraction of waterfowl to open water behind the dam or in the river downstream of it in early spring may compensate in part for some losses. Open water downstream from the Watana dam may provide important wintering habitat from the Watana dam in an area in which none currently exists. At least a few bald eagles have overwintered in similar habitat along the Tanana River in mild winters (Ritche 1974). However, the Watana impoundment, with its large drawdown and consequent lack of aquatic vegetation, is not anticipated to be particularly attractive to waterbirds as feeding habitat. On the other hand, bald eagles in the middle basin are almost certainly more limited by availability of nesting habitat than by availability of food. Assuming water fowl are never attracted to the impoundment, and that fisheries never develop there, surrounding habitat, including tributaries and water bodies near the impoundment zone, is likely to be adequate for those eagles that remain after construction and filling of the Watana reservoir.

.Gyrfalcons

Gyrfalcons may also hunt throughout the middle basin, but they tend to avoid wooded areas and probably concentrate their effort well above the impoundment zone. Their tendency to hunt in open, treeless areas including the alpine zone, coupled with their opportunistic nature, suggests that the loss of hunting habitat as a result of construction and filling of the Watana reservoir will not be a serious impact.

(ii) Disturbance

Bald eagles and golden eagles are specifically protected under the U.S. Bald Eagle Protection Act of 1940 (as subsequently amended). A part of this act prohibits the "taking" of any bald or golden eagles, parts thereof, or the nests or eggs of such birds without a permit. "Take" is defined to include molest or disturb.

The act does not authorize the taking of bald eagle nests which interfere with resource development or recovery operations. Take may only occur for scientific or educational purposes at the discretion of the Regional Director (USFWS). Recently an amendment to the Bald Eagle Protection Act was drafted (16 U.S.C. 668a) that allows golden eagle nests to be taken if they interfere with resource development or recovery operations. However, regulations pertaining to this amendment are not yet available. Clearly, the taking of eagle nests as a result of the project must be addressed and mutually agreed to in consultation with the Alaska Regional Director of the USFWS before the project can be built. Such consultation was initiated on February 1, 1983, in a letter from the Alaska Power Authority, to K. Schreiner, USFWS Area Director, Alaska.

In addition, there are state laws that provide similar protection for these and other raptor species. The Alaska Department of Fish and Game has also developed guidelines to protect raptor nests from destruction or disturbance.

Roseneau et al. (1981) reviewed and summarized most of the information on kinds and effects of disturbance to raptors. Most information is anecdotal. Responses of raptors to various types of disturbance are complex--several factors may affect the sensitivity of raptors to disturbance (Table E.3.163). Timing of the disturbance is an important factor

(Table E.3.164), and effects of disturbance may be additive.

Responses of raptors to disturbance and the effects of these responses are often highly variable. In many cases, nesting raptors have shown a surprising degree of tolerance and habituation to disturbances; yet in other cases, the same types and levels of disturbance have had detrimental effects (Roseneau et al. 1981). In general, a mounting body of evidence suggests that raptors will habituate to and tolerate at least moderate forms of disturbance. The same body of evidence suggests that the most detrimental forms of disturbance are those that occur within territorial defense zones (i.e., nesting locations). Prolonged disturbances, multiple disturbances, and direct overt harassment from either the ground or the air are particularly harmful.

Some species of raptors appear to be less tolerant of disturbance than others. Of species in Alaska, golden eagles appear to be the most sensitive, especially to aircraft disturbance and human presence (see Roseneau et al. 1981). Although golden eagles, like most raptor species, are reluctant to flush from nests as a result of aircraft passage during incubation, they often leave their nests well in advance of approaching aircraft during the nestling period (Roseneau et al. 1981). Furthermore, they often leave their nesting areas quickly when people approach, often at considerable distances (e.g., as much as 0.5 miles (0.8 km); Roseneau Personal communication) from the nest. Several documented nesting failures of golden eagles in some areas have been blamed on human interference (Roseneau et al. 1981).

Nesting locations of raptors and ravens that may be subject to disturbance by the construction and filling of the Watana reservoir are listed in Table E.3.162. Nesting locations were selected for inclusion on the basis of distance from project actions. Judgments as to the general level of disturbance were made on the basis of nest elevation above potential disturbance, distance to the disturbance, and general nature and scale of the disturbance, assuming year-round activity (clearing, material excavation and dam construction).

Seven golden eagle nesting locations within or on the edges of the Watana impoundment may be susceptible to disturbance from reservoir clearing operations (see Figure E.3.115 and Table E.3.162: the exceptions are GE-7 and GE-10). Five of those locations will be inundated later. Two of the five locations will also be susceptible to considerable disturbance from material excavation at Watana Borrow Site J (see Table E.3.162; however, both locations (GE-8 and GE-9) will be inundated. An eighth golden eagle nesting location (GE-11) will probably be physically destroyed by material excavation unless some action is taken to specifically preserve it (e.g., the establishment of a buffer zone limiting excavation to areas outside a radius of at least 300 feet from the nest cliff).

Four bald eagle nesting locations within the Watana impoundment are susceptible to disturbance from reservoir clearing operations (see Figure E.3.115 and Table E.3.162: the exceptions are BE-1 and BE-6). At least two of the four locations are tree-nests that will eventually be flooded (BE-3 and BE-5), and one is a cliff nest that will eventually be inundated (BE-4). The fourth location (BE-2) is also likely to be inundated or may be lost because of shoreline erosion unless specific safeguards are taken.

No known gyrfalcon nesting locations appear susceptible to major disturbance from Watana construction; however, one location (GYR-1) may be susceptible to some disturbance during reservoir clearing.

At least one known goshawk nesting location will be susceptible to disturbance from reservoir clearing (GOS-1); this nest will eventually be inundated (Figure E.3.115). A second nesting location (GOS-2) is located in the Devil Canyon reservoir, but may be susceptible to some disturbance as a result of material excavation at Watana Borrow Site I (see Table E.3.162).

Twelve common raven nesting locations within or on the edges of the Watana impoundment may be susceptible to disturbance from reservoir clearing operations, but as many as 11 of them will eventually be inundated (see Figure E.3.115 and Table E.3.162: the exception is R-1). Three of the locations (R-9, R-10 and R-11) that will eventually be inundated will also be susceptible to considerable disturbance associated with material excavation at Watana Borrow Site J (see Table E.3.162). Two other nesting locations (R-14 and R-15) are located downstream from the Watana damsite, but they may be susceptible to considerable disturbance during excavation of materials from Watana Borrow Site H. (This site will probably not be mined.)

(o) Waterbirds

Because of the low numbers of waterbirds in the Susitna Basin (Section 4.2.3[b]), impacts from the Watana development will not have a major effect on regional populations. Waterbirds of the basin will be affected during construction of the Watana development by loss of habitat, alteration of habitat and disturbance.

(i) Habitat Loss

Loons, grebes, swans, and several duck species in the Susitna Basin occur primarily on lakes (Appendix 3E). Most species will not be affected seriously by loss of habitat since only 94 acres (38 ha) of lakes (0.2 percent of total in Gold Creek and Watana watersheds) of lakes will be flooded by the Watana impoundment. However, some species will suffer a permanent loss of breeding habitat in fluviatile shorelines and alluvia: harlequin duck, common merganser, semipalmated plover, spotted sandpiper, wandering tattler, and arctic tern. Common goldeneyes and mergansers will lose nesting trees during reservoir clearing. Mergansers will nest on banks and other locations in the absence of cavities. Goldeneyes prefer to nest in relatively large diameter cavities. Prince (1968) reported the smallest cavity diameter in his study of common goldeneyes to be 6 inches (15.2 cm). Most large trees are on the lower slopes of the Susitna Valley and will be flooded. Open water in fast- flowing streams and in the main channel itself provides winter habitat for the dipper of which a significant portion may be lost.

During filling, the sandbars, islands, and shorelines used by shorebirds will be flooded. Two breeding species (spotted sandpiper, and semipalmated plover) and about seven migrant species will be affected. The Susitna River does not support many migrant shorebirds and the loss of habitat for migrants will not be serious. However, all of the shorebird breeding habitat in the impoundment area will be lost.

(ii) Habitat Alteration

During construction and filling, habitat alteration will occur primarily from clearing and flooding of shorelines. Clearing of forest will have little effect on waterbird habitats with the possible exception, as noted in the previous section, of cutting nest trees. Flooding will probably affect harlequin ducks and fish-eating common and red-breasted mergansers through some loss of food resources. Mainstream fish populations downstream are not expected to be seriously affected by flooding, but portions of the grayling populations in tributary streams may be lost (Section 2.3). Nevertheless, fish populations above impoundment level will probably remain sufficient to support the low merganser numbers in the area, and this impact will not be measureable.

Open-water areas below the dam and near the intake will provide habitat for spring migrants when other water bodies are still frozen. The reservoir will be of low quality to nesting waterfowl, but will provide loafing habitat for migrating waterfowl and, in the drawdown zone, feeding habitat for migrant shorebirds, whose main movement passes through central Alaska during the last three weeks of May. Feeding habitat for fall migrants will not be available as the reservoir will be full during that period.

(iii) Disturbance

A number of sources of disturbance to waterbirds will exist during Watana construction. The main sources of disturbance will be borrow extraction from wetland areas, transport of borrow and other materials, and reservoir clearing. The construction of the dam itself is such a sufficiently localized disturbance that few waterfowl will be affected.

Waterbirds in tundra areas have been shown to avoid immediate areas of intense human activity (Barry and Spencer 1976). Similar avoidance may occur in other areas of open wetland. Clearing of the impoundment area, especially near the river and its tributaries and near wetlands and lakes, will be the most serious disturbance factor for most waterbirds. Clearing and associated heavy machinery traffic will physically destroy nests of some species if conducted between May and July. Disturbance will be intense during clearing operations, and many species will be affected.

Results of studies of the effects of aircraft disturbance on ducks (Gollop et al. 1974, Schweinsburg 1974, Schweinsburg et al. 1974, Ward and Sharp 1974) have found changes in behavior, but little short-term effect on distribution of nesting or moulting ducks. Except at Stephan Lake, geese and whistling swans occur in only small numbers during migration in the Susitna area and are unlikely to be much affected by disturbance. Trumpeter swans nest in the middle basin; however, Kessel et al (1982a) report only one nest in the Fog Lakes area. Two other swan nests have been reported in the development area by R. Fleming (1983 pres. comm.); one on the east fork of Wakana Creek and are on the North Fork of the Talkeetna River approximately 5-10 miles downstream from the confluence with Prairie Creek. Other nests may occur in the area, although the majority of the basin population nests well to the east of the project area, and only small numbers occur in the Watana area during migration. Trumpeter swans are known to be sensitive to disturbance during the nesting and fledgling periods and any nests which occur in the project area would be adversely affected by even casual human intrusion (Hansen et al. 1971). Geese do not nest in the basin and are uncommon during migration; they are unlikely to be seriously affected by disturbance.

(p) Other Birds

(i) Construction

Terrestrial birds will be most affected during construction by habitat loss through clearing of the impoundment area, access roads, camps, borrow pits, and other facilities. Clearing of the impoundment area will affect the largest number of birds and will result in changes in the distribution and relative abundance of species in the area. Forest species will be replaced by birds of shrub and open habitats. Artificial habitats will be created for those species which will use them. Another impact to birds near construction zones is sensory disturbance from traffic, noise, dust, and people.

- Habitat Loss

Proportionate losses of various vegetation types to the Watana project are presented in Table E.3.82. The most severely affected vegetation types will be forest types; in particular, open birch, closed birch, and closed balsam poplar forest types. Open and closed mixed conifer-deciduous forests, open spruce forests, and woodland spruce forests will also be severely affected. The 12 census plots studied by Kessel et al. (1982a) represent an overview of the terrestrial avian habitat types present in the middle basin. The bird census study plots, their avian habitat equivalents (as provided by Kessel et al. 1982a), and approximate vegetation type equivalents are presented in Table E.3.139. Table E.3.165 presents the proportionate loss of vegetation type equivalents to the avian habitats represented in the census plots resulting from the Watana project.

Habitat is a vague concept which attempts to provide biologically meaningful explanations of where animals are found. Because habitat comprises both biotic and abiotic factors, habitat suitability for a given species and vegetation type (i.e., Viereck and Dyrness classifications) can be expected to be imperfectly correlated. Attempts have been made (through Principal Components Analysis, and related Ordination techniques) to define "habitat" for individual species by measuring numerous biotic and/or abiotic variables and correlating derived abstract factors with the distribution and use patterns of each species. Although such analyses are of great theoretical interest, they generally fail to provide the kind of information required for an assessment of impacts.

Although they are a crude approximation to actual avian habitat, the loss of vegetation types provides the only available measure of the impacts of the Susitna project on most terrestrial avian species. Kessel et al. (1982a) provide 2 cautions in the use of Viereck and Dyrness vegetation types as avian habitats: (1) Viereck and Dyrness "tall shrubland" supports two more or less distinct avian communities (medium and tall shrub birds of Kessel [1979]), and (2) Viereck and Dyrness closed coniferous and deciduous forests (with a minimum of 75 percent closed canopy cover) are not restricted enough for true coniferous or deciduous forest bird communities (which require at least 90 percent coniferous or deciduous components in the canopy, according to Kessel et al. 1982a). If this is the case, loss of 0.4 percent of the combined Gold Creek and Watana watersheds tall shrub vegetation will affect two avian communities, medium shrub birds and tall shrub birds (see Table E.3.140). Also, loss of mixed conifer-deciduous forest may underestimate loss to the mixed conifer-deciduous forest bird community while loss of coniferous forests and deciduous forest may overestimate the loss to the coniferous forest and deciduous forest bird communities (see Table E.3.140).

As shown in Table E.3.165, with the exception of low mixed shrub, proportional losses are greater for the most densely occupied vegetation types. Although much overlap in species use of vegetation types occurs, species restricted primarily to deciduous and mixed forests will be most severely affected. These include spruce grouse, hairy and downy woodpeckers, alder flycatcher, blackcapped and boreal chickadees, brown creeper, varied, hermit and Swainson's thrushes, yellow-rumped and blackpoll warblers, northern waterthrush, and dark-eyed junco.

Kessel (unpublished tables) provided an estimate of numbers of breeding birds of each species lost based on 1981 density data and general observations in the project area. These estimates, in Table E.3.166, are considered approximate order-of-magnitude figures. The total loss of breeding birds of these species is 82,500 for the Wakana facility alone, 4 percent of the total population within 16 km of the Susitna River between the McLaren River and Gold Creek. Largest numerical losses will be for species which occur in high densities in a range of vegetation types and include Swainson's thrushes, ruby-crowned kinglets, yellow-rumped warblers, Wilson's warblers, dark-eyed juncos, and tree sparrows. However, most of these species are abundant throughout the middle basin. The highest proportional losses will occur to species restricted to these vegetation types which suffer the highest proportional losses and include spruce grouse, hairy woodpecker, boreal chickadee, brown creeper, and northern waterthrush.

- Habitat Alteration

Habitat alteration resulting from clearing and construction of buildings, dams, and borrow sites will have negative effects on some species and positive effects on others. For species which are restricted to forest habitats, development-related alteration will represent effective habitat loss (see above discussion). Species found in closed forests will be reduced in numbers near those clearings which are in forested habitat. Areas to be affected by temporary facilities and borrow sites are relatively small, discrete areas and with or without reclamation will eventually result in openings of early successional habitats. Species associated with edges and disturbed or artificial habitats will increase in these areas. Clearing of forest vegetation may increase bird species diversity through the creation of a different habitat type and associated edge effects, depending on the size of the clearing (Anderson et al. 1977). However, some researchers have found no true edge effect (Kroodma 1982), and others have found a decrease in diversity (Anderson 1979) because of transmission line clearing through forested areas. Since forest vegetation in the Susitna basin supports a somewhat higher diversity of birds than shrub vegetation (Table E.3.138), there may be a decrease in bird diversity as the result of forest clearing.

Some species are capable of utilizing artificial habitats created by man and these species may benefit from certain habitat changes. For example, bank swallows and kingfishers may dig their nest cavities in sand walls of borrow sites that are not in active use or even in less disturbed areas of large sites that are in active use. Cliff swallows readily nest on buildings. Ravens and gulls will feed at refuse dumps if these are not properly maintained.

- Disturbance

Disturbance to terrestrial birds will result primarily from road traffic and is discussed in Section 4.3.3(c). Some disturbance may also result from activities of people at borrow sites and the construction site, but there is little quantitative information about the effects of such disturbance. Local disturbance of this nature will not have any serious effect on overall populations of terrestrial birds.

(ii) Filling

Since the reservoir is to be cleared, most of the habitat loss associated with the Susitna project will occur during the construction phase and was discussed above. During filling, the species that will be affected are those that had invaded the cutover area (mainly birds of shrub habitats) and birds dependent on shorelines, mudbars, and streams. These latter species are primarily shorebirds and the dipper. Dippers inhabit fast-running streams; dipper breeding and feeding habitat will be lost to the extent that the lower reaches of such streams are flooded (see Chapter 2). Dippers also winter in the Susitna River drainage along open-water of fast-running streams, including the Susitna River itself. Open water in winter at the dam intake zone is not expected to serve as dipper habitat. Loss of open water in winter throughout the impoundment zone will exclude dippers from wintering there. However, the large open-water reach below the dam in winter should compensate for the loss of dipper wintering habitat above the damsite.

(iii) Operation

The abundance and species composition of birds along the downstream reaches of the river will change as new riparian vegetation invades areas of the floodplain and proceeds through the successional stages described in Section 3.3.1. These changes will be most visible in the reaches upstream from Talkeetna where alteration of vegetation will be most pronounced. Because bird densities and species diversities are highest in tall shrub and mature forest stands, the vegetation changes over 100-200 years could be considered beneficial to terrestrial breeding birds. However, the proportionate changes in species abundance in the study area as a whole will be very small during the license period.

(q) Non-game (Small) Mammals

Population densities of most species of small rodents fluctuate widely under natural circumstances (Krebs and Myers 1974, Kessel et al. 1982a); it is consequently difficult to predict postconstruction population levels. Although the populations of some species will be diminished because of the project, most species respond quickly to disturbance, abandoning some areas and colonizing new ones. In addition, reproductive rates of small mammals are high, and most populations can recover quickly from population reductions if sufficient food resources and space are available.

Only those species of small mammals that are restricted to forest habitats are expected to show marked decreases, primarily because of loss of forest to the impoundment and construction sites. These decreases may, in turn, be reflected in changes in behavior and/or population levels of certain carnivore or raptor species that depend on small mammals for prey.

During the construction phase, small mammals will mainly be affected by the clearing of the impoundment area, the borrow sites and the construction camp. About 26,730 acres (10,818 ha) of forest will be cleared. The species that are restricted to forest habitats and will thus be most affected are porcupines, snowshoe hares, pygmy shrews, and red squirrels. Small numbers of hares and porcupines and extremely small numbers of pygmy shrews were observed in the project area. Because the area does not seem to be prime habitat for the former two species (Kessel et al. 1982a), their regional densities are not expected to be affected by the project. Red squirrels are common throughout the forested areas of the project area. About 3.5 percent of their preferred spruce habitat in the middle and upper basin will be cleared.

The other species that will be affected by clearing during Watana construction will be the northern red-backed vole. Red-backed voles were found in nearly every habitat type in the Watana area, but were most common in spruce and cottonwood forests. A decrease of up to 5 percent in the overall abundance of this species is expected.

During the three-year filling stage, many of the areas cleared during construction will be colonized by early successional plant species and small mammals. Meadow voles are expected to thrive in such areas (Dabbs et al. 1974). Tundra voles, masked shrews, and arctic shrews may also recolonize these areas. As water levels rise during the filling stage, these populations of small mammals will be displaced. However, no substantial reductions in regional populations are expected as a result of these effects.

The major impact on small mammals during the operation phase of Watana Dam will be the changes caused by succession of disturbed areas, such as the borrow sites and camps, and of the newly exposed land downstream from the dam. Species that occur in grasslands and early successional communities will be favored initially. These include meadow voles, and in some cases, tundra voles, masked shrews, and arctic shrews. As succession progresses to shrublands, the habitat will improve for species such as northern red-backed voles and masked shrews.

4.3.2 - Devil Canyon Development

(a) Moose

Because of steep topography and extensive mature forests in the Devil Canyon area, fewer moose occur in this portion of the Susitna Basin than in the area to the east of Watana Creek (ADF&G 1982a). Distributions of moose observed during surveys in March 1981 suggest that moose were not common in the vicinity of the Devil Canyon damsite but became more abundant in upstream areas near the Watana damsite. ADF&G (1982a) estimated that 30 moose were present within the Devil Canyon impoundment area during a census in late March 1981. The snow depth recorded at Devil Canyon at that time was 29 inches; this census underestimates the number of moose that would be present during winters with deeper snows.

Because of the low numbers of moose in the Devil Canyon area, impacts on moose in this region will be of smaller magnitude than in the Watana development area. The range of impacts to moose that may result from the Devil Canyon project are similar to those already discussed for the Watana project. Potential impacts include loss of habitat, alteration of habitat, interference with seasonal movements, mechanical and human disturbance, hazards associated with the drawdown zone, and hunting mortality. Impacts associated with the access roads, the railway and transmission lines are discussed in Sections 4.3.3 and 4.3.4.

(i) Construction

Construction of the Devil Canyon dam will involve intense construction activity at the actual damsite, establishment of a temporary camp, removal of forest cover in the impoundment, and the excavation and transportation of borrow material. The most important effects of construction on moose will be habitat loss, direct mortality, interference with seasonal movements, and disturbance.

As discussed for the Watana project, alteration of habitat resulting from construction activities will be minimal and effects on moose will be negligible.

- Habitat Loss

An estimated 7907 acres (32 km^2) will be cleared within the Devil Canyon impoundment area and an additional 529 acres (214 ha) will be used for operational areas, campsites and borrow sites. Losses of major forest cover types in relation to their availability indicate that the greatest proportion of losses will occur in woodland spruce, open spruce, and mixed forest cover types (Table E.3.83). Because moose in the Susitna Basin were most commonly relocated in spruce forest than in any other forest cover type (ADF&G 1982a), the loss of spruce habitat in the vicinity of Devil Canyon may be important to moose. However, the limited area of bottomland habitats and the steep slopes of the Susitna River valley in the Devil Canyon area probably limit present use by moose. Although almost all of the low elevation habitat will be lost, moose do not appear to commonly winter in the Devil Canyon area, and the loss of low elevation habitats probably will not appreciably alter overwinter survival of moose in the Devil Canyon area.

- Interference with Movements

The Devil Canyon impoundment generally will not exceed 1 mile (1.6 km) in width. Clearing of vegetation in the impoundment area may present a visual barrier to moose movements, and disturbances associated with clearing operations and construction could block or alter migration paths across or along the river. Moose relocations in the Devil Canyon area suggest that no major movement corridors for moose exist within the Devil Canyon impoundment area, but more frequent crossings may occur once the Watana impoundment is present.

- Disturbance

Effects of disturbance on moose in the Devil Canyon area will be minimal and will be similar to those impacts discussed for the Watana project.

- Mortality

Although a few moose may be killed as a result of collisions with vehicles or other accidents associated with construction areas, the effect of those mortalities on moose populations will be negligible. (Access road mortality is treated in Section 4.3.3.) The major mortality factor associated with the construction of the Devil Canyon dam will be the probable increase in hunting associated with the influx of construction workers and other personnel to a previously remote area. Because moose will be more abundant in the Watana area than in the Devil Canyon area, hunting activity by Devil Canyon personnel will likely be concentrated to the east of the project area. Effects of hunting on moose are described in more detail for the two development areas in Section 4.3.3(a).

(ii) Filling and Operation

The filling phase of the Devil Canyon impoundment is estimated to be approximately 2 months (as opposed to 3-4 years for the Watana project). In addition, the drawdown zone (to 50 ft [15 m] in some years during August and September) will be less than 3 ft (1 m) for most of the year. Because of the smaller area, local topography, the small drawdown zone during most of the year, and the rapid filling sequence, the effects of the Devil Canyon project on moose will be much less severe than those of the Watana project. The major impacts to moose will be alteration of habitat, loss of habitat, blockage of movements, direct mortality, and disturbance.

4-3 - Impacts - Devil Canyon

- Alteration of Habitat

As discussed for the Watana project, the Devil Canyon impoundment will cause some alterations of vegetation in the vicinity of the impoundment and in areas downstream from the dam.

Alteration of vegetation in the vicinity of the impoundment may occur as a result of several microclimatic changes such as seasonal temperatures, wind direction and speed, and ice fog. Effects of these changes on moose will probably be undetectable (Section 4.3.1[a]).

Alteration of vegetation downstream from the Devil Canyon site, however, may affect the distribution, abundance, and quality of moose habitat. The combined effects of the Watana and Devil Canyon dams will result in increased water temperatures in downstream portions of the river, and it is anticipated that with both dams the Susitna River will remain open in winter from the Devil Canyon dam to Talkeetna. Flow regimes following completion of the Devil Canyon dam are not expected to differ greatly from flow regimes of the Watana project. Hence, no additional differences in vegetation resulting from lower water flows are expected when the Devil Canyon dam becomes operational.

Open water in the Devil Canyon-Talkeetna reach of the Susitna River will affect vegetation in several ways. Steam fog will be common over the open water reach during winter. Because of the high moisture content of the air, icing of vegetation along the river will occur. However, the area of riparian habitat that will be affected depends on several topographical and climatic factors, and cannot be accurately predicted. It is also not known whether plant productivity will be detrimentally affected by icing or whether moose will utilize iced winter browse. Although it is probable the icing of vegetation will not make browse unavailable, it will increase energy requirements of those individuals that consume large quantities of ice. As a result, impacts on moose associated with vegetation icing along the Devil Canyon- Talkeetna portion of the Susitna River are difficult to quantify.

Because of the open-water conditions in the Devil Canyon-Talkeetna reach, ice scouring of lower level riparian areas will be eliminated. Annual disturbance of successional growth in these areas will be reduced (flooding will still scour some areas), and the vegetation will begin to colonize the unvegetated band resulting from ice scouring during operation of Watana only.

Riparian communities on higher ground of the river channel will gradually succeed to cottonwood forest, but at the same time will extend downward into the newly exposed areas of the river channel. Browse will increase in abundance along the river once Devil Canyon is commissioned. However, such browse may be partially unavailable, as described in the following section, or of reduced value due to icing, as described above.

- Interference with Movements

Movements of moose in the vicinity of the Devil Canyon impoundment and downstream from the dam may be affected by the Devil Canyon project. Moose attempting to cross the impoundment area may be inhibited by visual factors such as the 1-mile (1.6-km) wide impoundment or the presence of open water areas in winter. The width of the impoundment is not likely to present a physical barrier to moose in summer, but winter open-water areas could deflect movements.

Moose in the Devil Canyon-Talkeetna reach of the Susitna River overwinter in riparian habitats and on river islands of the Susitna River (ADF&G 1982b). Parturient cows apparently prefer to calve on river islands or in riparian areas, presumably because of the availability of high quality forage and reduced numbers of predators (Stringham 1974). The presence of open water between the dam and Talkeetna may interfere with use of these river island habitats during the winter and the early portion of the calving period. Moose in northern British Columbia are not known to cross sections of open water downstream from dams during winter (F. Harper 1982 personal communication). The effects of exposure to sub-zero temperatures following crossing of open water would presumably physiologically stress moose during a period when their energy balance is already precarious. Browse and cover occurring on islands must, therefore, be considered unavailable to moose for at least 3-5 months during winter.

- Disturbance

Mechanical and human disturbance should decline in the Devil Canyon area once the dam becomes operational. Increased public access will maintain disturbance at a higher level than is currently encountered, but at a level much lower than during construction. If animals are not directly harassed, disturbances during the filling and operation stages will at most have a slight effect on moose distributions.

- Mortality

During the filling and operation of the Devil Canyon dam, moose mortality may increase as a result of hunting and accidental deaths (see Section 4.3.1[a]).

(b) Caribou

Few impacts of the Devil Canyon development on caribou are expected. The impoundment area, particularly the area near the damsite, has been infrequently used by caribou either historically or in recent years. A small portion of the Nelchina herd may occasionally cross the impoundment, but because the crossing hazards are expected to be less severe than those associated with the Watana impoundment, fewer subtantial impacts are expected. There may be some impacts on caribou resulting from aircraft disturbance and the Watana to Devil Canyon road segment--these will be similar to those associated with the Watana development, and are discussed in Sections 4.3.1(b) and 4.3.3(b).

(c) Dall Sheep

The construction, filling and operation of the Devil Canyon dam will have no direct impact on any of the three Dall sheep populations in the middle Susitna Basin. All three populations are far removed from the damsite.

Any increase in air traffic to the Watana airstrip caused by the construction of the Devil Canyon dam has the potential for disturbing the Mt. Watana-Grebe Mt. population (coming from the south) or the Portage-Tsusena Creek population (coming from the north). The effects of aircraft traffic on Dall sheep are discussed in Section 4.3.1(c).

(d) Brown Bear

The impacts of the construction of the Devil Canyon dam on brown bears will be similar to those during construction of the Watana dam, except that the number of bears affected will be much smaller. The area near the Devil Canyon site is at lower elevations and is not prime habitat for brown bears.

Steep canyon walls will confine most of the Devil Canyon impoundment, thus minimizing the area inundated. There will be some loss of riparian areas, with their associated food sources - berries, early spring vegetation, and moose calves. No potential denning areas will be affected. Other long- term effects of the Devil Canyon development, such as increased hunting and aircraft disturbance, will be similar to those associated with the Watana development, but at a reduced scale.

Some human/bear contact is likely to occur during the construction of the dam, leading to increased bear mortality. As discussed in Section 4.3.1(d), improper food and garbage handling practices will increase problems with bears. Avoidance of areas of human activity by bears will cause some habitat loss, resulting in a lower carrying capacity for brown bears.

(e) Black Bears

The impacts of the Devil Canyon development on the local black bear population will be substantially less than those for Watana, because only a small portion of acceptable black bear habitat in the Gold Creek watershed will be lost. The impact on denning areas will also be considerably less; only one of 16 den sites (6 percent) found in the vicinity of the Devil Canyon impoundment will be flooded. Most of the potential impacts discussed for the Watana development will exist, but at a much-reduced level. Downstream effects of the Devil Canyon impoundment should be the same as those discussed in Section 4.3.1(e).

(f) Wolf

Impacts from the Devil Canyon development will be very similar to those from the Watana development. No known dens or rendezvous sites will be affected, and the loss of potential den sites is not expected to have significant effects on the wolf populations. Similarly, disturbance is not expected to affect wolves except possibly at den sites during May and June. Wolf pups moved from dens because of disturbance when they are very young may not survive (ADF&G 1982f).

It was argued in Section 4.3.1(f) that wolf populations are unlikely, at their present levels, to be seriously affected by loss of prey species. The same situation holds for the Devil Canyon development; only in the very unlikely event that management objectives require higher wolf populations would loss of prey species become a potentially significant impact. Computer modeling of moose populations is being conducted to assess the impact of altered predation rates, increased accidents, and habitat loss on moose. These modeling efforts will also provide insight into possible changes in predator/prey relationships.

(g) Wolverine

The effects of the Devil Canyon development on wolverine will be insignificant except for the potential of increased trapping as discussed in Section 4.3.3(g). Because wolverines range over large areas, the relatively minor changes in food availability and the effects of intensive human activity near the construction site should not noticeably affect the few wolverines near the Devil Canyon development area.

(h) Belukha Whale

As discussed in Section 4.3.1(h), the combined operation of Watana and Devil Canyon should have no detectable effect on belukha whales in Cook Inlet.

(i) Beaver

The Devil Canyon project will have a net beneficial effect on beaver. Several beaver colonies now occurring within Borrow Site K and near the campsite will be adversely affected, but an improvement in downstream habitat resulting from more stable flows and a lack of ice cover downstream to Talkeetna will offset these impacts.

No beaver are known to occupy the Devil Canyon reservoir, and thus, no adverse impact is expected as a result of inundation. However, during the period between the filling of the Watana and Devil Canyon reservoirs, some beavers may colonize this reach and be initially displaced. If the reservoir level remains stable for several years as a result of several wet years, beavers will successfully colonize the impoundment. Beavers will probably attempt to colonize the impoundment in other years, but the drawdown in August and September will occur at a critical time when food caches are being constructed and it is unlikely that beavers will successfully overwinter. Approximately 10 beavers are known to occupy the lakes in and adjacent to Borrow Site K and the proposed construction camp, and these areas will probably be lost during construction.

Downstream effects should be the same as with Watana, except that the lack of ice cover from Devil Canyon to Talkeetna will allow beaver use of some sloughs and side channels that are subject to freeze-out when ice cover is present. The mainstem may also be colonized once ice scouring is eliminated.

(j) Muskrat

Construction of the Devil Canyon dam should have no direct impacts upon muskrats, since no suitable habitat is known from the construction or borrow sites. Some habitat loss may occur from building camp facilities if ponds and lakes are filled in for roads, work pads, etc. Downstream effects will be similar to those described in Section 4.3.1(j).

If construction camp personnel and their families are allowed to trap in the area, muskrat populations throughout the lakes lying on either side of the Susitna River could be affected. Gipson et al. (1982) found muskrat sign in these lakes and noted their vulnerability to trapping.

No impact is foreseen from vegetation removal in the impoundment zone or from subsequent flooding.

(k) Mink and Otter

Effects of the Devil Canyon project on mink and otter will be similar to those already discussed for the Watana project (Section 4.3.1[k]), but because of the smaller size of the impoundment and the more stable water level, effects will be less severe. Because mink are most abundant east of Kosina Creek, the Devil Canyon project will probably have little effect on the regional population. Major impacts to otter and mink are loss of habitat, reduction in prey availability, increased human disturbance, and barriers to movement.

Because the combined Devil Canyon project and the Watana project will result in permanently open water from Devil Canyon to Talkeetna, mink and otter may be positively affected. Both species prefer areas of open water in rivers and streams in winter (Barber et al. 1975). Open water areas in the reservoir during winter should also have beneficial effects.

(l) Coyote and Red Fox

Coyotes are more common in the Devil Canyon area than in the Watana area, but they are still sufficiently uncommon that the project is unlikely to have any effect on them. As in the case of the Watana development, foxes will be affected primarily by increased trapping and by destruction of nuisance animals if garbage is not regularly incinerated or if regulations against feeding are not enforced. Habitat loss will not be a major impact since foxes tend to occur at mid and high elevations rather than in the forested areas along the river.

(m) Other Terrestrial Furbearers

Lynx, weasels, and marten will all be affected by the Devil Canyon development primarily by loss of habitat. As in the case of the Watana development, no estimates of the potential reduction in numbers of weasels can be made. Few if any lynx will be lost because of the poor habitat and current low number. Habitat for approximately 14 marten will be lost to the impoundment and construction sites, borrow sites, etc. If both Watana and Devil Canyon are built, about 11.5 percent of the middle Susitna Basin marten population will be lost (access road and transmission line not included). Both of these estimates are based on the conservative marten density derived in Section 4.3.1(m).

Marten, lynx, and weasels may be disturbed by construction activity, but there is no evidence that they will vacate areas as a result of these disturbances.

(n) Raptors and Ravens

(i) Construction and Filling

Construction and filling of the Devil Canyon reservoir would have similar effects on raptors and ravens to the Watana development, and would increase overall impact to those species; however, the increase would represent a relatively small proportion of the total impact of both developments.

- Habitat Loss

One or possibly 2 of the 16 (12 percent) total known golden eagle nesting locations in the general vicinity of the Devil Canyon impoundment will be lost (Tables E.3.160 and E.3.162). The cumulative loss of golden eagle nests to both projects represents 44-50 percent of known nest locations in the project area (Table E.3.160).

No bald eagle nesting locations will be lost as a result of Devil Canyon construction and filling.

No known gyrfalcon nesting locations will be inundated by the Devil Canyon reservoir, but one of the three total known locations may be located in Borrow Site K (see Table E.3.160). If this nesting location is indeed in Borrow Site K, it may be lost during material excavation, though overall impact to this species in the middle basin will remain minimal.

One of three (33 percent) known goshawk nesting locations in the general vicinity of the Devil Canyon project will be lost to clearing and filling of the Devil Canyon reservoir (Figure E.3.116, Tables E.3.160 and E.3.162). The nest location that will be lost is one of two discovered to date upstream of the Devil Canyon damsite. Although the loss from this goshawk nesting location doubles the number lost as a result of both reservoirs, total impacts to this woodland species are anticipated to remain minimal because appropriate nesting habitat appears to be relatively limited in both impoundments.

Four of 21 (19 percent) previously used raven nesting locations in the general vicinity of the Devil Canyon project will be lost as a result of construction and filling of the Devil Canyon reservoir (Figure E.3.116, Tables E.3.160 and E.3.162). All four will be lost by inundation, and one additional nest (R-19) will remain only a few meters above maximum flood level (see Figure E.3.116).

Although construction and filling of the Devil Canyon reservoir will increase the number of used nesting locations lost to 15 (71 percent of the previous total) (see Table E.3.160), total impact to ravens is still anticipated to be relatively low. Loss of nesting locations in Devil Canyon will probably increase the importance of remaining cliff areas there (see Table E.3.161) and in side tributaries. It may also increase the importance of trees for nesting (see Section 4.3.1[n]).

- Disturbance

Five golden eagle nesting locations within or on the edges of the Devil Canyon impoundment may be susceptible to disturbance from reservoir clearing operations (see Figure E.3.116: the two exceptions are GE-19 and GE-18). One and perhaps two of those locations will be inundated later (GE-13 and GE-14). One of the five locations (GE-11) may be susceptible to disturbance from the clearing operations in the Devil Canyon area only if it remains following the excavation of materials from Watana Borrow Site E. One other golden eagle nesting location (GE-18) is about 0.6 miles (0.9 km) downstream from the Devil Canyon damsite and may be susceptible to considerable disturbance as a result of activities associated with the construction of the dam itself.

No known bald eagle nesting locations appear susceptible to disturbance as a result of activities associated with the construction of the Devil Canyon dam, clearing operations within the impoundment zone, or filling of the reservoir.

Two known gyrfalcon nesting locations in the Devil Canyon impoundment area may be susceptible to disturbance. One of those locations (GYR-2) may be susceptible to some disturbance during the reservoir clearing and the subsequent increase in human presence as recreation activities develop and increase along the impoundment edges. A second location (GYR-3) may be susceptible to considerable disturbance from excavation and transport of materials from Devil Canyon Borrow Site K.

At least two known goshawk nesting locations (tree nests) may be susceptible to disturbance from construction and filling of the Devil Canyon reservoir. One of these nesting locations (GOS-2) is within the Devil Canyon reservoir. It may be susceptible to disturbance from material excavation (0.13 miles [0.2 km] to the west) at Watana Borrow Site I (see Section 4.3.1[n], [ii]) and will eventually be felled during reservoir clearing operations prior to inundation (Figure E.3.116). The other nesting location (GOS-3) is situated well above the reservoir level, but disturbance from human presence may increase as recreational activities develop along the impoundment edges.

Six raven nesting locations within or on the edges of the Devil Canyon impoundment may be susceptible to disturbance from reservoir clearing operations, but four of these will eventually be inundated (see Figure E.3.116: the exceptions are R-19 and R-21). One of the locations not inundated (R-19) will remain only a few meters above maximum flood level. The other nesting locations that is not inundated (R-21) is about 0.47 mile (0.7 km) downstream from the Devil Canyon damsite and may be susceptible to disturbance during construction of the dam.

(o) Waterbirds

Initially the clearing and construction activities at Devil Canyon may cause a temporary loss of suitable habitat for waterbirds. The Devil Canyon impoundment will have a relatively stable water level with a drawdown of only 1 m for most of the year (less than 1 m in wet years). This should allow for the development of some vegetation in the impoundment, although suitable shallow shoreline areas will be somewhat limited. The open-water area near each end of the reservoir should benefit some early and later migrants when other waterbodies are frozen, and the relatively stable water level in each year will allow a low level of use, typical of large lakes of the region, for nesting by waterbirds along the shoreline. On the other hand, species of alluvial and fluviatile shoreline habitats currently using the impoundment area will be eliminated. Breeding habitat for harlequin duck, common merganser, semipalmated plover, spotted sandpiper, wandering tattler, arctic tern, and dipper will be inundated. No significant amount of shorebird feeding habitat will be created by the Devil Canyon impoundment because of the small drawdown and steep shoreline.

Downstream effects will be similar to those discussed in Section 4.3.1(o). These will consist mostly of distributional shifts and minor changes in relative abundance of riparian species as vegetation proceeds through the successional sequence described in Section 3.2.1.

(p) Other Birds

The Devil Canyon development will result in the same types of impacts (habitat loss, habitat alteration, disturbance, direct mortality) with the same effects on terrestrial and shoreline birds as the Watana development (see Section 4.3.1[p]).

Flooding of the Devil Canyon impoundment will increase the proportionate loss of forest habitats in the middle basin by several percent over that lost to the Watana development (Table E.3.165). The largest losses will occur in closed birch forests, conifer-deciduous forests and open spruce forests (Table E.3.166). The total loss to the population within 10 miles (16 km) of the Susitna River between the McLaren River and Gold Creek resulting from both Watana and Devil Canyon Reservoirs and facilities is between 10 and 15 percent for the following species: spruce grouse, hairy woodpecker, northern three-toed woodpecker, boreal chickadee, brown creeper, varied thrush, hermit thrush, Swainson's thrush, yellow-rumped warbler,blackpoll warbler and northern waterthrush. For a few species, the proportionate loss to Devil Canyon results in a substantial additional loss over the Watana Development alone. Kessel (unpublished data) calculated order-of-magnitude losses for number of small- and medium-sized birds that would be lost to the Devil Canyon facilities (Table E.3.166). An estimated 17,300 breeding birds will be lost to the Devil Canyon facility, approximately 1 percent of the population within 16 km of the Susitna River between the McLaren River and Gold Creek.

As is the case for the Watana development, the dipper will be affected by loss of breeding habitat in the lower reaches of feeder streams and loss of winter habitat (open water) in both feeder streams and the Susitna River itself. However, open-water below the dam should compensate for this loss of winter habitat.

(q) Non-game (Small) Mammals

The types of impacts on small mammals that will result from construction of Devil Canyon dam will be similar to those already discussed for the Watana dam (see Section 4.3). The major impact will be loss of habitat due to clearing operations and subsequent flooding. The total area affected (approximately 34 km^2, 8401 acres) and percent of forested land affected (0.7 percent) are much smaller than in the Watana reservoir area. The impacts on small mammals are thus expected to be proportionately smaller.

4.3.3 - Access Roads and Railway

(a) Moose

Anticipated impacts on moose of the gravel access road from the Denali Highway to the Watana damsite and the later construction and operation of the Devil Canyon access road include a loss of habitat, alteration of habitat, disturbance and subsequent avoidance of the highway, interference with seasonal movements, and mortality. Moose will also be greatly affected by the indirect impacts of the access road, particularly hunting. Moose numbers will decline as a result of hunting mortality and avoidance of the corridor by moose. The railway from the Gold Creek area will have similar effects to those mentioned for the access roads, except that hunting mortality should be lower (as a result of poor vehicular access) and collision mortality during the winter may be higher.

(i) Mortality

The primary impact of the access roads will be the provision of improved public access to previously remote areas in the Susitna Basin. In turn, improved access will probably result in localized declines in moose as a result of hunting and avoidance of the highway corridor because of disturbance. Declines in moose along newly opened roads or along roads in areas opened for hunting have been reported for a number of northern areas (Goddard 1970, Cumming 1974, Ritchey 1974, Beak 1979). Although a good portion of these declines in moose was the result of hunting mortality, moose probably also avoid areas in the vicinity of access corridors during the hunting period.

A decline in moose numbers during construction of the Watana access road can be expected as a result of hunting. Effects would probably be most severe in the vicinity of campsites or the townsite. Public access to the Susitna Basin will increase once the road is operational, and further increases in hunting pressure will occur with resultant increases in hunting mortality of moose. Because the moose population will already be stressed by impacts associated with the Watana development and the subsequent redistribution of moose within the Susitna Basin, disturbances associated with hunting and hunting mortality may further aggravate impacts to the moose population. Because the Watana development will reduce the carrying capacity of the Susitna Basin for moose, it is possible that moose numbers will temporarily exceed those optimal for sustained productivity. Assuming that surplus moose may be present, carefully managed hunting may effectively mitigate for the indirect project effect of overutilization of remaining forage (see Section 4.4).

Construction and operation of the Watana-Devil Canyon access road segment and the railway will result in similar but less severe impacts on moose. The Devil Canyon segment will provide new access to a relatively smaller area, much of which is poorer quality moose habitat than is the Watana dam area. The railway will not provide as easy an access route to the general public as the roadways, and its use can be better controlled. Hunting pressure consequently will not increase as in the case of the access roads. In addition, much of the area that will be affected by railway access supports relatively low numbers of moose as compared to lower reaches of the Susitna River.

During the construction and operation of the access roads and railway, moose may be killed as a result of collisions with vehicles. High volumes of road traffic are expected along the Watana and Devil Canyon access roads during construction of the dams (primarily from workers commuting to the site), and the number of moose killed will be substantial, particularly during winters of deep snowfall or when darkness or poor weather results in poor visibility.

Collision mortalities along the railway could also be substantial. An additional 8 train trips per week in each direction are expected during the construction of the Devil Canyon dam. Rausch (1958) reported adjusted kill totals of 366 and 179 moose along a 86.9 km section of the Alaska Railway (Houston to Talkeetna) during the winters 1955-56 and 1956-57, respectively. During the winters of 1970-1971 through 1978-79, annual moose kills along the Willow-Talkeetna portion of the Alaska railway ranged from 0 to 151 animals (ADF&G unpublished data). Because moose are easily trapped within the steep snow embankments along railway lines and are usually more abundant in valley bottom habitats during winters with high snows, higher numbers of collision mortalities occur along rights-of-way in low elevation areas during severe winters.

ii) Loss of Habitat

Construction of the Watana and Devil Canyon access roads and the railway will result in loss of habitat associated with the construction corridor and borrow pits. Although the actual removal of moose browse will be small in relation to its availability in other areas of the Susitna Basin, the effective loss may be greater if moose avoid the access corridors or if migration routes are blocked. As discussed above, moose will tolerate disturbance along access corridors if they are not hunted. However, if hunting is permitted, moose may avoid an area of several kilometers from the corridor, consequently increasing the effective area of lost habitat.

Based on existing information, no special use areas for moose such as wintering range, calving areas, or breeding concentrations will be rendered unusable by the road access corridors. However, because most special use areas will be inundated by the impoundments, these road corridors could affect the location of new special-use areas. Anticipating such changes is obviously difficult.

The problem of railway corridors in moose wintering areas and resulting collision mortalities has already been discussed.

(iii) Alteration of Habitat

Construction of the access road and railway will necessitate the use of gravel berms that may impede or alter drainage systems (Boelter and Close 1974, Kemper et al. 1977). Permanent flooding of forested areas may result in the loss of some moose habitat through killing of trees and shrubs. However, growth of aquatic plants within flooded areas may partially compensate for this loss by providing additional summer forage. Drainage of wetland areas may result in a temporary increase in the growth of seral shrub communities, but without periodic flooding or disturbance, these areas will eventually develop into forest stands with low browse production.

(iv) Interference with Seasonal Movements

The proposed road access corridors will cross several areas where moose migrate seasonally between summer and winter ranges (ADF&G 1982a). Concentrations of movements by radio-collared moose that may be affected by the Watana road include the Watana-Butte Creeks area, and the Watana-Deadman creeks area (Section 4.2.1[a]).

During construction, mechanical activities may prevent some moose from crossing the road corridors, primarily as a result of moose avoiding the construction area. Avoidance of the road corridor would probably be most severe during the hunting season, if hunting is permitted. Steeply sloped road berms and/or the creation of deep snow embankments from road-plowing may act as physical barriers to moose crossings. As discussed earlier, the railway may interfere with movements of moose during the winter and early spring periods when snow embankments may either block movements by moose or trap animals within the cleared right-of-way.

(b) Caribou

The access road between the Denali Highway and the two damsites is likely to have a substantial effect on caribou movements. Few caribou movements have been recorded in the area traversed by the Devil Canyon to Watana dam segment, and the western segment between the two dams and Gold Creek should not pose a serious problem to caribou. The segment between the Denali Highway and Watana dam, however, traverses an historically important area of the herd's range, which is currently used by a resident subherd of up to 2500 caribou and also by some caribou from the main herd. The road is most likely to affect the herd by increasing mortality from collisions with vehicles and from hunting, and by altering movements between the area west of the road and the remainder of the herd's range. There may also be a slight increase in wolf predation in the area, since wolves often use roads to their advantage while hunting caribou (Roby 1978).

Detailed information on the effects of roads and associated human activities (e.g., vehicle traffic, construction activity, presence of workers) on caribou comes primarily from four sources: (1) studies by the ADF&G along the TAPS corridor since 1974, and along the Kuparuk oilfield access road since 1978; (2) a two-year study by Fancy (in press) in a floodplain area used by large numbers of caribou moving to and from insect-relief areas; (3) data from a study by Roby (1978), who worked with ADF&G along the TAPS corridor; and (4) a two-year study conducted along the Kuparuk oilfield access road by Curatolo et al. (1982). Alyeska Pipeline Service Company is also funding a three-year study along the TAPS corridor as a "second opinion" to the ADF&G studies; however, no reports have been released after two years of study. All of these studies involve the Central Arctic Herd on Alaska's North Slope.

The results of these studies are somewhat contradictory, and as a result, caribou biologists disagree on the severity of road effects on caribou. ADF&G studies (Cameron and Whitten 1979, 1980; Cameron et al. 1979) have concluded that caribou cows and calves avoid the Prudhoe Bay oilfield, based on a lower percentage of calves in caribou groups observed from the roads in their study area as compared to aerial sightings over a larger area. But, along the Kuparuk oilfield access road (oriented E-W and thus not confused by latitudinal biases), calf percentages have not been found to differ from those expected in three years of study (Cameron et al. 1981). During an aerial calving survey along that road in 1980, no calves were seen within 2.7 miles (4 km) either side of the road, but this was not the case in 1978 and 1979. Few calves have been born within the Prudhoe Bay complex in recent years. The Central Arctic Herd has been steadily increasing in size each year, and productivity has been "excellent" (Cameron et al. 1981) in spite of the localized effects on caribou distribution and group composition.

Recent detailed studies involving continuous observations of caribou as they approach roads and pipelines have found that most caribou will cross roads with light-to-moderate vehicle traffic, but that caribou will often first try to find a way around the obstacle (paralleling movements), and some groups (10-14 percent for the most detailed study) may refuse to cross at all (Fancy, in press). Preliminary results by Curatolo et al. (1982) have found that the proportion of groups that crossed the Kuparuk oilfield road and pipeline was significantly less than that expected (control). Many groups left their study area paralleling the road and pipeline, and thus the proportion of groups that eventually crossed could not be determined.

The responses of individual caribou to roads and traffic are extremely variable; some animals appear to avoid lightly traveled roads entirely, whereas others will cross roads during rates of traffic exceeding one vehicle per minute with no observable response. In general, however, moving vehicles and/or the presence of workers will alter the local movements and behavior of caribou. Horejsi (1981) reported that 88 percent of the caribou he observed along the Dempster Highway reacted to a moving pickup truck by running or trotting away. A fleeing animal can expend eight to twenty times the cost of basal metabolism, at the expense of body growth, development, and reproduction (Geist 1975).

The greatest concern for disturbance effects on caribou is for cows in late pregnancy and cows with young calves. Female caribou are particularly sensitive to disturbances during the calving period (Lent 1966, Bergerud 1974b, Calef et al. 1976, Surrendi and DeBock 1976), and disturbances at this time are more likely to result in lowered recruitment because of premature travel by calves, disruption of cow/calf bonds, or trampling (Lent 1966, Geist 1971b, Bergerud 1974b, Surrendi and DeBock 1976). Some calving has been documented north of the Susitna River, but the road has been realigned so that it is to the west of the areas where most calving has recently occurred. Cows calving in the area may avoid the road during the period of heavy use, but this will affect only a small number of animals.

Large volumes of vehicle traffic are expected during peak construction years, including 20 project support materials vehicles per day, hundreds of trips per day by workers driving to the site, and 70 project heavy trucks per day (Table E.3.162). If the road is opened to the public during or after construction, high traffic rates will continue. The traffic volume during the caribou studies cited earlier was only a small fraction of that expected during dam construction. A few caribou will cross the road regardless of high traffic frequencies, but the majority will probably cross only if lulls in traffic are provided. Since the area west of the road is currently a peripheral part of the main herd's range, failure of most animals to cross the road will not cause a major impact. As the herd increases in size, however, the importance of the area to the herd will greatly increase. It is thus important to design and operate the road so as to permit free crossings by caribou during the operation phase of the project.

The physical presence of a raised gravel road, in the absence of vehicles and human activities, will not be an insurmountable barrier to caribou movements (Surrendi and DeBock 1976). The exception to this is that plowed or blown snow along the road could, in combination with the raised road surface, act as a physical barrier to caribou movements (Surrendi and DeBock 1976). Caribou tend to select the lowest berms when crossing roads (Cameron and Whitten 1976, Surrendi and DeBock 1976, Roby 1978), and various studies have shown that caribou are wary of berms they cannot see over (Hanson 1981).

The Nelchina herd has been important to both sport and subsistence hunters because of its size and proximity to population centers. In 1981, 6662 people applied for 1600 permits to hunt for Nelchina caribou. The permit system currently in use will have to be continued if only the annual increment is to be harvested as stated in the herd management plan (ADF&G 1976). Public access provided by the Denali access road will have a greater effect on the distribution of hunting pressure than it will on the actual number of caribou harvested, since hunter success is currently very high. The Susitna-Nenana subherd is resident in the access road area and, although the rate of exchange of individuals with the main herd is unknown, the presence of the Watana impoundment in conjunction with heavy hunting pressure will probably result in a substantial decrease in this subherd.

(c) Dall Sheep

The effect of vehicle traffic along the access road should be insignificant, since sheep are not expected to occur close to the roads. MacArthur et al. (1982) found that only 19 of 215 documented passes (8.8 percent) of sheep by vehicles evoked heart rate responses, usually of low amplitude. Moreover, 73.7 percent of all heart-rate responses occurred when vehicles passed within 82 feet (25 m) of the sheep. They reported that only 2 of the 215 vehicle passes (0.9 percent) they recorded evoked withdrawal responses by sheep. In Denali National Park, Tracy (1977) found that the strength of reactions and the percentage of sheep showing visible reactions to buses and visitors decreased with increasing distances between the sheep and the road. She recorded no reactions by sheep at distances exceeding 2460 feet (750 m) from the road, whereas strong reactions were recorded only at distances less than 1312 feet (400 m). Dall sheep have continued to use lambing and wintering areas along the Dalton Highway (Hemming and Morehouse 1976, Fancy 1980), in spite of intensive pipeline construction and vehicle traffic along that road. Disturbance due to air traffice is treated in Section 4.3.1(d). Increased disturbances from human access as described in Section 4.3.1(d) for the construction phase will also occur during operation as recreational use of the area increases.

If the project area is opened to the public following construction, there will likely be an increase in hunting pressure in locations adjacent to the access roads and the reservoir. The number of sheep harvested in the area is not expected to increase greatly, however, because all or most legal rams in the area are already being harvested each year. Serious population depletions resulting from the increased hunting pressure are thus not expected to occur.

(d) Brown Bear

Both the Denali-Watana and Watana-Devil Canyon access road segments traverse prime brown bear habitat. Potential impacts of the access roads on brown bears include interference with movements, increased hunting mortality, and a decrease in acceptable denning and feeding areas. Direct mortality from hunting and nuisance animal control will probably have the greatest effect on the population in the long term.

Tracy (1977) reported on the reactions of brown bears to the Denali Park Road. She found that the densities of bears in study plots away from the road were consistently greater than densities along the road, suggesting an avoidance of roads by bears even where no hunting occurs. Many bears have habituated to the road, however, and those seen near the road were frequently engaged in such activities as nursing, playing, and sleeping, which suggests security and relaxation. The literature also includes a paper by Elgmark (1976), who reported that construction of a network of logging roads in Norway resulted in a lower density of brown bears, and a report by Miller and Ballard (1982) on the apparent short-term deflection of brown bear movements by the Glenn Highway in Alaska.

4.3 - Impacts - Access

The access road is likely to cause some alterations in the movements of brown bears, but there is little evidence to suggest that it will block bear movements altogether. Revegetation of the road shoulder will create forage which is attractive to brown bears, especially during early spring, when such areas will green-up earlier than surrounding vegetation. However, because brown bears in the middle basin are hunted, they are not likely to feed on berries and other foods occurring adjacent to the road during hunting season, and thus there will be a decrease in the availability of foods as a result of the road in that season. Several dens have been found in the Denali Highway to Watana access road segment. Brown bears in the project area do not appear to re-use existing dens and the availability of denning habitat does not appear to limit the population. However, it is likely that brown bears will find unacceptable the denning area used by three different bears in 1980 and 1981 near the proposed road once the road is present.

Abandonment of dens by bears in winter can result from human activity near the den (Craighead and Craighead 1972a,b; Harding 1976) or from disturbance caused by helicopters (Reynolds et al. 1976). Frozen ground would then prevent the bears from digging new dens. Disturbance of bears in winter dens during road construction may cause the death of several bears.

Although some brown bears are now harvested from the remote areas of the middle basin, most hunting occurs along or near the Denali Highway. The improved access resulting from the road and reservoir will probably cause a large increase in the number of brown bears killed by hunters in the basin. Habitutated bears, particularly young bears, will become particularly susceptible to hunting. Additional mortality will occur from the destruction of habituated and nuisance bears.

(e) Black Bear

The access road will impact black bears primarily through improved access for hunters. Black bears do not usually occur near the proposed road north of the Deadman Lake area, and much of the Watana-Devil Canyon segment is at elevations above acceptable black bear habitat. Road construction could cause abandonment of dens, particularly in the lower Deadman Creek area and near the Devil Canyon damsite. The probability of bear mortalities caused by collisions with vehicles is very low.

(f) Wolf

The major effect of the access route on wolves will be an increase in the numbers of hunters, trappers, and construction workers able to shoot wolves in the area. However, wolves may also be affected by disturbance from construction activities and traffic, and small numbers may be killed by vehicles. The number killed by vehicles is likely to be greater if wolves become habituated to vehicles through being fed. Since wolves do habituate readily to traffic and noise under most circumstances, disturbance is unlikely to have major effects. However, wolves appear to be more sensitive to disturbance during the denning season. Carbyn (1974) documented abandonment of two wolf dens near highways after the roads were upgraded and traffic volumes increased. The proposed Susitna access route passes through the home ranges of at least three wolf packs. Two den sites and one rendezvous site are known from the general vicinity of the access route; additional sites most likely exist.

Impacts from increased access by hunters and trappers cannot be quantified but may be severe. As many as 8-10 wolves per year have been taken in the immediate vicinity of the proposed impoundments since 1976-77 (ADF&G 1982f) in spite of the relative inaccessibility of the area at present. Increases in the number taken may be beyond the capability of the population to replace, or may reduce the ability of this population to produce excess animals that presently disperse to areas even more heavily hunted.

(g) Wolverine

The direct loss of habitat caused by the access road will have an insignificant effect on wolverine. Hornocker and Hash's (1981) statement that "the size and shape of (wolverine home) ranges were not affected by rivers, reservoirs, highways or mountain ranges" suggests that the road and associated traffic will also have an insignificant effect on wolverine movements and availability of prey. It is not clear whether wolverine will utilize carcasses of animals killed by collisions with vehicles, but this is a possibility, especially during periods of infrequent vehicle use. The potential for wolverines to be killed by vehicles is very low, considering the low densities of wolverine and their wariness.

Increases in trapping pressure as a result of improved access is more likely to affect wolverines than any other project-related activity. Wolverines are highly susceptible to trapping because they travel widely and are readily attracted to baits. Hornocker and Hash (1981) reported that all of the wolverines they captured were missing one or more toes, and many had broken teeth; many of these mutilations were attributed to encounters with leg-hold traps. Van Zyll de Jong (1975) stated that "predation by humans appears to be the most likely factor to have affected the number of wolverines. Direct evidence of negative effects of human exploitation on wolverine populations is not available, but indirect evidence from declining production of wolverine pelts and the disappearance of the species from areas with relatively dense human populations strongly suggests that exploitation by man contributed to the decline." Fifteen of the 18 known wolverine mortalities in Hornocker and Hash's (1981) study were human caused. Increased trapping pressure in the Susitna Basin will probably cause some instability in the social structure of the population, thus causing noticeable shifts in home ranges. However, population effects of trapping mortality would be difficult to detect because of emigration of wolverine from the large parcels of wolverine habitat surrounding the basin into the affected areas.

Wilderness or remote country where human activity is limited appears essential to the maintenance of viable wolverine populations (Van Zyll de Jong 1975, Hornocker and Hash 1981). However, Hornocker and Hash (1981) reported that they found "no differences in wolverine density between the wilderness and nonwilderness portions of our study area, nor was wolverine movement, habitat use, and behavior different. Marked wolverines used both areas and several individuals' home areas overlapped both wilderness and nonwilderness. The nonwilderness portion, about one half of the study area, is used by humans primarily for logging and recreation; logging roads and foot trails provide access to river and stream bottoms and lower elevations during summer and fall months. Loggers, summer recreationists, and hunters make considerable use of those areas." They went on to say, however, that wolverines and humans were effectively separated because the wolverines were at higher elevations away from people during summer and fall, and little use of the area by humans occurs during winter when wolverines move to the lower elevations. A similar situation will exist in the middle Susitna Basin; the most intensive human use of the area will occur in summer when wolverines are using primarily tundra habitats. Access to these tundra areas afforded by the roads and transmission corridors may cause several wolverines to avoid portions of their range. Winter use of the impoundment areas, except for trapping, should be considerably less than that during snow-free periods.

(h) Furbearers

The construction of the access road and the railway will result in some habitat loss for terrestrial furbearers, and may result in habitat loss for aquatic furbearers if wetlands are degraded. Minor effects on the local distribution of individuals of some species may also occur along the road. For example, Hawley and Newby (1957) believed that habitat openings were a psychological barrier to marten. Although subsequent studies have found that marten regularly cross openings 328-656 feet (100 to 200 m) wide (Koehler et al. 1975, Soutiere 1978), the access route will result in a redistribution of home ranges, and many marten will be forced to realign their home ranges along the road.

Similarly, some foxes may avoid the road area, but most will probably habituate to traffic. Tracy (1977) found several fox dens within 328 feet (100 m) of the road in Denali National Park and observed foxes traveling along the road while vehicles were using it. However, such habituation to human presence probably occurs only in the absence of trapping pressure. Access routing (Figures E.3.79 to E.3.82) is very near several red fox denning complexes, which, in the absence of mitigation could be made unusable or be physically destroyed.

Access to the Watana site from the Denali Highway has the potential to negatively impact large numbers of beaver. Approximately 65 beaver occupy 12.3 miles (18.4 km) of upper Deadman Creek, a relatively broad stretch along which the access route is proposed. Similar beaver densities may occur in adjacent areas designated as material sites. Use of the valley bottom for the road and material sites will negatively impact at least 40 beaver.

Two opposing scenarios are reported in the literature on possible effects of road construction on beaver habitat. In one (Watson et al. 1973), diversion or impoundment of stream and subsurface water flows by road berms has a negative effect on downstream beaver ponds and lakes through the introduction of heavy sediment loads and increased turbidity. These are the effects of bank instability caused by the clearing of riparian vegetation associated with rights-of-way construction and maintenance. Heavy sediment loads result in the gradual filling of downstream ponds and lakes; increased turbidity reduces light penetration and inhibits growth of aquatic vegetation.

Alternatively, ponding at culverts and bridges and restricted subsurface flows caused by road berms have often created attractive sites for beaver colonization. The use of bridges and culverts as damsites by beaver is well documented (Bradt 1947, Hodgdon and Hunt 1953, Huey 1956, Rutherford 1964, Johnson and Gunson 1976). However, habitat improvement through the introduction of a road in prime beaver habitat along upper Deadman Creek is unlikely, and a reduction in beaver numbers is expected there.

Muskrats along the proposed access routes will be affected through habitat loss and increased trapping mortality. Gipson et al. (1982) found sign of over wintering muskrats in several of the lakes lying along the proposed route from Watana dam to Devil Canyon dam. Many of these muskrats occurred in conjunction with the high beaver densities noted along the proposed route from the Denali Highway to Watana dam.

In addition to being very sensitive to water level changes which could occur because of draining or filling of ponds and lakes (Bellrose and Brown 1941), the small foraging area of muskrats, (usually within 32.8 ft [10 m]) of their house) makes them sensitive to loss of their preferred foods of aquatic and emergent plants (Butler 1940).

No substantial effects are anticipated on mink or otter populations with the possible exception of increased recreational disturbance resulting from public access to streams that may be important to these species.

The major impact of the access routes on furbearers is related to the probable increase in trapping pressure. The Susitna Basin is not heavily trapped at present and, for some species, the area may be a source from which animals disperse into more heavily trapped adjacent areas. The species that will be most affected by increased trapping pressure are probably marten, beaver, muskrat, and red fox. Marten are the most economically important furbearer in the basin; beaver and fox are also heavily exploited in adjacent areas. Mink and otter may be affected to a lesser extent, since they do not appear to be particularly desirable species in this part of Alaska (Gipson et al. 1982).

4.3 - Impacts - Access

(i) Raptors and Ravens

(i) Denali Highway to Watana Damsite

Some nesting habitat for ground-nesting raptors (e.g., merlins, northern harriers, short-eared owls) may occur along the Denali-Watana section of the access road and may be lost; however, cliff-nesting habitat does not appear to occur within at least a few kilometers of the route, and only one tree-nest appears to be associated with it (Roseneau 1982 Personal Communication).

No golden eagles, gyrfalcon, goshawk, or raven nesting locations will be lost as a result of road construction between the Denali Highway and the Watana campsite and Watana damsite.

One bald eagle nesting location (BE-6, see Tables E.3.160 and E.3.162) in Deadman Creek will be physically destroyed by access road construction between the Denali Highway and the Watana damsite. The active nest is located in a balsam poplar tree in a small stand of poplar and white spruce. The current road alignment passes directly through the stand of trees. This stand appears to be the best (and possibly only) potential bald eagle nesting habitat along Deadman Creek.

(ii) Watana Damsite to Devil Canyon Damsite

- Habitat Loss

Some nesting habitat for ground-nesting raptors (e.g., merlins, northern harriers, short-eared owls) and tree-nesting raptors (e.g., merlins, goshawks, sharp-shinned hawks and owls) may occur along the Watana-Devil Canyon section of the access road and may be lost; however, no known cliff-nesting habitat will be lost.

- Disturbance

Two nesting locations, one golden eagle (GE-18) and one raven (R-21), may be susceptible to disturbance from the Watana-Devil Canyon section of the access road. Both are near the western end of the road, within about 0.2-0.3 miles (0.4 km) of the centerline (see Table E.3.160). Furthermore, a bridge will be built across the river about 0.5 miles (0.8 km) downstream from the golden eagle location;

the activity during construction may result in temporary abanonment of this site (see Section 4.4.3[a]).

(iii) Devil Canyon Damsite to Gold Creek

- Habitat Loss

Some nesting habitat for ground and tree-nesting raptors may occur along the proposed railroad access route from Devil Canyon to Gold Creek; however, no known nesting locations will be lost. No known cliff-nesting locations occur in this section of the access road.

- Disturbance

The proposed railroad link between Devil Canyon and Gold Creek will pass about 0.3 mile (0.5 km) southeast across the river from one bald eagle location (BE-8, see Table E.3.160). Considerable disturbance may result from construction activities (Table E3.160) (see Section 4.4.3[a]).

(j) Waterbirds and Other Birds

Impacts of access roads on birds will result from habitat loss and alteration, disturbance from traffic and people associated with the project, direct mortality from both collisions with vehicles and increased hunting pressure, and indirect effects on nesting success because of increased recreational use. The most significant of these impacts vary with species group (Table E.3.166), but for most species, none will be as serious as the impacts resulting from the flooding of the impoundments.

A crude estimate of 2000 breeding birds will be lost because of habitat loss from construction of the access road (Table E.3.166). Largest numerical losses will occur in the following species: tree sparrow (550), savannah sparrow (416), Wilson's warbler (356), and white-crowned sparrow (156).

Habitat alteration will include some opening of the canopy where the road passes through closed forest and shrubland. This may result in a change in species composition of breeding birds. In at least one instance (Jeglum 1975), building of a road that blocked drainage through a portion of the boreal forest has been shown to improve habitat for some waterbirds.

Effects of disturbances from road traffic will probably be minor for most species, but there are few quantitative data to support this argument. In one of the few quantitative studies of disturbance to songbirds, Ferris (1979) reported no differences in breeding bird densities adjacent and distant from 4-lane and 2-lane highways in Maine. He did find a small difference in species composition that was ascribed to edge effects adjacent to the highway.

Some species of low open habitats may be more affected. Van der Zande et al. (1980) found that two and possibly three of the four shorebird species they studied nested at lower densities up to at least 0.67 mile (1 km) from both busy and relatively quiet roads. In some cases, nesting density was reduced by 60 percent. Quantitative studies of species nesting in open habitats in Alaska are not available, but similar effects could occur with ptarmigan, some shorebird species, and some passerine species.

Some birds will undoubtedly be killed by road traffic. Species such as spruce grouse will be attracted to the road as a source of gravel (Carbyn 1968), whereas scavengers, including ravens and possibly eagles, will be attracted by road-killed wildlife. However, mortality from collisions will probably have a lesser effect on gamebirds than will increased hunting pressure. The middle Susitna Basin is relatively inaccessible at present, and it is likely that little game bird hunting occurs there. When road access is provided, hunting will undoubtedly increase and will probably be concentrated along the road. Weeden (1972) found that hunters killed a much larger proportion of ptarmigan within 2624 feet (800 m) of the Steese Highway than farther away. The same would likely be true for other game birds.

Increased recreational use or human disturbance in wilderness areas in other parts of North America has been associated with various behavioral effects, and in some cases with reduced nesting success. Loons and grebes appear to be particularly affected by boating activity. Nesting success in both groups has been shown to decrease with increasing presence of boats and canoes (Ream 1976, Euler 1978, McIntyre 1978). Power boats may also destroy loon nests through wave action (Vermeer 1973).

Recreational activities, particularly in open habitats, may result in nest destruction by predators after incubating adults are flushed. This has been documented for at least two duck species and the Canada goose (Hammond and Forward 1956, MacInnes and Misra 1972). Presumably, similar nest losses could occur in upland tundra species flushed from their nests by all-terrain vehicles or other recreational activities.

(k) Non-Game (Small) Mammals

The proposed access roads to the Susitna dams will traverse a wide variety of small mammal habitats, but will mostly be in shrubland and tundra (Table E.3.84). Although all species of small mammals are expected to be affected to some extent, only the species most affected (those living in shrubland and tundra habitats) will be discussed below. Impacts include increased mortality, impeded dispersal, presence of new habitats, and changes in drainage patterns.

In areas of moist tundra, the gravel berm that will constitute the roadbed will act as a barrier to dispersal of small mammals. Traffic on the road will cause increased mortality in local populations. However, no serious changes in regional population sizes or structures are expected.

The well-drained gravel of the roadbed will provide ideal burrow sites for arctic ground squirrels and singing voles. The revegetated areas on the edges of the gravel berm may also be colonized by meadow or singing voles and some species of shrews.

Portions of the road will likely cause subtle changes in drainage patterns in lateral areas which in turn may result in alterations to vegetation. The types of vegetation that become established will depend on whether water levels increase or decrease as a result of the road. Species composition of small mammals in these areas will shift accordingly, with brown lemmings, bog lemmings, and tundra voles preferring the wetter areas; and red-backed voles, singing voles, and shrews attracted to the well-drained areas.

4.3.4 - Transmission Lines

The construction and operation of the transmission lines associated with the project will impact a wide variety of wildlife. The four segments of transmission lines--Cook Inlet-to-Willow, Healy-to-Fairbanks, Willow-to-Healy (the Intertie), and Watana-to-the Intertie--extend over 350 miles (563 km), traversing habitats ranging from closed forests to tundra (see Table E.3.86. Several types of impacts can be expected, including habitat alterations, disturbance during construction, direct impacts caused by the presence of the transmission lines, and indirect impacts resulting from improved access (see Section 4.3.3).

The cleared width of the corridor will be 300 feet (91.4 m) for 2 towers, 400 feet (121.9 m) for 3 towers, and 510 feet (155.4 m) for 4 towers (Figure E.3.85). Between Watana and the intertie, a 2-tower corridor will be cleared. With the addition of Devil Canyon power, a 2-tower corridor will be cleared from the Devil Canyon powerhouse to the Watana-Intertie line and the existing 2 tower corridor from that junction to the intertie (12.9 km) will be widened to 4 towers. From the junction with the intertie north to Healy, the intertie will be widened from 1 to 2 towers. From Healy, a new tower corridor, paralleling the old corridor, will be cleared to the Ester substation near Fairbanks. From the junction with the intertie south to Anchorage, the existing corridor will be widened from 1 to 3 towers. A map of the transmission corridor route appears on Figure E.3.37. Initial clearing will be done with a hydro-ax or other mechanical equipment. Vegetation will be cut to 6 inches for most of the corridor, as described in Section 3.4.2 and 3.4.3 (Figure E.3.85). Clipped vegetation will be stockpiled, then hauled to another site for burning or disposal. The vegetation will be maintained periodically by repeating these measures.

In general, the transmission corridor will impact local wildlife through disturbance during clearing, which will occur periodically throughout the life of the project and through habitat alteration. Disturbance is most likely to have a serious impact on nesting birds, particularly raptors near the corridor and raptors, small mammals, small terrestrial birds, and waterfowl which may suffer nest destruction within the cleared areas. Larger mammals which are sensitive to disturbance may avoid the corridor during clearing operations in areas where it overlaps their range (see sections below) but are unlikely to suffer any serious impacts. Moose calving concentrations and bear den sites, if they occur in the corridor, would be the most sensitive areas. Vegetation within the corridor will be maintained at early successional stages by periodic clipping. Areas of various vegetation types which will be altered by transmission corridor clearing appear in Tables E.3.35 through E.3.36. This will cause local alterations in home ranges of small species which are restricted to closed forests where they overlap the corridor. Large bodied, more mobile species, will be less affected. Many species will benefit from the vegetation diversity which the corridor will provide. Small mammals (particularly voles) are likely to colonize the corridor and will provide an easily accessible prey for some raptor species. Small birds which will colonize the corridor will also provide accessible prey for raptors. Moose and black bear will also experience positive impacts.

(a) Big Game

(i) Cook Inlet to Willow

The southernmost segment of the transmission corridor, from Cook Inlet to Willow, traverses mostly forest vegetation types (Table E.3.86). The most common community types are closed and open mixed forest and closed birch forest. The big game species that are most likely to be affected by the clearing of these forest types are moose and black bears. Both of these species utilize browse in early-to-mid-successional stands, and would likely benefit from the vegetative communities present in the transmission corridor after clearing (Scotter 1971, Lindzey and Meslow 1977). There are little data quantifying the effects of such clearings in terms of population productivity, but the general conclusion is that transmission line clearing should increase carrying capacity for moose and black bears (Sopuck et al. 1979).

The disturbances caused by human activities during construction will be temporary effects. Most big game animals will relocate during the construction phase, but are expected to return once construction is completed (Commonwealth 1982). Serious impacts are expected only if clearing and construction occur near moose calving grounds or bear denning sites. Disturbance of animals at such sites could cause decreases in productivity. The increase in human activity in the area between Willow-Cook Inlet during the construction of the transmission line is unlikely to affect regional distribution of big game species. This area is already subject to high levels of human activity. The most abundant big game species--moose and black bear--are fairly tolerant of human disturbance; those species easily disturbed (i.e., wolf, wolverine, brown bear) are already rare in the area.

(ii) Healy to Fairbanks

The transmission line right-of-way in this area will traverse mostly open spruce forests, along with mixed low shrub, open mixed forest, and open deciduous forest (Table E.3.86). In all cases, community types that will be affected by clearing operations are widespread and abundant in the area.

Impacts are expected to be similar to those discussed in the Cook Inlet to Willow section above. Most of the direct impacts will occur during the construction period, when disturbance will cause big game species to relocate. After construction, moose and bears are expected to benefit from the early successional communities along the corridor. The other big game species are uncommon in this area.

(iii) Willow to Healy

The transmission corridor from Willow to Healy (the intertie) will have to be widened to accommodate the power from the Susitna project. Most of the intertie is located in forest types: bottomland, lowland, and upland spruce-hardwood forests (Commonwealth 1982).

The additional clearing required will affect local populations of moose, caribou, Dall sheep, brown bears, and black bears. Animals that relocate because of disturbance from construction activities can be expectedto return.

Most of the major impacts associated with transmission corridors (discussed in the preceding sections) will already be effective because of the existence of the intertie. Thus, the modification required for the Susitna project is not expected to increase access, hunting, or long-term human disturbance levels.

(iv) Watana Dam to the Intertie

The transmission corridor from Watana dam to the intertie traverses mixed spruce-hardwood forests and brush communities, paralleling the road and railroad access routes (Table E.3.85). Clearing required in forested areas will probably have a beneficial effect on black bear and moose.

(b) Furbearers

Furbearers will be affected by construction of transmission lines caused by habitat alteration and increased trapping pressure resulting from improved access. Although it has been shown that clear-cut areas are not a barrier to travel by short-tailed weasel, least weasel, mink, marten, or other mustelids, cleared areas are usually not used for hunting (Soutiere 1978), and some furbearers may avoid disturbed areas. Forested areas offer better sub-nivian hunting conditions because the bases of trees, logs, and windfalls provide numerous entry points (Koehler et al. 1975). Forested habitat supporting approximately 6 marten (see winter model, Section 4.3.1 [m]) will be cleared for the transmission corridor.

Foxes and coyotes are sometimes attracted to cleared areas as movement corridors (Penner 1976). Both foxes and coyotes may benefit from the removal of forest vegetation, since they feed heavily on microtine rodents.

Transmission lines will increase access for trappers and could result in local population reductions of some furbearers, particularly in presently remote areas. Marten and beaver will probably suffer the greatest impact, since they are currently the target of most trapper effort.

The impact of trapping on coyote, red fox, and lynx will probably be less severe, since they are wider ranging than the smaller mustelids. Least weasels, short-tailed weasels, and mink have historically received little trapping pressure.

(c) Birds

The construction and operation of the transmission corridors will affect birds mostly as a result of changes in vegetation height, disturbance during initial construction and maintenance, and the electrocution or collision mortality of large raptors and swans from transmission wires. Since much of the transmission corridor passes through forest, forest species will be replaced by birds of shrub and open habitat. Species diversity may also change (see Section 4.3.1 [p][i] - Habitat Alteration.

Currently, there are no transmission lines in the vicinity of the project (the nearest comparable lines occur between Anchorage and Willow, and between Healy and Fairbanks). Although no studies have been conducted and no data are currently available regarding incidents of bird collisions or electrocutions with these transmission lines, shorebirds have collided with various kinds of guy wires in western coastal Alaska during foggy weather (Gibson 1982 personal communication), and collisions of birds (especially waterfowl) with overhead ground wires have been documented elsewhere in North America (James and Haak 1979). Among waterfowl, swans are particularly susceptible to collisions with power lines (Avery et al 1980). In general, bird collisions with transmission lines are difficult to prevent (marking lines may minimize collisons to some extent), but also tend to be biologically insignificant (James and Haak 1979).

Birds of prey are susceptible to electrocution as a result of perching on the structures (Harrison 1963). Electrocution is the greatest potential impact of power lines on both raptors and ravens. However, the selected transmission tower and line configuration is such that little possibility for bird electrocution exists. However, the possibility of electrocution still exists along the single 34 kv construction transmission line to be built from Cantwell to Watana via the Denali Highway. Larger size is the greatest factor affecting species vulnerability to electrocution (Oldendorff et al. 1981). Consequently, golden and bald eagles are the most susceptible of the raptors inhabiting the area being considered. In addition, immature or subadult eagles are more susceptible to electrocution than adults. Buteos (e.g., red-tailed hawk and rough-legged hawk) are also vulnerable, but accipiters (e.g., goshawk and sharp-skinned hawks) and even the larger falcons (e.g., peregrines and gyrfalcons) are rarely electrocuted (Olendorff et al. 1981).

Only one known raptor nest occurs near the proposed transmission route, but this nest is of special concern because it was once occupied by peregrine falcons, an endangered species. The nest occurs along the Tanana River on the east side of the corridor between Healy and Fairbanks. This nest was first discovered in the early 1960s, but was inactive in the early 1970s (Roseneau 1982 personal communication). It was checked by the U.S. Fish and Wildlife Service in 1982 and was also inactive that year (Amaral 1982 personal communication). 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 line construction, however, it will most likely be acceptable for later use during the operational phase of the the line. If necessary, the transmission line in this area could be constructed during a time period that would reduce the likelihood 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 affected.

4.3 - Impacts - Transmission Lines

Potential disturbance to bald eagles as a result of construction and maintenance of the intertie line between Willow and the Gold Creek Switching Station will probably be minimal because the majority of the known nesting locations and nesting habitat occur along the banks and on the islands of the Susitna River (Table E.3.129). However, at least three nesting locations occur 1 mile (1.6 km) or less from the corridor, and verifications of more accurate distances will be made to identify locales where mitigation may be necessary. Although no nests of bald eagles are known to occur in the immediate vicinity of the corridor centerline, some potential bald eagle nesting habitat may be lost as a result of clearing balsam poplar and white spruce trees in some sections of the proposed line.

Potential disturbance will be minimal to golden eagles and gyrfalcons as a result of construction and maintenance of the intertie line between the Gold Creek Switching Station and Healy. No known nesting locations or nesting cliffs occur in the valley bottom along the proposed route. All known nests and nesting habitat are at elevations well above the valley floor. Although no nests of bald eagles are known to occur along the route north of the mouth of Indian River, some nesting habitat may be lost as a result of clearing poplar trees in some areas between Chulitna, Butte, and Hurricane.

Minimal disturbance of raptors and ravens in the study area is anticipated as a result of construction of the high voltage transmission lines between the Watana dam and the intertie. Only one golden eagle and two raven nesting locations may be susceptible (GE-18, R-13, and R-21; see Table E.3.160). Potential for disturbance as a result of summer construction would be greatest at GE-18 and R-21 if these nesting locations were active in the year when construction occurred. However, this potential impact, although additive, is considered far less severe than the longer term potential impacts associated with nearby dam construction upriver and bridge construction and associated traffic downriver from GE-18 and R-21.

Table E.3.71.5 indicates an order-of-magnitude of 655 of 1,200 small to medium-sized breeding birds lost to the transmission line, less than 0.1 percent of the population within 16 km of the Susitna River between the McLaren River and Gold Creek.

(d) Non-game (small) Mammals

The transmission lines for the Susitna project will traverse a wide variety of small mammal habitats. These transmission corridors will be cleared of trees and tall shrubs. Because most small mammals are ecotone species, they are expected to benefit from the edge effects created by the clearings. One example is the snowshoe hare, which relies on dense black spruce forests for cover, but prefers more open areas for forage (Kessel et al. 1982a). Overall, transmission corridors are not expected to adversely impact small mammals.

4.3.5 - Impact Summary

This section summarizes those impacts on wildlife populations predicted to be of sufficient magnitude to influence mitigation planning. The emphasis is concentrated on what are considered to be the most serious impacts to wildlife population levels; both positive and negative impacts are discussed.

Whether impacts to wildlife are judged to be positive or negative depends on the perspective of judgment. For example, increased access by hunters and trappers usually depresses population levels of big game species and furbearers. But at the same time, increased access has the potential to increase the long-term yield and value of this wildlife to consumptive users.

Herein we address impacts only from the perspective of the wildlife populations *per se*. An increase in wildlife abundance or production is a positive impact; a decrease in wildlife abundance or production is a negative impact. Project actions known or speculated to cause measurable changes in project area wildlife population or production levels are discussed, but those actions thought to cause negligible or no changes are not.

(a) Big Game

The big game populations expected to be affected by the Susitna project are moose, black bear, brown bear, wolf, wolverine, Dall sheep, and caribou. The main effect on these species will be through habitat loss by inundation, interference with movements, habitat alteration, disturbance, collision mortality, increased necessity for killing nuisance animals, and increased access afforded to hunters.

Moose will be most severely affected by habitat loss caused by inundation of spring and winter range. In winters of relatively light snowfall (i.e., less than 30 inches), approximately 300 moose occur in the impoundment zones. A preliminary estimate of winter carrying capacity for the

Watana impoundment zone is 301 resident moose (see Appendix 3.H). However, when snow depths exceed 30 inches, much higher numbers of moose are expected to move to the impoundment zones (ADF&G 1982a). The effects of habitat loss on moose are being addressed through continuing studies and through the development of a habitat-based model of carrying capacity.

Moose displaced from the impoundment zones will compete for food and space with other moose. The consequences of this competition could seriously reduce the carrying capacity of adjacent range with potential long-term effects on mortality rates, predator populations, and natality. The computer model being developed will be used to determine whether adjacent areas can support these additional moose (see Section 4.3.1[a][iii] and Section 4.4.2[b] Mitigation Plan 6. Borrow sites, camps, and the airstrip at Watana will remove winter habitat for about 37 moose. These areas will revegetate after construction, but plant growth where topsoil has been removed will be very slow. Transmission corridors contain browse supplies that will support 47 moose for 180 winter days. The growth of vegetation between years of vegetation maintenance (clearing) will compensate for the loss just after clearing.

The reduced summer flows and increased winter flows will alter the distribution of floodplain communities downstream from Devil Canyon. When Watana only is operating, the width of the unvegetated floodplain between Devil Canyon and Talkeetna will increase, but with both dams, some of the floodplain will be recolonized by vegetation. The open water in winter from Devil Canyon to Talkeetna (both dams) will make much of this vegetation unavailable because moose will not cross the open water to islands and heavy frosting will cover vegetation near the river. Changes downstream from Talkeetna cannot be predicted because vegetation patterns will be influenced by snow depths each winter, by the speed of spring breakup, by flow releases as they are affected by power demand, and by river morphology along the various reaches. Because large numbers of moose (over 1000 in 1982) move to the lower river floodplain, small changes in vegetation patterns could have an adverse affect.

Disturbance and altered movement patterns are unlikely to have detectable population-level effects. Some calving areas (on islands downstream from the project area to Talkeetna) may become unavailable because of open water. However, moose are capable of altering habitual movement patterns to adapt to such changes in range, and no long-term population-level effects are anticipated to result from construction-related disturbances or altered movements.

The consequences of increased moose mortality caused by impoundment hazards, collisions with trains and vehicles, and increased predation levels are being explored through the use of computer modeling. These factors alone are likely to have a much lesser effect on moose than will habitat loss. However, their cumulative effects with habitat loss and reduction in carrying capacity of adjacent range may be severe.

The Nelchina caribou herd will be most affected by interference with movements across the impoundment zone and access road. At the current herd size, no population-level effect is likely to be detected during the construction period. but the access road may block the movements of 90 percent or more of those caribou which may attempt to cross, thus isolating the mountains north of the river and west of the road from the remainder of the herd's range. As the herd increases, the importance of this historically used range will increase and the loss of areas to the west of the road may decrease the carrying capacity of the range by up to 10 percent. Caribou cows with calves may avoid the road, but no direct effect on productivity or survival of calves is expected.

The Devil Canyon impoundment and transmission lines will have little effect on caribou. The Watana impoundment, however, will alter caribou movements and may result in crossing mortalities because of hazardous ice conditions or floating debris. The potential for increased mortality cannot be predicted, since ice conditions will vary each year and the number of caribou crossing the impoundment as the herd expands is unknown.

Increased recreational use of the area may become a severe impact. The calving area and summer range of females with calves would be most sensitive. Heavy use of widespread areas by all-terrain vehicles would also seriously reduce carrying capacity through vegetation damage. Although no quantification is possible, the cumulative effects of intense and unpredicable recreational disturbance on the historically used calving ground and the potential loss of some portions of the range due to blocked access in concert with increased mortality during migration across the Watana impoundment may constitute a severe impact.

4.3 - Impacts - Summary

The ADF&G has expressed concern that impacts with no measureable effect on current population levels may nonetheless further reduce the ratio of harvest to demand, which is already low, by eliminating the option to allow a substantial increase in herd size for that reason.

Dall sheep will be affected primarily by partial inundation and disturbance at the Jay Creek mineral lick. Disturbance anticipated is mostly recreational, both during and after the construction phase, and from low-flying aircraft. The consequences of sheep abandoning the Jay Creek lick are unclear. Several other licks occur within the range of the Watana Hills population, but because sheep show high fidelity to particular areas, it is not known if these licks would replace Jay Creek.

Brown bears will lose important spring feeding areas to the impoundment zones and will also be adversely affected by lower numbers of moose. Sows with cubs do not use the impoundment zones but about half of the remaining radio-collared bears moved there in spring during recent studies. During the construction phase, a number of bears may be killed for safety reasons or may die after being disturbed from winter dens by people on the ground or in low-flying aircraft. In addition, bear/human conflicts have a great potential to cause significant loss of work time for contractors, injuries to employees, and property damage. No denning areas will be flooded by the impoundments.

The reservoir may alter the movements of brown bears between seasonally important food sources, particularly when floating ice or debris are present. Because the relationship between brown bear foods and population levels is poorly understood, the impact of the project on brown bear carrying capacity cannot be predicted. The effect of reductions in salmon spawning between Portage Creek and Talkeetna similarly cannot be predicted.

Management strategies and priorities beyond the control of the Power Authority will determine to what extent hunting and poaching become severe mortality sources. Historically, brown bear have been sacrificed to the benefit of ungulate species more desirable to subsistence users by management guidelines.

Black bears will be severely affected by the project, primarily as a result of inundation of denning and feeding habitat upstream from Tsusena Creek. The Watana reservoir will inundate approximately 69 percent of the denning habitat occurring in that area (black bears are restricted to the band of forest along the river), whereas about 6 percent of the denning habitat in the Devil Canyon reservoir vicinity will be lost. Additional denning areas will be impacted by road and transmission line construction. The resident population of about 30-50 bears between the Tyone River and Tsusena Creek will probably be eliminated. Bears residing downstream from Tsusena Creek may also be affected by project facilities near Watana interfering with movements upstream in summer. As discussed for brown bear, the effects of possibly reduced salmon runs downstream from Portage Creek and disturbance from recreational users during salmon runs on the black bear population cannot be quantified. Cumulative impacts of mortality from hunting increased encounters with brown bears and bear/human conflicts in concert with loss of denning and feeding habitats due to facilities and disturbance will greatly reduce the black bear population in the middle basin.

Wolf populations are currently controlled by human harvest levels (much of it illegal), and the reduction in moose numbers will not be a major factor under these conditions. Improved access in the project area may result in even heavier exploitation of wolves. If wolf survival greatly increases because of better enforcement and management, the lower prey base may affect as many as 10 wolf packs in the project area. The Watana pack will be seriously reduced and possibly eliminated due to loss of hunting areas and reduced moose populations. Immediately following filling of the Watana reservoir displaced moose will be more vulnerable to predation. Impoundment hazards and the advantages conferred on predators along the impoundment shoreline will also act to increase the availability of prey. However, the long-term effects of the impoundment are more likely to result in a reduced availability of prey for the Watana pack. Winter availability of caribou to individual wolf packs varies year to year. However, no net decrease in availability of caribou to the wolves of the middle basin is anticipated. The above discussion of caribou trials the elimination of a management option for substantially increasing herd size to allow greater satisfaction for subsistence users. Although this also eliminates the option of substantially greater wolf populations, those management goals would conflict with this eventuality anyway. The extent to which increased access and use of the middle basin reduces wolf populations depends almost entirely on management priorities of the Alaska Department of Fish and Game and is beyond the control of the Alaska Power Authority. Because wolves are uncommon downstream from Devil Canyon, changes in moose numbers there are unlikely to have any effects.

Wolverine will be affected primarily by improved access for trappers. Habitat supporting about two wolverine will be lost to the project. Additional temporary loss of habitat due to both construction related and recreational disturbance is possible but likely to affect only small areas of the territories of a few individuals. Higher turnover rates hypothesized for moose populations would result in increased availability of carrion. Overall, changes in wolverine populations will be difficult to detect due to naturally low density and dispersal from surrounding productive habitat.

Belukha whales will not be measurably affected by the project at any time of the year.

(b) Furbearers

Overall, beavers are expected to benefit from the project because of regulated flows in downstream reaches, but local populations will be adversely affected during road and dam construction, and many will be vulnerable to increased trapping because of improved access. Approximately 40 beavers now occupy sections of Deadman Creek designated as borrow sites for road construction. No beavers reside in the impoundment areas, but the lakes in and adjacent to Borrow Site K at Devil Canyon support approximately 10 beavers. There are approximately 25 beavers along Jack Long Creek; these beavers could be adversely affected by increased siltation or clearing of riparian vegetation during construction of the railroad and staging area. In total, about 75 beavers will be lost to the project during its construction. It is not known if improved habitat downstream will compensate for this loss without enhancement.

Habitat improvements anticipated for beaver in downstream reaches include: an increase in availability of suitable overwintering sites caused by increased flow (i.e., deeper water preventing freeze out), greater stability in anchoring food caches due to stabilized flows, and availabililty of shallower sites than are currently used for overwintering because of open water. A beaver habitat model is being developed to assist in impact assessment and mitigation planning. This model incorporates data on river flows, water temperatures, depth of water under the ice, vegetation, bank substrates, and beaver populations with various flow releases and trapper effort.

4.3 - Impacts - Summary

The project will have an insignificant effect on muskrat, except that improved access may result in overtrapping of some areas. No muskrat occur in lakes to be used as borrow sites or other facilities, but 5 lakes within the impoundment zone (on lower Watana Creek) are occupied by muskrats. Approximately 5-10 muskrats will be lost because of impoundment filling and construction. Improved habitat for beaver downstream from the dams will also have a beneficial effect on muskrat, and should easily compensate for the minor loss of habitat within the impoundment.

Mink and otter will be adversely affected by clearing and inundation of the impoundment areas, removal of road- building materials from Deadman Creek and wetland areas, and by increased trapping pressure. Both mink and otter are somewhat sensitive to disturbance and may suffer significantly from increased presence of fishermen and recreational users in remaining river habitat. Assuming that all habitat along the mainstem upstream from Gold Creek and its tributaries supports equal densities of mink and otter, about 21 percent of the river and stream habitat of these species will be lost. Few impacts on lakes and ponds will occur. Regulated flows are expected to improve downstream habitat for these species, and the stable water level on the Devil Canyon reservoir during most of the year will probably allow these species to reside there.

All upland furbearer populations are expected to decline for two main reasons--inundation of portions of their habitats by impoundments, and increased trapping pressure caused by easier trapper access.

Coyotes are uncommon upstream from Devil Canyon and are likely to remain so; the impact on this species will be negligible throughout the project area. Increases in numbers of coyotes would be anticipated only if wolves are severely reduced or eliminated. Red foxes will be adversely affected by loss of habitat in the impoundment area, habituation to human activity along the roads and at camps and landfills, and by increased trapping pressure. The access roads occur within 0.5 mile of several large red fox denning complexes, and local overharvesting of foxes may occur. Because foxes den and feed primarily at elevations above the impoundment level, major population effects due to habitat loss are not anticipated. Direct mortality caused by trapping and the killing of nuisance animals is likely to have a significant population level effect.

Marten will be the most severely affected furbearer species. Habitat supporting approximately 100 marten will be lost to the Watana reservoir; the Devil Canyon reservoir contains habitat supporting about 21 marten; and forested areas supporting about 6 marten will be cleared for transmission corridors. In total, habitat supporting approximately 130 marten will be lost to the project. Although improved access may allow a higher trapping yield from the remaining population, local overharvesting of marten in some areas may occur. Major impacts on lynx, short-tailed weasel, and least weasel are not expected.

(c) Birds and Non-game Mammals

Birds will be affected primarily by habitat loss to inundation and disturbance of nests. Sixty-three to sixty-eight percent of the known raptor cliff-nesting locations in the middle and upper basins and 70 percent of the known raptor tree-nesting locations will be affected by the project. This includes over half of the golden eagle nests, 75 percent of the bald eagle nests, 33 percent of the gyrfalcon nests, and 66 percent of the known goshawk nests (Table E.3.160). Raptors downstream from Gold Creek will not be affected, except in a few cases where construction of transmission lines disturbs raptors at their nests. Small numbers of raptors may be lost as a result of electrocution along power lines.

Waterbirds of lacustrine habitats will suffer only minor impacts, since only 38 ha of lakes and ponds will be flooded. Trumpeter swans which nest on lakes near the project area may be adversely affected by low-flying aircraft. Most swan nests are some distance to the east of project facilities and no disturbance is anticipated. Birds of fluviatile habitats will suffer a significant loss of habitat. Breeding habitat for spotted sandpiper, mew gull, harlequin duck, common and red-breasted merganser, semipalinated plover, wandering tattler, and arctic tern will be lost. Additional losses of breeding habitat in forests will occur for goldeneyes and lesser yellowlegs. Sandbars, islands and riparian shoreline areas used for feeding, roosting and loafing by shorebirds will be flooded. River and stream flooding habitat for breeding dippers, mergansers, harlequin ducks and goldeneyes will be lost. Although the middle basin is not a migration corridor, the open water areas within the impoundments will be used for leafing by early migrants before other waterbodies are open. The drawdown zones will be used as loafing habitat for migrant shorebirds, but food availability will be low. The impoundments are likely to offer very few food resources to migrants or residents, although low densities of fish and invertebrate prey will be present. Open-water areas downstream from the dams may benefit migrant waterfowl and shorebirds and provide winter habitat for the dipper. Although the large impoundments will greatly increase in surface area of water in the middle basin, the drawdown of the Watana reservoir will minimize its importance as lacustrine habitat. The Devil Canyon impoundment will be more appropriate lake habitat, although recreational boating will limit its use for shoreline nesters.

Populations of small and medium sized birds within 16 km of the Susitna River between the McLaren River and Gold Creek will be reduced by 5 to 17 percent for most species and the total number of breeding terestrial birds lost will approach 103,000. Proportionate losses are greatest for birds restricted to forest habitats, and over 12 percent of the populations within 16 km of the river of the following species will be lost: spruce grouse (16 percent), hairy woodpecker (16 percent), northern three-toed woodpecker (12 percent), brown creeper (16 percent), varied thrust (12 percent), Swainson's Thrush (12 percent), yellow-rumped warbler (13 percent), and northern waterthrush (16 percent). Largest numerical losses will be for species which are found at high densities in a range of vegetation types: yellow-rumped warbler (13,020), tree sparrow (10,112), dark-eyed junco (7,990), Swainson's Huush (7,062), Wilson's warbler (6,760), savannah sparrow (6,150), fox sparrow (6,060), and white-crowned sparrow (5,992). Habitat alteration will affect the distribution and abundance of species, again with birds restricted to closed forest habitats suffering losses, while species associated with edge disturbed, or artificial habitats will benefit. The increase in amount of edge may increase species diversity and density in localized areas. Bank and cliff swallows and kingfishers will experience increases in availability of nesting habitats. Ravens and gulls are likely to increase in numbers in the basin, particularly if refuse dumps are not adequately maintained.

Only those species of small mammals which are restricted to forest habitats are expected to experience a decrease in regional abundance. Porcupines, snowshoe hares, pygmy shrews and red squirrels will be most affected. Although they are found in nearly every vegetation type in the Watana area, red-backed voles are most common in spruce and cottonwood forests and will suffer a decrease of up to 5 percent in the basin population. Meadow voles may actually increase in the basin due to the appearance of disturbed and reregulated areas. The major impact of the projects on small mammals will be local alterations in the distribution and abundance of species.

4.4 - Mitigation Plan

This mitigation plan has been developed for impacts likely to have population-level effects on important species in accordance with the approach outlined in Sections 1.2 and 1.3. As discussed in those sections, mitigative measures have been prioritized as follows: avoidance, minimization, rectification, reduction, and compensation. Avoidance and minimization of impacts are best achieved by incorporating environmental criteria into preconstruction planning and design and by modifying certain construction practices. In many cases, measures to avoid, minimize, or rectify impacts to wildlife are identical to the preferred measures for mitigating impacts to botanical resources. The mitigation plan for botanical resources (Section 3.4.2) discussed modifications to engineering design and construction planning for environmental reasons, such as changes in the alignment of access roads and transmission corridors; avoidance of certain riparian areas for gravel extraction, consolidation, and resiting of certain project facilities; and rehabilitation of temporary construction sites. Since botanical resources assume their greatest importance as wildlife habitat, the wildlife and botanical resources mitigation plans complement each other. Measures discussed in the botanical resources plan that also apply to wildlife mitigation are repeated only in appropriate cases.

Field studies sponsored by the Power Authority are continuing to refine and quantify the results from three years of baseline and impact research. As additional information from these continuing studies becomes available, certain concepts contained in this mitigation plan will be refined to specify the number, location, and design of mitigation features.

The impact summary (Section 4.3.5) describes the impacts and criteria used to identify impacts requiring mitigation. Impact issues are treated here in three categories: (1) impact mechanisms resulting in reduction in carrying capacity; (2) impact mechanisms which increase mortality, thereby altering population structure and the ability of populations to recover from other secondary impacts or natural mortality phenomena; (3) disturbance. Impact issues defined in Section 4.3 as habitat loss, habitat alteration, and barriers to movement represent effective habitat loss and are treated as mechanisms resulting in reduced carrying capacity. An analysis of mitigation options is presented for each species or group for each mechanism. Separate mitigation plans are then presented which may apply to an individual species or group (Section 4.4.2). A cost analysis and schedule for mitigation appear in Section 4.4.3, and Section 4.4.4 documents all agency recommendations for mitigation.

4.4.1 - Impact Issues and Option Analysis

The following discussion presents an analysis of mitigation options for each impact. The options to be implemented are detailed in Section 4.4.2, and an analysis of residual impacts with the chosen mitigation plans appears in Section 4.4.3.

(a) Reduction in Carrying Capacity

(i) Moose

Project impacts on upstream habitat will reduce carrying capacity through inundation of spring and winter range. Approximately 37,502 acres (15,177 ha) of vegetated habitat will be permanently lost to facilities and impoundments for both projects. This represents winter habitat for 302 moose based on carrying capacity estimates presented in Table E.3.92 and Appendix 3.H. The winter carrying capacity of the Watana permanent facilities is 266 moose; that for Devil Canyon is an additional 36. Additional habitat alteration due to temporary facilities and borrow sites (4532 acres [1875 ha]) will bring the total affected area to 42,135 acres (17,052 ha) in the immediate vicinity of the impoundments. The total carrying capacity of these areas is 340 moose. The no- project option is the only means of avoiding this impact.

The impoundment zones may be important as a source of early spring foods and as calving areas, and also as winter range for moose (ADF&G 1982a). Their loss could be temporarily avoided by delaying clearing of the impoundment areas. However, the impoundment zones must be cleared to avoid producing large quantities of timber debris on the reservoirs. Habitat loss because of clearing could be minimized by: (1) scheduling clearing as close to reservoir filling as is feasible; (2) leaving relatively large "islands" of riparian vegetation uncleared; and/or (3) clearing only trees and tall shrubs, leaving the browse species preferred by moose.

To reduce vehicle traffic and impacts to other areas, it is preferable to burn the cleared vegetation in place rather than to transport it to some other area. In order to retain browse vegetation, the slash would have to be burned in piles (rather than a broadcast burn). The increased use of machinery required for piling may offset the benefits of preferential clearing of trees and tall shrubs.

4.4 - Mitigation Plan

Temporary facilities during construction will remove approximately 4532 acres (1875 ha) of vegetated habitat. Avoidance is possible only by the no-project alternative. Minimization is possible by using side-borrow techniques for road construction, which will reduce the number of borrow sites, and by depositing spoil in the future impoundment areas or in depleted borrow sites. (This is discussed more fully in Section 3.4.2.[a][i].) Further minimization is possible by consolidating facilities. Rectification is possible through revegetation (Section 3.4.2[a][i]).

The village and impoundments will permanently remove about 37,502 acres (15,177 ha) of vegetated habitat. These facilities are essential to the project, and thus, this loss can be avoided only by not building the project. No measures to rectify or reduce this impact are feasible, and therefore, only compensation is feasible for mitigation.

Clearing of vegetation in the transmission corridor will result in habitat alteration. This alteration cannot be completely avoided because some clearing is necessary to permit construction to minimize maintenance costs and to permit rapid restoration of power in case of line breakage. Minimization could be accomplished by aligning the corridor through tundra types where possible and by designing the corridor to leave as much shrub vegetation as possible. Compensation for clearing could be provided by allowing shrubs and trees to grow between maintenance clearing, which would maintain the corridor in early seral stages preferred by moose.

Moose displaced from the impoundment zones during construction and filling will compete for food and space with moose in adjacent areas. This may result in overbrowsing of areas adjacent to the impoundments and subsequently affect additional moose outside the impoundment areas. This impact would be avoided by managing the moose population through a controlled hunt of moose in excess of the carrying capacity.

It is unclear whether regulated flows will result in a net increase or decrease in the amount of browse available to moose in the Susitna floodplain downstream from the Devil Canyon dam. However, because the lower basin may support very high densities of moose in some winters, a small decrease in browse availability could affect a large number of moose. Additional impacts on browse availability and quality will result from blockage of movements by open water between Devil Canyon and Talkeetna and possible frosting of adjacent browse.

No measures are available to avoid this impact. Minimization is possible through regulating river temperature to maintain nearly normal ice conditions in the lower reaches of the river. Rectification may be possible through controlled flow releases, river training structures, and enhancement techniques. Additional compensation will occur because of the increased availability of winter browse which will result from the construction and maintenance of the transmission corridor. Much of the route is adjacent to the river and will provide winter browse in areas adjacent to those in which browse could be lost.

(ii) Caribou

The likelihood of a reduction in carrying capacity caused by blockage of movements by the Watana impoundment is unknown and undeterminable at current population levels. If such an effect were demonstrated, compensation would be the only feasible mitigation alternative.

The physical presence of the access road and the vehicle traffic and other human activities associated with it will interfere with the movements of caribou, particularly in the Denali Highway to Watana section. Avoidance of the road or failure to cross it would result in habitat loss and decreased carrying capacity of the project area for caribou.

This impact cannot be avoided except through the no-project alternative. Minimization is possible through realignment to avoid the center of the calving ground and through design changes to minimize physical and visual impacts (i.e., side-borrow construction). Further minimization would be possible by regulating traffic on the road and by reducing dust. No rectification is possible. Compensation would be required if the access road is shown to affect the size, productivity, or distribution of the Nelchina herd.

(iii) Dall Sheep

Partial inundation of the Jay Creek mineral lick and blockage of access to the lick may reduce carrying capacity of the area for Dall sheep. Up to 42 percent of the surface area of the Jay Creek mineral lick will be inundated each year by the Watana impoundment. Only 22 percent will be under water during May and June when sheep use of the lick is greatest. It is not known whether water in the reservoir will leach minerals from the lick soils and reduce the value of the annually inundated portion to sheep. However, the reservoir may interfere with the movements of sheep between the west and east side of the creek.

No avoidance, minimization, rectification, or reduction is possible. Compensation may be provided by exposing new mineral soil at the lick site to replace that possibly lost to leaching.

(iv) Brown Bears

Impoundment clearing is necessary to eliminate debris on the impoundment surface. The clearing of the impoundment zone and permanent facility areas will reduce the carrying capacity of the project area for bears by eliminating spring feeding areas and other habitats. Loss caused by clearing could be minimized (as described for moose above) by: (1) scheduling clearing as close to reservoir filling as feasible, and/or (2) leaving large "islands" of riparian vegetation uncleared.

Temporary facilities increase loss of habitat, but no avoidance is possible. Minimization is possible through use of side-borrow techniques for road construction which reduce the number of borrow sites and by depositing spoil in the future impoundment or in depleted borrow sites. Further minimization is possible by consolidating facilities. Rectification is possible through revegetation.

Permanent habitat loss can be avoided only through the no-project alternative. No measures to minimize, rectify, or reduce this impact are feasible, and therefore, compensation is the only mitigation alternative.

A reduction in salmon spawning between Portage Creek and Talkeetna has been identified as a possible factor which would reduce carrying capacity for brown bear. This impact will be avoided through maintenance of downstream sloughs for salmon spawning (see Section 2.4.4 [a]).

A reduction in ungulate prey is also hypothesized to reduce carrying capacity for brown bear. Mitigation measures proposed for ungulate populations will avoid, minimize, or compensate for this impact.

A possible secondary impact of the project on brown bear is displacement from the Prairie Creek area, a bear concentration area during salmon runs. Project access roads may accelerate mineral and recreational developments in this area, making conflicts with bear use of this resource occur sooner than they would in the absence of the project. This impact could be reduced through cooperative management of development and access by the Power Authority and resource agencies.

(v) Black Bears

Impacts of impoundment clearing, temporary facilities, permanent habitat loss, and reduced prey availability are similar to those for brown bear, treated above. Residual impacts to be treated through compensation are much greater for black bear than for brown bear for both denning and feeding habitats (see Section 4.3.1 and 4.3.2).

Clearing of vegetation in the transmission corridor will also result in habitat loss. Some clearing is necessary to facilitate construction and maintenance and to permit rapid restoration of power in case of line breakage. Minimization could be achieved by aligning the corridor through tundra types where possible and by designing the corridor to leave as much vegetation as possible.

Additional habitat loss will result from the access corridor and interference of Watana facilities with upstream movements (see Section 4.3.1). Disturbance may also make some denning habitat unsuitable. No avoidance is possible for these impacts. Alignment of the road away from spruce forest habitats would minimize habitat loss. No other minimization, rectification, or reduction is possible. Compensation is the only alternative mitigation.

(vi) Wolves

Loss of hunting areas will reduce carrying capacity for wolves mostly through reduced prey availability. Mitigation measures proposed for ungulate populations will avoid, minimize, or compensate for this impact.

(vii) Wolverine

Loss of winter foraging habitat will reduce carrying capacity for wolverine through reduced availability of prey. A detectable change in populations is unlikely. Avoidance is not possible. Minimization through consolidation of facilities, spoil disposal in the impoundment, and side-borrow techniques is possible. Some compensation may occur through an anticipated increase in availability of carrion due to hazards created by the impoundment, access roads, and other facilities.

(viii) Beavers and Muskrat

The impoundments, facilities, and access road will remove habitat for approximately 75 beaver and 5-10 muskrat. The impact cannot be avoided except through the no-project alternative. Partial avoidance is possible through realignment of the access road route and design changes to reduce the area disturbed. Additional loss may be avoided by using only borrow sites D, E, I, J, and K and obtaining access road material from small upland sites rather than from Deadman Creek. Some compensation will occur through improved habitat downstream from the dams.

(ix) Mink and Otter

Riverine habitat will be inundated and some stream habitat along Deadman Creek will be lost to the access road. Partial avoidance is possible through realignment of the road and design changes to reduce the area disturbed. Additional loss may be avoided by obtaining road material from outside Deadman Creek. Some compensation will occur through improved habitat downstream from the dams.

(x) Marten

Forest habitat supporting approximately 130 marten will be lost to the impoundments access and transmission corridors. Selective clearing and narrowing of the transmission corridor could reduce the impact to marten by allowing free movements across the corridor. Marten movements are inhibited by open areas (see Section 4.3.4). No further avoidance, minimization, rectification, or reduction is possible for loss of preferred conifer forest habitat. Further mitigation would require compensation.

(xi) Raptors and Raven

Ravens are not limited by nest sites and are not anticipated to require any specific mitigation measures.

Clearing and filling of the impoundment will destroy the following nesting locations of raptors: 3 bald eagle, 2 goshawk, 7 golden eagle, and 1 gyrfalcon. An unknown number of other cliff- and tree-nesting locations for owls and small hawks will also be destroyed. Loss of tree-nesting locations will occur during impoundment clearing, and could be temporarily avoided by leaving nest trees (and adjacent perch sites for bald eagle).

The actual number of breeding pairs of golden eagles affected will be 4 or 5, as some of the nesting locations are alternate nest sites and unlikely to be used simultaneously. Most of the suitable cliff-nesting habitat upstream from the Watana dam will be lost. Total avoidance of this impact is feasible only through the no-project alternative. Destruction of the golden eagle nesting location in Borrow Site E could be avoided. No minimization, rectification, or reduction is possible for other tree- or cliff-nesting locations. Compensation could be provided through the creation of cliff habitat, repositioning of some nests, and providing artificial platforms, nests, and/or cavities for tree-nesters. The success of such methods and a description of the techniques available appear in Appendix 3.I.

Without mitigation, salmon runs are expected to decrease in the reach downstream from Devil Canyon as far as Talkeetna. This may affect bald eagles in this reach. The impact will be entirely avoided by maintenance-level mitigation for salmon in this reach (see Section 2.4.4[a]).

(xii) Waterbirds

The impoundment will flood riparian and river breeding and/or feeding habitats for spotted sandpiper, mew gull, harlequin duck, common and red-breasted merganser, semipalmated plover, wandering tattler, arctic tern, and dipper. Additional losses of nesting habitat in forests will occur for goldeneye and lesser yellowlegs. Trumpeter swans are not known to nest in any of the affected project areas. No avoidance, minimization, rectification, or reduction is possible. Densities of all waterbird species are low in the middle basin, and compensation on a scale comparable to loss is not realistic.

(xiii) Terrestrial Birds

The impoundment and other project facilities will cause loss of habitat for some estimated 103,000 small terrestrial birds. No avoidance is possible. Reduction of loss in the most densely populated and high diversity habitats is possible through aligning access and transmission corridors away from these habitats. Although numerical losses are large and proportionate losses to the middle basin populations of some species are significant, specific in-kind compensation for each species on the exact scale of project impact does not appear realistic. Habitat enhancement measures for other species will provide some in-kind mitigation for certain assemblages of small birds, although the most highly affected communities (i.e., forest birds) will not be provided mitigation in this way.

(xiv) Small Mammals

The impoundment and other project facilities will cause a significant loss of habitat for some species of small mammals. No avoidance is possible. All species are quite common in other areas, and only species restricted to forested habitats (i.e., red squirrel, porcupine, snowshoe hare, and pygmy shrew) would lose a large proportion of potential habitat in the basin. Reduction of loss to these species may be accomplished by aligning the access and transmission corridors away from forest habitat. Specific in-kind compensation for each species does not appear to be realistic. Habitat enhancement measures for other species will provide some in-kind compensation for certain assemblages of small mammals. The most severely affected species, mentioned above, will not be provided mitigation in this way.

(b) Mortality Factors

(i) Hunting and Trapping Mortality

Improved access to the middle basin is anticipated to have a negative impact on some wildlife populations by increasing mortality from hunting and trapping. Protection conferred through management by the ADF&G varies between species and areas.

Moose, caribou, and Dall sheep are considered high profile and high priority species. Census data collected annually by ADF&G will provide data sufficient for management through regulation of harvest for these species. Harvest of Dall sheep is stringently controlled, and nearly all legal rams are currently harvested each year. The legal take for this species is not likely to change, although, with improved access, demand may increase. The distribution of harvest of moose and caribou will change with improved access, effectively distributing the take over larger portions of the basin populations. The harvest of caribou, like that of Dall sheep, is controlled by permit. Because of increased success anticipated to result from improved access, the number of permits issued may be reduced. However, assuming that management goals for the Nelchina herd remain the same, the legal harvest allowed by ADF&G is also likely to remain constant. Caribou subpopulations with little or no current harvest will face increased mortality, while currently accessible populations may experience a decrease in hunter take. If management goals are altered to treat subpopulations of the herd, or to allow a change in herd size, the legal harvest may either increase or decrease. Moose harvest in the middle Susitna basin is not as stringently regulated as Dall sheep or caribou harvest. GMU 13 is a trophy management area for moose (only bull moose with racks 36" across may be taken), a strategy designed to protect the resource in an area with poor recruitment (see Section 4.2.1 [a]). With present regulations, improved access will increase the harvest of moose. Carry capacity will simultaneously decrease because of loss of habitat resulting from development. Harvest regulations for moose are likely to be changed to maintain the remaining population of moose in the middle basin. ADF&G management can avoid negative impacts to moose caused by increased harvest resulting from improved access.

Improved access could also increase the illegal take of all species. For moose, caribou, and Dall sheep, which are all monitored and managed to assure future harvest opportunities, the impact of increased poaching would be transferred to the legal users through a decrease in the legal harvest.

Large predators (black bear, brown bear, and wolf) are considered competitors for the harvest of ungulates and are frequently given lower priority or are subject to control to insure future harvest opportunities for more desirable species. The current take of wolves is largely illegal. Improved access will reduce populations of these species in the absence of specific protection. For users, harvest opportunity will increase substantially until populations are reduced through overharvest or provided protection. Considering reduced moose populations and increasing harvest demand, reduced predator populations are likely to be considered advantageous. Protection is not likely until populations are reduced to a level in accordance with harvest goals of ungulates.

Furbearers are rarely given specific protection. Population data for furbearers are generally not collected by ADF&G, and local areas subject to heavy use are vulnerable to overharvest. The take of furbearers and the risk of overharvest are controlled by fur values. When fur values are high enough, access is probably a less important factor, and even relatively remote areas can become vulnerable to overharvesting. All furbearers are likely to become less available above the damsites because of adverse population effects of the project. Aquatic and semi-aquatic furbearers will increase in abundance and accessibility in the downstream reach between Devil Canyon and Talkeetna. Some additional compensation for upstream loss of beaver and muskrat habitat would be possible by enhancement of those sloughs which are not reserved as salmon-spawning habitat (13 sloughs; see Section 2.4.4[a]). Adjacent prime beaver habitat would provide an adequate source of colonizing individuals for the river sloughs even with a substantial annual harvest, as long as those adjacent areas (which will remain inaccessible) maintain viable populations.

Impacts of increased hunting and poaching mortality resulting from increased access can be avoided during construction by prohibiting access to nonproject personnel and by restricting and/or prohibiting hunting and trapping by project personnel. During operation, regulation of hunting and trapping will be under the jurisdiction of the ADF&G and beyond the control of the Power Authority, although the Power Authority may assist the ADF&G in a number of ways. Some compensation for project impacts on wildlife populations can be accomplished through improved management ability conferenced by providing data obtained through monitoring programs to the ADF&G and by continued interaction between the agencies in identifying and treating project impacts on both wildlife and user populations.

The powers of the Board of Game and the Commissioner of Fish and Game to regulate harvest in response to problems that might arise from the Susitna Hydroelectric Project were outlined by ADF&G (1983a). The two main problems requiring a regulatory response were : (1) increased harvest and (2) reduction of harvestable surplus. The following actions were identified as being frequently taken:

- Shorten or close the season;
- Schedule the season at a time when animals are less vulnerable or hunters are less efficient;
- Reduce the bag limit;
- Restrict the harvest to specific sex and age classes;
- Create a closed area;

- Create a special use area, e.g., where motorized vehicles are prohibited for hunting, thereby making hunters less efficient;

- Use a permit hunt where a limited number of indivuals are allowed to hunt; and

- Use a registration hunt where hunters must check in before and after hunting. This allows careful monitoring of hunter effort and harvest. When the desired number of animals is harvested, the season is closed by announcement.

ADF&G (1983a) indicates that each of these actions has adverse secondary effects such as increasing the cost of management or restricting user opportunities. The typical sequence of events is : monitoring and identifying a problem; regulatory changes are proposed to the Board of Game by either the Department of Fish and Game or any individual or group; extensive opportunities for public comment are provided; and the Board then closes regulations to protect the problem with the least adverse impact on users. The Board typically responds within a one-yer period (ADF&G 1973a). If the problem is acute, the season can be immediately closed by the Commissioner of Fish and Game.

(ii) Additional Mortality

Mortality to populations of some species is likely to increase significantly because of hazards associated with project features. The access road will cause accidental mortality of moose, caribou, some furbearers, small mammals, and birds. The rail access and increased train traffic on the Alaska Railroad are likely to become substantial mortality factors for moose. Transmission lines are a source of electrocution mortality for large raptors and collision mortality for swans. The selected transmission tower and line configuration is such that little possibility of electrocution exists. However, the possibility of electrocution remains along the temporary 34-kv construction transmission line to be built from Cantwell to Watana via the Denali Highway.

4.4 - Mitigation Plan

The significance to wildlife population levels of mortality because of project features cannot be predicted at the present time. Monitoring of mortality levels and modeling of their population effect would allow a more thorough analysis of their significance. For moose and caribou, any significant impact would be transferred to users through regulation to maintain viable populations.

Electrocution can be totally avoided through proper pole/line configurations. No avoidance is possible for other mortality sources. Mortalities caused by collision with vehicles could be minimized through regulation of traffic when caribou are present in large numbers and through decreasing the maximum speed limit at all seasons. Further reductions could be conferred through minimizing or prohibiting private vehicle traffic, bussing employees to their work sites, and/or reducing the frequency of project vehicle traffic through a traffic-scheduling and control program.

The destruction of nuisance animals will be a source of mortality for bears, foxes, and wolves. The creation of nuisance animals will negatively affect the wildlife populations, the health and safety of project personnel, and the overall cost of the project. Bears, with their low reproductive potential, low densities, and large home ranges, will be susceptible to severe population-level impacts. The impact can be avoided only through strict enforcement of state regulations prohibiting feeding of wild animals; fencing all construction camps and landfills; incinerating all putrescible kitchen waste daily; covering solid waste landfills with soil daily; providing secure garbage containers in work areas and requiring their use by employees and adequate cleaning and emptying schedules; assigning personnel responsibility for maintaining clean work areas; and strictly enforcing all related regulations. During construction of the trans-Alaska oil pipeline, workers were prohibited from feeding animals and infractions were treated through immediate firing. Infractions of this type increase the vulnerability of <u>all</u> project personnel to mauling and disease, and the problem must be dealt with seriously. No amount of facility maintenance or incorporation of specific design features will eliminate this impact if project personnel are not adequately informed and controlled. Additional problems commonly arise when comprehensive garbage incineration plans are not adequately implemented. The most typical shortcoming is careless incineration. Incinerators must be large enough or numerous enough to ensure that garbage is completely burned and not just charred. The project construction facilities, village, and campsites should also be fenced securely and gates monitored to maintain the effectiveness of fencing. In addition to the above mitigation measures, a worker orientation program including briefings on feeding regulations and project site cleanliness would assist in avoiding this impact. An animal control strategy with trained personnel should also be incorporated into project design to allow a timely and effective handling of any wildlife problems which may develop during construction.

(c) Disturbance Impacts

Disturbance is likely to reduce productivity at specific den sites of foxes and wolves and nest sites of swans and raptors. In addition, disturbance by low-flying aircraft, particularly helicopters, may have an effect on population productivity of ungulates. Females in late pregnancy and young animals are particularly sensitive. These impacts can be partly avoided through the development of guidelines restricting ground and air activity in identified sensitive areas. Protection criteria for Alaskan raptors are given in Table E.3.168.

Disturbance of bears in dens during winter months will cause direct mortality of individuals who abandon their dens. Because locations of all dens in the project area may not be known, restrictions of ground activity in identified sensitive areas will only partially avoid this impact.

Disturbance of Dall sheep at the Jay Creek mineral lick by clearing activity before flooding, boat traffic on the impoundment, and low-flying aircraft may cause abandonment of the lick which could possibly result in a decreased carrying capacity in the Watana hills population's range. This impact can be avoided through regulation of access and air traffic in this area.

4.4 - Mitigation Plan

4.4.2 - Mitigation Plans and Monitoring Investigations

This discussion describes continued study progams and the mitigation plans incorporated into project design. A tabular summary of the mitigation plans isprovided in Table E.13.178. Section 4.4.2(a) identifies the data required during and after construction to ensure appropriate types and levels of mitigation and to identify hypothetical and unanticipated impacts. Section 4.4.2(b) describes the mitigation plans which have been incorporated into the project design as a result of the impact analysis. Section 4.4.2(c) contains a brief description of residual or untreated impacts.

(a) Continued Monitoring and Study Needs

Many of the mitigation plans require current data which must be provided through continuous monitoring of wildlife distribution and/or population levels throughout the construction phase, and, in some cases, throughout the license period. Individual study needs are listed below.

(1) Data on the frequency and location of access road and railroad mortality will be continuously collected to allow an analysis of population effects on moose and caribou. Data for moose mortality will be used in the modeling approach (Mitigation Plan 7) to assess its importance and allow full mitigation through enhancement (Mitigation Plan 6). Mortality data for caribou will also be used to assess its importance to the population and to assist in scheduling traffic patterns (Mitigation Plan 12).

(2) Data on changes in vegetative cover in the downstream floodplain between Devil Canyon and Cook Inlet are required to identify unpredictable changes in the availability of early successional habitats and to verify the success of mitigation through habitat enhancement plans for moose (Mitigation Plan 6 below). Low-level aerial photographs of the floodplain between Devil Canyon and Cook Inlet will be taken every 10 years throughout the license period and compared with photos from a flight to be made in 1988-1989 prior to filling to determine the relative amounts of early successional habitats.

(3) Data on movements and population size of caribou are required throughout the license period to identify unanticipated impacts and to provide information for traffic scheduling (Mitigation Plan 12).

Particular attention should be placed on assessing the impact of the impoundment as a barrier, impediment, or hazard to movement. The status of the herd will be monitored before, during, and after the construction phase to determine impacts on range use, productivity, disturbance, and road effects. This will require investigations throughout the license period.

(4) Records of impoundment crossings and impoundment-caused mortality during the open-water period are required. Impoundment surveys would identify possible hazards to wildlife from floating debris and allow avoidance of impacts through removal described in Mitigation Plan 9. Records of impoundment-caused mortality will be used to assess the impacts of such mortality on wildlife populations and the secondary impacts to carrying capacity for caribou.

(5) Data on the seasonal use of the Jay Creek lick and the distribution of use within the lick are required prior to inundation of the lower portion of the lick to assess changes in lick availability and value to Dall sheep and moose. In 1983, ground observations of the lick will be conducted. The potential for soil leaching will be addressed by collecting 30 soil samples, 20 from various locations within the lick above and below maximum operating level (2190 feet) and 10 from nearby control soils. These samples will be analyzed in a commercial laboratory for sodium, potassium, calcium, and magnesium. The collections and tests will be repeated three years after inundation to determine whether leaching has occurred. This will provide data to determine the appropriate level of mitigation (Mitigation Plan 13).

(6) Information on the locations of black and brown bear dens and active fox and wolf dens is required to identify sensitive areas in which major ground and aerial activity will be controlled (Mitigation Plan 10). This will require investigations of brown bear and black bear and spring aerial surveys for active wolf and fox dens throughout the construction phase.

(7) Investigation of wolf populations is required to identify secondary impacts on ungulate populations and to identify hypothesized population-level impacts to wolves. Data will be used to determine the need for compensation for project impacts. This will require

studies throughout the construction phase and three years into the operation phase of the Watana project.

(8) Detailed information on beaver distribution in Deadman Creek and in the downstream floodplain between Devil Canyon and Talkeetna before and after construction is required to determine the level of downstream mitigation required. Such data will be collected throughout the license period in order to assess the effects of various flow releases downstream.

(9) The locations of active raptor nests must be determined each spring during the construction phase to identify sensitive areas in which aerial and ground activity will be restricted (Mitigation Plan 10). Surveys will continue during operation to provide data on the need for continued mitigation through nest habitat enhancement and provision of artifical nest sites (Mitigation Plan 22). Surveys will continue until 100 percent mitigation has been realized.

(10) The locations of swan nests in development areas must be determined each spring throughout the construction phase to identify sensitive areas in which major ground and aerial activity will be prohibited (Mitigation Plan 10).

(11) A monitoring program will be implemented and continued throughout the license period to document the browse production of lands enhanced for moose (Mitigation Plan 6). Research on the proposed Alphabet Hills burn (scheduled for August 1983) has already begun. Field data on browse production in transmission corridors and other disturbed habitats, enhanced lands, and the downstream floodplain will allow the modeling approach (described in Mitigation Plan 7 and Section 4.3.1 [a][iii]) to provide an evaluation of mitigation success and indicated additional needs.

<u>Mitigation Plans</u>

(1) Impoundment clearing activities will not begin until two or three years prior to filling. Patches of riparian vegetation will be left uncleared until just prior to filling. Delayed clearing will temporarily avoid impacts of habitat loss to marten, moose, and black bear. Avoiding clearing during the winter and early spring months would prevent disturbance of moose

during calving and brown and black bears during hibernation. Precise clearing schedules will be determined in consultation with resource agencies.

(2) Habitat loss for all species will be minimized through use of side-borrow techniques for road construction (described in Section 3.4.2[a][i]), depositing spoil in future impoundment areas or depleted borrow sites, and consolidation of project facilities. Side-borrow techniques will reduce the number of borrow sites required for construction of the access road between the Denali Highway and Watana. Airport, construction sites, and camp structures will be as confined and as close to the dams as possible.

(3) Revegetation and fertilization of disturbed sites (described in Section 3.4.2[a][i]) will minimize the period of temporary habitat loss. In particular, it will provide spring and winter forage for moose for 2 to 20 years after the initiation of reclamation. Bears are typically attracted to such sites by the high productivity and early availability of spring forage. In some areas, this may increase the frequency of bear/human encounters, with possible negative impacts (see Mitigation Plans 14, 15, 16).

(4) Minimization of habitat loss to the transmission corridor will be accomplished by selective clearing in the corridor (Figure E.3.85), leaving small shrubs and trees, and by leaving a 35-foot (10 m) wide strip of vegetation up to 10 feet (3 m) tall. Additional rectification for habitat loss will be provided by allowing vegetation to grow to a height of 10 feet (3 m) during operation. The transmission corridor design is described more completely in Section 3.4.2. This design will actually enhance habitat for moose and other wildlife preferring vegetation types in early successional stages. Impacts of habitat loss from other project features will be compensated for through increased carrying capacity for moose provided with this corridor design. Many other species (marten, hare) will also benefit from this corridor design because the retention of cover in the corridor will present less of a psychological or visual barrier to movements.

(5) Habitat alteration which will occur downstream from the Devil Canyon dam will be reduced through the use of multilevel intake structures that will maintain river temperatures as close to normal as possible (see

Section 2.4.2). This will minimize problems of vegetation frosting and blockage of movements by open water in winter.

(6) Compensation for permanent habitat loss and habitat alteration for moose, brown bear, and black bear will be provided through habitat enhancement measures conducted in the middle basin and on replacement lands downstream from Gold Creek.

Carrying capacity for moose and bears can be improved on most lands through the use of burning, logging, vegetation crushing, or land clearing. These methods allow development of early successional vegetation which has higher browse production (and therefore carrying capacity) than the existing late-successional vegetation types. Each of these methods has certain advantages and disadvantages. Controlled burning is usually the most economical and results in higher browse production than the other methods because nutrients are immediately released to the soil, and soils are warmed by greater insolation (Viereck and Schandelmeir 1980). Burning also produces higher berry production than other methods (Friedman 1981). However, controlled burning is often impractical because of land ownership and logistic problems. Logging can also increase browse production, particularly when the soil is scarified in summer (Zasada et al. 1981). Logging is not feasible in some areas because of topography or access and is usually more costly than burning. Vegetation crushing has been used on the Kenai Peninsula to improve moose habitat (Regelin 1982). Access and topography also limit the use of crushing to certain areas.

For purposes of providing an estimate of the number of acres of land required for mitigating this impact and the cost of these measures, the following mitigation scenario is presented:

- A controlled burn will be conducted on state lands north of the Susitna River on the east side of Watana Creek. A total of 6400 acres of woodland conifer forest in several separate stands will be burned to improve both browse and berry production. The browse production in woodland conifer stands is approximately 10 kg/ha (Table E.3.92). Low shrub stands, which would result from the burning effort (Figure E.3.117), provide approximately 30 kg/ha. Burning of 6400 acres would thus provide compensation for 12,800 acres of lost habitat. Since browse production begins to decrease after about 12-14 years (see Figure E.3.117), the same or nearby areas will be burned again after 15 years. The feasibility of this approach will be verified by long-term research on the Alphabet Hills burn, which began in 1982. The Power Authority has already provided support for pre-burn moose and vegetation studies of the proposed Alphabet Hills burn area. Burning is scheduled for August 1983.

- The Susitna watershed in the reach between Watana and Devil Canyon currently supports low numbers of moose. This area was considered for habitat enhancement measures. However, the area is largely tundra, tall shrub (alder), and mixed forest. Based on current data, it is unlikely that browse production in tundra or tall shrub stands could be significantly improved, and mixed forest stands already support high browse production (Table E.3.92). This area is therefore excluded from consideration for habitat enhancement.

- Sites exist near the Susitna River floodplain downstream from Gold Creek which were cleared for agriculture but left unplanted. Early successional vegetation has developed in these areas and they are used by large numbers of moose in winter. The browse production of these disturbed areas has not been measured, but during moose surveys in November-December 1982, more than 50 moose were often seen in disturbed fields of less than 640 acres. Browse production in these dense stands of willows probably begins to decline rapidly after 20 years. The availability of browse and the duration of high browse production in these areas will be determined in 1983. For a preliminary estimate of the area required to compensate for loss of moose browse, it will be assumed that areas currently classed as conifer forest have only one third the browse production of cleared areas. The Power Authority will improve moose habitat by clearing 16,000 acres of state land within 10 miles of the Susitna River in scattered patches. These areas will be cleared to mineral soil by stockpiling the cleared vegetation in windrows. Assuming tht browse production is improved three-fold for 16 years and that these areas are cleared three times during the license period, these 16,000 acres will compensate for the loss of 32,000 acres of moose habitat to the im-

impoundment areas. The exact location and number of acres to be improved will be determined using data from downstream vegetation studies and using the habitat-based modeling approach described below (Mitigation Plan 7). If browse production is greater than the 3-fold increase hypothesized above, less area will be required. A 3-fold increase in browse production is a very conservative estimate, and a 5- to 10-fold increase may be possible in some vegetation types.

Burning of 6400 acres in the Watana Creek area and clearing of an additional 16,000 acres near the downstream floodplain will mitigate for the loss of 42,135 acres to the impoundments, temporary and permanent structures. Clearing and maintenance of the transmission corridor will provide additional mitigation where the corridor traverses vegetation types which would be enhanced by periodic clearing (i.e., conifer forests). It is possible that regulated flows may result in a net increase in moose habitat along the downstream floodplain during the license period through an increase in early successional riparian vegetation. In this case, no additional mitigation would be required for downstream impacts. A monitoring program will be implemented and continued throughout the license period to document the browse production of the lands enhanced for moose (see monitoring Plan 11). This monitoring program will provide input into the habitat-based approach being developed by the Power Authority, and will result in an increase or decrease in the number of acres managed as moose habitat, depending on the level of mitigation achieved. Estimated costs for the proposed browse enhancement measures are summarized in Table E.3.169 This flexible approach to mitigation is designed to provide total mitigation for habitat loss to moose.

The controlled burns described above will also enhance habitat for bears. However, it will not fully compensate for loss of early spring foods for bears, particularly not in years of berry crop failure. It will increase the availability of fall foods for fattening.

Additional enchancement and partial compensation for loss of spring habitat for brown bears will occur in revegetated areas and disturbed areas. The increased productivity in these areas, particularly in revegetated areas, is attractive to bears in early spring and at all seasons because greater insolation creates earlier green-up and increased availability of some preferred plants.

(7) As a compensation measure to mitigate for impacts to moose, the Power Authority is developing a habitat-based model in conjunction with the ADF&G, the USFWS, the University of Alaska, and private consultants. This approach will use a variety of data to determine the impact of habitat loss on present and future moose populations. Data requirements are presently more completely in Section 4.3.1(a)(iii).

An estimate of the number of acres required to mitigate for habitat losses for moose will be determined using this habitat-based approach and information from continuing studies by the Power Authority. Preliminary estimates of the level of mitigation required are given in Mitigation Plan 6 above based on the preliminary browse production figures presented in Section 4.2.1(a) (see also Appendix 3.H).

The model will also incorporate population data and will be used to assess the significance of cumulative impacts of habitat loss, mortality factors, habitat alteration, and disturbance. The refinement and use of this model will allow 100 percent compensation for impacts to moose. Development of the modeling approach should also be considered out-of-kind mitigation for species impacts which cannot be otherwise addressed.

(8) The Power Authority will assist the Alaska Board of Game in conducting a controlled moose hunt within the project area to avoid over-browsing of the area by displaced moose. The need for such a hunt will be assessed using the modeling approach described above. Available energy and protein will be measured to determine carrying capacity of adjacent range in 1983 and 1984. A census of the impoundment and adjacent areas will be conducted just prior to clearing to assess the status of the moose population relative to carrying capacity. A hunt would be conducted if studies determine that the receiving areas cannot support displaced moose without degradation of carrying capacity.

(9) Hazards to movement created by the impoundment will be reduced through clearing of the impoundment zone prior to flooding and through a program of debris removal as

necessary to continue throughout the license period. Monitoring of the impoundment during the open water period will identify debris hazards.

(10) Sensitive wildlife areas identified in the monitoring studies will be protected from disturbance from project aircraft by the following guidelines and measures:

- Pilots will be required to maintain a minimum altitude of 1000 feet above ground level except during take-off and landing throughout the basin.

- Aircraft landings will be prohibited within 1/2 mile of the Jay Creek mineral lick between April 15 and June 15.

- Aircraft landings will be prohibited within the Nelchina caribou herd calving area in the Talkeetna Mountains (see Figure E.3.93) between May 15 and June 30.

- Aircraft landings will be prohibited within 1/4 mile of known active wolf dens or rendezvous sites during May 1 through July 31.

- Aircraft landings will be prohibited within 1/2 mile of active golden eagle nests between March 15 and August 31 each year (Table E.3.168).

- Aircraft landings will be prohibited within 1/4 mile of active bald eagle nests between March 15 and August 31 (Table E.3.168).

- Aircraft landings will be prohibited within 1/4 mile of active gyrfalcon nests between February 15 and August 15 (Table E.3.168).

- An aircraft buffer zone of at least 0.25 mile or 1000 vertical feet will be established around lakes used by trumpeter swans during the nesting season.

- All aircraft restrictions and schedules will be provided to aircraft pilots in a concise manual.

Ground disturbance of identified sensitive areas will be avoided through the guidelines and measures described below. For the purposes of this discussion, minor ground activity includes short-term reconnaissance and exploration type programs such as field inventories. Major ground activity involves large numbers of personnel; equipment; surface disturbance; noise; or vehicular activity; such as clearing, pad construction, blasting, and facility construction.

Protection criteria for nesting raptors which are currently accepted as guidelines by the ADF&G, and the USFWS were developed for the proposed Alaska Natural Gas Transportation System (Behlke 1980) by raptor biologists in the state. These general criteria were modified for application to the Susitna Basin based on known phenology of nests and are presented in Table E.3.168. Although there may be a very small amount of nesting activity before or after these dates, the vast majority of nesting attempts will be covered under the proposed criteria. In general, the early nest period is more sensitive and the criteria are more conservative in the early season, reflecting this difference.

- Known raptor nesting locations will be assumed to be occupied until June 1 of each year, after which, protection measures will be withdrawn for the remainder of the year if the nest is documented to be inactive.

- Major ground activity will be prohibited within 1/2 mile of the Jay Creek mineral lick between April 15 and June 15. The reservoir adjacent to the lick will be closed to boat and floatplane use within 1/2 mile of the lick.

- Clearing activities in the impoundment area will be restricted to nonsensitive periods near areas identified as sensitive to disturbance (e.g., concentrations of calving moose, brown and black bears, denning wolves, migrating caribou, raptor nests, etc.).

- Major ground activity will be prohibited within 1/4 mile of all known active bear dens between September 15 and May 15.

- Major ground activity will be prohibited within 1/2 mile of waterbodies used by swans during the nesting season and other times when swans are present.

- Ground activity will be prohibited within 1/4 mile of known active wolf dens or rendezvous sites between May 1 and July 31.

- Major ground activity will be prohibited within 1/2 mile of active golden eagles nests between March 15 and August 31, within 1/4 mile of active bald eagle nests between March 15 and August 31, or within 1/4 mile of gyrfalcon nests between February 15 and August 15 (Table E.3.168).

In addition to these general guidelines, two specific nests are anticipated to be vulnerable to disturbance. These are treated below.

The Watana-Devil Canyon portion of the access road between Mile 32.5 and Mile 35 cannot be realigned away from golden eagle nesting location GE-18 because of topographic and engineering considerations. To minimize disturbance from construction activities, construction within 0.5 mile of the nesting location will be limited to the nonsensitive period (August 31-March 14) if the nest is active (see Table E.3.168). Disturbance after road construction will be kept to a minimum by ensuring that no activities occur south of the road or along the cliff-top for a distance of 0.5 mile east and west during the sensitive period.

It is not feasible to realign the railroad access route farther away than 0.25 mile from bald eagle nesting location BE-8 between Mile 2 and Mile 3 because of topographic and engineering considerations. If the nesting location is active, efforts will be made to limit construction to the nonsensitive period (August 31-March 14) to minimize disturbance.

(11) Although complete avoidance of the impacts of altered caribou movements and range use is not possible with the route chosen, design changes in the access road and realignment to minimize effects on current major use areas of the Nelchina range will minimize or reduce its impact. Although this alignment avoids some areas for caribou calving, some cows that calve in the mountains to the west of the road would still be affected. Changes in road alignment are described in greater detail in Section 3.4.2[a][i]). Use of side-borrow techniques will minimize physical and visual barrier effects of the road to caribou and other species. This technique results in a finished road profile less than 4 feet above original ground level (see Figure E.3.83) and minimizes amount of habitat lost to material sites.

(12) The effects of vehicle traffic on caribou movements (a more serious impact than the actual presence of the road) can be minimized by reducing the volume, speed, or frequency of traffic on the road. Public access will be prohibited during the construction period. The Power Authority is currently reviewing options for reducing traffic volume. Further minimization of impacts could be provided through bussing workers to the site, allowing only convoy traffic, or reducing the speed limit and volume of traffic during sensitive periods. Because dust clouds behind vehicles add to the visual effect on caribou, water trucks will be used to control dust along the road during the construction phase. Continued monitoring (Monitoring Plan 3) will evaluate the residual impact (if any) on caribou and the need for out-of-kind mitigation for caribou.

(13) If monitoring of Dall sheep (described in Section 4.4.2 [i]) indicates a population-level effect of partial inundation of the Jay Creek mineral lick, new soil will be exposed to rectify the impact. Monitoring use and comparison of soil samples (Continued Study 5) will allow evaluation of the effectiveness of this mitigation.

(14) The impact of overharvest of game species with improved access will be avoided during construction by prohibiting public access via the project road or air field, prohibiting employees and their families from using project facilities or equipment for hunting and trapping, and by providing data from monitoring investigations (described in Section 4.4.2[i]) which may assist the Alaska Board of Game in regulating hunting and trapping activities in the area. During the operation phase, the Power Authority will have no control over harvest activities but will continue to provide any pertinent data to the ADF&G and assistance in their management activities.

Studies will provide information on the bear population and the distribution of bear harvest which will indicate the need to recommend restrictions on bear hunts to the ADF&G to protect brown and black bears. Concentrations of bears may occur in some project areas which will also receive regular human access and presence. Regulations on either the season or the location of the hunt could be used to protect bear populations from overharvest.

The Power Authority will recommended hunting and trapping restrictions to protect wolves within the project area and allow the formation of new home ranges and hunting patterns. This would minimize the secondary impact of social strife and upheaval caused by the alteration of historical pack boundaries. Further restrictions may be recommended for other furbearers if data from ongoing investigations indicate a need for protection.

(15) The creation of nuisance animals will be avoided through combined implementation of the following garbage-control and education measures:

- An Environmental Briefing Program for employees will be required (described in Appendix 3.B) and will include briefings on regulations prohibiting feeding of animals and reasons for the restrictions.

- State regulations prohibiting feeding of wild animals will be strictly enforced.

- Construction camps and landfills will be fenced with bear-resistant fencing and gates will be monitored to ensure the effectiveness of the fencing.

- Secure garbage containers will be required in work areas.

- Personnel will be assigned the responsibility for picking up and disposing of all discarded refuse in work areas and along roads.

- Putrescible kitchen wastes will be stored indoors and completely incinerated daily or more often, if required, in adequate incinerators.

- Solid waste landfills will be covered with soil daily, or as required by permit stipulations.

Wildlife problems may persist to a small degree even with such precautions. Increased use of bear concentration areas by humans (e.g., Prairie Creek) and attraction of bears to some sites (e.g., revegetated areas) will both increase bear/human conflicts. The construction manager will be instructed to develop an animal control strategy directed at avoiding and minimizing all project-related problems and to respond promptly to any situations that arise.

(16) Decreased availability of salmon to bears will be completely compensated for by enhancement of 13 sloughs between Devil Canyon and the confluence of the Chulitna and Talkeetna rivers (see Section 2.4.4[a]). Increased activity at Prairie Creek would be a secondary impact of the project that would have a negative effect on brown and black bears which make seasonal movements to the area during salmon runs. The Power Authority will assist resource management agencies in assessing this impact and in preparing recommendations for mitigating actions. Without protection, the stream is likely to be developed for mining or for recreational sites. The occurrence of bear/human encounters is likely to increase in Prairie Creek, no doubt to the detriment of both parties. Deliberate recreational development would also be severely detrimental to the basin populations of bears who make regular movements to Prairie Creek.

The impacts of decreased availability of ungulate prey for brown bear, black bear, and wolf will be reduced through measures to avoid, minimize, or compensate for impacts to ungulate populations. However, it is likely that predator populations will be reduced through harvest as a management strategy to allow increased harvest of ungulates by humans. Therefore, complete mitigation of impacts is not planned for these species.

Additional compensation for bears for reduction in both spring forage and prey availability will be provided through revegetation of disturbed sites (see Section 3.4.2[a][i]). Bears are adaptable and may be able to replace some prey in their diet through increased consumption of vegetation. The occurrence of disturbed and, in particular, revegetated sites will provide additional attractive forage for bears. In areas of frequent human use, revegetated sites will have a potential negative impact (see Mitigation Plans 3, 14, and 15).

(17) Loss of habitat for aquatic furbearers will be minimized by reducing gravel requirements through side-borrow techniques and utilizing only Borrow Sites D, E, I, J, and K. In addition, material for the access road in the Deadman Creek area will be obtained if necessary from small upland sites outside the Deadman Creek drainage (Figure E.3.37). Further mitigation will be provided in the downstream floodplain as described in Mitigation Plans 18 and 19 below.

(18) Mitigation for loss of habitat and a quantitative assessment of potential beaver habitat will be provided by the development and testing of a model of beaver carrying capacity for the Devil Canyon to Talkeetna portion of the floodplain. Inputs to the model will include data on hydrology, slough morphology, and forage availability; and the results of different flow releases and water temperatures on availability of overwintering habitat will be tested. Continued monitoring of beaver populations will test the validity of the model and refine its accuracy. The development of this model will also mitigate for residual impacts on furbearers.

(19) Loss of habitat for aquatic and semiaquatic furbearers (especially beaver) will be compensated for through enhancement of sloughs in the reach between Devil Canyon and the confluence with the Chulitna and Talkeetna rivers. Thirteen sloughs in this reach will be managed as salmon spawning sloughs, and beaver are likely to be actively excluded from these. Of the remaining sloughs, the beaver model will indicate enhancement measures required for colonization and overwintering by beavers. Slough enhancement measures will also benefit muskrat, mink, and otter and may provide complete compensation for aquatic and semiaquatic furbearers.

(20) The loss of raptor tree-nesting locations will be temporarily minimized by delaying impoundment clearing operations until the two or three years prior to filling and, thereafter, by leaving islands of vegetation around known nesting locations. Clearing activities will be scheduled to avoid the early nesting season. Active nests will thereafter be protected by disturbance guidelines outlined in Mitigation Plan 10.

Destruction of the bald eagle nest in Deadman Creek (BE-8) will be avoided through realignment of the access road northwestward and westward to pass 0.5 mile from the nest tree. This distance will also minimize disturbance to the nesting pair.

Destruction of the currently inactive golden eagle nest (GE-11) located within Borrow Site E will be avoided by not mining that area of the site. Disturbance of the nest, if it becomes active, will be avoided by prohibiting mining of the site during the nesting period, March 15 through August 31.

4.4 - Mitigation Plan

(21) The unavoidable loss of raptor nesting locations will be fully compensated for by site enhancement and the creation of artificial nesting locations. The technique is described with examples in Appendix 3.I. The following specific measures will be taken.

- A combination of several of the enhancement measures described in Appendix 3.I will be used to provide artificial nesting locations for bald eagles until at least four successful new eagle nests have been established in the middle or upper basin. Bald eagles have shown little reluctance to use nests that have been reconstructed after having been blown down (Olendorff et al. 1980). The nests that are to be inundated will be reconstructed in adjacent areas.

- Natural-appearing nests will be placed in appropriate trees (especially large balsam poplar) in suitable habitat downstream from the damsite or along tributaries such as Portage Creek (presently unused by bald eagles). Additionally, the canopies of other trees will be modified by removing tops or some upper limbs to make them more attractive as nesting locations for bald eagles.

  The success of these measures will be monitored to insure that at least 4 successful bald eagle nestings occur. The estimated cost of this mitigation approach is summarized in Table E.3.171.

- Ten nesting platforms for golden eagles containing artificial stick nests will be placed on the tops of transmission towers as construction occurs (see Figure E.3.117). Costs estimates are provided in Table E.3.172.

- Nesting habitat for goshawks will be improved both by providing artificial nests and by increasing the edge effect in large forest stands (D. Weir 1982 Personal Communication and D. Roseneau, unpublished data). Great horned and great gray owls commonly use abandoned goshawk nests in Alaska (Roseneau and Bente 1981), and will, therefore, also benefit from these measures. Twenty nest boxes for cavity-nesting kestrels, boreal owls, and hawk owls will also be provided and monitored. Cavities will be created in the tops of several mature birch or spruce trees in an additional attempt to attract hawk owls and other cavity-nesting birds. Estimated costs of these mitigation measures are summarized in Table E.3.173.

- Nests that can be physically repositioned higher on the cliff (at least 50 feet above maximum pool level) and cliffs suitable for enhancement measures will be identified in 1983. Some otherwise suitable cliffs have no ledges for nest building. Nesting ledges and perches can be created with explosives and/or hand tools. Artificial stick nests (see below) can also be provided on such sites. Cliff enhancement measures will begin in 1984. Nesting ledges will be created on exposed cliffs using small, shaped explosive charges and/or hand tools. It may also be possible to attach metal and masonry nest ledges to some cliffs. The feasibility of physically moving original nests to new points higher on the cliff will be demonstrated and perfected using an inactive nest. Areas where bedrock cliffs can be exposed by blasting and digging away overburden will also be identified for possible future enhancement.

  The success of these measures will be determined through annual monitoring efforts. A combination of measures including subsequent modifications will be used until the number of successful new nestings equals or exceeds the number of nesting golden eagle pairs lost to the project.

(22) Electrocution of raptors by the temporary 34 kV transmission line from Cantwell to the Watana site will be avoided by employing pole/line configurations and other safeguards proven effective in other parts of North America (Olendorff et al. 1981). Special attention will be given to wire-gapping and ground wire placement (Figure E.3.118), armless configurations (Figure E.3.119), and transformer installation (Figure E.3.120). Perch guards (Figure E.3.121) and elevated perches (Figure E.3.122) will be used if necessary to further avoid electrocutions. These measures will totally avoid this impact.

(23) Loss of forest habitat for black bear, marten, small birds, and small mammals will be minimized through the alignment of the access road and transmission corridor to avoid most forest areas; through using the narrowest corridor allowable; through minimizing the area

used for borrow extraction by side-borrow techniques for road construction; and through consolidation of facilities. Loss will be temporarily avoided by delaying reservoir clearing operations until two or three years prior to filling. Habitat loss in the transmission corridor will be minimized by selective clearing and minimization of the width of cleared areas. Inhibition of marten and small mammal movements across the corridor will also be minimized by leaving a strip of vegetation along the centerline. The alignment of the access corrdor has also been altered to avoid four red fox denning areas.

(c) Residual Impacts

(i) Moose

The measures described above will provide complete mitigation for habitat loss to moose through enhancement of adjacent areas and acquired replacement lands. The carrying capacity of the middle basin will be reduced and populations there may decrease. The development of a carrying capacity model will allow an estimate of both carrying capacity and current population level impacts. It will also allow evaluation of the enhancement techniques and determination of acreage required for enhancement. The opportunity exists to further enhance moose habitat downstream from Talkeetna as out-of- kind mitigation for residual impacts to other species (see discussion of residual impacts on bears, wolves, marten).

The model will also incorporate population data and will allow an assessment of the population-level effects of accidental mortality factors and harvest. With this additional information, complete mitigation will also be provided for these impacts.

(ii) Caribou

The impacts of mortality factors and disturbance can be minimized as described above, and no population-level effects are anticipated. The likelihood of a reduction in carrying capacity resulting from blockage of movements by the impoundment is unknown. Continued monitoring of the Nelchina herd will allow evaluation of realized impacts. If unanticipated impacts are demonstrated, mitigation will be provided. No in-kind mitigation would be possible for a demonstrated decrease in carrying capacity of the Nelchina range. The Power Authority is evaluating options for out-of-kind mitigation in the eventuality that residual impacts are demonstrated.

(iii) Dall Sheep

The impacts of disturbance at the Jay Creek mineral lick will be fully avoided for through restrictions on activity in the area. The need for further mitigation will be determined by continued study of lick use and soil composition. Demonstrated population-level impacts will be mitigated for by exposure of new soil in the area.

(iv) Brown Bears

The most significant potential impact of the Susitna hydro development project on brown bears, the creation and destruction of nuisance animals, can be prevented by the measures outlined above. Disturbance impacts are also easily avoided or minimized. Slough enhancement for salmon and cooperative management of lands adjacent to Prairie Creek could fully mitigate for loss of these food resources. The loss of habitat has been minimized as much as feasible. No analysis of the value of habitat lost is possible. Adequate methods for evaluating brown bear habitat are not available. Brown bears are a low density species adapted to opportunistic utilization of a large number of available food resources in a very large home range. The impact of loss of spring feeding areas cannot be assessed, and a population-level effect ascribable to this impact would be difficult to demonstrate. Although enhancement measures for moose habitat will not fully mitigate for loss of spring forage for brown bears, burning will increase abundance of berries, a major fall and spring food of brown bears. Management and mitigation plan conflicts militate against any in-kind mitigation through replacement lands for brown bear. Any reduction in the bear population is likely to improve recruitment to moose and caribou populations and will constitute out-of-kind mitigation for these species.

(v) Black Bears

The above discussion of brown bear is also applicable to black bear, except that black bear are generally restricted to forested habitat, a significant portion of which will be destroyed by the Susitna hydro project. Residual impacts will, therefore, be much larger, and a significant decrease in black bear numbers and distribution is anticipated. Increased recruitment in ungulate populations resulting from decreased bear densities will constitute out-of-kind mitigation for black bear.

(vi) Wolves

Disturbance of wolves at dens will be avoided as described above. Decreased availability of prey will be minimized through the mitigation measures proposed for ungulates. The Watana pack is likely to be eliminated and the remaining packs' composition and ranges are likely to shift and fluctuate until a new equilibrium is reached. Harvest management goals for ungulates and mitigation plan conflicts militate against ADF&G management of replacement lands for wolves. Considering the increasing demand for harvest of ungulates and the possible decreased opportunity for harvest of moose in the middle basin, reduced wolf populations are likely to be considered advantageous and will constitute out-of-kind mitigation for moose and caribou.

(vii) Wolverine

Wolverine are wide-ranging and occur in low densities. Therefore, loss of habitat and increased harvest are unlikely to cause a detectable decrease in wolverine abundance. The anticipated increase in availability of carrion caused by higher turnover rates in moose populations will mitigate for a decrease in food resources resulting from habitat loss. Further mitigation is not anticipated to be necessary.

(viii) Aquatic and Semiaquatic Furbearers

Habitat loss upstream from the damsites will be compensated for through habitat enhancement between

Devil Canyon and Talkeetna. Loss of stream habitat in Deadman Creek will be minimized. The modeling effort to be developed for beaver will allow determination of flows and slough enhancement required for complete compensation for that species. Quantification of impacts and the extent to which mitigation is provided for muskrat, mink, and otter cannot be determined from currently available data.

No compensation for increased harvest is possible beyond the provision of enhanced downstream habitat. If fur values are high, sustained high levels of harvest may decrease populations. Adjacent prime habitat, on which access will not be improved, will continue to be a source of colonizing individuals as long as those populations remain viable.

(ix) Terrestrial Furbearers

Disturbance of red fox dens will be avoided. Loss of forest habitat for all species will be minimized. Precise quantification of residual impacts is not possible for any terrestrial furbearer. However, only marten are expected to suffer substantial population reductions and decrease in carrying capacity. Residual impacts for marten are large. Enhancement methods for moose will further increase loss of habitat for marten. Opportunities for mitigation for loss of forest habitat are limited both by management priorities for economically more valuable species and conflict with mitigation plans for moose.

(x) Raptors and Ravens

Ravens are not limited by nest sites and are not anticipated to decrease in abundance in the middle basin. Mitigation will completely compensate for loss of nesting habitat and nesting locations for bald and golden eagles, and gyrfalcons. A precise assessment of impacts to other tree-nesting raptors which will be negatively affected is not possible. The increase in edge habitat near project facilities, the transmission corridor, and revegetated sites will enhance habitat for accipiters (goshawks and sharp-shinned hawk), thereby compensating for loss of the limited available habitat in the impoundment area. Ground-nesting species are not expected to suffer loss of nest habitat.

(xi) Waterbirds

No in-kind mitigation is possible for loss of fluviatile and river habitat for waterbirds. Disturbance impacts on trumpeter swan nests will be avoided as described above. Combined loss of breeding habitat and nest trees will reduce populations of waterbirds in the middle basin. However, waterbirds nest in low densities throughout the middle basin, and residual impacts represent a regionally insignificant loss of low-density habitat.

(xii) Other Birds and Small Mammals

Numerical losses of small mammals and breeding birds are large in the impoundment areas. Additional losses will be minimized through alignment of the access road through tundra and low shrub habitats which support relatively low numbers and species richness. The mitigation measures proposed will leave large residual impacts, particularly for species restricted to forest habitats. Enhancement programs for moose will increase losses for these species, in both the lower and middle basins. No in-kind compensation on the project site can be obtained. Management priorities and conflicts between mitigation plans prevent specific compensation on a scale comparable to loss. However, the replacement land acquisitions and enhancement measures described in Mitigation Plans 3, 4, and 5 will provide out-of-kind mitigation through the creation and protection of habitat for birds and small mammals of disturbed and early successional habitats.

4.4.3 - Cost Analysis and Schedules

Schedules are indicated in the continued study and mitigation plans described in Sections 4.4.2(a) and 4.4.2(b) respectively. To develop estimates of compensatory mitigation and study costs, 1982 cost estimates were prepared for each activity (Tables E.3.169 to E.3.175). These cost estimates were based on unit cost information derived from past and recent experience in Alaska and elsewhere, escalated to arrive at a 1982 cost estimate applicable to south-central Alaska. Costs for the mitigation program were separated into two categories: costs incurred during construction and costs incurred during operation. Operating costs are in annual 1982 dollar amounts averaged over the 50-year license period. For the major compensatory mitigation activities these costs are:

Construction costs:

Downstream aerial photography of vegetation	(E.3.170)	10,000
Browse enhancement programs	(E.3.169)	$10,340,000
Bald eagle nest-site compensation	(E.3.171)	$ 36,100
Golden eagle nest-site compensation	(E.3.172, E.3.174, & E.3.175)	$ 161,200
Other raptors nest-site compensation	(E.3.173)	$ 9,400
Total Construction Costs		$10,546,700

Average Annual Operating Costs:

Downstream aerial photography of vegetation	(E.3.170)	$ 1,000
Browse enhancement programs	(E.3.169)	$ 82,000
Total Average Annual Operating Costs		$ 83,000

These estimates do not include contingency costs or owner's administrative costs.

The cost analysis and schedule for Mitigation Plan 5 (compensation for moose, brown bear, and black bear foraging habitat loss) are given in Table E.3.169. The controlled burning program in the middle basin will require $240,000 from project construction costs for labor, equipment and logistics, and land leases from private owners. No firm predictions can be made concerning lands which may be made available or their cost. It is arbitrarily assumed that 1/4 of the land to be enhanced through burning would be leased from private landowners. For the purpose of this calculation, the land is valued at $1,000/acre and the lease price is assumed to be 5 percent of the purchase value per year. The average annual cost of maintenance burning to obtain the optimal seral ages of vegetation is $2,000/year over the 50-year license period. The clearing program in the lower Susitna basin will require $9,600,000 from construction costs for labor and equipment. It is assumed that all necessary lands (estimated as 16,000 acres, based on current data) can be obtained from state or federal governments through interagency agreement. The average annual cost of maintenance clearing to maintain the optimal seral age of vegetation is $384,000 per year for the 50-year license period.

4.4 - Mitigation Plans

The cost analysis and schedule for Continued Study Plan 2 (aerial photography to measure changes in vegetation in the downstream floodplain) are presented in Table E.3.170. Initial photography in 1988-89 to establish a pre-project baseline will be funded from project construction costs and will require an estimated $10,000. Repeat photography will be taken five times in the license period (i.e., every 10 years) at an average annual operating cost of $1,000.

Five programs of compensatory mitigation for the loss of raptor nesting locations are costed in Tables E.3.171 to E.3.175. The provision of modified and artificial nesting locations will be funded initially as a construction cost. As indicated in Mitigation Plan 21, efforts will continue until 100 percent compensation in new active nesting locations has been achieved. This may require some funding from operating costs in the first few years of operation. No firm prediction can be made. However, the total dollar costs are relatively small: for bald eagle, $36,100; for golden eagle, $161,200; and for cavity-nesting raptors, $9,400.

Other continued study and mitigation costs, which are an integral part of project design, are included in project capital costs (presented in Exhibit D).

4.4.4 - Documentation of Agency Recommendations

This section documents agency recommendations or mitigation measures and facilities made to the Alaska Power Authority.

(i) Access Route Recommendations

The most extensive recommendations concerned the route of access to the project (USFWS 1983, SHSC 1982, ADF&G 1980). The agencies were in agreement on recommending that the Denali Highway to Watana access route be avoided. Specific concerns addressed the substantial disturbances in the Deadman Creek area. USFWS (1983) pointed out the importance of that area to calving moose, brown bear denning, caribou movements, wolf denning, beaver, and bald eagle nesting. The SHSC (1982) and ADF&G (1980) further indicated that routes crossing the Indian River and through wetlands to the Parks Highway, routes on the south side of the Susitna, the Butte Lakes area, and routes through the Prairie Creek-Stephan Lake-Fog Lakes area should be avoided. Recommended routes include routing between Watana and Devil Canyon on the north side of the Susitna (USFWS 1982, SHSC 1982, ADF&G 1980) and between Devil Canyon and Gold Creek on the south side of the river (USFWS 1982, ADF&G 1980). Additional recommendations on access include rail access to the project site, to the exclusion of a road connection (USFWS 1982, SHSC 1982), and consolidation of the access and transmission corridors (EPA 1981).

The access corridor from the Denali Highway to Watana was chosen to provide timely access to the project site. Justification for the project design chosen appears in Chapter 10 describing the design criteria for project features. Railroad access to Devil Canyon has been incorporated into project design and uses the south side route. Road access between Watana and Devil Canyon follows the preferred north-side route. Rail access alone is not deemed feasible. The Denali Highway-Watana route has been relocated farther west to avoid the Butte Lake area, and no project facilities will be located in the Prairie Creek-Stephan Lake area or in the Fog Lakes area. Further design changes and alternatives of the Denali Highway-Watana route to avoid sensitive areas will minimize impacts to wildlife species. Specifically, the use of side-borrow techniques and restriction of road materials borrow sites to areas outside the Deadman Creek area will minimize habitat loss. No special use areas for moose are anticipated to be made unusable by the access corridor (see Section 4.3.3[a]). No indication that brown bear denning habitat is in any way limiting has been presented in ADF&G (1982e). Although no population-level effects on caribou are anticipated to result from the presence of the road, the alignment has been moved to the west of most current major use areas. Continued monitoring of caribou will assess the occurrence of unanticipated impacts and allow mitigation through a traffic control program, if necessary. The wolf dens near the access corridor are unlikely to be made unusable, and the Power Authority will assist the ADF&G in regulating access to active den sites to avoid disturbance during critical periods as described in Mitigation Plan 10. Loss of beaver habitat will be minimized as described in Mitigation Plan 17, and complete compensation is anticipated downstream for unavoidable impacts to beaver in Deadman Creek. The access route has been realigned to avoid both destruction and disturbance by traffic of bald eagle nest 8. The transmission corridor is routed and designed for ease of construction and to improve maintenance and reliability. A common corridor is used between Watana and Gold Creek.

4.4 - Mitigation Plans

(ii) Continued Monitoring Recommendations

A need for continued monitoring has been indicated by USFWS (1983). Key components of the program recommended include: (1) inclusion of appropriate federal, state, and local agency participation; (2) full financial funding by the Alaska Power Authority; and (3) utilization of the monitoring program to modify, augment, or delete mitigation procedures as indicated by ongoing studies. In particular, the USFWS (1983) made recommendations for monitoring and removing floating debris on the reservoir, continued studies and habitat models for beaver and pine marten, monitoring of mitigation for beaver to insure levels anticipated, and providing data to assist ADF&G in regulation of harvest.

The monitoring and continued studies programs are described in Section 4.4.2(i). The inclusion of federal, state, and local agencies is indicated in the mitigation plans where appropriate. In particular, the development of a modeling approach for management and habitat enhancement of moose includes representation of the USFWS, ADF&G, and the University of Alaska. All data from monitoring will be provided to the ADF&G with recommendations regarding the regulation of harvest, which is entirely their domain. The funding levels of the individual mitigation plans are presented in Section 4.4.3. The flexibility of mitigation plans to identify, measure, and respond to hypothesized, unanticipated, and currently unmeasurable impacts has been stressed. The process by which mitigation will be refined and implemented is described in Section 1.3. The structure for a review group including agency, project, and subcontractor representation is also outlined in that section.

Provisions to monitor and to remove reservoir debris appear as Mitigation Plan 9. Monitoring programs for beaver are outlined in Section 4.4.2(i). Continued monitoring of marten is considered an inefficient use of available resources because of conflicts with mitigation plans for higher priority species (see Section 1) and because of the lack of jurisdiction of the Power Authority in regulating the harvest of game on replacement lands. The modeling program for beaver is described in Mitigation Plan 18.

(iii) Environmental Briefings Program Recommendation

USFWS (1983) expressed strong support for the Environmental Briefings Program and recommended that it be a mandatory requirement for all project personnel before they begin work on the project.

The Environmental Briefings Program has been described more completely and has been made a mandatory requirement for project personnel.

(iv) Jay Creek Mineral Lick Recommendation

USFWS (1983) recommended that the reservoir adjacent to the Jay Creek mineral lick be closed to boat and floatplane use. Such restrictions will be imposed on access during the construction phase, as indicated in Mitigation Plan 10.

(v) Garbage Incineration and Fencing Recommendation

USFWS (1983) strongly recommended adequate fencing and garbage incineration and indicated the need to clearly post and monitor gate closures. This is treated in detail in Mitigation Plan 15.

(vi) Prohibition of Hunting and Trapping Recommendations

USFWS (1983) recommended that workers and their families be prohibited from hunting or trapping while working in the project area.

Mitigation Plan 14 describes the measures incorporated into project design to treat the possible impact of overharvest of game. The Power Authority has no moral or legal right to prohibit hunting or trapping on adjacent state, federal, or private lands. However, control can be exercised over the use of project equipment and facilities. Although the Power Authority can have no control over harvest activities, they will continue to provide any data from monitoring investigations to the Alaska Board of Game to assist in regulation of hunting and trapping.

(vii) Transmission Corridor Recommendations

In addition to consolidation of access and transmission corridors (treated under access, above), the USFWS (1983) recommended selective clearing, winter and helicopter construction and maintenance, and controlled access along the transmission line.

The transmission corridor has been re-routed to simplify construction and maintenance and to increase reliability. While those concerns must dominate, the chosen design minimizes overall disturbance. Selective clearing has been incorporated into the design (see Section 3.4.2[a][ii]). High priority species to which summer clearing would be detrimental (e.g., eagles and falcons) will be protected by disturbance regulations presented in Mitigation Plan 10. There is no plan at the present time to control access along the transmission corridor. Fencing would obstruct movements of game and is likely to be ineffective unless monitored.

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APPENDIX E3A
Fish and Wildlife Mitigation Policy

APPENDIX 3.A

SUSITNA HYDROELECTRIC PROJECT - FISH AND WILDLIFE MITIGATION POLICY

NOVEMBER 1981
REVISED MARCH 1982
REVISED APRIL 1982

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 consisted of staff members of Terrestrial Environmental Specialists, 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 was to develop the technical specifics of the mitigtaion 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, and
National Marine Fisheries Service.

A mandate of the Alaska Power Authority (hereinafter called the Power Authority) charter is to develop supplies of electrical energy to meet the present and future needs of the state of Alaska. The Power Authority also recognizes the value of our natural resources and accepts the responsibility of insuring that the development of any new projects is as compatible as possible with the fish and wildlife resources of the state and the habitat that sustains them, and that the overall effects of any such projects will be beneficial to the state as a whole. In this regard, the Power Authority 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 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 Rulemaking as it appeared in the November 13, 1981, issue of the Federal Register (46 FR 55926-55953) and adopted. Exhibit E of the proposed FERC regulations 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 (FWCA) 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 a 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 FWCA.

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 Power Authority 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 Power Authority 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 the Power Authority and the resource agencies. The FERC will resolve any disputes which the agencies and the Power Authority cannot resolve. It is the intent of the Power Authority to negotiate directly and resolve conflicts with the concerned agencies.

The mitigation plan will be submitted by the Power Authority 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 responsibility for implementation of the plan will be that of the Power Authority and will be carried out by the Power Authority 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.

The Power Authority 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 responsibility for implementation of the mitigation plan rests with the Power Authority. Prior to implementing the plan, an agreement will be reached as to the most efficient and effective 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.

The mitigation plan will include a brief statement of each impact issue, the technique or approach to be utilized to mitigate the impact, and the goal expected to be achieved through implementation of these actions.

With the realization that a mitigation monitoring team will be necessary to insure the proper and successful execution of the mitigation plan and to determine its effectiveness, 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 FERC. It is the intent of the Power Authority to reach agreement with the resource agencies concerning modification of the plan prior to seeking FERC approval. The Power Authority will seek approval of the resource agencies, with FERC as the final arbitrator. The need for continuing this monitoring will be reviewed periodically. The monitoring program will be terminated when the mitigation goals described in the plan have been achieved or determined unachievable. Termination will be subject to FERC approval.

4 - APPROACH TO DEVELOPING THE FISH AND WILDLIFE MITIGATION PLANS

The develoment of the Susitna Fish and Wildlife Mitigation Plans will follow a logical step-by-step process. Figure E.3.1 illustrates this process and identifies the major components of the process. Also identified in this figure are the organizations responsible for each step. The following discussion is based on Figure 1 and uses the numbers in the lower right corner 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 identification 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. Ths 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. If additional impacts materialize, the plan will be modified as discussed in Section 3.4. This could also include a shift in the prioritization of impacts.

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 E.3.2). If a proposed form of mitigation is technically infeasible, only partially effective, or in confict with other project objectives, additional options including project modification will be evaluated. All options considered will be evaluated and documented; this documentation will include an identification of the impact issue, mitigation options, and conflicts (if any) with project objectives. 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.

Step 3 concerns the development of an acceptable mitigation plan. The feasible mitigation options identified through Step 2, and a description and explanation of those deemed infeasible, 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 the Power Authority 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, revised and circulated to the agencies for formal review and comment. The plans will then be revised and submitted 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 the Power Authority and appropriate natural resource agencies.

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. This will be done in consultation with the Fish and Wildlife Mitigation Review Group.

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 Power Authority 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). Any modifications to the mitigation plan will not be implemented without consultation with appropriate state and federal agencies and approval of FERC. As discussed in Section 3.4, it is the intent of the Power Authority to reach agreement with the resource agenices concerning modification of the plan prior to seeking FERC approval. The Power Authority will seek approval of the resource agencies, with FERC as the final arbitrator.

Following satisfactory implementation of any plan modifications and documentation of evidence that the goals of the modification have been reached, the mitigation planning process and monitoring will terminate (Steps 7 and 8).

APPENDIX E3B

Environmental Guidelines Memorandum

APPENDIX 3.B

SUSITNA HYDROELECTRIC PROJECT

MEMORANDUM

October 25, 1982

TO: Dr. John Hayden, Acres American, Inc.
Dr. Richard Fleming, Alaska Power Authority

FROM: Dr. Robert Sener, LGL Alaska Research Associates, Inc.
Dr. Larry Moulton, Woodward Clyde Consultants, Inc.
Mr. Robert Erickson, EDAW, Inc.

SUBJECT: Environmental Guidelines for Facility Siting, Design, Construction, Operation and Rehabilitation

The attached environmental guidelines are provided for your review and consideration. They were prepared cooperatively by our three firms and represent a consensus of our professional judgement. We believe that these guidelines, if followed, will make a major contribution toward avoiding, minimizing, rectifying, and reducing adverse impacts of the project on the environment.

We strongly recommend that these guidelines be followed for all future engineering design and construction planning programs of the Susitna Hydroelectric Project. Furthermore, we urge that the following steps be taken immediately:

1. Provide the guidelines to all persons responsible for preparing exhibits or sub-sections of the FERC license application. The document should consistently reflect the incorporation of appropriate environmental protection measures into the basic thinking underlying the project.

2. Make the guidelines available to Phase II contractors as part of a special communication which emphasizes the importance of integrating environmental protection strategies into the earliest stages of engineering design and construction plannning.

   Please note that these are only guidelines. Site-specific facility designs and construction plans should be considered on a case-by-case basis to ensure that project requirements are satisfied with minimal adverse impact to the environment. To achieve this goal, environmental specialists should work side-by-side with project engineers in the same design offices, and in the field through pre-construction siting studies.

SUSITNA HYDROELECTRIC PROJECT

Environmental Guidelines for Facility Siting, Design, Construction, Operation , and Rehabilitation

Prepared by

LGL Alaska Research Associates, Inc.
Woodward-Clyde Consultants, Inc.
EDAW, Inc.

October 21, 1982

A. ALL FACILITIES

1. A 500-foot minimum-width buffer of undisturbed vegetation should be maintained between a facility and any stream, lake, or wetland.

2. Siting should minimize requirements for clearing or removal of vegetation.

3. Where removal of vegetation is required, organic overburden should be segregated and stockpiled for use in subsequent rehabilitation. Stockpiles should be placed in well-drained locations and bermed to contain runoff. Depleted or non-operational borrow pits should be used as overburden storage areas where feasible.

4. Structures should be consolidated to disturb the minimum necessary area of ground surface.

5. Design should minimize gravel requirements by avoidance of wet areas or permafrost zones, structure consolidation, and balanced cut and fill.

6. Where gravel pads must be used, adequate provision for cross-drainage should be made to avoid impoundment of sheet flow.

7. A minimum distance of 1/2 mile should be maintained between any facility and the following:

   - Salmon spawning area;
   - Bald eagle nest;
   - Golden eagle nest;
   - Brown bear den;
   - Black bear den;
   - Wolf den;
   - Dall sheep lambing area; and
   - Mineral lick.

8. Blasting should avoid times and locations which are sensitive to fish and wildlife. These times and locations should be determined on a case-by-case basis by the environmental consultant and in accordance with resource agency guidelines. Proper sizing and sequencing of blasting charges can minimize fish and wildlife impacts. Streamside excavation should not be done by blasting. Blasting procedures and schedules must be sufficiently flexible to allow alteration at short notice for the protection of wildlife. Alaska Department of Fish and Game blasting guidelines should be followed.

9. Excavation spoil should be disposed of in the future impoundment area of the dam under construction. Where haul distances prohibit this, spoil should be used in the rehabilitation of depleted or non-operational material sites, or for solid waste disposal site maintenance. Spoil retained for these applications should be stockpiled in stable, well-drained locations, and bermed to contain runoff.

10. Solid waste disposal sites should be established in stable, well-drained locations. Siting should utilize existing excavations such as depleted upland borrow pits. Intermittent drainages, ice-rich soils, or other erosion-susceptible features should be avoided. Deposited material should be covered daily with non-silty excavation spoil stockpiled for this purpose at the site. Solid waste disposal site design and operation should conform with guidelines established by the Alaska Department of Environmental Conservation.

11. Facility siting should avoid thaw-susceptible areas (discontinuous permafrost zones) capable of slumping or thermal erosion.

12. Where hydraulic erosion is unavoidable, appropriate measures (ranging from filtration fabric to settling ponds) should be employed to minimize siltation.

13. Erosion-prone slopes should be fertilized and dry-seeded with a fast-growing native grass.

14. Equipment, structures, and materials should be removed from a site prior to rehabilitation. The site should be graded to contours which are consistent with surrounding terrain and allow complete drainage with minimal erosion potential.

15. Where it can be demonstrated that erosion is not likely to be a problem, restoration should emphasize fertilization and scarification, and minimize seeding, to encourage the invasion of native plants from the surrounding parent population. Where seeding is employed, native grasses appropriate to the climate and geography of the project area should be used.

16. A systematic program to avoid or mitigate project activity-related impacts should be developed during Phase II. At a minimum, this program should include the following components:

- A Petroleum and Hazardous Substance Plan which sets forth detailed specifications for training of personnel and for procedures and equipment to ensure the safe storage, handling, transportation, collection, and disposal of petroleum products and hazardous substances. This program should include the preparation of a Petroleum and Hazardous Substances Manual to be used by all project personnel. Special attention should be given to the design of this manual so that size, format, and contents facilitate routine on-the-job use.

- An Environmental Briefings Program to familiarize project personnel with environmentally sensitive features of the stipulations, and specific project policies and restrictions regarding protection of vegetation, fish, wildlife, and cultural resources. The Environmental Briefings Program should be combined with the project Safety Program and involve continuing updates and reviews through regularly-scheduled weekly meetings. The Environmental Briefings Program should be positive and informative in nature, and use visual aids to stimulate interest. The program should strive to explain why a certain feature or organism is vulnerable to disturbance, and therefore, why protective measures are needed in each case.

17. Storage containers for fuels and hazardous substances should be located at least 1,500 feet from water bodies and bermed to contain 110 percent of the maximum volume to be stored. Containment areas should be lined with impervious material.

18. Project construction and operation activities should be planned and scheduled to avoid or minimize disturbance to fish streams. Where activities affecting fish streams cannot be avoided (e.g., construction of stream crossings), activities should be scheduled for periods when fish are not present. Where stream crossings are planned for winter construction, the thalweg, banks, and other locational features should be identified and staked in the field prior to snowfall or freeze-up.

B. CONSTRUCTION CAMPS

1. To minimize scavenging by birds and mammals, with resultant adverse contacts between people and animals, all putrescible kitchen wastes should be stored indoors in sealed containers, and incinerated on the same day they are produced.

2. Camp incinerators should be properly sized and operated by trained personnel to ensure that all putrescible wastes are completely burned to mineral ash. Incinerator capacity should be carefully specified to accommodate peak camp occupancy.

3. Camp perimeters should be protected with animal-resistant fencing designed and built to specifications provided by the environmental consultant.

4. The liquid waste treatment system should be operated by State-of-Alaska accredited personnel. Greywater must be treated along with other liquid wastes. A regular effluent sampling and testing program should be followed to ensure compliance with NPDES and State of Alaska Wastewater Disposal Standards (18 AAC 72). Effluent testing should be conducted by a State-of-Alaska certified water quality laboratory. Effluent discharge to streams should be located to achieve maximum dilution.

5. Wells should be established for potable water withdrawal. If wells are not feasible at a given location, water should be withdrawn from lakes. Streams should be considered only as a last resort, and only after a determination is made on a case-by-case basis that fish or wildlife will not be adversely affected by water withdrawal, particularly during overwintering and reproductive periods. Intake structures should be designed to preclude entrapment or entrainment of fish eggs or larvae.

C. <u>ACCESS ROADS</u>

1. Road design speeds should be kept to the minimum consistent with project requirements, and should not exceed 40 miles per hour. Lower design speeds allow greater flexibility for alignment adjustments to avoid environmentally sensitive features, and reduce requirements for major road cuts. Lower design speeds also enable routing to follow higher, drier terrain, thereby reducing requirements for gravel extraction and fill placement in wetlands. A 40-mile-per-hour design speed will increase road safety and enhance recreational resource potential.

2. Road profile elevations should be minimized and side slopes made sufficiently gentle to allow free passage of big game.

3. Routes should avoid wetland and riparian areas, and minimize stream crossings and encroachments.

4. Road design should keep gravel extraction requirements to a minimum by avoiding wet areas and emphasizing balanced cut and fill.

5. Where stream crossings cannot be avoided, they should be aligned at right angles to the stream and located to minimize requirements for bank cutting and streambed disturbance. Fish spawning and overwintering areas within streams should be avoided by route adjustments.

6. Bridges should be installed in preference to culverts or low-water crossings (fords). Bridge supports should be located outside active channels.

7. Culverts should be properly sized to accommodate all species and age groups of fish utilizing that portion of the stream (see Alaska Department of Fish and Game stream crossing guidelines).

8. Culverts should be placed to conform with the slope of the undisturbed streambed at the place of installation, and should not be perched.

9. Low-water crossings should be used only where a stream will sustain infrequent, light traffic. Such crossings should conform to the slope of the undisturbed streambed and should be constructed of materials that will preclude water percolating through rather than over them.

10. Where stream crossings are planned for winter construction, the thalweg, banks, and other locational features should be identified and staked in the field prior to snowfall or freeze-up. Overwintering areas of fish or aquatic mammals must not be disturbed during winter construction.

11. All access roads not required for project operation or recreational purposes should be "put to bed" as soon as they are no longer required, if possible during the same season. Drainage structures should be removed and the roadbed recontoured to a stable configuration providing proper drainage. Rehabilitation should inlcude scarification, fertilization, and blockage with a berm followed by a cut. Erosion-prone locations should be seeded with fast-growing native grasses. Where impoundment of sheet flow has occurred, non-operational roads should be structurally altered to restore normal flow.

12. Road dust control should utilize water rather than oil or other synthetic compounds. Water withdrawal procedures and sources for dust control should be approved on a case-by-case basis by environmental personnel following site-specific inspection.

13. Grading or other road maintenance activities should not push material into streams. Culverts should be checked periodically and kept free of ice and debris to avoid blocking flows. Special attention to culverts is required immediately prior to, during, and following spring break-up.

D. MATERIAL SITES

1. A detailed, site-specific mining plan should be prepared for each borrow operation. Design should be an interdisciplinary team effort involving civil engineers and environmental specialists experienced in design, construction, and permit requirements. Mining plans should include all roads, facilities, mining techniques, schedules, and rehabilitation procedures.

2. Borrow areas required for dam and ancillary facility construction should be sited in the future impoundment area of the dam under construction.

3. Siting of borrow areas outside the impoundment zone should place first priority on well-drained upland locations. Second priority consideration should be given to first-level terrace sites. Active floodplain and streambed sites should be avoided unless they are within the impoundment area of the dam under construction. Stockpiling within active floodplains should be prohibited. Floodplain gravel mining should follow the guidelines set forth in the U.S. Fish and Wildlife Service "Gravel Removel Guidelines Manual for Arctic and Subarctic Floodplains," 1980.

4. All material sites should be developed in phases by aliquots. The phases should be prioritized to save until last those portions of the site which are more sensitive from an environmental standpoint.

5. First-level terrace sites outside the impoundment zone should be located on the inactive side of the floodplain and mined by pit excavation rather than by shallow scraping. Excavations should be separated from the active floodplain by a 500-foot buffer of undisturbed, vegetated terrain.

6. If wet processing is required, water withdrawal and discharge locations should be carefully sited to minimize fish and wildlife disturbance. Drawdown in overwintering pools used by fish or aquatic mammals, and any disturbance to spawning areas, must be avoided. Water intake structures should be designed to preclude entrapment or entrainment of fish eggs or larvae. Gravel washing should employ recycled water. If pit dewatering is required because of ponding or wet processing, settling poinds should be designed, operated, and monitored to ensure that NPDES standards for discharge are achieved. Settling ponds should be designed and sited to avoid fish entrapment. Water discharge should be directed in a manner that will minimize erosion. Energy dissipators should be used where necessary.

7. Abandoned access roads, camp pads, and airstrips should be used wherever feasible as material sources for operations, in lieu of expanding existing sites or initiating new ones. Where riprap is required, material produced during excavation of the powerhouse, galleries, and tunnels should be used if feasible.

8. Material site design features should facilitate restoration. Sites should have irregular boundaries, including projections of undisturbed, vegetated terrain into the site. Slopes should incorporate a diversity of contours created during actual excavation, rather than during restoration.

9. Where ponding will occur, as in first-level terrace sites, irregular boundaries and slope contours should be accentuated. Islands of undisturbed vegetated terrain should be left within the perimeter of the operational site.

10. Organic overburden, slash, and debris stockpiled during clearing should be distributed over the excavated area prior to fertilization. This includes sites which have ponded.

11. Once operational material sites are depleted or no longer required, they should be rehabilitated by the end of the next growing season following last use.

E. <u>TRANSMISSION CORRIDORS</u>

1. Where they are not adjacent to an existing road, transmission corridors should be constructed by helicopter support to avoid unnecessary clearing of vegetation. In tundra locations where clearing is not required for access, winter construction on a snow base may be an acceptable substitute for helicopter-supported construction, provided Rolligon or flat-tread Nodwell-type vehicles are used. Transmission corridor development should avoid creating an alternative access route for all-terrain vehicles.

2. Transmission line additions should be made adjacent to established transmission corridors. Where transmission lines have a common destination, they should follow a common route.

3. Transmission towers should not be placed in active floodplains and should avoid streams and lakes by a minimum 500 feet.

4. Herbicides should not be used for vegetation control along transmission corridors.

5. Transmission corridors should follow the forest edge (i.e., the transition zone between forest and shrub or forest and tundra), and avoid crossing wetlands.

APPENDIX E3C

Preliminary List of Plant Species
Upper and Middle Susitna River

APPENDIX 3.C: PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED IN SUMMERS OF 1980 AND 1981 IN THE UPPER AND MIDDLE SUSITNA RIVER BASIN* (U), THE DOWNSTREAM FLOODPLAIN (D), AND THE INTERTIE (I) (AFTER MCKENDRICK ET AL. 1982)

Pteridophyta

Aspidiaceae

		U	D	I
Dryopteris dilatata (Hoffm.) Gray	Shield fern	U	D	I
Dryopteris fragrans (L.) Schott	Fragrant shield fern	U		I
Gymnocarpium dryopteris (L.) Newm.	Oak fern	U	D	I

Athyriaceae

		U	D	I
Athyrium filix-femina (L.) Roth	Lady fern	U	D	
Cystopteris fragilis (L.) Bernh.	Fragile fern	U		
Cystopteris montana (Lam.) Bernh.	Mountain fragile fern	U		
Matteuccia struthiopteris (L.) Todaro	Ostrich fern		D	I
Woodsia alpina (Bolton) S. F. Gray	Alpine woodsia	U		

Equisetaceae

		U	D	I
Equisetum arvense L.	Meadow horsetail	U		
Equisetum fluviatile L. ampl. Ehrh.	Swamp horsetail	U		
Equisetum palustre L.	Marsh horsetail		D	
Equisetum pratense L.	Meadow horsetail	U	D	
Equisetum silvaticum L.	Woodland horsetail	U		I
Equisetum variegatum Schleich.	Variegated scouring-rush	U	D	
Equisetum sp.	Horsetail			I

Isoetaceae

		U	D	I
Isoetes muricata Dur.	Quillwort	U		

Lycopodiaceae

		U	D	I
Lycopodium alpinum L.	Alpine clubmoss	U		
Lycopodium annotinum L.	Stiff clubmoss	U		
Lycopodium clavatum L.	Running clubmoss	U		
Lycopodium complanatum L.	Ground cedar	U		
Lycopodium selago L. ssp. selago	Fir clubmoss	U		

Thelypteridaceae

		U	D	I
Thelypteris phegopteris (L.) Slosson	Long beech fern	U		

Gymnospermae

Cupressaceae

		U	D	I
Juniperus communis L.	Common juniper	U		I

Pinaceae

		U	D	I
Picea glauca (Moench) Voss	White spruce	U	D	I
Picea mariana (Mill.) Britt., Sterns & Pogg.	Black spruce	U		I

Monocotyledoneae

Cyperaceae

		U	D	I
Carex aquatilis Wahlenb.	Water sedge	U		
Carex bigelowii Torr.	Bigelow sedge	U		
Carex capillaris L.	Hairlike sedge	U		
Carex canescens L.	Silvery sedge	U	D	I
Carex concinna R. Br.	Low northern sedge	U		

Carex filifolia Nutt.	Thread-leaf sedge	U		
Carex garberi Fern.	Sedge		D	
Carex limosa L.	Shore sedge	U		
Carex loliacea L.	Sedge	U		
Carex media R. Br. ex Richards.	Sedge	U		
Carex membranacea Hook.	Fragile sedge	U		
Carex podocarpa C. B. Clarke	Short-stalk sedge	U		
Carex rhynchophysa C. A. Mey.	Sedge	U		
Carex saxatilis L.	Sedge		D	
Carex spp.	Sedge	U	D	I
Eleocharis sp.	Spike rush			I
Eriophorum angustifolium Honck.	Tall cottongrass	U		
Eriophorum scheuchzeri Hoppe	White cottongrass	U		
Eriophorum vaginatum L.	Tussock cottongrass	U	D	I
Eriophorum sp.	Cottongrass		D	I
Scirpus microcarpus Presl.	Small-fruit bullrush		D	
Trichophorum caespitosum (L.) Hartm.	Tufted clubrush	U		
Gramineae (Poaceae)				
Agropyron boreale (Turcz.) Drobov	Northern wheatgrass		D	
Agropyron caninum (L.) Beauv.	Wheatgrass		D	
Agropyron macrourum (Turcz.) Drobov	Wheatgrass		D	
Agropyron sp.	Wheatgrass	U		
Agrostis scabra Willd.	Tickle grass	U	D	
Agrostis sp.	Bent grass	U		
Alopecurus alpinus Sm.	Mountain foxtail	U		
Arctagrostis latifolia (R. Br.) Griseb.	Polargrass	U		
Beckmannia syzigachne (Steud.) Fern	Slough grass		D	
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint	U	D	I
Calamagrostis purpurascens R. Br.	Purple reedgrass	U		
Cinna latifolia (Trev.) Griseb. in Ledeb	Woodreed		D	
Danthonia intermedia Vasey	Timber oatgrass	U		
Deschampsia atropurpurea (Wahlenb.) Scheele**	Mountain hairgrass	U		
Deschampsia caespitosa (L.) Beauv.	Tufted hairgrass	U	D	
Festuca altaica Trin.	Fescue grass	U		
Festuca rubra L. Coll.	Red fescue	U		
Hierochloe alpina (Swartz) Roem. & Schult.	Alpine holygrass	U		
Hierochloe odorata (L.) Wahlenb.	Vanilla grass	U	D	
Phleum commutatum Gandoger	Timothy	U		
Poa alpina L.	Alpine bluegrass	U		
Poa arctica R. Br.	Arctic bluegrass	U		
Poa palustris L.	Bluegrass	U		
Trisetum spicatum (L.) Richter	Downy oatgrass	U	D	
Iridaceae				
Iris setosa Pallas	Wild iris	U		I
Juncaceae				
Juncus arcticus Willd.	Arctic rush	U	D	
Juncus castaneus Sm.	Chestnut rush	U		
Juncus drummondii E. Mey.	Drummond rush	U		
Juncus mertensianus Bong.	Mertens rush	U		
Juncus triglumis L.	Rush	U		
Luzula campestris (L.) DC. ex DC. & Lam.**	Woodrush	U		
Luzula confusa Lindeb.	Northern woodrush	U		
Luzula multiflora (Retz.) Lej.	Woodrush	U		
Luzula parviflora (Ehrh.) Desv.	Small-flowered woodrush	U		
Luzula tundricola Gorodk.	Tundra woodrush	U		
Luzula wahlenbergii Rupr.	Wahlenberg woodrush	U		

Liliaceae				
Lloydia serotina (L.) Rchb.	Alp lily	U		I
Streptopus amplexifolius (L.) DC.	Cucumber root	U	D	I
Tofieldia coccinea Richards	Northern asphodel	U		
Tofieldia pusilla (Michx.) Pers.	Scotch asphodel	U		I
Veratrum viride Ait.	False hellebore	U		I
Zygadenus elegans Pursh	Elegant death camas	U		I
Orchidaceae				
Listera cordata (L.) R. Br.	Twyblade			I
Platanthera convallariaefolia (Fisch.) Lindl.	Northern bog-orchis	U		
Platanthera dilatata (Pursh) Lindl.	White bog-orchis	U		
Platanthera hyperborea (L.) Lindl.	Northern bog-orchis	U		I
Potamogetomaceae				
Potamogeton epihydrus Raf.	Nuttall pondweed	U		
Potamogeton filiformis Pers.	Filiform pondweed	U		
Potamogeton gramineus L.	Pondweed	U		
Potamogeton perfoliatus L.	Clasping-leaf pondweed	U		
Potamogeton robbinsii Oakes	Robbins pondweed	U		
Sparganiaceae				
Sparganium angustifolium Michx.	Narrow-leaved burreed	U		
Dicotyledoneae				
Araliaceae				
Echinopanax horridum (Sm.) Decne. & Planch.	Devil's club	U	D	I
Betulaceae***				
Alnus crispa (Ait.) Pursh	American green alder	U		I
Alnus sinuata (Reg.) Rydb.	Sitka alder	U	D	I
Alnus tenuifolia Nutt.	Thinleaf alder		D	
Alnus sp.	Alder			I
Betula glandulosa Michx.	Resin birch	U		I
Betula nana L.	Dwarf arctic birch	U	D	I
Betula occidentalis Hook.	Water birch	U		
Betula papyrifera Marsh.	Paper birch	U	D	I
Boraginaceae				
Mertensia paniculata (Ait.) G. Don	Tall bluebell	U	D	I
Myosotis alpestris F. W. Schmidt	Forget-me-not	U		
Callitrichaceae				
Callitriche hermaphroditica L.	Water starwort	U		
Callitriche verna L.	Vernal water starwort	U		
Campanulaceae				
Campanula lasiocarpa Cham.	Mountain harebell	U		I
Caprifoliaceae				
Linnaea borealis L.	Twin-flower	U		I
Sambuons callicarpa	Pacific red elder			I
Viburnum edule (Michx.) Raf.	High bush cranberry	U	D	I

Caryophyllaceae

Minuartia obtusiloba (Rydb.) House	Alpine sandwort	U		
Moehringia laterifolia (L.) Fenzl	Grove Sandwort			I
Silene acaulis L.	Moss campion	U		
Stellaria crassifolia Ehrh.	Chickweed			I
Stellaria sp.	Starwort	U		
Wilhelmsia physodes (Fisch.) McNeill	Merckia	U		

Compositae (Asteraceae)

Achillea borealis Bong.	Yarrow	U	D	
Achillea sibirica Ledeb.	Siberian yarrow	U	D	
Antennaria alpina (L.) Gaertn.	Alpine pussytoes	U		
Antennaria monocephala DC.	Pussytoes	U		
Antennaria rosea Greene	Pussytoes	U		
Arnica amplexicaulis Nutt. ssp. *prima* Maguire	Arnica	U		
Arnica chamissonis Less. (?)	Arnica		D	
Arnica frigida C. A. Mey.	Arnica	U		I
Arnica lessingii Greene	Arnica	U		
Artemisia alaskana Rydb.	Alaska wormwood	U		
Artemisia arctica Less.	Wormwood	U		I
Artemisia tilesii Ledeb.	Wormwood	U	D	I
Aster sibiricus L.	Siberian aster	U	D	I
Erigeron acris subsp. *politus* (L.) (E. Fries) Schinz & Keller	Fleabane	I		
Erigeron humilis Graham	Fleabane daisy	U		
Erigeron lonchophyllus Hook.	Daisy		D	
Erigeron purpuratus Greene	Fleabane			I
Hieracium triste Willd	Wooly hawkweed	U		
Petasites frigidus (L.) Franch.	Arctic sweet coltsfoot	U		I
Petasites sagittatus (Banks) Gray	Arrowleaf sweet coltsfoot	U		
Petasites sp.	Sweet coltsfoot		D	I
Saussurea angustifolia (Willd.) DC.	Saussurea	U		I
Senecio atropurpureus (Ledeb.) Fedtsch.	Ragwort	U		
Senecio lugens Richards.	Ragwort	U		I
Senecio sheldonensis Pors.	Sheldon groundsel	U		
Senecio triangularis Hook	Ragwort			I
Senecio sp.	Ragwort			I
Solidago multiradiata Ait.	Northern goldenrod	U	D	
Taraxacum sp.	Dandelion	U		

Cornaceae sp.

Cornus canadensis L.	Bunchberry	U	D	I

Crassulaceae

Sedum rosea (L.) Scop.	Roseroot	U		I

Cruciferae (Brassicacea)

Draba aurea Vahl	Draba			I
Cardamine bellidifolia L.	Alpine bittercress	U		
Cardamine pratensis L.	Cuckoo flower	U		
Cardamine umbellata Greene	Bittercress	U		
Draba nivalis Liljebl	Rockcress	U		
Draba stenoloba Ledeb.	Rockcress	U		
Parrya nudicaulis (L.) Regel	Parrya			I

Diapensiaceae

Diapensia lapponica L.	Diapensia	U		I

Droseraceae				
Drosera rotundifolia L.	Sundew			I
Elaeagnaceae				
Shepherdia canadensis (L.) Nutt.	Soapberry	U	D	I
Empetraceae				
Empetrum nigrum L.	Crowberry	U		I
Ericaceae				
Andromeda polifolia L.	Bog rosemary	U		
Arctostaphylos alpina (L.) Spreng.	Alpine bearberry	U		I
Arctostaphylos rubra (Rehd. & Wilson) Fern.	Red-fruit bearberry	U		I
Arctostaphylos uva-ursi (L.) Spreng.	Bearberry	U		I
Cassiope tetragona (L.) D. Don	Four-angle mountain heather	U		I
Ledum decumbens (Ait.) Small***	Northern Labrador tea	U		I
Ledum groenlandicum Oeder	Labrador tea	U		I
Ledum sp.	Labrador tea		D	I
Loiseleuria procumbens (L.) Desv.	Alpine azalea	U		I
Menziesia ferruginea Sm.	Menziesia			I
Oxycoccus microcarpus Turcz.	Swamp cranberry	U	D	
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay	U		I
Vaccinium caespitosum Michx.	Dwarf blueberry	U		
Vaccinium uliginosum L.	Bog blueberry	U	D	I
Vaccinium vitis-idaea L.	Mountain cranberry	U		I
Vaccinium sp.	Blueberry			I
Fumariaceae				
Corydalis pauciflora (Steph.) Pers.	Few-flowered corydalis	U		I
Gentianaceae				
Gentiana glauca Pall.	Glaucous gentian	U		
Gentiana propinqua Richards.	Gentian	U		
Menyanthes trifoliata L.	Buckbean	U	D	I
Swertia perennis L.	Gentian	U		I
Geraniaceae				
Geranium erianthum DC.	Northern geranium	U		I
Haloragaceae				
Hippuris vulgaris L.	Common marestail	U		
Leguminosae (Fabaceae)				
Astragalus aboriginum Richards.	Milk-vetch	U		
Astragalus alpinus L.**	Milk-vetch	U	D	
Astragalus umbellatus Bunge	Milk-vetch	U		
Hedysarum alpinum L.	Alpine sweet-vetch	U	D	I
Lupinus arcticus S. Wats.	Arctic lupine	U		I
Oxytropis campestris (L.) DC.	Field oxytrope		D	
Oxytropis huddelsonii Proslid	Huddelson oxytrope	U		
Oxytropis maydelliana Trautv.	Maydell oxytrope	U		
Oxytropis nigrescens (Pall.) Fisch.	Blackish oxytrope	U		I
Oxytropis viscida Nutt.	Viscid oxytrope	U		

Lentibulariaceae				
Pinguicula villosa L.	Hairy butterwort	U		
Utricularia vulgaris L.	Common bladderwort	U		
Myricaceae				
Myrica gale L.	Sweet gale	U	D	I
Nymphaeaceae				
Nuphar polysepalum Engelm.	Yellow pond lily	U		
Onagraceae				
Circaea alpina L.	Enchanter's nightshade		D	
Epilobium angustifolium L.	Fireweed	U	D	I
Epilobium latifolium L.	Dwarf fireweed	U	D	I
Epilobium palustre L.	Swamp willow-herb	U		
Orobanchaceae				
Boschniakia rossica (Cham. & Schlecht. Fedtsch.	Poque	U	D	I
Polemoniaceae				
Polemonium acutiflorum Willd.	Jacob's ladder	U	D	I
Polygonaceae				
Oxyria digyna (L.) Hill	Mountain sorrel	U		I
Polygonum bistorta L.	Meadow bistort	U		
Polygonum viviparum L.	Alpine bistort	U		I
Rumex arcticus Trautv.	Arctic dock	U		I
Rumex sp.	Dock	U		I
Portulacaceae				
Claytonia sarmentosa C. A. Mey.	Spring-beauty	U		I
Primulaceae				
Androsace chamaejasme Hult.	Androsace			I
Dodecatheon frigidum Cham. & Schlecht.	Northern shooting star	U		I
Primula cuneifolia Ledeb.	Wedge-leaf primrose	U		
Trientalis europaea L.	Arctic starflower	U	D	I
Pyrolaceae				
Moneses uniflora (L.) Gray	Single delight	U	D	
Pyrola asarifolia Michx.	Liverleaf wintergreen		D	
Pyrola grandiflora Radius	Large-flower wintergreen	U		
Pyrola minor L.	Lesser wintergreen	U		
Pyrola secunda L.	One-sided wintergreen	U	D	
Pyrola sp.	Wintergreen			I
Ranunculaceae				
Aconitum delphinifolium DC.	Monkshood	U		I
Actaea rubra (Ait.) Willd.	Baneberry		D	
Anemone narcissiflora L.	Anemone	U		I
Anemone parviflora Michx.	Northern anemone	U		I
Anemone richardsonii Hook	Anemone	U	D	I
Anemone sp.	Anemone			I
Caltha leptosepala DC.	Mountain marsh-marigold	U		I

Delphinium glaucum S. Wats	Larkspur			I
Ranunculus confervoides (E. Fries) E. Fries	Water crowfoot	U		
Ranunculus macounii Britt. (may be R. pacificus or something similar)	Macoun buttercup		D	
Ranunculus nivalis L.	Snow buttercup	U		
Ranunculus occidentalis Nutt.	Western buttercup	U		
Ranunculus pygmaeus Wahlenb.	Pygmy buttercup	U		
Ranunculus sp.	Buttercup	U		I
Thalictrum alpinum L.	Arctic meadowrue	U		
Thalictrum sparsiflorum Turcz.	Few-flower meadowrue	U	D	I
Rosaceae				
Dryas drummondii Richards.	Drummond mountain-avens	U	D	I
Dryas integrifolia M. Vahl.	Dryas	U		I
Dryas octopetala L.	White mountain-avens	U		
Geum macrophyllum Wild.	Avens			I
Geum rossii (R. Br.) Ser.	Ross avens	U		I
Luetkea pectinata (Pursh) Ktze.	Luetkea	U		
Potentilla biflora Willd.	Two-flower cinquefoil	U		
Potentilla fruticosa L.	Shrubby cinquefoil	U		I
Potentilla hyparctica Malte	Arctic cinquefoil	U		
Potentilla palustris (L.) Scop.	Marsh cinquefoil	U	D	I
Rosa acicularis Lindl.	Prickly rose	U	D	I
Rubus arcticus L.	Nagoon berry	U	D	I
Rubus chamaemorus L.	Cloudberry	U		I
Rubus idaeus L.	Raspberry	U	D	I
Rubus pedatus Sm.	Five-leaf bramble	U		I
Rubus sp.	Raspberry			I
Sanguisorba stipulata Raf.	Sitka burnet	U		I
Sibbaldia procumbens L.	Sibbaldia	U		
Sorbus scopulina Greene	Western mountain ash	U		I
Spiraea beauverdiana Schneid.	Beauverd spirea	U	D	I
Rubiaceae				
Galium boreale L.	Northern bedstraw	U		I
Galium trifidum L.	Small bedstraw	U		
Galium triflorum Michx.	Sweet-scented bedstraw		D	
Salicaceae***				
Populus balsamifera L.	Balsam poplar (or cottonwood)	U	D	I
Populus tremuloides Michx.	Quaking aspen	U		I
Salix alaxensis (Anderss.) Cov.	Feltleaf willow	U	D	
Salix arbusculoides Anderss.	Littletree willow	U	D	
Salix arctica Pall.	Arctic willow	U		
Salix barclayi Anderss.	Barclay willow	U		
Salix brachycarpa Nutt.	Barren-ground willow	U		
Salix fuscescens Anderss.	Alaska bog willow	U	D	
Salix glauca L.	Grayleaf willow	U		
Salix lanata L. ssp. richardsonii (Hook) A. Skwortz.	Richardson willow	U		
Salix monticola Bebb	Park willow	U		
Salix novae-angliae Anderss.	Tall blueberry willow	U	D	
Salix phlebophylla Anderss.	Skeletonleaf willow	U		
Salix planifolia Pursh ssp. planifolia	Planeleaf willow	U		
Salix planifolia Pursh ssp. pulchra (Cham.) Argus	Diamondleaf willow	U		
Salix polaris Wahlenb.	Polar willow	U		
Salix reticulata L.	Netleaf willow	U		
Salix rotundifolia Trautv.	Least willow	U		
Salix scouleriana Barratt	Scouler willow	U		
Salix sp.	Willow	U	D	I

Santalaceae				
Geocaulon lividum (Richards.) Fern.	Sandalwood	U		
Saxifragaceae				
Boykinia richardsonii (Hook.) Gray	Richardson boykinia	U		
Leptarrhena pyrolifolia (D. Don) Ser.	Leather-leaf saxifrage	U		
Parnassia palustris L.	Northern Grass-of-Parnassus	U		I
Parnassia kotzebuei Cham & Schlecht.	Kotzebue Grass-of Parnassus	U		I
Parnassia sp.	Grass of Parnassus			
Ribes hudsonianum Richards.	Northern black currant			
Ribes laxiflorum Pursh (may be R. glandulosum)	Trailing black currant		D	
Ribes triste Pall.	Red currant	U	D	I
Saxifraga bronchialis L.	Spotted saxifrage	U		
Saxifraga davurica Willd.	Saxifrage	U		
Saxifraga foliosa R. Br.	Foliose saxifrage	U		
Saxifraga hieracifolia Waldst. & Kit.	Hawkweed-leaf saxifrage	U		
Saxifraga lyallii Engler	Red-stem saxifrage	U		
Saxifraga oppositifolia L.	Purple mountain saxifrage	U		I
Saxifraga punctata L.	Brook saxifrage	U		
Saxifraga serpyllifolia Pursh	Thyme-leaf saxifrage	U		
Saxifraga tricuspidata Rottb.	Three-tooth saxifrage	U		I
Scrophulariaceae				
Castilleja caudata (Pennell) Rebr.	Pale indian paintbrush	U		I
Mimulus guttatus DC.	Yellow monkey flower			I
Pedicularis capitata Adams	Capitate lousewort	U		
Pedicularis kanei Durand	Kane lousewort	U		I
Pedicularis labradorica Wirsing	Labrador lousewort	U		I
Pedicularis parviflora J. E. Sm. var. parviflora	Lousewort	U		
Pedicularis sudetica Willd.	Lousewort	U		
Pedicularis verticillata L.	Whorled lousewort	U		
Pedicularis sp.	Lousewort			I
Veronica americana				I
Veronica wormskjoldii Roem. & Schult.	Alpine speedwell			I
Umbelliferae (Apiaceae)				
Angelica lucida L.	Wild celery	U		
Heracleum lanatum Michx.	Cow parsnip	U	D	I
Valerianaceae				
Valeriana capitata Pall.	Capitate valerian	U		I
Violaceae				
Viola epipsila Ledeb.	Marsh violet	U		I
Viola langsdorffii Fisch.	Violet	U		
Viola biflora L.	Violet			I
Viola sp.	Violet			I
Nonvascular Plant Species				
Lichens				
Cetraria cucullata (Bell.) Ach.		U		
Cetraria islandica (L.) Ach.		U		
Cetraria nivalis (L.) Ach.		U		
Cetraria richardsonii Hook.		U		
Cetraria sp.		U		
Cladonia alpestris (L.) Rabenh.		U		

Cladonia mitis Sandst.		U
Cladonia rangiferina (L.) Web.	Reindeer moss	U
Cladonia sp.		U
Dactylina arctica (Hook.) Nyl.		U
Haematomma sp.		U
Lobaria linita (Ach.) Rabh.		D
Nephroma sp.		U
Peltigera sp.		U
Rhizocarpon geographicum (L.) DC.		U
Stereocaulon paschale (L.) Hoffm.		U D
Thamnolia vermicularis (Sw.) Schaer.		U
Umbilicaria sp.		U
Mosses		
Climacium sp.		U
Hypnum spp. and other feather mosses		U
Paludella squarrosa (Hedw.) Brid.†		U
Polytrichum sp.		U D
Ptilium crista-castrensis (Hedw.) DeNot.	Knight's plume	U
Rhacomitrium sp.		U D
Sphagnum sp.		U D

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* Vascular plant species nomenclature according to Hulten (1968) except where noted. Lichen nomenclature according to Thomson (1979). Moss nomenclature according to Conard (1979).

** Nomenclature according to Welsh (1974).

***Nomenclature according to Viereck and Little (1972).

† Nomenclature according to Crum (1976).

APPENDIX E3D

Preliminary List of Plant Species

Intertie Area

APPENDIX 3.D

PRELIMINARY LIST OF PLANT SPECIES IDENTIFIED DURING 1981 IN THE INTERTIE PROJECT AREA (FROM COMMONWEALTH 1982)

Pteridophyta

Aspidiaceae

Dryopteris dilatata subsp. *americana*	Shield fern
Dryopteris fragrans	Fragrant shield-fern
Gymnocarpium dryopteris	Oak-fern

Athyriaceae

Matteuccia struthiopteris	Ostrich fern

Equisetaceae

Equisetum sp.	Horsetail
Equisetum silvaticum L.	Woodland horsetail

Gymnospermae

Cupressaceae

Juniperus communis	Common juniper

Pinaceae

Picea glauca	White spruce
Picea mariana	Black spruce

Monocotyledoneae

Cyperaceae

Carex spp.	Sedge
Eriophorum spp.	Cottongrass

Gramineae

Calamagrostis canadensis	Bluejoint

Iridaceae

Iris setosa	Wild Flag

APPENDIX 3.D: (Page 2)

Monocotyledoneae (Cont'd)

Liliaceae

Lloydia serotina	Alp lily
Streptopus amplexifolius	Twisted-stalk
Tofieldia pusilla	Scotch asphodel
Veratrum viride subsp. eschscholtzii	False hellebore
Zygadenus elegans	White camas

Orchidaceae

Listera cordata	Twayblade
Platanthera hyperborea	Bog orchis

Dicotyledoneae

Araliaceae

Oplopanax horridum	Devil's Club

Betulaceae

Alnus crispa	American green alder
Alnus sinuata	Sitka alder
Betula glandulosa	Resin birch
Betula nana	Dwarf arctic birch
Betula papyrifera	Paper birch

Boraginaceae

Mertensia paniculata	Bluebell

Campanulaceae

Campanula lasiocarpa	Bellflower

Caprifoliaceae

Linnaea borealis	Twin-flower
Sambucus callicarpa	Pacific red elder
Viburnum edule	High bush cranberry

Caryophyllaceae

Stellaria crassifolia	Chickweed
Moehringia lateriflora	Grove sandwort

Dicotyledoneae (Cont'd)

Compositae	
Arnica frigida	Arnica
Artemisia arctica subsp. *arctica*	Wormwood
Artemisia tilesii subsp. *unalaschcensis*	Wormwood
Aster sibiricus	Siberian aster
Erigeron acris subsp. *politus*	Fleabane
E. purpuratus	Fleabane
Petasites frigidus	Arctic sweet coltsfoot
Saussurea angustifolia	Saussurea
Senecio sp.	Ragwort
Senecio lugens	Ragwort
Senecio triangularis	Groundsel
Cornaceae	
Cornus canadensis	Bunchberry
Crassulaceae	
Sedum rosea	Roseroot
Cruciferae	
Draba aurea	Rockcress
Parrya nudicaulis	Parrya
Diapensiaceae	
Diapensia lapponica	Diapensia
Droseraceae	
Drosera rotundifolia	Sundew
Elaeagnaceae	
Shepherdia canadensis	Buffaloberry
Empetraceae	
Empetrum nigrum	Crowberry

Dicotyledoneae (Cont'd)

Ericaceae	
Arctostaphylos alpina	Alpine bearberry
Arctostaphylos rubra	Red-fruit bearberry
Arctostaphylos uva-ursi	Bearberry
Cassiope tetragona	Four angle mountain heather
Ledum decumbens	Northern Labrador tea
Ledum groenlandicum	Labrador tea
Loiseleuria procumbens	Alpine azalea
Menziesia ferruginea	Rusty menziesia
Rhododendron lapponicum	Lapland rosebay
Vaccinium uliginosum	Bog blueberry
Vaccinium vitis-idaea	Mountain cranberry
Fumariaceae	
Corydalis pauciflora	Few-flowered corydalis
Gentianaceae	
Menyanthes trifoliata	Buckbean
Swertia perennis	Gentian
Geraniaceae	
Geranium erianthum	Cranesbill
Leguminosae	
Hedysarum alpinum subsp. *americanum*	Alpine-sweet-vetch
Lupinus arcticus	Arctic lupine
Oxytropis nigrescens	Blackish oxytrope
Myricaceae	
Myrica gale	
Onagraceae	
Epilobium angustifolium	Fireweed
Epilobium latifolium	River beauty
Orobanchaceae	
Boschniakia rossica	Poque

Dicotyledoneae (Cont.)

Polemoniaceae	
Polemonium acutiflorum	Jacob's ladder
Polygonaceae	
Oxyria dignya	Mountain sorrel
Polygonum viviparum	Alpine bistort
Rumex arcticus	Arctic dock
Portulacaceae	
Claytonia sarmentosa	Spring-beauty
Primulaceae	
Androsace chamaejasme subsp. lehmanniana	Rock jasmine
Dodecatheon frigidum	Northern shooting star
Trientalis europaea subsp. arctica	Arctic starflower
Pyrolaceae	
Pyrola sp.	Wintergreen
Ranunculaceae	
Aconitum delphinifolium subsp. delphinifolium	Monkshood
Actaea rubra	Baneberry
Anemone narcissiflora	Anemone
Anemone parviflora	Northern anemone
Anemone richardsonii	Anemone
Caltha leptosepala	Mountain marsh-marigold
Delphinium glaucum	Larkspur
Ranunculus sp.	Buttercup
Thalictrum sparsiflorum	Few-flower meadowrue
Rosaceae	
Dryas drummondii	Drummond mountain-avens
Dryas integrifolia	White mountain avens
Geum macrophyllum subsp. perincisum	Avens
Geum rossii	Ross avens
Potentilla fruticosa	Bush cinquefoil
Potentilla palustris	Marsh fivefinger
Rosa acicularis	Prickley rose
Rubus arcticus	Nagoon-berry
Rubus chamaemorus	Cloudberry
Rubus idaeus var. strigosus	Raspberry

Dicotyledoneae (Cont.)

Rosaceae (Cont.)	
Rubus pedatus	Five-leaf bramble
Sanguisorba stipulata	Sitka burnet
Sorbus scopulina	Greene mountain-ash
Spiraea beauverdiana	Beauverd spirea
Rubiaceae	
Galium boreale	Northern bedstraw
Galium sp.	Bedstraw
Salicaceae	
Populus balsamifera	Balsam poplar
Populus tremuloides	Quaking aspen
Salix	Willow
Saxifragaceae	
Parnassia palustris subsp. *neogaea*	Northern grass-of-Parnassus
P. kotzebuei	Grass-of-Parnassus
Ribes triste	Red currant
Saxifraga oppositifolia	Purple mountain saxifrage
Saxifraga tricuspidata	Three-tooth saxifrage
Scrophulariaceae	
Castilleja sp.	Indian paintbrush
Mimulus guttatus	Yellow monkey flower
Pedicularis sp.	Lousewort
Pedicularis kanei	Kane lousewort
Pedicularis labradorica	Labrador lousewort
Veronica americana	Brooklime
Umbelliferae	
Heracleum lanatum	Cow parsnip
Valerianaceae	
Valeriana capitata	Capitate valerian
Violaceae	
Viola epipsila subsp. *repens*	Marsh violet
Viola biflora	Violet

APPENDIX E3E

Status, Habitat Use and Relative Abundance of Bird Species in the Middle Susitna Basin

APPENDIX 3.E: STATUS, HABITAT USE AND RELATIVE ABUNDANCE OF BIRD SPECIES IN THE MIDDLE SUSITNA BASIN

(Adapted from Kessel et al. 1982a)

Species	Status[1]	Main Habitats	Relative Abundance[2]
Common loon *Gavia immer*	B	lakes	U-sp, F; FC-S
Arctic loon *Gavia arctica*	B?	lakes	U-sp, S
Red-throated loon *Gavia stellata*	B?	lakes, rivers	U-sp, S
Red-necked grebe *Podiceps grisegena*	B	lakes	U
Horned grebe *Podiceps auritus*	B	lakes	U
Whistling swan *Cygnus columbianus*	T	lakes	U-sp, F
Trumpeter swan *Cygnus buccinator*	B	lakes	U-sp, F, FC-S
Canada goose *Branta canadensis*	T	lakes, rivers	U-sp, F
White fronted goose *Anser albifrons*	T	lakes	U-sp
Snow goose *Chen caerulescens*	T	lakes	U-sp
Mallard *Anas platyrhynchos*	B	lakes, rivers	C-sp, FC-S,F
Gadwall *Anas strepera*	T, S	lakes	R-sp, S
Pintail *Anas acuta*	B	lakes	C-sp, FC-S, U-F
Green-winged teal *Anas crecca carolinensis*	B	lakes	FC-sp, S, U-F
Blue-winged teal *Anas discors*	T	lakes	R-sp, F
American wigeon *Anas americana*	B	lakes	FC
Northern shoveler *Anas clypeata*	B	lakes	U
Redhead *Aythya americana*	T	lakes	U-sp
Ring-necked duck *Aythya collaris*	T	lakes	R-sp, F

Species	Status[1]	Main Habitats	Relative Abundance[2]
Canvasback *Aythya valisineria*	T	lakes	U-sp
Greater scaup *Aythya marila*	B	lakes	C-sp, F
Lesser scaup *Aythya affinis*	B	lakes	FC-S
Common goldeneye *Bucephala clangula*	B	lakes, rivers	FC-sp, F, U-S
Barrow's goldeneye *Bucephala islandica*	B	lakes, rivers	
Bufflehead *Bucephala albeola*	T	lakes	U-sp, FC-F
Oldsquaw *Clangula hyemalis*	B	lakes	FC-sp, S; U-F
Harlequin duck *Histrionicus histrionicus*	B	rivers	FC
White-winged scoter *Melanitta deglandi*	T	lakes	FC
Surf scoter *Melanitta perspicillata*	B	lakes	U
Black scoter *Melanitta nigra*	B	lakes	FC
Common merganser *Mergus merganser*	B	lakes, rivers	U
Red-breasted merganser *Mergus serrator*	B	lakes, rivers	U
Goshawk *Accipiter gentilis*	B	deciduous and mixed forest	U
Sharp-shinned hawk *Accipiter striatus*	B?	coniferous and mixed forest	U
Red-tailed hawk *Buteo jamaicensis*	B	coniferous and mixed forest	U
Golden eagle *Aquila chrysaetos*	B	cliffs	FC
Bald eagle *Haliaeetus leucocephalus*	B	forests, cliffs	U
Marsh hawk *Circus cyaneus*	B?	meadows	FC-sp, F; U-S
Osprey *Pandion haliaetus*	T	lakes	R-sp

Species	Status[1]	Main Habitats	Relative Abundance[2]
Gyrfalcon *Falco rusticolus*	B, W	cliffs	U
Peregrine falcon *Falco peregrinus*	T?	cliffs	2 records (1974)
Merlin *Falco columbarius*	B?	scattered woodland, forest edge	U
American kestrel *Falco sparverius*	T	open forest	R-F
Spruce grouse *Canachites canadensis*	B, W	coniferious and mixed forest	FC
Ruffed grouse *Bonasa umbellus*	V	forest	R
Willow ptarmigan *Lagopus lagopus*	B, W	low shrub land	C
Rock ptarmigan *Lagopus mutus*	B, W	low , dwarf shrubland, block fields	C
White-tailed ptarmigan *Lagopus leucurus*	B, W	high elevation dwarf shrub tundra and block fields	U
Sandhill crane *Grus canadensis*	T	wetlands	U
Semipalmated plover *Charadrius semipalmatus*	B	alluvial bars	U
American golden plover *Pluvialis dominica*	B	dwarf shrub mat and meadow	C
Whimbrel *Numenius phaeopus*	B?	dwarf shrub meadow	U
Upland sandpiper *Bartramia longicauda*	B?	dwarf shrub meadow near scattered woodland	R
Greater yellowlegs *Tringa melanoleuca*	B?	wet, meadows, lakes and river shorelines	U
Lesser yellowlegs *Tringa flavipes*	T, S	lake and river shorelines	FC-sp; R-S
Solitary sandpiper *Tringa solitaria*	B?	scattered woodland, forest edge near lakes	U

Species	Status[1]	Main Habitats	Relative Abundance[2]
Spotted sandpiper *Actitis macularia*	B	alluvial bars	C
Wandering tattler *Heteroscelus incanus*	(B?), T	tundra streams	U
Turnstone *Arenaria* sp.	T	alluvial bar	R
Northern phalarope *Phalaropus lobatus*	B?	wet meadows with ponds	FC
Common snipe *Capella gallinago*	B	wet meadows	C
Long-billed dowitcher *Limnodromus scolopaceus*	T	lake and river shores and bars	U-sp
Surfbird *Aphriza virgata*	B?	dwarf shrub mat	R
Sanderling *Calidris alba*	T	lake and river shores and bars	R-F
Semipalmated sandpiper *Calidris pusilla*	T, S	lake and river shores and bars	U-sp, R-S
Least sandpiper *Calidris minutilla*	B?	wet and dwarf shrub meadow	FC
Baird's sandpiper *Calidris bairdii*	B	dwarf shrub mat	U
Pectoral sandpiper *Calidris melanotos*	T	wet meadows, pond, lake edges	U
Long-tailed jaeger *Stercorarius longicaudus*	B?	dwarf shrub mat and meadow	FC
Herring gull *Larus argentatus*	T, S	lakes, rivers	U
Mew gull *Larus canus*	B, S	lakes, rivers	C
Bonaparte's gull *Larus philadelphia*	B, S	lakes, rivers, scattered spruce woodland	U
Arctic tern *Sterna paradisea*	B	lakes and lakeshores	FC
Great horned owl *Bubo virginianus*	B?, W	open and closed forest	U
Snowy Owl *Nyctea scandiaca*	T	tundra	R

Species	Status[1]	Main Habitats	Relative Abundance[2]
Hawk owl Surnia ulula	B?, W	mixed forest	U
Short-eared owl Asio flammeus	T, S, (B?)	open habitat	U
Boreal owl Aegolius funereus	B? W	mixed forest	R
Belted kingfisher Megaceryle alcyon	B?	cutbanks, rivers	U
Common flicker Colaptes auratus	B	forest edge	U
Hairy woodpecker Picoides villosus	B, W	deciduous and mixed forest	U
Downy woodpecker Picoides pubescens	B?, W	open deciduous and mixed forest	U
Black-backed three-toed woodpecker Picoides arcticus	B?, W	coniferous forest	R
Northern three-toed woodpecker Picoides tridactylus	B, W	coniferous forest	U
Eastern kingbird Tyrannus tyrannus	A	open shrubland	Accidental
Say's phoebe Sayornis saya	B	upland cliff	U
Alder flycatcher Empidonax alnorum	B?	medium and tall shrubs	U
Western wood pewee Contopus sordidulus	B?	deciduous forest	R
Olive-sided flycatcher Nuttallornis borealis	B?	open and scattered forest	U
Horned lark Eremophila alpestris	B	dwarf shrub mat, block field	C-sp, F; FC-S
Violet-green swallow Tachycineta thalassina	B?	riparian cliffs, rivers	FC
Tree swallow Iridoprocne bicolor	B?	rivers, lakes	FC
Bank swallow Riparia riparia	B	cutbanks, rivers	U
Cliff swallow Hirundo pyrrhonota	B	rivers, lakes	U, L

Species	Status[1]	Main Habitats	Relative Abundance[2]
Gray jay Perisoreus canadensis	B, W	coniferous and mixed forest	C
Black-billed magpie Pica pica	S, (B?) W	open tall shrubs, scattered forest	U
Common raven Corvus corax	B, W	riparian and upland cliffs	C
Black-capped chickadee Parus atricapillus	B, W	deciduous forest	U
Boreal chickadee Parus hudsonicus	B, W	coniferous and mixed forest	FC
Brown creeper Certhia familiaris	B	deciduous and mixed forest	U
Dipper Cinclus mexicanus	B? W	rivers, streams	U
American robin Turdus migratorius	B	forest, medium and tall shrubland	C-sp,S; U-F
Varied thrush Ixoreus naevius	B	forest, tall alder thickets	O-sp,S; U-F
Hermit thrush Catharus guttatus	B	strip forested slopes, tall-alder thickets	C-sp,F; U-F
Swainson's thrush Catharus ustulatus	B	forest	FC
Gray-cheeked thrush Catharus minimus	B	scattered spruce, dwarf spruce, deciduous forest	FC
Wheatear Oenanthe oenanthe	B	block fields	U
Townsend's solitaire Myadestes townsendi	B	cliffs	U
Arctic warbler Phylloscopus borealis	B	scattered forest, medium shrubland	FC
Golden-crowned kinglet Regulus satrapa	T	coniferous and mixed forest	U
Ruby-crowned kinglet Regulus calendula	B	coniferous forests	C

Species	Status[1]	Main Habitats	Relative Abundance[2]
Water pipit *Anthus spinoletta*	B	dwarf shrub mat, block field	C
Bohemian waxwing *Bombycilla garrulus*	B?	scattered forest	CTsp,F, U-S
Northern shrike *Lanius excubitor*	B	scattered forest, tall shrubs	U
Orange-crowned warbler *Vermivora celata*	B	scattered forest, medium and tall shrubland	U
Yellow warbler *Dendroica petechia*	T, S?	riparian willows	R
Yellow-rumped warbler *Dendroica coronata*	B	forest	C
Blackpoll warbler *Dendroica striata*	B	tall shrubs, forest	FC
Northern waterthrush *Seiurus noveboracensis*	B?	tall shrubs near water	FC
Wilson's warbler *Wilsonia pusilla*	B	medium shrubs with or without forest overstory	C
Rusty blackbird *Euphagus carolinus*	T, S? (B?)	open coniferous forest, tall shrubs	U
Pine grosbeak *Pinicola enucleator*	T, S (B?)	open coniferous forest	U
Gray-crowned rosy finch *Leucosticte tephrocotis*	B?	cliffs, block fields	U
Common redpoll *Carduelis flammea*	B, W	low shrubs, open woodland	A
Pine siskin *Carduelis pinus*	B?	mixed forest, tall shrubs	U
White-winged crossbill *Loxia leucoptera*	S, B?	coniferous forest	FC
Savannah sparrow *Passerculus sandwichensis*	B	low shrubs with graminoid ground cover	A
Dark-eyed junco *Junco hyemalis*	B	open and closed forest	C

Species	Status[1]	Main Habitats	Relative Abundance[2]
Tree sparrow _Spizella arborea_	B	low shrubs	A
White-crowned sparrow _Zonotrichia leucophrys_	B	low and medium shrubs	C
Golden-crowned sparrow _Zonotrichia atricapilla_	B?	low shrubs, dwarf spruce	U
Fox sparrow _Passerella iliaca_	B?	medium and tall shrubs with forest overstory	FC
Lincoln's sparrow _Melospiza lincolnii_	B?	low and medium shrubs near water	U
Lapland longspur _Calcarius lapponicus_	B	dwarf shrub, meadow and mat	A
Smith's longspur _Calcarius pictus_	B?	dwarf shrub, meadow and mat	U
Snow bunting _Plectrophenax nivalis_	B?	high elevation cliffs and block fields	FC

[1]B = breeding confirmed, B? = probably breeds, (B?) = possibly breeds, T = transient, W = winters, S = summers, A = accidental

[2]A = abundant, C = common, FC = fairly common, U = uncommon, R = rare, sp = spring, S = summer, F = fall, L = local

APPENDIX E3F

Status and Relative Abundance of Bird Species in the Lower Susitna Basin

APPENDIX 3.F: STATUS AND RELATIVE ABUNDANCE OF BIRD SPECIES OBSERVED ON THE LOWER SUSITNA BASIN DURING GROUND SURVEYS CONDUCTED JUNE 10 TO JUNE 20, 1982
(Adapted from Kessel et al. 1982b)

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Arctic loon *Gavia arctica*	M		0 (2 seen in May 1982)
Red-throated loon *Gavia stellata*	M, (PB)[2]		6 (2 seen in May 1982)
Red-necked grebe *Podiceps grisegena*	M		0 (5 seen in May 1981)
Double-crested cormorant *Phalacrocorax auritus*		(R)[2]	1
Whistling swan *Cygnus columbianus*	M		0 (60 seen near mouth of river in May 1981 and 420 seen near mouth of river in May 1982)
Brant *Branta bernicula*	M		0 (2 seen in May 1981)
White-fronted goose *Anser albifrons*	M		<50 (89 seen in May 1981 and 51 seen in May 1982)
Snow goose *Chen caerulescens*	(M) (M)		1
Canada goose *Branta canadensis*	M, (PB)		3 (1 seen in May 1981 and 26 seen in May 1982)
Green-winged teal *Anas crecca*	M, (PB)	U	Several 2's and 3's (42 seen in May 1981)
Mallard *Anas platyrhynchos*	M, (PB)	U	6
Pintail *Anas acuta*	M, (PB)	U	≤6
American wigeon *Anas americana*	M, (PB)	U	Most numerous surface feeding duck; seen in pairs along main river and sloughs almost every day
Canvasback *Aythya valisineria*	M	U	a few individuals in aerial waterbird surveys
Greater scaup *Aythya marila*	M		2
Harlequin duck *Histrionicus histrionicus*			6
Surf scoter *Melanitta perspicillata*	M		2
Common goldeneye *Bucephala clangula*	M, B	U	4

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Common merganser _Mergus merganser_	M, (PB)	FC	Small flocks of up to 10 seen along the main river; most numerous ducks seen in May and June
Red-breasted merganser _Mergus serator_	M	FC	a few birds along the river; less common than its congenor
Bald eagle _Haliaeetus leucocephalus_	(M), B	U	17 active nests seen in riparian cottonwood stands
Sharp-shinned hawk _Accipiter striatus_	(M), (PB)		Several seen
Goshawk _Accipter gentilis_	(R), (PB)		Several seen
Red-tailed hawk _Buteo jamaicensis_	(M), (PB)		1
American kestrel _Falco sparverius_	(M), (PB)		1
Merlin _Falco columbarius_	(M), (PB)		A few seen hunting along river
Sandhill crane _Grus canadensis_	M		Several heard at a distance along main river (27 seen near mouth of river in May 1982)
Semipalmated plover _Charadrius semipalmatus_	(M), B	U	Nests in alluvium along the river
Greater yellowlegs _Tringa melanoleuca_	(M), PB	U	Seen and heard foraging along river
Solitary sandpiper _Tringa solitaria_	(M), (PB)	FC	Courtship rituals observed along river
Spotted sandpiper _Actitus macularia_	(M), B	C	Regularly seen; 5 nests seen along shores of main river, sloughs and feeder streams
Whimbrel _Numenius phaeopus_	M		Only 1 observed; assumed to be late northbound migrant
Common snipe _Capella gallinago_	(M), (PB)	FC	Winnowing snipe were heard and/or seen along the river

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Northern phalarope Phalaropus lobatus			2
Parasitic jaeger Stercorarius parasiticus			3
Bonaparte's gull Larus philadelphia	(M), PB	FC	Pairs and small groups seen feeding along main river and sloughs
Mew gull Larus canus	(M), PB	FC	
Herring gull Larus argentatus	(M), B	C	7 breeding colonies of 20 - 100 pairs seen on alluvial islands along river between Talkeetna and mouth of river
Black-legged kittiwake Rissa tridactyla	(T)	(R)	130; normally a pelagic species; nearest breeding colony at Chisik Island in lower Cook Inlet
Arctic tern Sterna paradisaea	(M), B	FC	Pairs and small groups
Great horned owl Bubo virginianus	(R), (PB)		Tracks seen; signs found in beach sand below Bell Island indicate this owl was feeding on dead eulachon
Short-eared owl Asio flammeus	(M)		Remains of one owl were found below Bell Island
Belted kingfisher Megaceryle alcyon	(PB)	U	Pairs regularly seen on feeder streams
Downy woodpecker Picoides pubescens	(R), (PB)		1 male observed in riparian cotton-wood forest
Hairy woodpecker Picoides villosus	(R), B	FC	Seen or heard regularly
Northern three-toed woodpecker Picoides tridactylus	(R), (PB)		2 seen in mixed forests along lower river
Common flicker Colaptes auratus	(M), (PB)		A few seen and heard in riparian cottonwood

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Alder flycatcher Empidonax alnorum	PB	C	Seen regularly (4th most numerous landbird
Tree swallow Tachycineta bicolor	(M), B	FC	Seen regularly; 3 nests seen
Violet-green swallow Tachycineta thalassina	(M), (PB)	U	Small numbers seen
Bank swallow Riparia riparia	(M), B	FC	Some colonies of 30 - 50 pairs
Cliff swallow Hirundo pyrrhonota	(M), B	LC	Seen only at Talkeetna where commonly breeds around building eaves
Gray jay Perisoreus canadensis	(R), (PB)		Very few seen or heard
Black-billed magpie Pica pica	(R)		1
Common raven Corrus corax	(R), (PB)	U	Uncommon but widely distributed
Black-capped chickadee Parus atricapillus	(M), B	FC	Seen regularly
Brown creeper Certhia familiarus	(M)		1
Gray-cheeked thrush Catharus minimus	(M), B	C	Seen regularly (5th most numerous passerine on census
Swainson's thrush Catharus ustulatus	(M), (B)	C	Seen regularly (7th most numerous small landbird)
Hermit thrush Catharus guttatus	(M), PB	U	Not recorded downstream from Talkeetna
American Robin Turdus migratorius	(M), B	FC	2 nests observed
Varied thrush Ixoreus naevius	(M), B	FC	Seen regularly (10th most common passerine
Golden-crowned kinglet Regulus satrapa	(M)		1

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
Ruby-crowned kinglet *Regulus calendula*	(M), PB	FC	Seen regularly
Bohemian waxwing *Bombycilla garrulus*	(M)	U	Fewer than 12 seen
Northern shrike *Lanius excubitor*	(M), (PB)		2
Orange-crowned warbler *Vermivora celata*	(M), (PB)	FC	Seen regularly
Yellow warbler *Dendroica petechia*	(M), B	FC	1 nest seen; tall shrubs
Yellow-rumped warbler *Dendroica coronata*	(M), B	C	2nd most common passerine seen regularly in mixed forest, cottonwood and tall shrubs
Blackpoll warbler *Dendroica striata*	(M), B	C	3rd most common passerine seen regularly in tall riparian shrubs, cottonwood and mixed forest
Northern waterthrush *Seiurus noveboracensis*	(M), B	C	Most numerous passerine seen regularly in riparian cottonwood and mixed cottonwood
Wilson's warbler *Wilsonia pusilla*	(M), PB	FC	
Rusty blackbird *Euphagus carolinus*	(M), B	U	2
White-winged crossbill *Loxia leucoptera*	(M)	U	48
Savannah sparrow *Passerculus sandwichensis*	(M), PB	U	
Fox sparrow *Passerella iliaca*	(M), B	C	1 nest seen
Lincoln's sparrow *Melospiza lincolnii*	(M), B	FC	
Golden-crowned sparrow *Zonotrichia atricapilla*	(M), B	U	1 individual was heard just above Bell Island

Species	Status[1]	Relative Abundance	No. of Individuals Observed[1]
White-crowned sparrow <u>Zonotrichia leucophrys</u>	(M), B	C	9th most numerous passerine seen regularly in medium to tall shrub thickets and cottonwood forests on small islands
Dark-eyed junco <u>Junco hyemalis</u>	(M), B	FC	
Common redpoll <u>Carduelis flammea</u>	(M)	FC	
Pine siskin <u>Carduelis pinus</u>	(M)	U	A few were heard or seen in cottonwoods along river

[1] Includes information on migration from aerial surveys in May 1981 and 1982.

[2] ( ) indicates assessments of status or relative abundance other than those provided by the University of Alaska museum.

[3] B = breeding confirmed, PB = probably breeds, M = migrant, R = resident

[4] R = rare, U= uncommon, FC = fairly common, C = common, LC = locally common

APPENDIX E3G
Scientific Names of Mammal Species

APPENDIX 3.G: SCIENTIFIC NAMES OF MAMMAL SPECIES FOUND IN THE PROJECT AREA

Common Name	Scientific Name
Masked Shrew	Sorex cinereus
Dusky Shrew	Sorex monticolus
Northern Water Shrew	Sorex palustris
Arctic Shrew	Sorex arcticus
Pygmy Shrew	Microsorex hoyi
Little Brown Bat	Myotis lucifugus
Collared Pika	Ochotona collaris
Snowshoe Hare	Lepus americanus
Hoary Marmot	Marmota caligata
Arctic Ground Squirrel	Spermophilus parryii
Red Squirrel	Tamiasciurus hudsonicus
Beaver	Castor canadensis
Northern Red-backed Vole	Clethrionomys rutilus
Meadow Vole	Microtus pennsylvanicus
Tundra Vole	Microtus oeconomus
Singing Vole	Microtus miurus
Muskrat	Ondatra zibethica
Brown Lemming	Lemmus sibiricus
Northern Bog Lemming	Synaptomys borealis
Porcupine	Erethizon dorsatum
Belukha Whale	Delphinapterus leucas
Coyote	Canis latrans
Wolf	Canis lupus
Red Fox	Vulpes fulva
Black Bear	Ursus americanus
Brown Bear	Ursus arctos
Marten	Martes americana
Short-tailed Weasel	Mustela erminea
Least Weasel	Mustela nivalis
Mink	Mustela vison
Wolverine	Gulo gulo
River Otter	Lutra canadensis
Lynx	Lynx canadensis
Moose	Alces alces
Caribou	Rangifer tarandus
Dall Sheep	Ovis dalli

APPENDIX E3H

Methods Used to Determine Moose Browse Utilization and Carrying Capacity within the Middle Susitna Basin

APPENDIX 3.H

METHODS USED TO DETERMINE MOOSE BROWSE UTILIZATION AND CARRYING CAPACITY WITHIN THE MIDDLE SUSITNA BASIN

Moose habitat research was conducted in the middle basin in 1982 by the Plant Ecology Team of the University of Alaska Agricultural Experimental Station. The objective of the moose browse study was to estimate the availability of browse and herbaceous plants for each vegetation type.

Field Methods

Sites sampled were randomly selected using a grid overlay on a vegetation map of the area within about 5 mi of potential dam impoundments. However, eight sites were located mid-slope at the phenology study sites on both north and south-facing slopes to insure that some samples occurred in the immediate impoundment area. Sites were classified to Levels IV and V of Viereck et al. (1982), when possible. Forty-seven stands were examined from July through August 1982. Some habitat types were sampled more intensively than others, based on their importance to moose and/or land area occupied by that type.

At each sample site, three parallel 50-m line transects were established, approximately 10 to 20 m apart. Every 10 m along each transect line, a plot (1 x 0.5 m) was located. Percent cover of each plant species, including trees less than 1.13 m in height, was estimated in each 0.5 m^2 plot. All grasses, Carex, forbs, and the current annual growth of tall shrubs were clipped in each plot. Clipped samples were bagged, oven-dried at 60°C for 48 hours, then weighed. Kg/ha of graminoids, forbs, and leaves and twigs of moose browse species were calculated by multiplying the biomass (in grams) from 0.5 m^2 plots by 20.

A circular plot with a 5 m radius was established every 10 m along each transect line. This plot was divided into 4 even-sized quadrants. Within each quadrant, the distance to the nearest stem of each browse species represented within a quadrant was measured. The basal diameter and average height of that stem was measured and the number of twigs, above 50 cm (19 inches), was counted and noted as to evidence of recent browsing. A twig was defined as a branch that had a diameter equal to the estimated diameter at point of browsing for that species. The average diameter at point of browsing for each species was estimated by randomly measuring twigs that were browsed at a number of sites over the entire study area. Percent utilization was determined by dividing the number of browsed twigs by the total number of twigs above 50 cm. At each site, 25 twigs from each browse species present were also randomly harvested at the average point of browsing. These twigs provided an estimate of biomass removed when the shrubs had been browsed by moose.

Carrying Capacity

A preliminary estimate of moose carrying capacity was calculated from the browse biomass estimates obtained in summer 1982. A simulation modeling approach is being developed to calculate carrying capacity and project impacts on moose based on available energy and nitrogen, snowfall, and other important inputs, and therefore, a greatly refined estimate of carrying capacity will eventually be available. The preliminary estimate shown in Table E.3.92 is based on the following data and assumptions:

1. Browse biomass estimates for each Level III vegetation type are representative of all other similar stands throughout the middle basin (e.g., all open conifer forest stands have the same biomass as those sampled).

2. The vegetation maps produced in 1980-81 accurately portray the vegetative cover of the middle basin (vegetation is being remapped now that low-level photography is available).

3. Moose in winter eat only the current annual growth of twigs of the following species: Richardson willow, grayleaf willow, diamondleaf willow, Sitka alder, and resin birch. The calculations assume that none of the twigs are consumed in summer, and that snow does not make any twigs unavailable. Both of these assumptions are in fact false; however, the analysis is also biased in the other direction because moose can consume more than the current annual growth of twigs, eat other browse species in winter, and consume some leaves and forbs available in winter.

4. A moose in winter requires 5.0 kg dry weight of browse per day (Gasaway and Coady 1974). This value takes into account the composition and digestibility of the diets of moose in interior Alaska.

5. Areas mapped as closed conifer forest, closed birch forest, closed mixed forest, tall shrub (mostly alder), and tundra, contain no moose browse available to moose in winter. Except for tundra and tall shrub types, these types cover only a small proportion of the middle basin, and closed forest stands support low browse biomass. Little, if any browse is available to moose in tundra areas and tall shrubs are mostly alder, which is not a preferred browse species.

6. The number of moose days the areas can support is calculated for the Watana impoundment and adjacent village and borrow sites and for the entire watershed upstream of Gold Creek. The number of winter residents these areas can support is calculated assuming that winter lasts for 180 days and food requirements are the same throughout that period, and that moose do not move into or out of the study areas.

APPENDIX E3I

Explanation and Justification of Artificial Nest Mitigation

APPENDIX 3.I

EXPLANATION AND JUSTIFICATION OF ARTIFICIAL NEST MITIGATION

The concept of modifying cliff-nesting and tree-nesting habitat to provide raptors new nesting locations and nest sites appears to offer an effective and feasible means of compensating for losses of nesting habitat incurred in the upper Susitna River basin as a result of construction and operation of the Susitna Hydroelectric Project. A major advantage of this type of compensation is that it allows actual mitigation of losses in the same area where they were incurred, rather than on distant lands or by some form of out-of-kind compensation. The concept relies on the fact that raptors are one of the few groups of birds that are limited by availability of nesting locations and nest sites in most regions, rather than food (see Newton 1979). Many methods and techniques have proven successful, and additional techniques and methods are being developed and tested (e.g. Olendorff et al. 1980). Some successful applications and experiments involving several raptor species are given below.

1. Nest sites ("pot-hole" type) have been successfully provided for prairie falcons (E. Mexicanus) in cliffs that lacked natural cavities in Alberta (Fyfe and Armbruster 1977). Originally, some holes were blasted out of the rock, but it became more effective to locate soft spots in the sandstone and dig them by hand. The program has provided about 200 new cavities for nesting prairie falcons, about 25 percent of which have been used successfully, and has increased the number of prairie falcons in several Alberta river drainages.

2. A ledge was excavated in December 1979 on a cliff in California that was rated as a potential peregrine falcon nesting location, but had no history of previous use. Four months later, early in the 1980 nesting season, a female peregrine occupied it. She laid eggs on the new ledge and was observed incubating them (see Olendorff et al. 1980).

3. Because nest sites at some peregrine nesting cliffs in the Massif Central of Europe were accessible to predators (genets), a new artificial, but natural appearing, ledge was constructed in a rock face near the top of one of the nesting locations. It was readily accepted by a pair of peregrines (Cugnasse 1980).

4. The nesting ledge fell off an abandoned peregrine falcon nesting cliff in California. A steel and lightweight metal ledge was fabricated, artistically modified to look relatively natural, and installed on the rock face in four days time. The following year a pair of prairie falcons accepted the ledge and successfully fledged young from it (Boyce et al. 1980).

5. A golden eagle tree-nest was blown down. The nesting location was not occupied by eagles the following year and later that summer an artificial nest was built. Golden eagles nested at it the next year (Craig and Anderson in Call 1979).

6. A nest site designed for gyrfalcons was constructed on a cliff in northern Europe. It was used by gyrfalcons the following year (see Olendorff et al. 1980).

7. A cliff used by gyrfalcons was found in 1968 on the Seward Peninsula, Alaska. The cliff had only one useable ledge on it, although an excellent potential pot-hole site was also present. The pot-hole site was unuseable because the floor lacked detritus and soil for scraping in, and it also sloped steeply to the rear of the cavity. Two years later (1970) the original ledge had become unstable and was in danger of falling off the cliff. At the completion of the 1970 breeding season, material (sand, dirt and fine gravel) was placed in the pot-hole cavity to level the floor. A rim was constructed of wired-together sticks and in turn wired to the rock (the rim simulated the remains of a rough-legged hawk nest, often used by gyrfalcons). The falcons scraped in the new site the following year (1974), but still used the old, unstable ledge (D.G. Roseneau and W. Walker II, unpubl. data). In later years the original ledge became very delapidated and was not used by the gyrfalcons, but the modified site was (W.R. Tilton pers. comm.).

8. A golden eagle nest in a tree in Wyoming was located on lands that were to be strip-mined for coal. Through a series of manipulations involving first providing and then destroying several artificial platforms and nests, moving a nestling after it was capable of thermoregulation, and moving a nest constructed by the eagles, the nesting pair was successfully relocated over the course of two breeding seasons to a new nesting location outside of the coal development area and 2.5 km from the original nesting location (Postovit et al. 1982).

9. An active bald eagle nest was blown down. It was reconstructed and the two nestlings successfully fledged from it (Dunstan and Borth 1970).

10. In two separate attempts several nest boxes were placed out specifically for boreal owls near Fairbanks, Alaska. In both cases several pairs of boreal owls readily accepted them, and in one instance a pair of hawk owls also used one of the boxes (D.G. Roseneau and W.R. Tilton pers. comm.).

In several cases attempts to provide a variety of artificial structures have not worked for some species. However, in virtually all such cases, no attempt was made to provide natural appearing nesting locations and natural appearig nesting sites or nests. Other failures have also clearly involved elements of design and choice of locations. The failure of an attempt to provide nest sites for peregrines and gyrfalcons at Sagwon Bluffs, Alaska (see Olendorff et al. 1980), is more readily explained by elements of design, an abundance of nearly natural nest sites relative to the abundance of peregrines and gyrfalcons at that particular Arctic Slope location, and other factors rather than by a failure of the technique.

In several instances, successful experiments and applications have involved only one or two pairs of some raptor species. At present, limited numbers of experiments and applications are more a result of lack of opportunity and support than a lack of sufficient knowledge, methods and techniques. Successful applications and experiments involving many raptor species clearly suggest that chances of success of such compensatory measures in the Susitna River drainage are high for the species involved, especially if proper planning, appropriate design, and expertise are employed. Chances of success and ultimate overall effectiveness can be increased further by modifying a larger number of a variety of currently unused potential nesting locations than are lost, including those remaining along the impoundment edge above maximum reservoir level, those in the nearby vicinity of the project, and those that may occur in other more distant areas of the middle and upper Susitna River basins. This would allow pairs of raptors a greater variety of choices. Only appropriate numbers of pairs of each species have accepted and established themselves at the artificially modified locations. Excess locations can be remodified to prevent their use, and thereby achieve a balanced state.

Methods and techniques used to provide compensatory raptor nesting locations and nest sites will be individually tailored to each species and may vary slightly as each particular situation dictates. Basic methods employed will center around modifying microrelief of existing but currently unuseable cliffs near the project areas and in some outlying areas of the middle and upper basins, and providing natural-appearing artificial nests where appropriate (cliff-nesters, especially golden eagles); modifying selected tree-cover and supplying natural appearing artificial nests where appropriate (tree-nesters, especially bald eagles); and providing both natural appearing and less modified nesting boxes in appropriate habitat (cavity nesters, including boreal owls, hawk owls and kestrels). Artificial platforms with artificial but natural appearing stick nests that can be installed on selected transmission towers will also be experimented with (especially for golden eagles).

Compensatory measures will take into account such factors as slope, aspect, height, overlook, distance to alternates, and overall distribution of nesting locations, accessability to predators, drainage, sun shadow, and vegetation types and size used to construct nests as applicable to each species. All compensatory measures will be monitored and modifications made as necessary. Detailed accounts of methods, techniques and results will be kept to ensure maximum scientific value for further evaluation and use.

APPENDIX E3J

Personal Communications

APPENDIX 3.J

PERSONAL COMMUNICATIONS

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GLOSSARY

Accipiter - a member of the family accipitridae, which includes kites, hawks, and eagles

Adipose fin - a small, thick, posterior dorsal fin containing much fatty matter, typical of salmonid fish

Albedo - the percentage of light reflected from a surface

Alevins - newly hatched salmon still attached to the yolk sac

Alpine tundra - plant communities which occur above timberline. Vegetation is low and matlike and includes a high proportion of grasses and sedges

Anadromous - an organism that ascends freshwater rivers from the ocean in order to breed

Aspect - appearance, composition, or inferred environmental implication of a rock body. Also a particular compass direction

Aufeis - a sheet of ice formed on a river plain when shoals freeze or are dammed so that water spreads over the floodplain and freezes

Bankfill stage - that river stage which fills the river banks up to the shoreline vegetation, typical of mean annual flood

Browse - leaves, shoots, and twigs of shrubs and trees utilized as food

Calcareous - growing on limestone or soils high in lime

Calciphilic - having a tendency to grow in soils rich in calcium or limestone

Closed forest - forested areas in which the overstory prevents most of the sunlight from reaching the ground

Coniferous - plants which are cone bearing and nondeciduous, such as pines and spruce

Coregonid - member of the whitefish family Coregonidae, related to the salmonids, has a rayless adipose fin

Decadent - decaying or declining in vigor

Deciduous - referring to plants which shed their leaves at a certain season each year

Ecotone - the area where two or more plant communities meet and blend together

Escapement - the process by which adult anadromous fish migrate from the ocean to their freshwater spawning sites

Floristics - study of the species composition of vegetation

Frazil ice - ice of small plate-like crystals suspended in the flow

Gillnetting - a method of capturing fish by hanging nets in which the gills of the fish become entangled

Glacial flour - silt and clay sized generally nonplastic particles derived from glacial grinding

Gley - a dense clay layer often present under waterlogged soils

Ground truthing - the process of conducting onsite field studies to determine if identification of vegetation cover types from aerial photographs is correct

Herb - plant such as grasses which have no persistent parts above ground, as distinct from shrubs and trees

Herbaceous - a plant having the characteristics of an herb

Lentic system - relating to still water such as lakes and ponds

Lotic system - relating to moving water such as rivers and creeks

Mainstem - the major portion of a river into which tributaries enter

Mesic - referring to site conditions that are intermediate between wet and dry

Micro-relief - very slight changes in elevation

Milling area - an area in a river or stream where anadromous fish hold or rest prior to continuing their upstream movements

Mixed forest - area which contains both coniferous and deciduous trees

Mosaic - a composite resulting from the joining of separate and different parts

Mustelids - member of the family mustelidae which includes weasels, mink, skunk, otter, fish and marten

Open forest - forested areas in which the spacing of trees and closure of the canopy is such that the majority of the sunlight reaches the ground

Parturient - bringing forth or about to bring forth young

Peri-glacial - adjacent to the margins of a glacier

Redd - spawning ground or nest of fish

Seral growth - the process by which any stage of a plant community which is transitory will eventually reach a climax condition

Smolt - a young salmon approximately two years old

Sub-nivean - underneath the snow

Successional stands - any stage of a plant community which is transitory and will eventually lead to a climax condition

Taxa - plural of taxon

Taxon - a separate and distinct group in a formal system of classification

Thermokarst - settling or caving in of the ground due to melting of ground ice

Ungulates - hoofed mammals such as deer, caribou, and moose

Vascular - containing vessels which conduct fluid

Xerosere - a plant successional stage originating on a dry site