# COAL TO METHANOL FEASIBILITY STUDY BELUGA METHANOL PROJECT



DOE GRANT DE-FG01-80RA-50299

FINAL REPORT

VOLUME IV
ENVIRONMENTAL






## COOK INLET REGION, INC.
## AND
## PLACER AMEX INC.

SEPTEMBER 1981

## BELUGA COAL TO METHANOL PROJECT

This submission to the Department of Energy consists of six volumes, namely,

- An Executive Review of the project as of September, 1981, and
- A five volume report presenting the findings of the Phase I Feasibility Study.

The contents of the above volumes are indicated by main headings from their Tables of Content , as listed below:

### EXECUTIVE REVIEW



### VOLUME I MINING



### VOLUME II COAL TO METHANOL PLANT



### VOLUME III GEOTECHNICAL, INFRASTRUCTURE



### VOLUME IV ENVIRONMENT AND SOCIOECONOMIC



### VOLUME V COMMERCIAL

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# GLOSSARY OF ENVIRONMENTAL TERMS

## AGENCIES

| | | |
|---|---|---|
| ACMP | - | Alaska Coastal Management Program |
| AEIDC | - | Artic Environmental Information and Data Center |
| CEQ | - | Council on Environmental Quality |
| COE | - | U.S. Army Corps of Engineers |
| DEC | - | Department of Environmental Conservation (Alaska) |
| DF&G | - | Department of Fish & Game (Alaska) |
| DNR | - | Department of Natural Resources (Alaska) |
| DOE | - | U.S. Department of Energy |
| DOSH | - | Division of Occupational Safety and Health (Alaska) |
| DPDP | - | Division of Policy Development and Planning (Alaska) |
| EPA | - | U.S. Environmental Protection Agency (unless designated as state agency) |
| FAA | - | Federal Aviation Administration |
| FWS | - | Fish and Wildlife Services (Federal) |
| MSHA | - | Mine Safety and Health Administration |
| NRDC | - | National Resource Defense Council |
| OSHA | - | Occupational Safety and Health Administration |
| OSM | - | Office of Surface Mining |
| USGS | - | United States Geological Service |

## REGULATIONS/ACTS

| | | |
|---|---|---|
| AAC | - | Alaska Administrative Code |
| ANCSA | - | Alaska Native Claims and Settlement Act |
| CAAA | - | Clean Air Act Amendments of 1977 |
| CFR | - | Code of Federal Regulations |
| CWA | - | Clean Water Act of 1977 |
| EA | - | Environmental Assessment |

EIS - Environmental Impact Statement
DEIS - Draft Environmental Impact Statement
FEIS - Final Environmental Impact Statement
FR - Federal Register
FWPCA - Federal Water Pollution Control Act
MSHA - Mine Safety and Health Act of 1977
NAAQS - National Ambient Air Quality Standards
NEPA - National Environmental Policy Act of 1969
OSHA - Occupational Safety and Health Act of 1970
RCRA - Resource Conservation and Recovery Act of 1976
SMCRA - Surface Mining Control and Reclamation Act of 1977
TSCA - Toxic Substances Control Act of 1976

REGULATIONS/ENGINEERING

BACT - Best Available Control Technology
BAT - Best Available Technology: Economically Achievable
BMP - Best Management Practices
GEP - Good Engineering Practice
LAER - Lowest Achievable Emission Rate
NPDES - National Pollutant Discharge Elimination System
NSPS - New Source Performance Standards
PSD - Prevention of Significant Deterioration
SPCC - Spill Prevention Control and Countermeasure Plans
UNAMAP - User's Network for Applied Modeling of Air Pollution (series of meteorological models developed by the U.S. EPA)
PTMAX - Single stack meteorological model in EPA UNAMAP series
VALLEY - Meteorological model used by USEPA to calculate concentrations on elevated terrain

INTRODUCTION

# INTRODUCTION

## 1.0 PURPOSE OF THE REPORT

The objectives of the environmental, health, safety and socioeconomic assessment tasks of this feasibility study were to define the major environmental issues relevant to development of a coal gasification and methanol fuels production facility and related coal mining activities and transportation systems in the west Cook Inlet area, Alaska. To achieve this, extensive review into existing information on the Beluga region of west Cook Inlet was conducted and updated with the findings of current and on-going land resource projects. Specific field activities then were initiated to expand the environmental data base in areas relevant to this project where there was a paucity of information. Based on these findings the project was reviewed in detail to identify significant environmental issues and to outline the state and federal permit requirements to ensure that these elements are an integral component of all subsequent project planning and management decisions.

While the format of this report is similar to that of an environmental assessment, this document is not a formal environmental assessment. The initial scope of work was to provide for the assemblage of sufficient information to develop a more detailed scope of work for the initiation of the requisite permitting procedures and for the preparation of an Environmental Impact Statement. Therefore, data gaps may be identified but not necessarily addressed beyond the level necessary to identify or define the issue of concern. This document includes the results of the literature review and substantial contributions from the 1981 field program. The report also incorporates input from various state and federal agencies, from other consultants participating in the feasibility study, and from the staffs of both CIRI and Placer Amex.

## PROJECT LOCATION

The proposed project is located on the west side of middle Cook Inlet approximately 75 air miles southwest of Anchorage. A general location map is shown in Figure 1.1. The overall project area is bordered on the north and south by the Beluga River and Nikolai Creek and on the east and west by the Cook Inlet and the terminus of the Capps Glacier and the Chichanta River. A project location map is shown in Figure 1.2.

## PROJECT DESCRIPTION

The proposed project consists of several components: The methanol plant site, a dock site, a new town site, a construction camp site, and a transportation corridor, as well as the coal mine areas.

The plant site would occupy some 400 acres located about two miles inland from the Granite Point shoreline of Cook Inlet. About half the area would be occupied by methanol processing facilities and the remainder would be for coal handling and general plant grounds.

The transportation corridor is a 300-foot-wide unspecified alignment easement 27½ miles long between the Capps coal field and Cook Inlet. A preferred route has been selected which has a maximum gradient of 2%. A heavy duty railroad line capable of transporting approximately 42,000 tons of coal daily would be constructed to transport coal from the mines in 100-ton cars. Ash would be returned to the Chuitna West mine site in special 80-ton ash handling cars. A 40-foot-wide access road would generally parallel the railroad route within the same easement corridor.

The construction camp site is located about one mile north of the proposed plant site. It would be used to house construction personnel in four quadrants of dormitory style barracks.

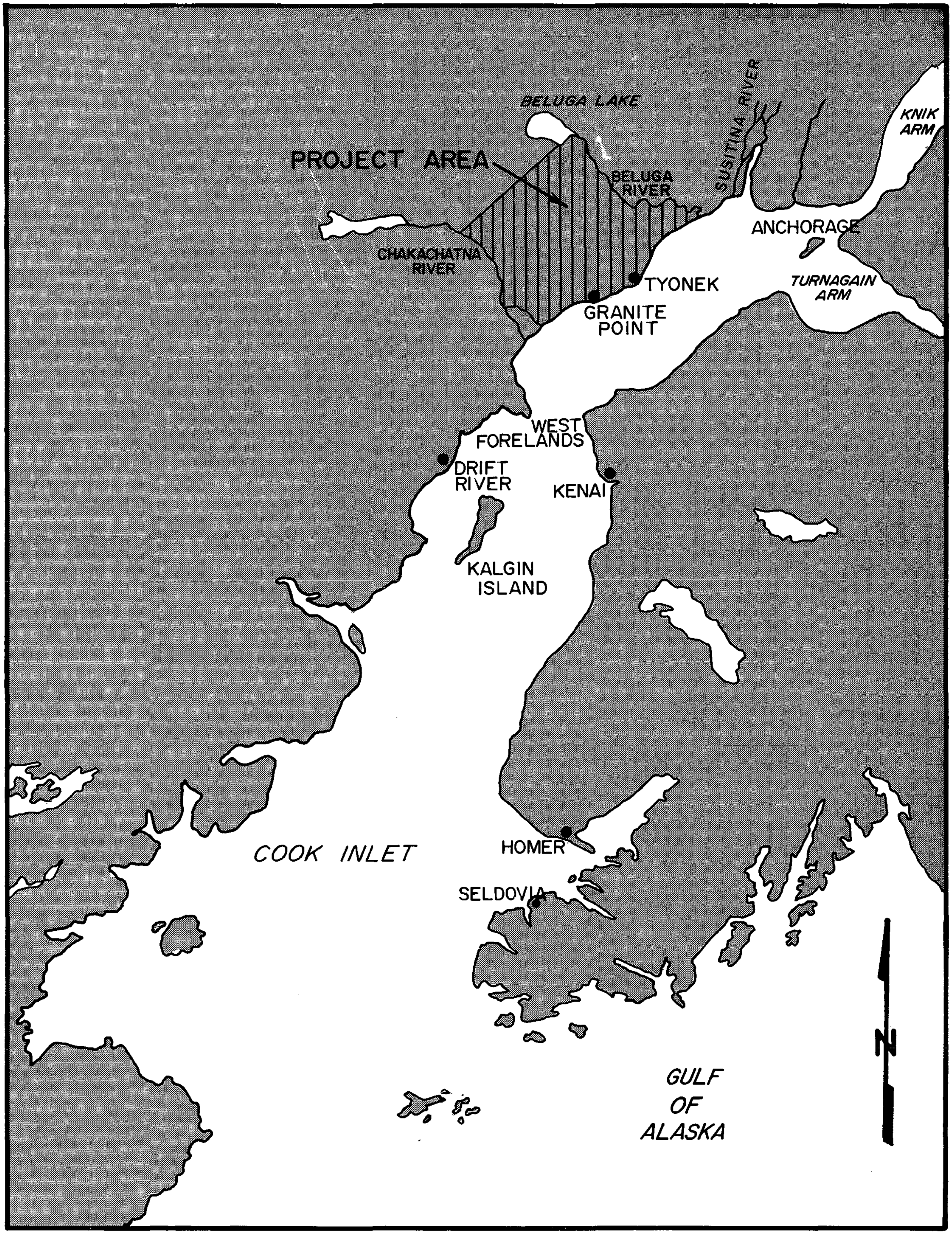



FIGURE 1.1 GENERAL LOCATION - BELUGA METHANOL PLANT

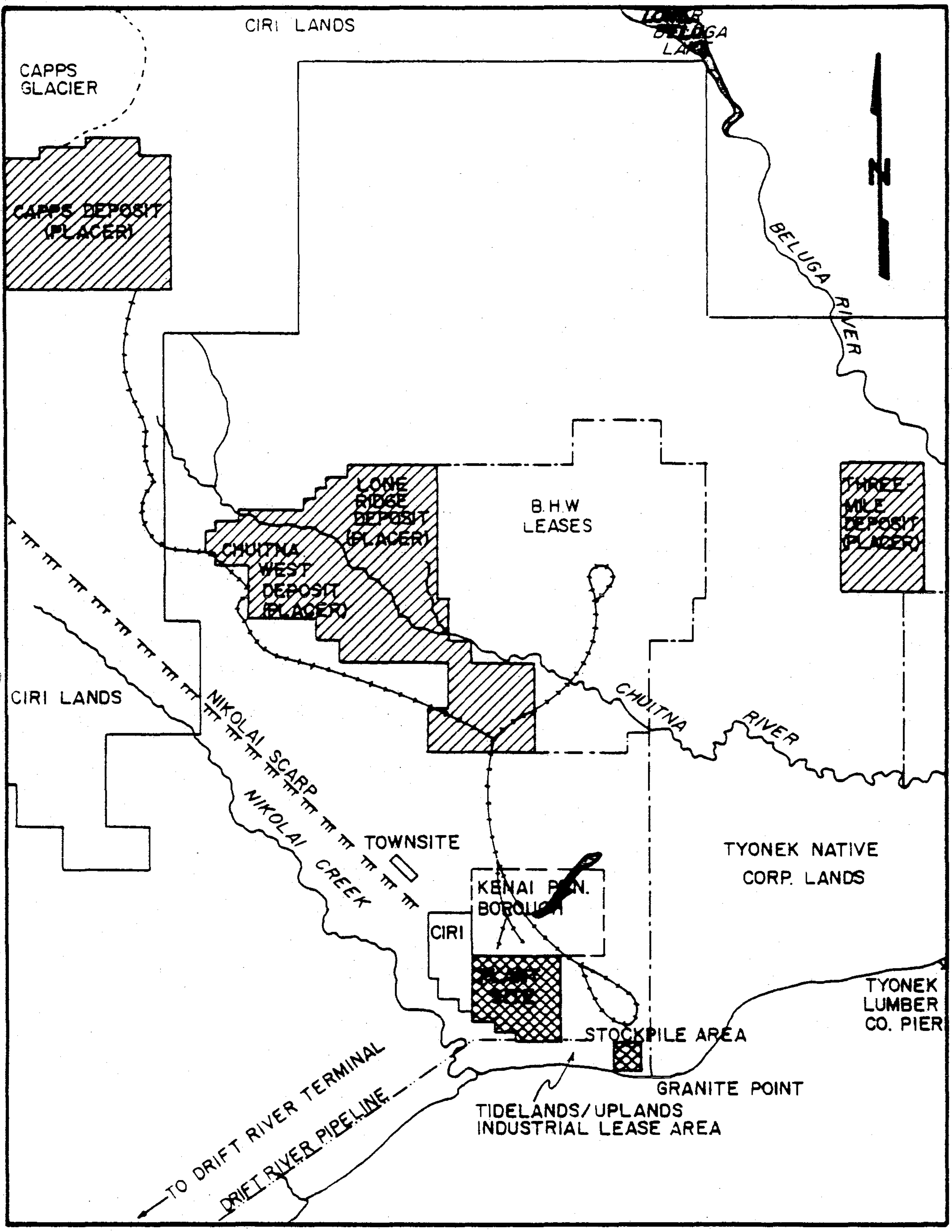


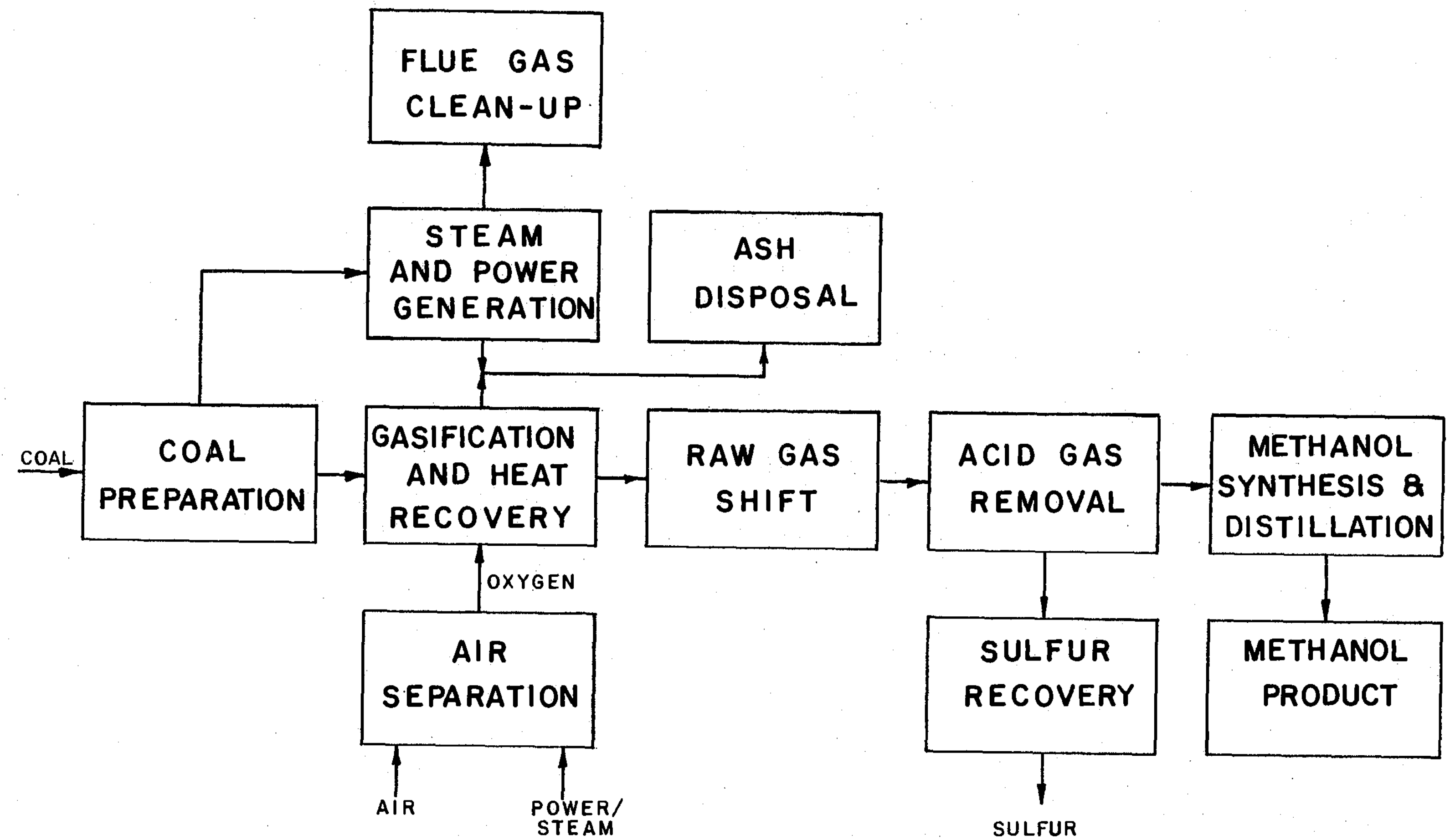

FIGURE 1.2 PROJECT LOCATION MAP (BELUGA METHANOL PLANT)

The town site is an area about three miles northwest of the proposed plant site, which has tentatively been selected for development of a permanent new community in which plant and mine employees and their families could live. It is envisioned that this community would eventually contain all the amenities of a self-sufficient town.

The dock site is an area near Granite Point on Cook Inlet where a permanent dock structure is proposed. The dock's initial use would be to receive equipment and construction materials during the development phase of this project.

Presently mineable coal reserves of the area exceed one billion tons, all within 25 miles of the proposed plant site and deep water in Cook Inlet. The coal is characterized as sub-bituminous (6,500 - 7,500 Btu/lb.), with low sulfur (0.2%), high moisture (25 - 28%), and high ash content (14 - 25%). The rate of coal consumption by the methanol plant would be less than 10 million tons per year. The coal feedstock for this project would be extracted from both the Chuitna Center Ridge mine area and the Capps lease. The coal would be mined open pit with shovels and/or draglines, would pass through a crushing process at the mine and would be transported via railroad a distance of 15 to 25 miles to the coal receiving station at the methanol plant near Cook Inlet.

Following preparation the coal would be gasified utilizing the Winkler procedure followed by the remaining two major processing steps in the production of methanol: syngas upgrading and methanol synthesis (see Figure 1.3). These are commercially proven processing systems currently in operation in various parts of the world. Approximately 80% of the commercial plants now in operation use the methanol synthesis technology proposed for this project. The basic design philosophy has been to select process steps in widespread use with proven reliability which would maximize the possibility for future increases in production with limited additional capital investment. The resulting production of the plant would be approximately 54,000




| | |
|---|---|
| FIGURE 1.3 | SIMPLIFIED BLOCK FLOW DIAGRAM OF A TYPICAL COAL TO METHANOL PLANT |

barrels per day of fuel grade methanol targeted primarily for power plant consumption on the west coast of the United States. The methanol would be batched at the plant and transported approximately 40 miles south via the existing Cook Inlet pipeline to the existing Drift River Terminal currently operated by the Cook Inlet Pipe Line Company. The Drift River marine terminal is a single-berth, fixed-platform, offshore loading facility capable of accommodating tankers up to 70,000 DWT. The methanol would be loaded at this dock and transported by tanker to market.

## 2.0 SUMMARY OF THE STUDY

### METHODOLOGY

#### General

To achieve the objectives stated in the purpose of the report, a five-step process was utilized:

a. Review all existing data and published environmental and socio-economic information relative to the project area.

b. Supplement the published information with the findings of recent and ongoing land resource projects (conducted primarily by state and federal agencies).

c. Identify specific areas where the environmental data base is insufficient to make meaningful appraisals of the environmental effects and permit requirements of this project. Following this identification, develop, plan and conduct specific field investigations in the highest priority areas.

d. Review the total project design and consider its effect on each major environmental attribute.

e. Summarize the issues and make preliminary findings relative to permit requirements, general environmental acceptability of the project, and environmental factors (data gaps) material to the next stage of planning and development.

Participation by and input from concerned state and federal agencies was encouraged during the course of this work. Briefing meetings were conducted on numerous occasions with the various agencies at both the state and federal levels. Representatives of the U.S. Army Corps of Engineers (COE), Alaska Department of Fish and Game

(DF&G), and federal Fish and Wildlife Service (FWS), Environmental Protection Agency (EPA) and Department of Energy (DOE) visited the project site to review the general project concept and observe the environmental field activities. It has been the intention during the course of this study to encourage as broad a participation as possible and to present the findings in a systematic format that would be compatible with the National Environmental Policy Act outline for an Environmental Impact Statement (EIS). The goal was to produce the data base in a form that could be utilized efficiently to prepare the scope of work for the preparation of an EIS, which would be the next major step in the orderly progression of project permitting. DOWL staff members and consultants as well as personnel from CIRI/Placer Amex also participated in an Adaptive Environmental Assessment program sponsored by the FWS in Anchorage in late July 1981 which focused on the broader aspects of coal development in the Beluga region. Although this study generally addresses the entire project area from the inlet to the coal mine areas, the emphasis of the investigation and field program was on the proposed methanol plant site.

Field Programs

The field program was initiated in the fall of 1980 with a reconnaissance survey of aquatic and terrestrial habitats. In the early spring of 1981, aerial reconnaissance of the general area was undertaken to determine the onset of spring "break-up" and the migratory patterns of moose and emerging bear populations. Following scoping meetings with representatives of CIRI/Placer Amex and Davy McKee, the spring-summer field program was initiated in early May. A summary of the highlights of the activities and the participants is shown in Table 2.1. The field program was designed to address specific gaps in available background information under three general categories:

- Geotechnical (soils)
- Hydrologic (groundwater)
- General Environmental

Table 2.1

BELUGA FIELD PROGRAM

SUMMARY OF PRINCIPAL ACTIVITIES, 1980-81

| Dates | Activities | Participants |
| --- | --- | --- |
| November 3-7, 1980 | Reconnaissance of aquatic and terrestrial habitats | DOWL Engineers, Arctic Environmental Information & Data Center (AEIDC) |
| May 4 - June 8, 1981 | Soils and groundwater investigations including the drilling of 2 water wells and 1 observation well | DOWL Engineers, Alaska Testlab with support of Exploration Services and M-W Drilling |
| May 2-6, June 1-5, July 13-17, & August 3-7, 1981 | Field programs in hydrology, fisheries, wildlife, habitat evaluation of aquatic, terrestrial & marine habitats | DOWL Engineers, with support from AEIDC, Radian Corp. and individual consultants. Included site visits by personnel representing the state DF&G, and the federal FWS, EPA and COE |

Under the general environmental program, preliminary work was undertaken to perform reconnaissance surveys of aquatic habitats and determine the presence or absence of fish in the numerous streams in the area; perform reconnaissance surveys of big game distribution (moose and bear); and conduct a reconnaissance survey of the intertidal habitat near the proposed dock location. Other tasks also fell under this general category: vegetation mapping, wetlands determination, socioeconomics, etc.

In this report, the perspective of the current field program must always be considered. The areas of ecological concern for a project of this magnitude varies with the specific activity and the resource concerned. It will only be when the assemblage of baseline data is more complete that the functional relationships of these ecosystems can be understood and habitat values established.

The hydrology and geotechnical programs included drilling two test water wells and an observation well; drilling six test holes; digging 32 test pits; and collecting six grab samples from existing road cuts.

Personnel and/or organizations involved in the field program are shown in Figure 2.1. In addition, contributions from Benno Patsch of Placer Amex and John Ramsey of the Bass-Hunt-Wilson leaseholder group provided valuable insight into the geology and groundwater conditions of the general area. Details as to field methodologies, sample sizes and handling techniques, nature of laboratory tests, and general operational procedures have not been provided as part of the various overviews and summary sections. Numerous state and federal agencies (Table 2.2) were briefed as to the intent and scope of the program, and valuable input was received from many of these agencies.

BELUGA FIELD PROGRAM - 1981
(Organization)

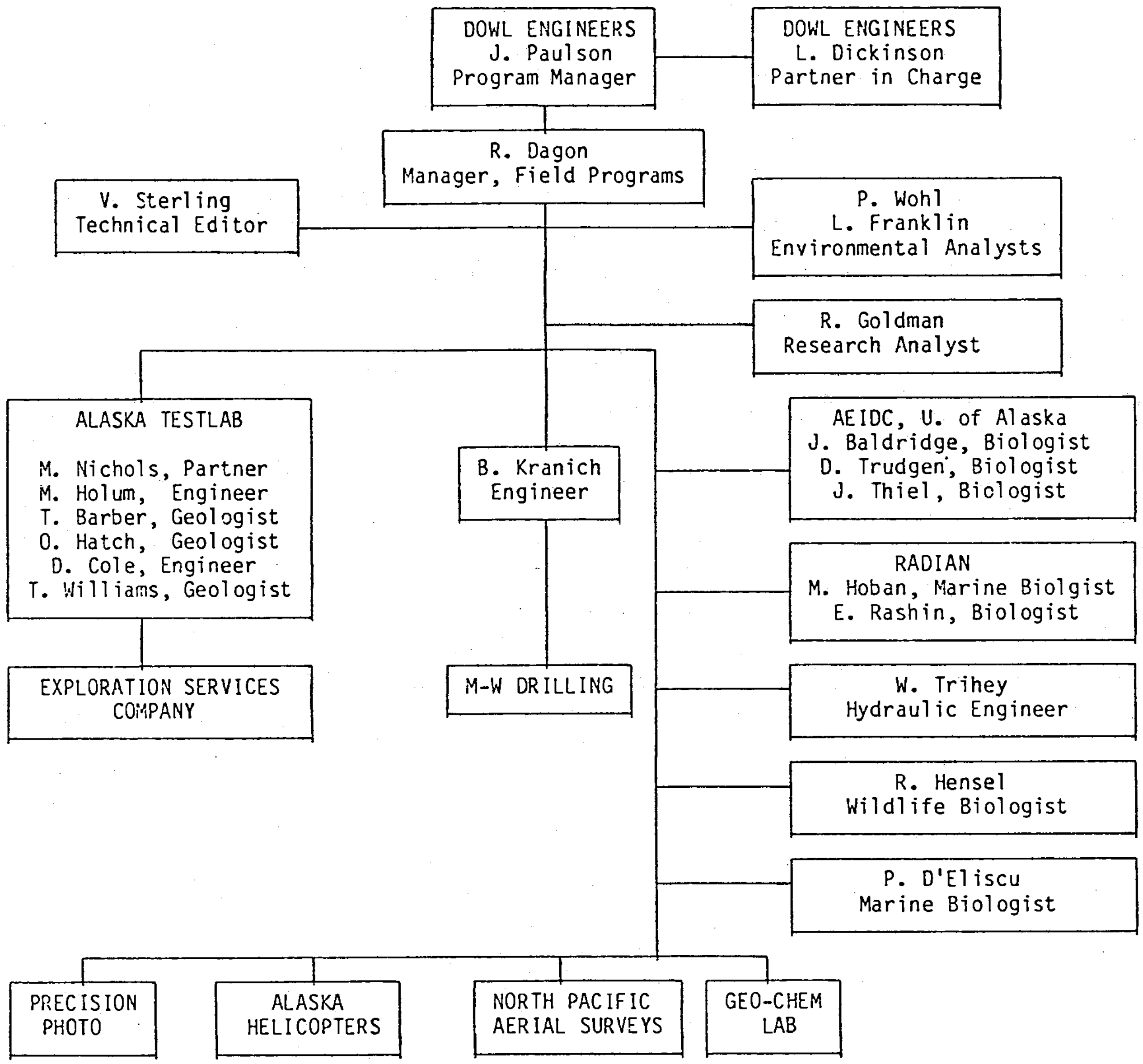



FIGURE 2.1 FIELD PROGRAM PARTICIPANTS

Table 2.2

BELUGA FIELD PROGRAM

AGENCIES CONTACTED OR BRIEFED BY DOWL IN 1981

U.S. GOVERNMENT

| | |
|---|---|
| Department of the Army, Corps of Engineers (COE) | - Alaska District, Regulatory Functions Branch |
| Department of the Interior, Fish and Wildlife Service (FWS) | - Land & Water Resources Development; Biological Services; Environmental Contaminant Evaluation |
| Department of the Interior, Geological Survey (USGS) | - Water Resources Branch |
| Environmental Protection Agency (EPA) | - Region 10, Environmental Evaluations Branch |
| Department of Agriculture, Soil Conservation Service (SCS) | - Susitna Task Force |
| Department of Agriculture, Forest Service (USFS) | - Forestry Science Laboratory, Susitna Task Force |
| Department of Energy (DOE) | - Region 10 Representative |

STATE OF ALASKA

| | |
|---|---|
| Department of Fish & Game (DF&G) | - Habitat; Game Management; Sport Fish; Office of the Commissioner |
| Department of Community & Regional Affairs (DCRA) | - Division of Community Planning |
| Department of Commerce & Economic Development (DCED) | - Office of the Commissioner; Director of Industrial Development |
| Department of Environmental Conservation (DEC) | - Southcentral Region; Division of Environmental Quality; Office of the Commissioner |
| Department of Natural Resources (DNR) | - Lands; Research; Geological Survey; Water Resources; Office of the Commissioner |
| Governor's Commission | - Coal Task Force |

## SUMMARY OF MAJOR ISSUES

### Fisheries

The Beluga area, although not one of the major salmon fisheries in Alaska, has three principal drainage systems containing relatively productive fish habitat: Nikolai Creek and its tributaries to the immediate south of the project area; the Beluga River system to the north; and the Chuitna River and its extensive tributary system in between, which flows through major portions of the overall project area. Prior to the 1981 environmental baseline field work conducted for this study, relatively few details were known about the salmon populations in these systems. The system best known is the Chuitna River which supports four species of Pacific salmon (pink, chum, coho and king). Other species of fish (i.e., rainbow trout and Dolly Varden) are also present in these systems. A key environmental issue concerns the fish populations in each of these three areas, primarily the Chuitna River system due to its immediate proximity to the Chuitna mine area. Any water discharges to this river system or development activities near it would involve particularly close scrutiny by the Alaska departments of Fish and Game and Environmental Conservation. Alaska Statute 16.05.870 "Protection of Fish and Game" defines the requirements of one of the major permits that would be necessary to get approval for development activities near a fishery. Principal impacts to the fisheries resource would result from disruption or elimination of habitat in the feeder streams of the principal creeks and the possible disruption of the groundwater that supplies these habitats. Consequently one of the major unknowns that will require extensive exploration is the nature and operation of the ground water regime. There are two major groundwater considerations. It is potentially an operational problem to the mining activities and it has a potential impact on the flows in adjacent streams. A reasonable determination will probably have to be made as to whether alteration of mine area groundwater flows will reduce or deplete flows in important streams and if so how you re-establish the water source. At this time, fisheries are considered one of the key environmental issues relative to opening the coal mine portion of the proposed project. The methanol plant and proposed town site would have no affect on the Chuitna or Beluga river systems but could potentially impact the lower reaches of Nikolai Creek.

Water Source

Operation of a methanol plant requires large volumes of water. The plant process and cooling concept requires approximately 15,000 gpm. Present freshwater surface sources have been ruled out as insufficient, and desalination of Cook Inlet water to fill the freshwater requirement was considered unfeasible due to the extraordinary power requirements. This study confirmed that deep groundwater is available in limited quantities, but even with storage it would be far too inadequate to provide the anticipated supply. An infiltration gallery system in the lower reaches of Nikolai Creek appears to be the most viable alternative for large volumes of fresh water. It appears that this could be done with an acceptable impact on the water flows in Nikolai Creek. The lack of alternate sources, however, and the possible affects on the Nikolai drainage system remain significant development issues to be further defined.

Wetlands

Although wetland areas constitute major portions of the general Beluga area, the plant site area avoids standing bodies of water and appears relatively dry. There is a fairly high water table and the plant site supports types of vegetation representative of a wetland, and for this reason a major portion of the plant site may be considered a wetland by definition. A preliminary determination by the Corps of Engineers, however, indicates that plant development in this area may fall under the jurisdiction of the Corps of Engineers nationwide permit procedure thereby possibly simplifying future permit requirements.

Erosion and Sedimentation

The potential sedimentation from mining activities and runoff during the construction and operation phases of the plant remain an issue of major concern, relative to fisheries. The potential discharge of sediment laden wastewaters may be one of the factors that would prompt the Environmental Protection Agency to require an environmental impact statement for this project. New Source Performance Standards exist for a point wastewater (drainage) discharge from a coal mine, and these discharges would require a National Pollution Discharge Elimination System (NPDES) Permit under the Clean Water Act. An industry which would create potential discharges for which there are New Source Performance Standards can be required to file environmental impact statements. One of the principal concerns, primarily in mining activities, will be sedimentation and its potential impact on existing fishery habitat.

Tyonek Village

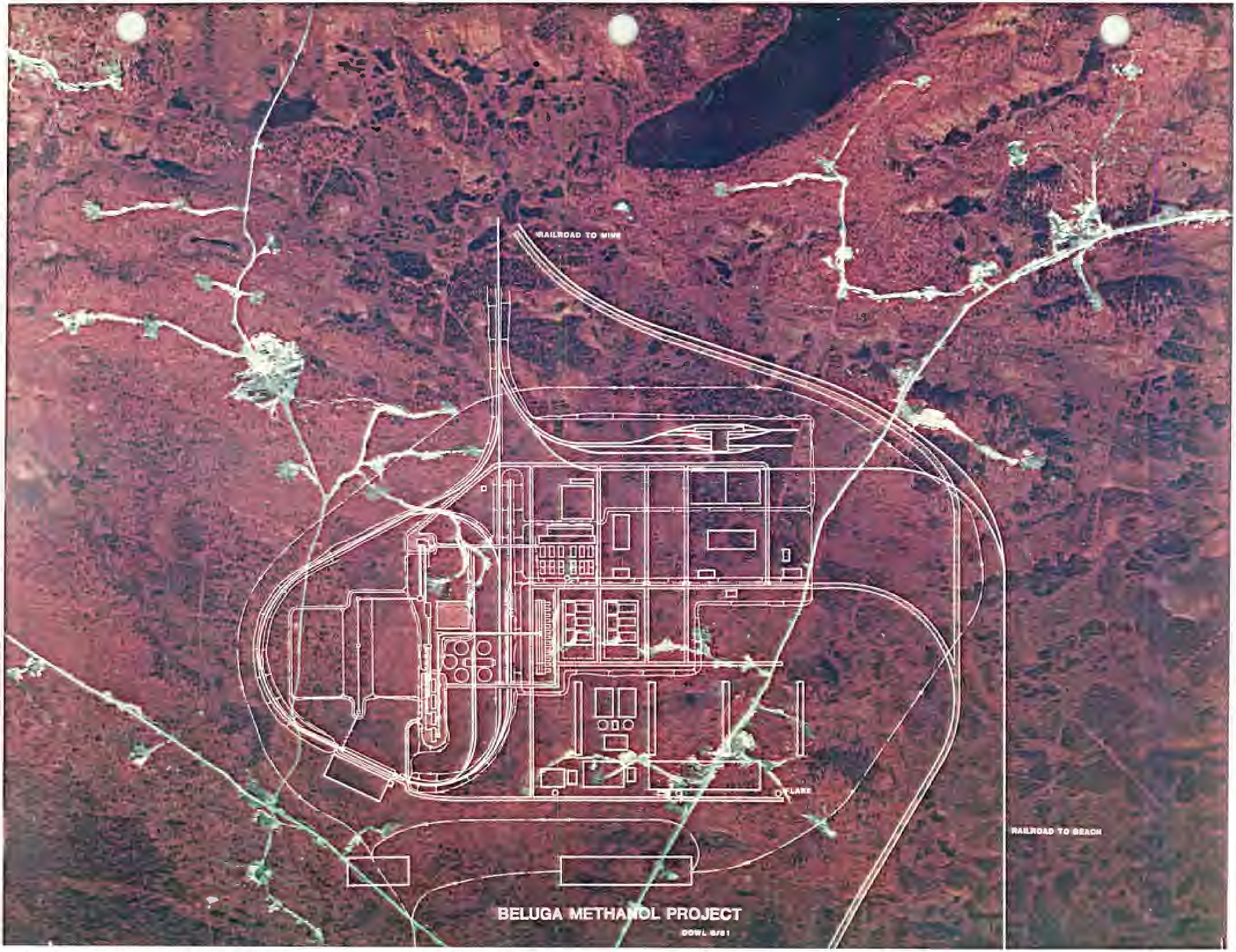
Due primarily to likely cultural changes and the changes to the present subsistence life-style, the neighboring Village of Tyonek generally does not welcome the inevitable growth that would accompany development of one the the state's major energy resources in the Beluga area. Special consideration should be given to the potential socioeconomic conflicts with village residents. Coal development would probably mean that for the first time in their long history, the Tyonek residents would be in the minority in their own region.

Air Quality

The primary air pollutant emitted from the mining operation would be suspended particulates, and from the plant operation it would be products of combustion. The existing air quality of the Beluga area is considered virtually pristine, being relatively unaffected by industrial activities in the Kenai area. Because this project would constitute an introduction of air emissions into a clean air shed, there would be air quality impacts. However, these all should be well within the limits of the air quality regulations under the Clean Air Act.

## ENVIRONMENTAL ACCEPTABILITY OF THE PROJECT

Based on the present level of environmental knowledge in the project area and current environmental law and regulations, Cook Inlet Region, Inc./Placer Amex, Inc. should be able to obtain permits for this project and mitigate major environmental concerns with prudent construction and operation practices. The information gathered in the field, previous assessments of the issues in the Beluga area and the periodic involvement and comments of state and federal agency personnel during the course of the on-going environmental studies revealed no single environmental or permit issue which could preclude proceeding with this project. There would be environmental impacts, as with any large project involving land or water resources. However, it appears that if managed properly, an acceptable balance between orderly industrial and social growth and the preservation and enhancement of environmental values can be achieved.


RAILROAD TO MINE
RAILROAD TO BEACH
FLARE
BELUGA METHANOL PROJECT
DOWL 8/81

BASELINE DATA

# AFFECTED ENVIRONMENT (BASELINE DATA)

## 3.0 GEOTECHNICAL

### THE COOK INLET REGION

To understand the geology of the Beluga area, it is necessary to consider a much larger geographic area, and to discuss the geologic events that have occurred in the area over a broad time frame.

### Geologic History

The Cook Inlet area has been described as a topographic, structural and sedimentary basin containing 60,000-70,000 cumulative feet of marine and non-marine sedimentary and volcanic rocks ranging in age from Late Paleozoic to Recent (Barnes, 1966). Rocks of Triassic to Recent age outcrop in the Cook Inlet Basin, while older rocks are overlain by an estimated 40,000 feet of sediments. Figure 3.1 shows the sequence or general correlation of sediments occurring in the Cook Inlet Basin.

During Paleozoic and early Mesozoic eras, sediments were deposited in a linear depression occurring in Southeastern Alaska. Volcanic islands and other land masses served as the source of these sediments and reef limestone depositions. Sediments which were deposited at this time include bedded cherts, tuffaceous silts, shales and carbonates. The Triassic (early Mesozoic) rocks outcrop on the southeastern rim of the Cook Inlet Basin near Seldovia. These rocks include limestone, tuff, and banded chert underlain by ellipsoidal lava, slate and graywacke. The thickness of the Triassic rocks in the Cook Inlet Basin is estimated to exceed 2,000 feet.

Jurassic rocks of southern Alaska represent the most complete sequence of this age in North America. During the middle Jurassic,

Figure 3.1

STRATIGRAPHIC COLUMN

UPPER COOK INLET BASIN

| ERA | PERIOD | EPOCH | GROUP | FORMATION | THICKNESS (Feet) |
|---|---|---|---|---|---|
| CENOZOIC | TERTIARY | Pliocene | KENAI GROUP | Sterling Formation | 6,000 |
| | | Miocene | | Beluga Formation | 5,000 |
| | | Oligocene | | Tyonek Formation | 7,000 |
| | | | | Hemlock Conglomerate | 1,500 |
| | | Eocene<br>Paleocene | | West Foreland Formation | 3,300 |
| MESOZOIC | CRETACEOUS | | | Matanuska Formation | 8,500 |
| | | | | Matanuska Formation | 2,400 |
| | | | | Nelchina Limestone | 700 |
| | JURASSIC | | | Naknek Formation<br>Chinitina Formation | 7,200<br>2,300 |
| | | | Tuxedni Group | | 9,700 |
| | | | | Talkeetna Formation | 8,400 |
| | TRIASSIC | | | Unnamed Rocks | 1,300 |

the sediments within the Southcentral Alaska area were tilted, uplifted and/or depressed to form anticlinal and synclinal belts - large linear ridges and troughs. Volcanic activity increased during this time and large batholiths and other intrusions of igneous rocks took shape.

The rocks of Jurassic time comprise the Talkeetna Formation, Tuxedni Group, and Chinitna and Naknek formations, and are widely distributed along the western shores of Cook Inlet and the Matanuska Valley. These formations contain rocks predominantly consisting of tuff and volcanic agglomerates in lower, older sections. The Talkeetna Formation is composed of volcanic detritus containing fossil plants and marine invertebrates, and is estimated to be several thousand feet thick. The middle Jurassic Tuxedni Group consists of sandstone, shale, conglomerate, and arkose with an estimated thickness of up to 7,000 to 10,000 feet.

The Chinitna Formation, composed of several thousand feet of red and dark argillaceous marine shales, is dated upper Jurassic and lies conformably on the Tuxedni Group. The Chinitna Formation is comformably overlain by the Naknek Formation. The Naknek Formation is the uppermost of the Jurassic system and consists of a basal conglomerate overlain by shales, arkose, and sandstone. The formation ranges in thickness from 2,000 to more than 7,000 feet.

During the early Cretaceous era the seas of the Jurassic era shallowed and the land rose. This emergence of land masses caused increased erosion in some areas and less deposition in other areas, causing a linear structural belt. The rock formations associated with the Cretaceous era include a limestone unit referred to as the Nelchina Formation; the Matanuska Formation which consists of shales, siltstone and sandstone sequences; and the Arkose Ridge Formation, consisting of well indurated arkose and conglomerate.

The rocks which comprise the Kenai and Chugach mountains probably also were formed during the late Cretaceous era. The strata consists primarily of slate and graywacke which has been intensely deformed and metamorphosed. Considerable volcanics and ultra-basic intrusions also are present, but these are considered to be late additions to the area. More than 30,000 feet of sediments were deposited from the time of the late Paleozoic era to the early Mesozoic era. This period of deposition was followed by a period of uplift, erosion and mountain building. The Alaska range was also formed during this period of mountain building, by large-scale batholithic intrusions.

In early Tertiary time a change occurred in Southcentral Alaska. As the Chugach and Kenai mountain ranges began to emerge, the seas were closed off and a fresh-to-brackish water basin was created. It was within this basin that the extensive formations of the Tertiary were laid down.

## Formation of Coal Bearing Units

During early Tertiary time a narrow, deep basin, some 200 miles long and 70 miles wide, formed in the area now known as Cook Inlet. It was in this basin that more than 26,000 feet of non-marine sediments were deposited during repetitive cycles of clastic sedimentation alternating with coal swamps. In addition, considerable igneous activity occurred in the northern part of the basin.

The formations deposited in the Cook Inlet Basin vary within the basin. In the Matanuska Valley, the northern part of the basin, the Tertiary sequences include three formations: The Chickaloon, Wishbone and Tsadaka. The Chickaloon Formation, deposited in the Paleocene epoch, consists of more than 5,000 feet of non-marine clastic sediments including many beds of bituminous coal, and random intrusions of igneous stocks, sills, and dikes. The Chickaloon Formation is conformably overlain by the Wishbone Formation. This late Paleocene/early Eocene formation consists of a sequence of coarse clastic, non-marine sedimentary rocks, and is about 3,000 feet thick. The Tsadaka Formation, a sandstone and conglomerate of more than 1,000 feet thick, rests with angular unconformity on the Wishbone and Chickaloon formations.

Outside the Matanuska Valley and in the southern portions of the Cook Inlet Basin including the Beluga area, the Kenai Group is the primary sequence of sediments. The Kenai Group is a mixture of conglomerates, sandstone, siltstone, claystone and coal deposits and has been divided into five formations: The West Foreland, Hemlock Conglomerate, Tyonek, Beluga and Sterling formations. Of these, three are significant with respect to energy resources. All of the oil, gas and proposed coal production within the Cook Inlet Basin originates from the Kenai Group. Oil production comes from the Hemlock and lower Tyonek formations, gas production from the Beluga Formation (minor amounts from the Sterling Formation), and proposed coal extraction would be primarily from the Tyonek Formation. Figure 3.2 illustrates the stratigraphic sequence of the Kenai Group as proposed by Calderwood and Fackler (1972).

The lowest member of the Kenai Group is the West Foreland Formation, a tuffaceous siltstone and claystone. There are also scattered lenticular beds of sandstone and conglomerates within this formation. The West Foreland Formation rests unconformably on older Tertiary, Cretaceous and Jurassic rocks, and varies in thickness from a few hundred feet to more than 1,000 feet.

The Hemlock Formation is the principal oil horizon in the basin. It is composed of poorly to moderately sorted sandstone and conglomerate, with interbedded carbonaceous siltstone, shale and coal. The Hemlock Formation varies in thickness from a few hundred feet to about 1,000 feet.

The middle member of the Kenai Group is the Tyonek Formation. It is a massive unit varying in thickness between 4,000 feet and 8,000

Figure 3.2

PROPOSED STRATIGRAPHIC NOMENCLATURE
FOR KENAI GROUP

| ERA | PERIOD | GROUP | FORMATION | DESCRIPTION |
|---|---|---|---|---|
| CENOZOIC | QUAT. | | Alluvium and Glacial Deposits | |
| | TERTIARY | KENAI GROUP | Sterling Formation | Massive sandstone and conglomerate beds with occasional thin lignite beds and gray clay |
| | | | Beluga Formation | Claystone, siltstone and thin sandstone beds, thin sub-bituminous coal beds |
| | | | Tyonek Formation | Sandstone, claystone & siltstone interbeds and massive sub-bituminous coal beds. |
| | | | Hemlock Conglomerate | Sandstond and conglomerate. |
| | | | West Foreland Formation | Tuffaceous siltstone & claystone. Scattered sandstone & conglomerate beds. |
| | | Rests unconformably on older Tertiary, Cretaceous and Jurrasic rocks | | |

Source: Calderwood and Fackler, 1972

feet, and is composed of alternating lenticular beds of sandstone, siltstone and claystone, with massive sub-bituminous coal beds. Overlying the Tyonek Formation is the Beluga Formation. It varies in thickness to a maximum of about 6,000 feet and is primarily claystone and siltstone interbedded with thin sandstone beds and sub-bituminous coal.

The upper unit of the Kenai Group is the Sterling Formation which varies in thickness to about 11,000 feet. It consists primarily of massive, fine to medium grain, unconsolidated sandstone and conglomerate with occasional thin beds of coal and gray claystone.

SURFICIAL SOILS

The landscape in the Beluga coal fields and proposed methanol plant area is dotted with unconsolidated Quaternary deposits which mask the underlying structures and bedrock. These deposits include glacial morainal and outwash deposits; alluvium in stream valleys; and talus and landslide masses. The thickness of Quaternary deposits varies to a maximum of 300 feet. This variation in thickness is due primarily to irregular deposition on a surface of considerable relief, and post glacial erosion.

Shallow discontinuous glacial debris consisting of gravel, sand, and silt was deposited over the bedrock of the Kenai Group during the Quaternary. These deposits include a complex system of lateral and ground moraines deposited by the numerous glaciers which have scoured the area. Lateral moraines are parallel to the Nikolai escarpment and then broaden into kames and ground moraines. The glaciers which deposited these sediments extended southeastward across Cook Inlet almost to Boulder Point on the Kenai Peninsula. Isolated eskers also dot the area.

Other surficial soils are a result of Holocene marine deposition. It is thought that the Chakachatna River and McArthur River region, south of the Nicholai escarpment and the Chuitna River, is the setting of Recent (Holocene) marine deposition. The most recent and near surface deposits are probably tidal or estuarine shallow water sediments, primarily of fine grain. These sediments include sandy beach deposits, silty/sandy lagoon and outwash deposits, and silt and clay tidal, estuarine, or shallow marine deposits.

Pond and bog deposits of Holocene age dot the post-glacial deposits in discontinuous depressions. These deposits, chiefly peat and other organic debris, also contain silt, clay and fine-grain sands. There are also several thin beds of volcanic ash. The pond and bog deposits can be found in areas of poor drainage where the ground is soft and wet except when frozen in winter.

Landslide deposits are found in several areas within the vicinity of the Beluga coal fields. They are generally comprised of slumped beds of the Kenai Group and occur along the steep slopes of the upper Chuitna Valley and other locations where slopes have been over steepened by erosion or mountain building. A large landslide of approximately six square miles in area is located on the east-facing slope of the valley below the Capps Glacier. Another massive landslide extends for about two miles along the west ridge of the Beluga River near Felt Lake.

## THE BELUGA AREA

### Topography

The proposed methanol plant site, townsite, construction dock, and transportation corridor areas are located on the west shore of Cook Inlet. The Cook Inlet-Susitna Lowlands form an intermontane province between the Aleutian Range and the Kenai-Chugach mountains of the coast range.

The topography of the western shore of Cook Inlet is generally characterized by high glaciated mountains dropping rapidly to a glacial moraine/outwash plateau which slopes gently to the inlet. The outwash/moraine deposits generally begin at an elevation of 2,500 feet and drop to tidewater in about 30 to 50 miles. The beach area often consists of either a steep (1:2) escarpment which may be 50 to 120 feet high and which is caused by beach erosion of glacial deposits, or it may be composed of extensive mud flats. The upper portion of Cook Inlet is relatively shallow and the submarine topography slopes at only a few degrees.

The proposed development sites are on the Nikolai moraine, which runs southeast from the vicinity of the Tordrillo Mountains and has been mapped as extending across Cook Inlet to the Kenai Peninsula (Schmoll, et al., 1981). A well defined escarpment (Nikolai escarpment) marks the southwestern edge of the moraine, but the northeastern edge (Susitna escarpment) is cut by numerous streams and is not as steep or distinct. The surface of the moraine is generally of low relief, and in the vicinity of the proposed plant there are numerous level areas containing peat bogs. Relief is generally 50 feet or less in this area.

Stream channels are deeply eroded and may be hundreds of feet deep. Slopes along the eroded stream channels and near the mountains often exceed the maximum angle of repose of soil, and numerous landslides have occurred, some of which cover areas of more than five square miles. Bluffs along eroding rivers such as the Chuitna, and along tidewater have also been unstable. However, the proposed methanol plant site is on the upper portion of the moraine and has little slope except near the escarpment. The escarpment is generally stable near the plant site. Maximum slopes are approximately 10°

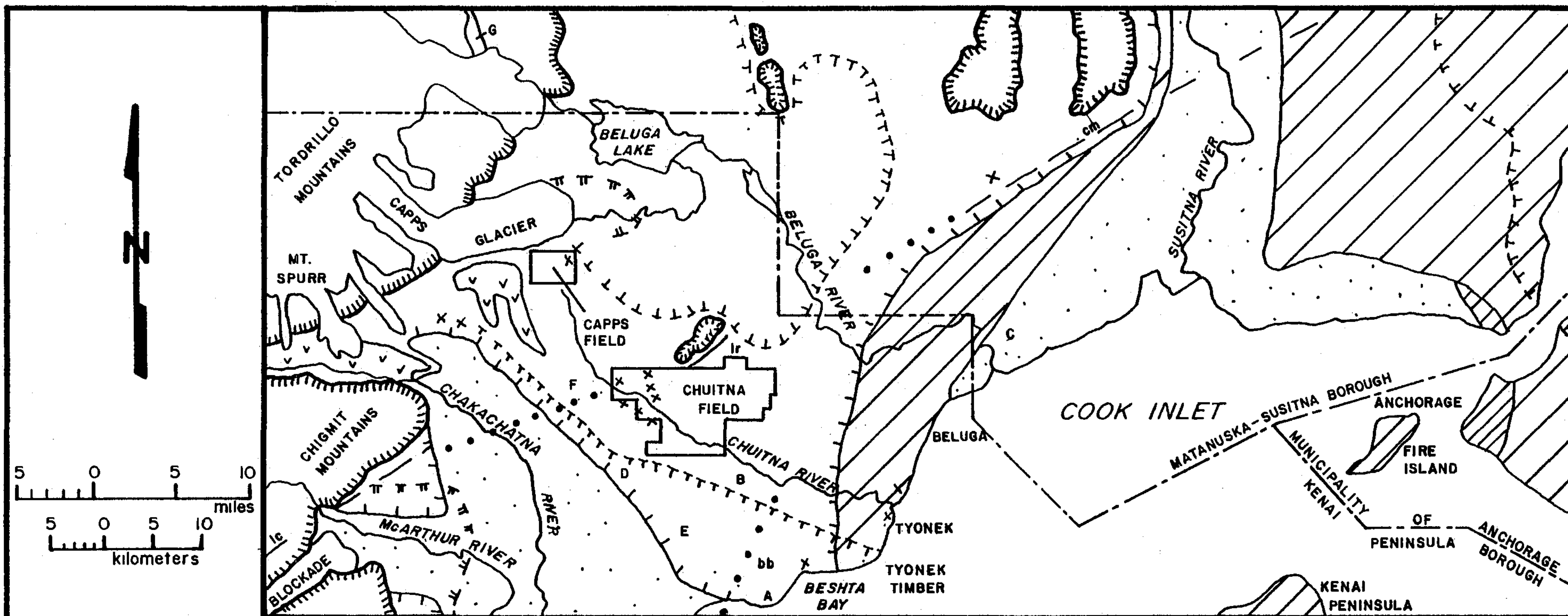
except at small eroded areas and at the base of the escarpment where the slope is about 20°.

## Geology

Extensive reconnaissance geologic mapping, most recently by H.R. Schmoll and others (USGS 1980), has resulted in a detailed geologic map in the vicinity of the proposed development, shown on Figures 3.3 and 3.4. The town and plant sites are on the Nikolai moraine, and the construction dock site is on the submarine extension of the moraine. The moraine consists of a complex group of ground and lateral moraines with numerous kames and eskers.

The moraine appears to lie in contact with sedimentary Tertiary rocks, but subsurface conditions have not been extensively investigated. The depth to bedrock is not accurately known, although gas and water wells have been drilled in this area. The age and extent of the moraine are unresolved. It appears to be slightly older than many of the other moraines in Cook Inlet which formed about 10,000 years ago during the last major glacial retreat. No lacustrine or marine deposits are known to underlie the moraine, and hence it may have formed earlier than the extensive lacustrine/marine Bootlegger Cove clay which underlies much of upper Cook Inlet and which has been dated as 10,000 years old. Test Well #2, which was drilled at the plant site during the 1981 field program, indicated some fine sand at depths below 200 feet, but the samples were obtained by wash boring, which may have produced nonrepresentative samples. The log of Test Well #2 appears in Section 4.0 HYDROLOGY.

The Nikolai moraine is bounded on the southwest by the Chakachatna-McArthur embayment, an area containing Recent alluvial and marine deposits of sand and silt. Coarse material is generally found at higher elevations in the embayment, and gray silt is found near tidewater. No soils exploration was conducted in this area, but




Margin of mountains and hills underlain by pre-Tertiary metamorphic rocks and igneous rocks mainly of early Tertiary age.

Margin of plateau underlain by sedimentary rocks of Tertiary age.

Glacial and marine deposits of Pleistocene age; Bootlegger Cove clay present in area of more widely spaced diagonal lines, overlain by gravel, sand, or peat.

Alluvial and tidal sand, silt, and gravel of Holocene age.

Areas underlain by semiconsolidated volcanic debris flows late Tertiary or Quaternary in age.

Outer limit of moraines of early Holocene age.

Outer limit of prominent moraines of late Pleistocene age.

Major fault zones (dotted where less certain): bb, Bruin Bay; cm, Castle Mtn.; lc, Lake Clark; lr, Lone Ridge.

SELECTED LOCALITIES:

A Granite Point

B young landslides

C Beluga River mollusk - shell locality

D possible area of gravitational spreading

E surface-exposed volcanic clasts in diamicton (till?) Stedatna Creek area

F soft ground along access trail

G Strandline Lake

x Selected areas of extensive landsliding

FIGURE 3.3 GENERALIZED PHYSIOGRAPHY AND GEOLOGY OF THE BELUGA AREA, ALASKA

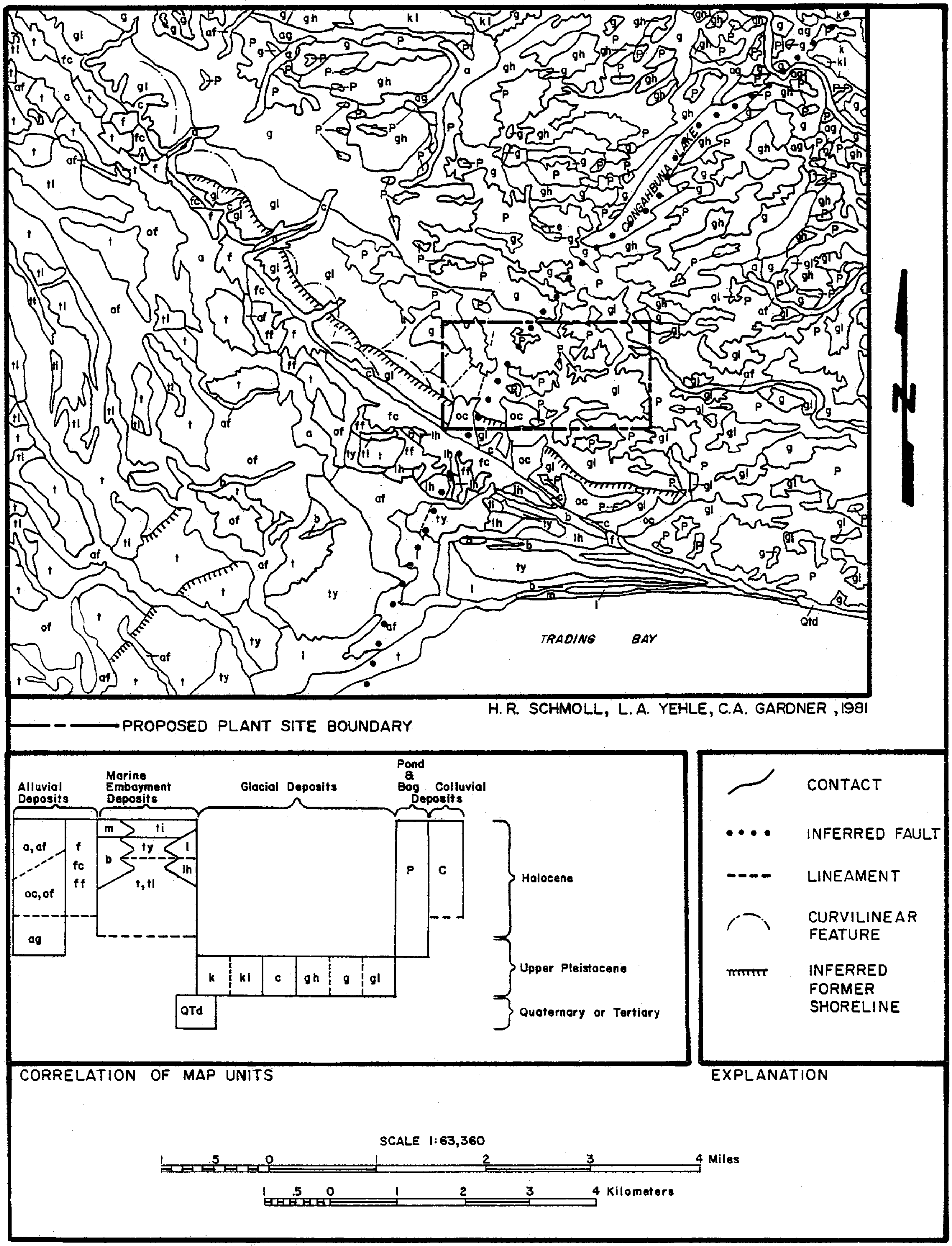



FIGURE 3.4 PRELIMINARY GEOLOGIC MAP OF THE CONGAHBUNA AREA, COOK INLET REGION, ALASKA

water well drillers have indicated that coarse material overlays fine-grain-material near the Nikolai escarpment. The layer of coarse material becomes thinner west of the escarpment. In Test Well #1, which was drilled west of the proposed town site at Nikolai Creek, coarse material was encountered to 85 feet and silt was found below 85 feet.

The Chuitna River approximately follows the northeast boundary of the Nikolai moraine, but this edge is cut with numerous stream channels and forms an indistinct boundary. This area exhibits no evidence of recent glaciation and appears to be a long-established drainage channel for runoff from the Nikolai and adjacent moraines. Hence, the area contains well washed alluvium with a small amount of fines and is generally a good source of aggregate.

The Nikolai moraine has been mapped as extending across Cook Inlet. The area to the south of the moraine, which forms the present beach, consists of a thin deposit of fine sand and silt over very dense moraine type material. The proposed dock area appears to be underlain by a dense soil exhibiting properties similar to that of the onshore moraine.

The Nikolai moraine consists of a complex group of ground and lateral moraines with numerous kames and eskers. It is composed of very dense diamicton including boulders up to 10 feet or more in diameter. The diamicton exhibits well to obscure bedding and contains layers of volcanic clasts, sandstone, siltstone, and at one location east of the site, coal. The diamicton may be generally characterized as a silty sand although numerous inclusions of silty sandy gravel and sandy silt were observed. The very dense diamicton was only observed at ground surface along steep bluffs, but drilling revealed similar soil at several sites on the moraine. Numerous deposits of clean sand and boulders were also found, often in distinctly bedded planes. The upper soils have been mapped as more recent moraine deposits.

Alluvial deposits of sand and gravel are found in broad channels along the moderate slopes near the plant site and consist of material which is less dense and which contains less fines than the surrounding moraines. These areas (OC material in Figure 3.4) may present loose soil conditions. Test Pit 7 was placed in this area.

Peat generally covers the moraine and is usually at least one foot thick except upon eroding surfaces and may be 10 feet thick or more on level, poorly drained areas. Vegetation was observed to have little correlation with peat depth. Large black spruce, cottonwood, and birch were observed to grow on peat which was more than 10 feet thick.

Surface water is relatively high in areas with peat bogs, which includes the top of the moraine and most of the plant site, but many wells in the vicinity of Tyonek and elsewhere on the moraine indicate a water table at depths of 30 to 50 feet or more. Surface water drainage is impeded by the layer of organic material and organic silt immediately below the peat. During soil exploration drilling, water was encountered at depths which varied from 0 to more than 24 feet. The deeper water levels were observed in areas with little or no peat.

## SITE CHARACTERIZATION

### Methanol Plant Site

Most of the subsurface exploration was performed along the existing road system (Figure 3.5).

- Topography

  The site lies entirely upon the Nikolai moraine and generally slopes to the south at a rate of about 50 feet per mile. The

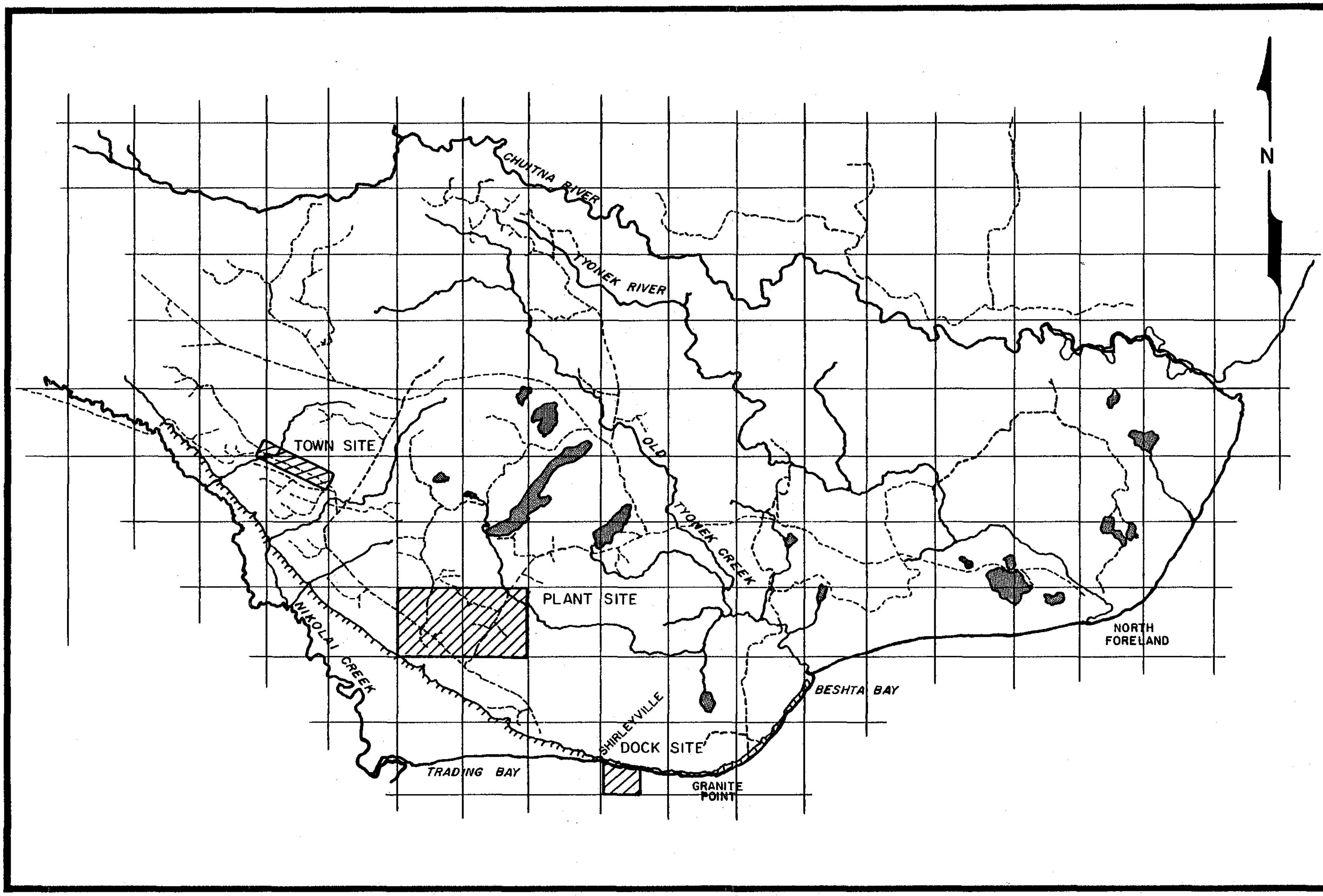



FIGURE 3.5 VICINITY MAP, CIRI/PLACER-AMEX, METHANOL PLANT

maximum elevation is about 350 feet. The southwest section of the site approaches the Nikolai escarpment and has slopes of up to 10% or more.

The topography of the area is characterized by low moraines structures with relief of less than 50 feet set among nearly level peat bogs. This topography changes to one of increasing slope with steeply eroded stream channels along the south and southwest portions of the site.

° <u>Subsurface Conditions</u>

Existing information on subsurface conditions was expanded with a field program that included backhoe excavation of 32 Test Pits (TP1 through TP32); drilling nine Test Holes to depths up to 50 feet (B1 through B9); and taking six grab samples from existing road cuts (G1 through G6). Logs of borings from two test water wells (Well #1 and Well #2) and from one observation well (Well #3), which were drilled during the 1981 field hydrology investigation for this study, also provided data. Locations of test pits, borings, and grab samples are shown on Figures 3.6 and 3.7. These investigations indicate the subsurface conditions at the site consist of an upper layer of peat of varying depth (Figure 3.8) underlain by very dense silty sand and hard sandy silt. One to three feet of organic silt may also be found beneath the peat. Layers of clean sand are present occasionally, and cobbles and boulders are encountered frequently. Logs for a typical test hole and test pit are shown in Figures 3.9 and 3.10. The upper soil contains large amounts of boulders, cobbles, and angular sand and gravel. These angular particles differ from the deeper soil which contains subangular to moderately rounded fragments.

Although both types of material appear to be glacially transported, sources and distance to the sources may differ for each group. The silty sand resembles the diamicton exposed along the steep

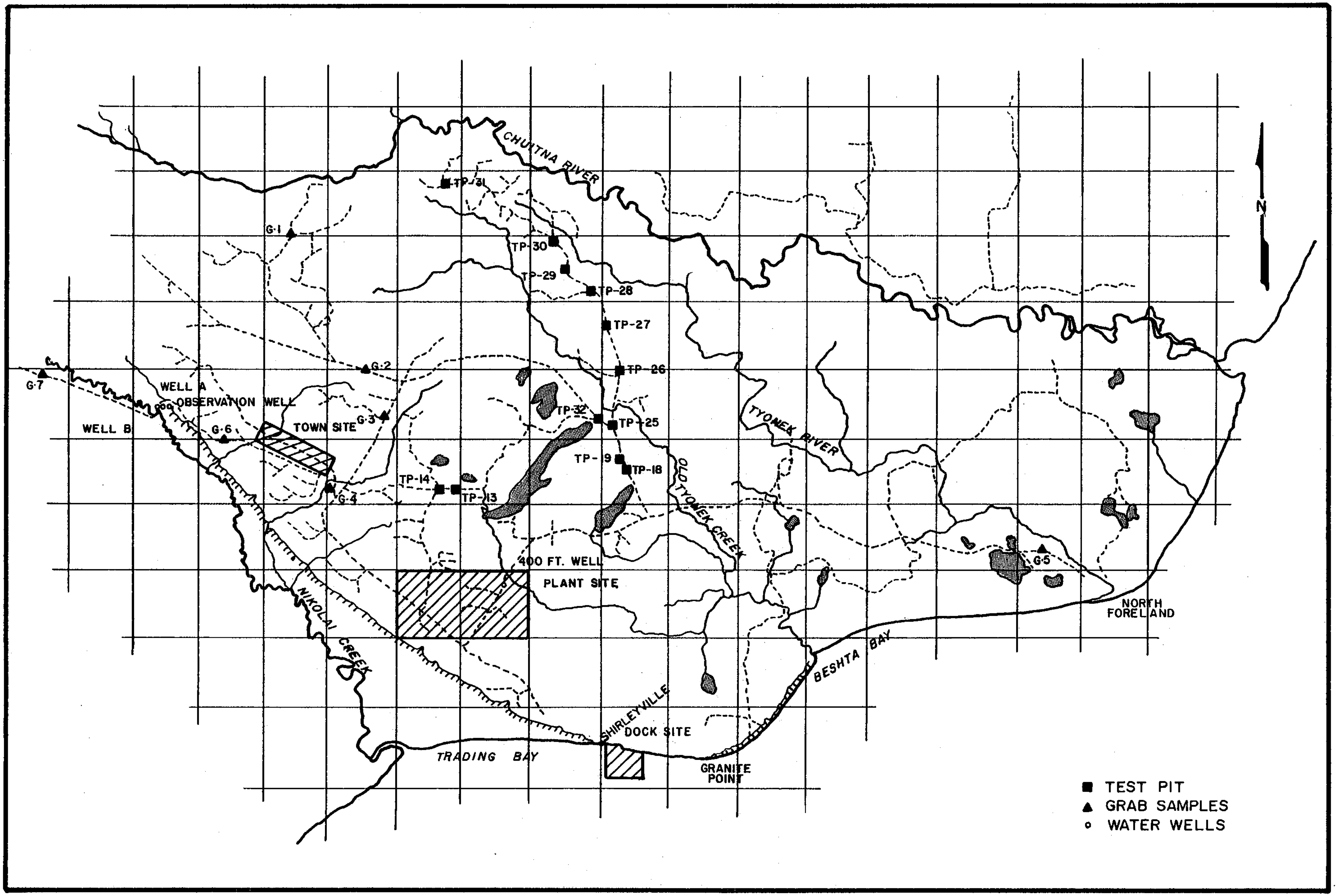



FIGURE 3.6 SOIL SAMPLES AND WELL LOCATIONS, CIRI/PLACER-AMEX, METHANOL PROJECT

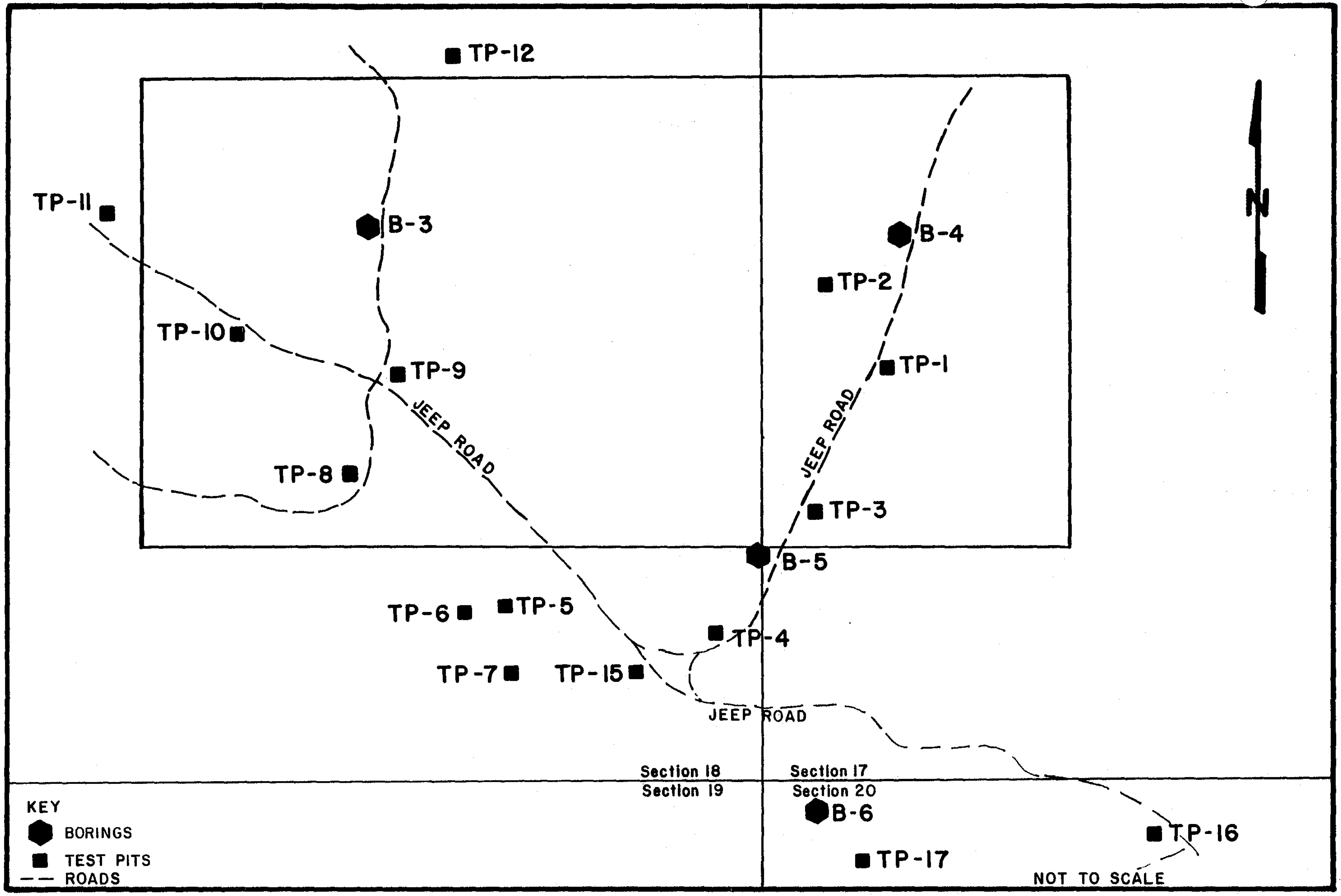



FIGURE 3.7 LOCATIONS OF SOIL TEST (CIRI/PLACER-AMEX PLANT SITE)

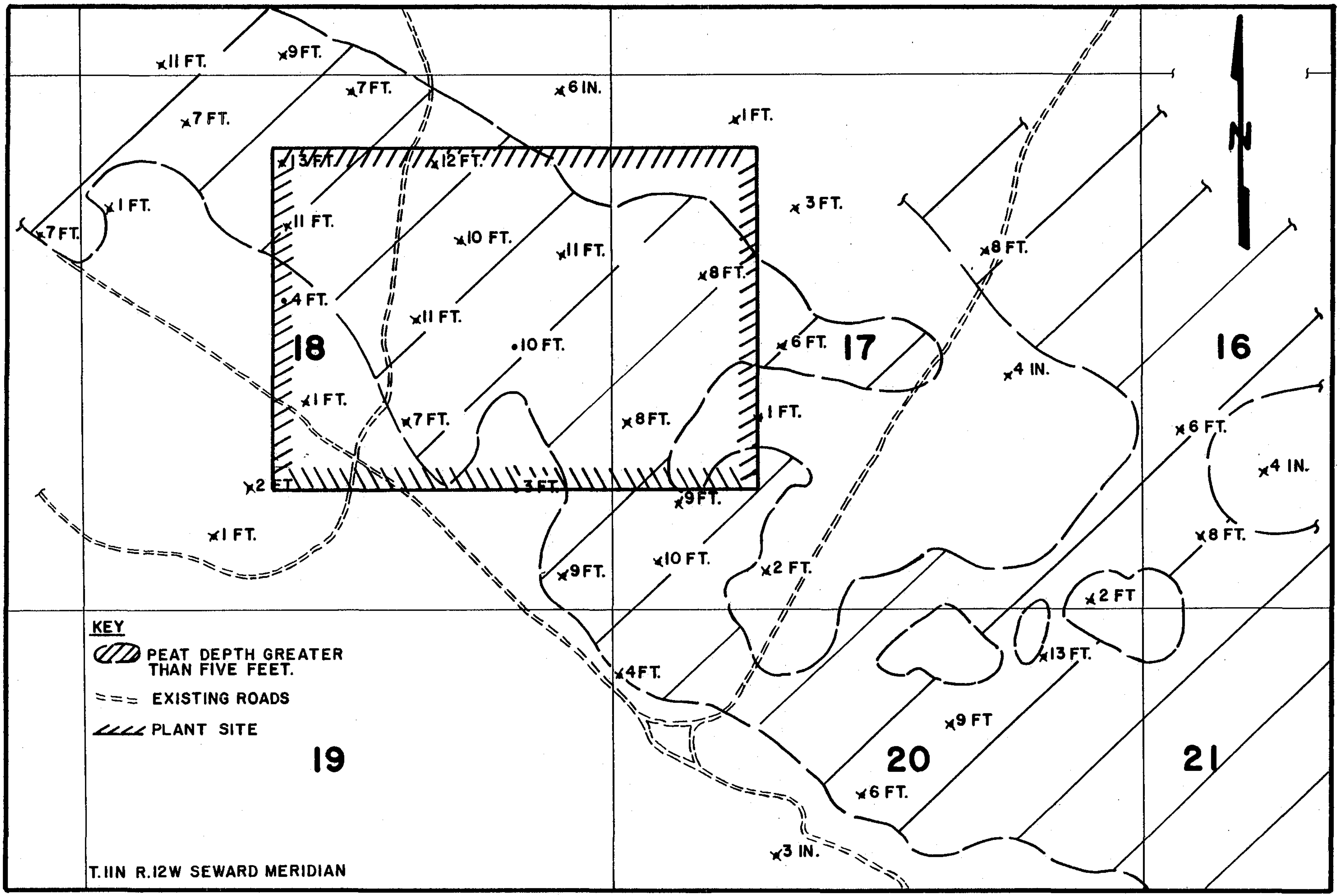
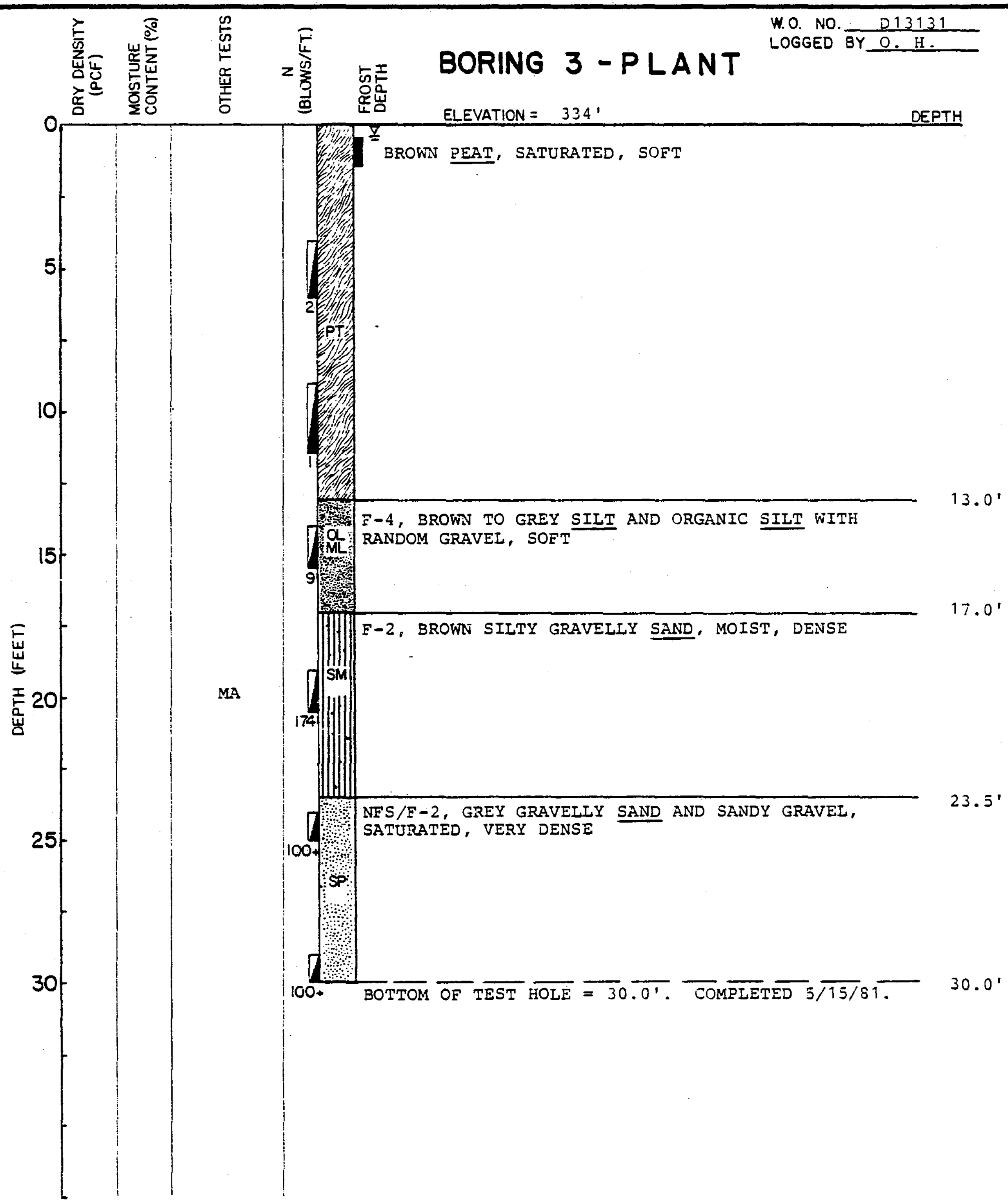



FIGURE 3.8 IDEALIZED PEAT DISTRIBUTION METHANOL PLANT AREA

W.O. NO. D13131
LOGGED BY O. H.

# BORING 3 - PLANT




KEY

PP = UNCONFINED COMPRESSIVE STRENGTH (PENETROMETER) (TSF)
TV = SHEAR STRENGTH (TORVANE) (TSF)
MA = MECHANICAL ANALYSIS
LL = LIQUID LIMIT (%)
PI = PLASTIC INDEX

☐ - GRAB SAMPLE
◪ - SPT SAMPLE
■ - 2.5" I.D. SPOON SAMPLE 340# WEIGHT, 30" FALL
S - SHELBY TUBE - PUSHED
⊻ - GROUND WATER TABLE WHILE DRILLING

DOWL

## LOG OF BORING

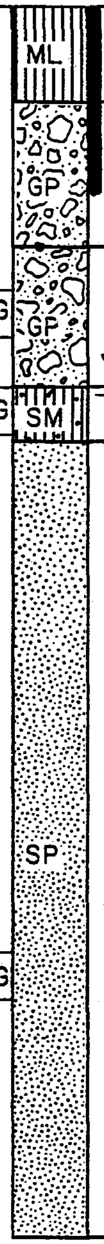
FIGURE 3.9

# TEST PIT 9

WORK ORDER D13132
LOGGED BY T. Barber

ELEVATION = N E

| DEPTH | TEST RESULTS | SAMPLES | DESCRIPTION | DEPTH |
|---|---|---|---|---|
| 0 | | | F-4, BROWN SANDY SILT, (TOPSOIL) | 1.0' |
| 1 | | | F-1, BROWN SILTY SANDY GRAVEL, SUB-ROUNDED 3" GRAVEL | 2.5' |
| 3 | | G | NFS, BROWN TO GREY SANDY GRAVEL, 4" SHARP AND SUBROUNDED GRAVEL | 4.0' |
| 4 | | G | F-2/F-3, GREY VERY SILTY SAND AND VOLCANIC ASH MIXED, WET TO SATURATED, MEDIUM DENSE | 4.5' |
| 4.5 | | G (10) | F-2, GREY SILTY GRAVELLY SAND, SUBROUNDED GRAVEL, 10" COBBLE, WET TO SATURATED, VERY DENSE | 13.0' |




BOTTOM OF EXPLORATION = 13.0'

TEST KEY:

W = MOISTURE CONTENT
LL = LIQUID LIMIT
PL = PLASTIC LIMIT
MA = MECHANICAL ANALYSIS

# LOG OF TEST PIT

bluffs. It is very dense as shown by the standard penetration blow counts in excess of 100, and consists of poorly graded, brown silty sand with gravel. A gradation curve for a sample from Test Hole 3 is shown in Figure 3.11. The sandy silt is hard, nonplastic to slightly plastic, and contains some gravel. No clay was found on the site.

A layer of volcanic ash was observed close to the bottom of the peat layer and resembles reddish brown silt. This layer is less than one foot thick.

- Groundwater

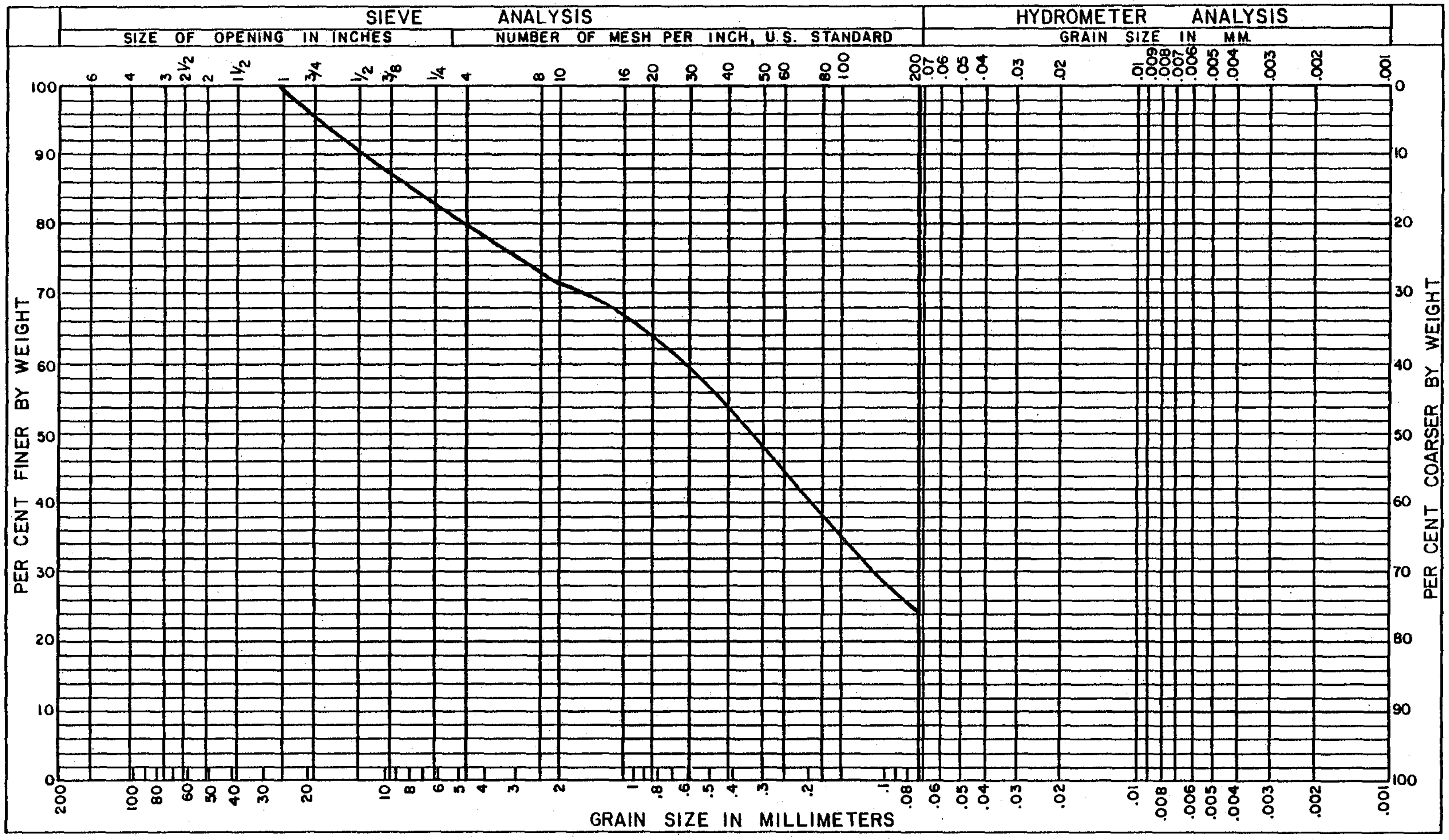
Groundwater is near the surface due to the high water level in the peat. Water level depth increased north of the site in areas with little peat and along the southern bluff. Well drillers indicated artesian conditions may exist in deep, water bearing strata. Groundwater is discussed in more detail in Section 4.0 HYDROLOGY.

Permeability of the dense silty sand is low (estimated to be .0001 inches/second or less), but the occasional layers of poorly graded, clean sand have moderate to high permeabilities. Estimates of the coefficient of permeability for this material range from 1 to .001 inches/second. However, these highly permeable layers are not expected to be large in area, and well pump tests also indicate limited aquifer extent.

Steeply eroded stream channels provide surface water drainage. These channels also are found in the peat bogs, where they may be 5 to 10 feet deep.

- Plant Site Conditions

The inorganic soils in the plant site are medium dense to very dense and offer generally excellent foundation conditions, but




| KEY | LOCATION | SAMPLE NO. | DEPTH | UNIFIED CLASS. | FROST CLASS. | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|
| ——— | TH 3. | 4 | -- | SM | F-2 esti. | Silty Gravelly Sand |
| | | | | | | |
| | | | | | | |
| | | | | | | |

W.O. D12780

FIGURE 3.11

GRAIN SIZE DISTRIBUTION — GRADATION CURVE these soils are often covered with peat and/or organic silt to depths up to 13 feet (Figure 3.8). The peat is generally unacceptable foundation material although limited service roads may be constructed on it using deep gravel overlays. Peat depths are deep near the middle of the site, and become shallower along the northern and southern boundaries. Existing roads were generally placed in areas with little peat.

The dense inorganic soil has good stability and a very low potential for settlement or liquefaction. Soil bearing capacity is good, generally in the range of 4,000 to 8,000 lbs. per square foot. However, the very dense, coarse material is moderately difficult to excavate, especially in areas with numerous boulders. Boulders with diameters of 5 feet and more were observed, and they appear to be well distributed throughout the site. Soil strength was not measured directly, but standard penetration values indicate the very dense till has an angle of internal friction of approximately 40°, and no cohesion.

The till, or silty sand, which forms much of the moraine should be easily compacted with vibratory equipment, provided the moisture can be closely controlled. The material contains a moderate amount of silt (10 to 20%) and will not compact if it contains too much water. The silty material may require dust control during dry periods. The clean sands and coarse upper soils found in isolated areas throughout the moraine should compact easily with vibratory equipment within a wide range of moisture content.

The lack of large quantities of clean on-site fill indicates that silty sand may be needed for a large amount of fill, both for plant and road foundations. Frost protection of roads would require use of up to 18 or more inches of non-frost-susceptible (NFS) sub-base. NFS materials are granular inorganic soils which contain less than 3% by weight finer than 0.02 millimeters. Existing logging roads are in excellent condition and are constructed with material from on-site borrow pits and with gravel obtained from the Chakachatna River. Much of the road material is silty sand, but NFS material was scalped from many small knolls. Roads occasionally are of gravel-covered log corduroy construction in deep peat areas.

No impermeable fine-grain soils were found on site, but some clayey silt was found in the Granite Point beach area. These slightly plastic silts generally make poor impoundment material, but a specific analysis should be performed for each application. Beach borings in the prospective dock area indicate large quantities of the silt material, but the quality may vary from slightly plastic silt to nonplastic sandy silt.

An investigation of the extent of organic soils was performed at the proposed plant and town sites. This entailed an interpretation of available air photos and literature, field reconnaissance traverses of the site, and hand-probing the depth of organic soils. The peat probes were spaced approximately 600 feet apart, with traverses following existing seismic line cuts, and on random traverses. An idealized map of the plant area has been prepared (Figure 3.8) showing the depth of organic soils to range from 0 to 13-plus feet. The organic soil ranged in depth from 0.2 to 3 feet in the town site. A map showing the location of organic soil in the proposed town site was not prepared because there are no significant deep organic soil areas.

Slope stability is generally good due to the dense soil and moderate slopes in the vicinity of the plant site. Small areas adjacent to streams have been over steepened by erosion and are unstable, but these areas can be avoided or cut to a stable slope. The maximum observed slopes of 10° to 20° would be marginally stable under 0.4g loading and high groundwater conditions, but the majority of the slopes would be stable for all expected earthquake accelerations. Cut stability would be good and temporary cuts should stand at slopes of 1:1 for short periods. Long-term slope stability probably would be controlled by erosion criteria, and slopes approaching 2:1 may be required. The very dense coarse material generally has a low potential for erosion, but layers of silty material can erode rapidly under either wind or water action.

## Town Site

### ° Topography

The proposed town site is located on the Nikolai moraine, two miles northwest of the plant site. The site is approximately one mile from the Nikolai escarpment and has an elevation of about 450 feet.

Topography generally slopes to the southwest at about 200 feet per mile, but becomes increasingly steep near the escarpment. An intermittent stream with a steeply eroded channel cuts across the north end of the site.

The land surface is typical of the Nikolai moraine, which is a complex of ground and lateral moraines with numerous kames. The area has generally low relief but is moderately well drained. Peat bogs which contain 2 to 3 feet of peat are found in poorly drained areas near the southern portion of the site, but most of the proposed town site appears to have, at most, only a few feet of peat.

### ° Subsurface Conditions

Two borings and five test pits to depths up to 30 feet reveal the town site has a surface layer of peat which is underlain by medium dense silty sand or sandy silt extending to a depth of about 2 to 5 feet (Figure 3.12). The next deeper layer is NFS gravelly sand which may contain numerous boulders between depths of 5 and 15 feet. Very dense silty sand and sand are

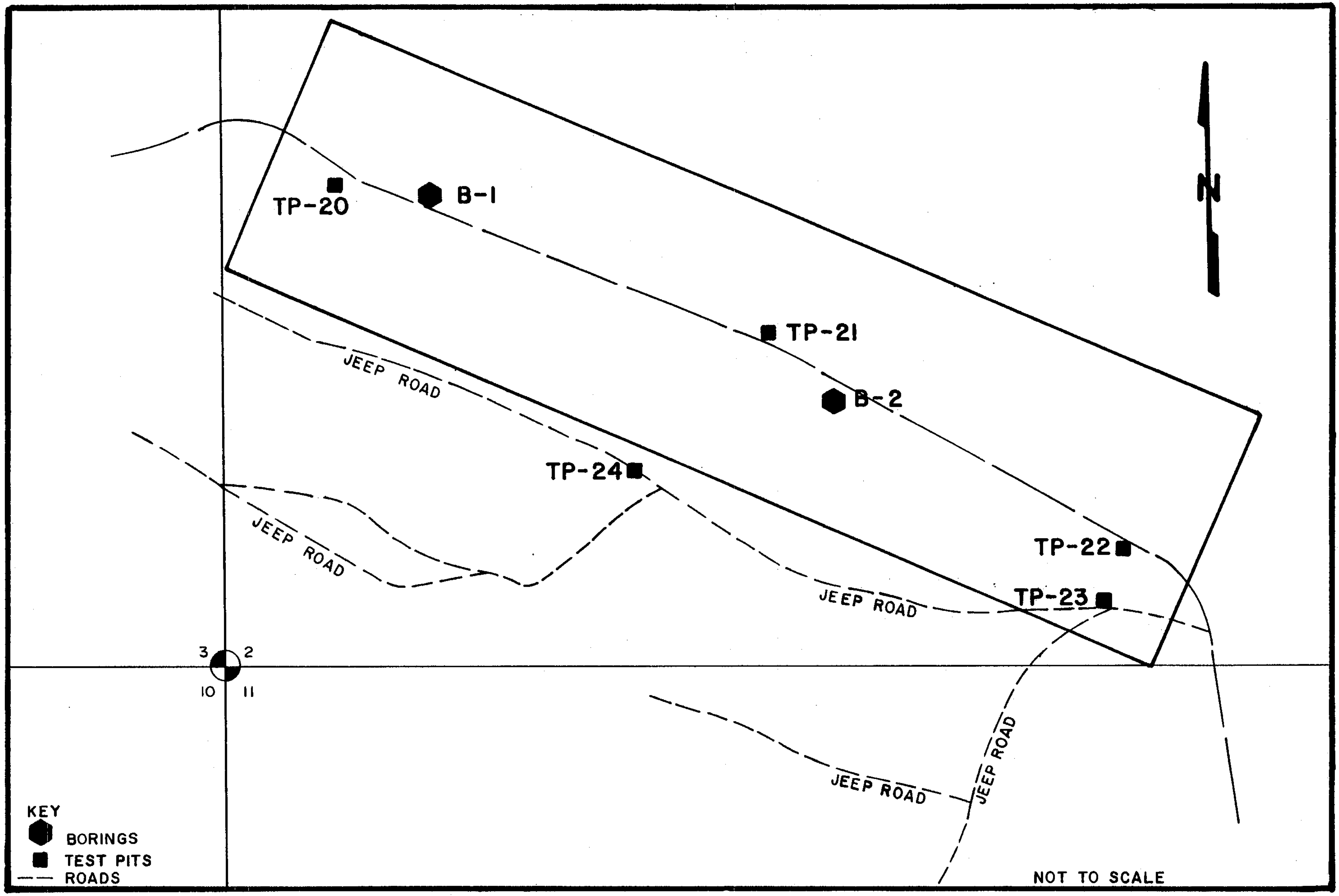



FIGURE 3.12 LOCATIONS OF SOIL TEST (CIRI/PLACER-AMEX TOWNSITE)

found below the boulders. Volcanic ash layers up to 4 inches thick may also be found beneath the boulder layer.

A boulder layer has been identified in many parts of the moraine, but its source has not been firmly established. It may represent volcaniclastic debris or glacially transported volcanic material. Volcanic debris at this distance from known volcanos would represent volcanic activity more intense than currently anticipated. Logs of a typical test hole and test pit are shown in Figures 3.13 and 3.14.

- Groundwater

The town site is generally well drained due to the proximity of the escarpment, but the southern section of the town site contains small areas of peat. The upper coarse soils have a moderate to high permeability, but the underlying silty sand is very dense and possesses a moderate to low permeability.

Groundwater was observed in the peat at depths of 2 to 4 feet, but this appears to be surface water which is inhibited from draining by the low permeability silt underlying the peat. Sufficient slope exists to permit surface drainage through channels, and the shallow water level should not provide extensive problems for construction. Coarse soils with moderate to high permeabilities are found directly below the surface silt and peat. This soil could be used to provide on-site wastewater disposal if systems could be placed in areas with a low water table.

- Construction Feasibility

The proposed town site is characterized by very dense soil underlying a few feet of surface peat and silt. The upper soft soils are sufficiently thin to allow excavation to expose very dense granular soil. The dense soil provides excellent bearing capacity,

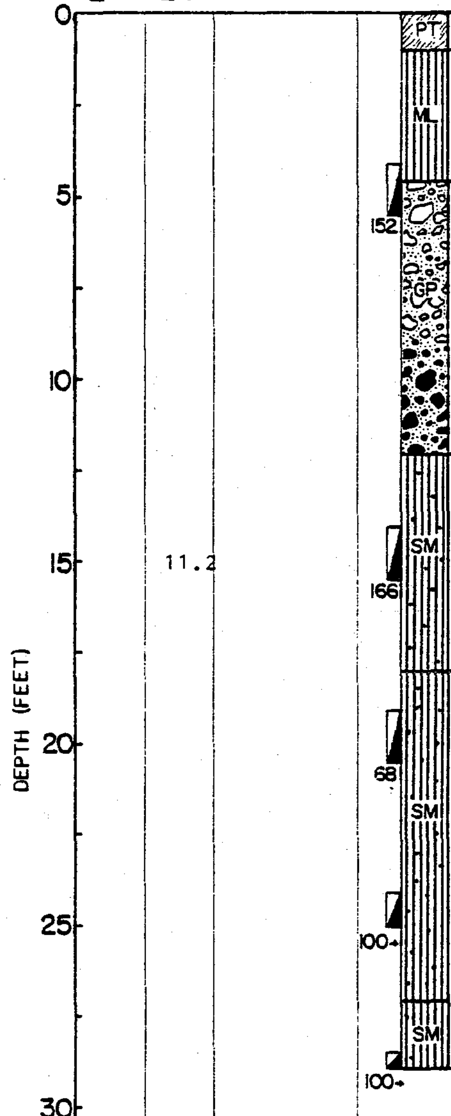
W.O. NO. D13131
LOGGED BY O. H.

# BORING 2-TOWN

ELEVATION = 430'

| DRY DENSITY (PCF) | MOISTURE CONTENT (%) | OTHER TESTS | N (BLOWS/FT.) | FROST DEPTH | DESCRIPTION | DEPTH |
|---|---|---|---|---|---|---|
| | | | | PT | BROWN PEAT, SOFT | 1.0' |
| | | | | ML | F-4, BROWN SILT, SLIGHTLY PLASTIC, SATURATED, SOFT TO STIFF | 4.5' |
| | | | 152 | GP | NFS, BROWN SANDY GRAVEL WITH OCCASIONAL COBBLES TO 12"+ MAXIMUM PARTICLE SIZE, MOIST, DENSE | 12.0' |
| | 11.2 | | 166 | SM | F-2, BROWN GRAVELLY SILTY SAND WITH OCCASIONAL COBBLES TO 12"+ MAXIMUM PARTICLE SIZE, MOIST, VERY DENSE | 18.0' |
| | | | 68, 100+, 100+ | SM | F-2, BROWN GRAVELLY SILTY SAND WITH OCCASIONAL COBBLES, MOIST, MEDIUM DENSE TO VERY DENSE | 29.0' |

BOTTOM OF TEST HOLE = 29.0'. COMPLETED 5/14/81.




KEY

PP = UNCONFINED COMPRESSIVE STRENGTH (PENETROMETER) (TSF)
TV = SHEAR STRENGTH (TORVANE) (TSF)
MA = MECHANICAL ANALYSIS
LL = LIQUID LIMIT (%)
PI = PLASTIC INDEX

- GRAB SAMPLE
- SPT SAMPLE
- 2.5" I.D. SPOON SAMPLE 340 # WEIGHT, 30" FALL
- S SHELBY TUBE - PUSHED
- GROUND WATER TABLE WHILE DRILLING

## LOG OF BORING

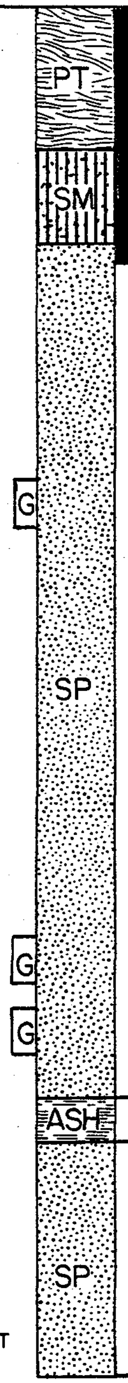
DOWL

FIGURE 3.13

# TEST PIT 20

WORK ORDER D13132
LOGGED BY T.B.

DEPTH | TEST RESULTS | SAMPLES | ELEVATION= N E | DEPTH




| Depth (ft) | Description | Depth |
|---|---|---|
| 0 – 1.5 | F-4, BROWN PEAT AND ORGANIC SANDY SILT. | 1.5' |
| 1.5 – 2.5 | F-2, GREY SILTY GRAVELLY SAND WITH WOOD AND ORGANICS MIXED, ANGULAR AND SUBROUNDED 8"+ GRAVEL AND COBBLES, MEDIUM DENSE. | 2.5' |
| 2.5 – 11.5 | F-2, BROWN SILT SAND AND 1' COBBLES, MEDIUM DENSE. BECOMING CLEANER WITH DEPTH. | 11.5' |
| 11.5 – 12.0 | GREY AND PINK VOLCANIC ASH AND SILT. | 12.0' |
| 12.0 – 14.5 | F-2, GREY SILTY GRAVELLY SAND WITH COBBLES, MOIST TO WET, VERY DENSE. | 14.5' |

BOTTOM OF EXPLORATION = 14.5'

TEST KEY:
W = MOISTURE CONTENT
LL = LIQUID LIMIT
PL = PLASTIC LIMIT
MA = MECHANICAL ANALYSIS

# LOG OF TEST PIT

generally in the range of 4,000 to 8,000 lbs. per square foot for spread footings. Stability of the dense soil is good, and the liquefaction and settlement potentials are low.

Extensive cobbles and boulders found there would create moderately difficult excavation conditions, but cuts and exposed slopes would be stable at relatively steep angles. Precautions to prevent boulder slides should be provided during excavation. Slope stability is good, and only the small slopes along streams which have been over steepened by erosion present stability problems. These areas may be cut to a stable configuration or avoided entirely with only a small loss of area. Removal of the surface peat and silt near bluffs would contribute to increased water infiltration and may possibly increase bluff erosion.

Dock Site

° Topography

Topography at the proposed dock area consists of a narrow (200 feet or less), level beach which is submerged or only a few feet above water during extreme high tides. The shore slopes southward at a rate of about 20 to 40 vertical feet per mile. Bluffs up to 120 feet high with slopes of 30° to 40° border the beach strand on the north. The bluffs are cut by numerous small streams which have formed narrow channels. Ground surface above the bluffs also slopes to the south at about 50 feet per mile.

The bluffs are continuously eroding and the toe of the slope often has deposits formed by erosion debris or slumped material. This material forms a bench about 10 to 30 feet above extreme high water.

° <u>Subsurface Conditions</u>

A thin layer of soft gray silt covers the beach between mean and low tide levels. Three test borings and two probes indicate that soft or loose deposits of silt and sand extend to a depth of about 15 feet, below which is found very dense silty sand (Figures 3.15 and 3.16) The very dense material resembles the material of the Nikolai moraine which has been mapped as extending across Cook Inlet. The borings indicate that only a relatively thin marine deposit covers the very dense material of the moraine. A log for the boring Test Hole 2 is shown in Figure 3.17. The marine deposits contain fine sand, silt, and clayey silt. The silt resembles rock flour, being generally nonplastic and only slightly compressible ($C_c$ = .1).

° <u>Dock Construction</u>

The soils in the proposed dock area have excellent bearing capacity below the Recent soft, loose marine deposits (Figure 3.16). However, boulders are present and may create difficult pile driving conditions.

The existing beach is narrow with little or no back beach area, and lack of space may limit the amount of activity near the dock. The beach is generally only a few feet above extreme high water, and portions of it may have to be raised to provide protection against high water. The bluffs which border the site on the north are steep and are eroding continuously. They also represent a hazard of landslides onto the narrow beach. The slopes should be stabilized if activity were to occur near the toe of the steep slopes. The bluffs are composed of very dense, granular material and should be stable at about a 1½:1 slope, provided water is prevented from eroding the bluffs.

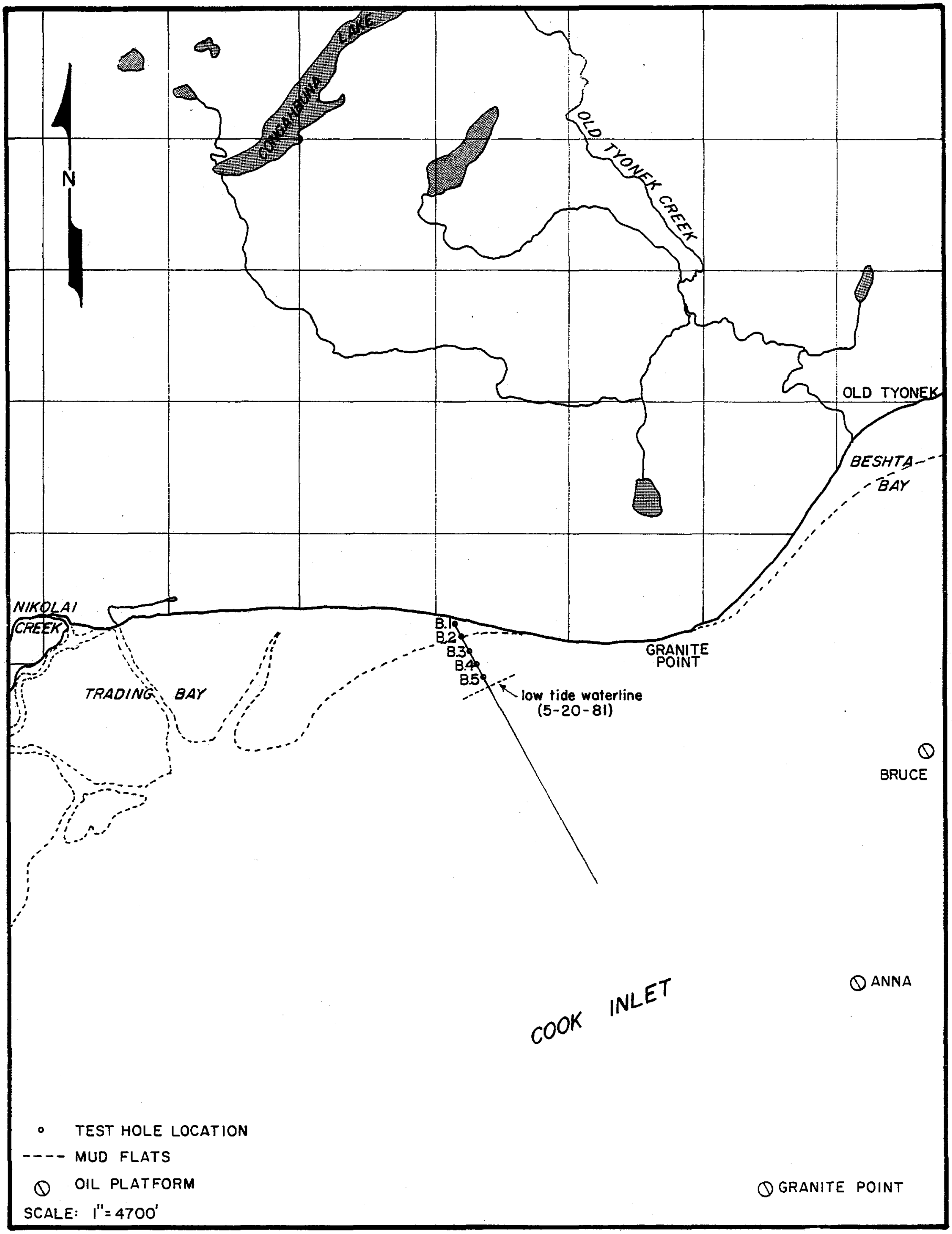



FIGURE 3.15 DOCK SITE TEST HOLE LOCATIONS

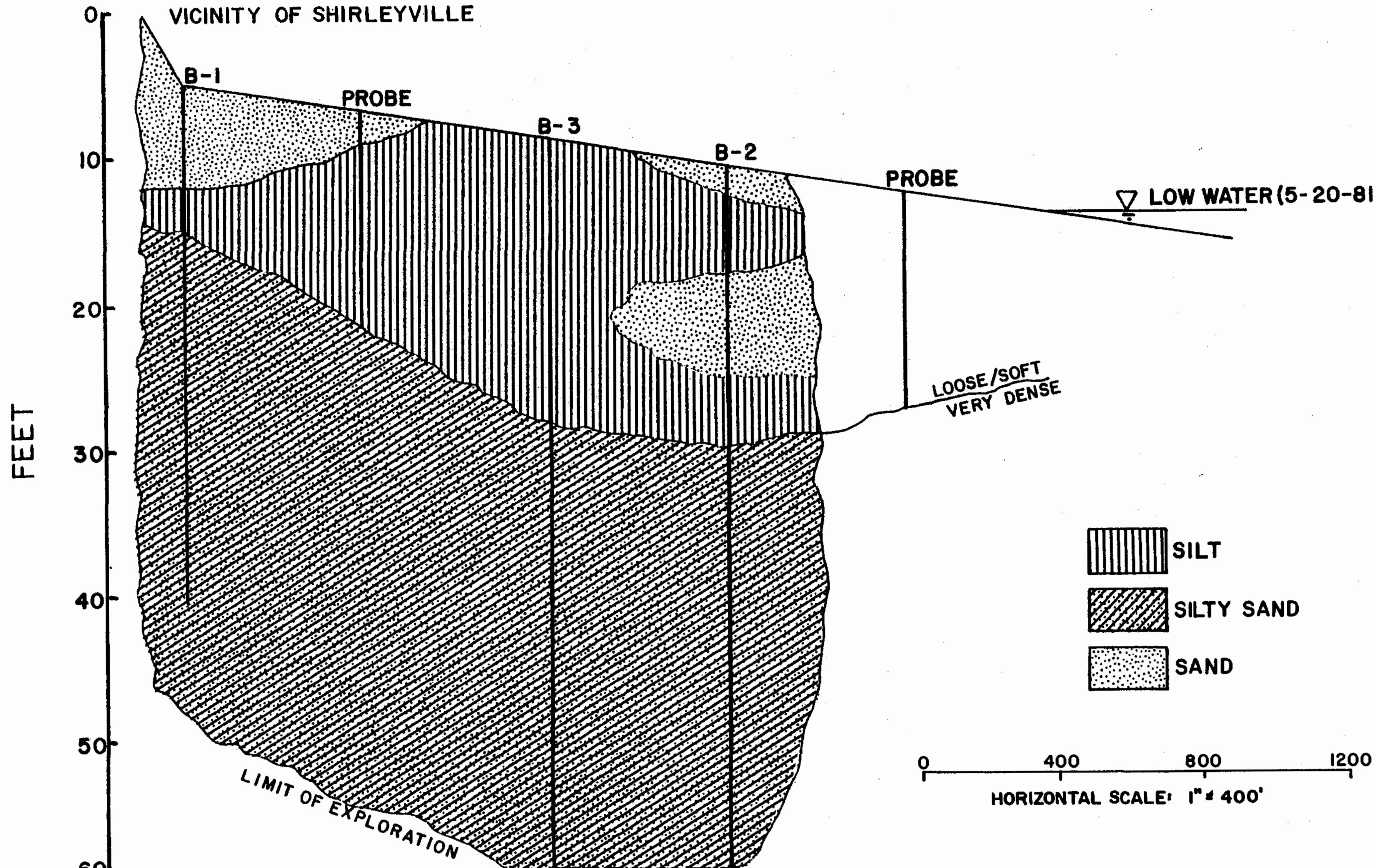



FIGURE 3.16 DOCK SITE IDEALIZED SOIL PROFILE

# BORING 2 - DOCK

W.O. NO. D13132
LOGGED BY O. H.

ELEVATION = Refer to Profile

| DEPTH (FEET) | DRY DENSITY (PCF) | MOISTURE CONTENT (%) | OTHER TESTS | N (BLOWS/FT) | SOIL | DESCRIPTION | DEPTH |
|---|---|---|---|---|---|---|---|
| 0 | | | | | SP | NFS, BROWN SAND, SATURATED, MEDIUM DENSITY | |
| | | | | 7 | ML | F-4, GREY SANDY SILT, NON-PLASTIC, SATURATED, SOFT | 2.0' |
| 10 | | | | 13 | SM | F-2, GREY SILTY SAND, SATURATED, MEDIUM DENSE | 8.0' |
| | | | | 5 | ML | F-4, GREY SILT WITH SILTY SAND LENSES, NON-PLASTIC TO SLIGHTLY PLASTIC, SATURATED, SOFT | 14.0' |
| 20 | | | | 125 | SM | F-2, GREY SILTY GRAVELLY SAND, MAXIMUM PARTICLE SIZE TO 2"+, MOIST, VERY DENSE | 19.0' |
| | | | | 100+ | | | |
| 30 | | | MA | | | | |
| 40 | | | | 112 | | | |
| | | | | | | BOTTOM OF TEST HOLE = 48.0'. COMPLETED 5/20/81. | 48.0' |
| 50 | | | | | | | |

KEY

PP = UNCONFINED COMPRESSIVE STRENGTH (PENETROMETER) (TSF)
TV = SHEAR STRENGTH (TORVANE) (TSF)
MA = MECHANICAL ANALYSIS
LL = LIQUID LIMIT (%)
PI = PLASTIC INDEX

- GRAB SAMPLE
- SPT SAMPLE
- 2.5" I.D. SPOON SAMPLE 340 # WEIGHT, 30" FALL
- S SHELBY TUBE PUSHED
- GROUND WATER TABLE WHILE DRILLING

DOWL

## LOG OF BORING

FIGURE 3.17

Erosion of the beach appears to occur at a rate of about 2 feet per year as shown by aerial photographs. Dock structures would need protection from tidal current, ice scour, and wave action. Protection in the form of riprap could be provided from several sources. Boulder deposits occur on-site and appear to be widespread, but their quality and quantity are unknown. Quarry sites containing volcanics and intrusives of Jurassic time exist at elevations above the outwash/moraine plateau and at various locations throughout Cook Inlet.

## Transportation Corridor and Mine Areas

The proposed mine sites include the Capps coal field area and the west half of the Chuitna coal fields (Center Ridge).

### ° Topography of Mine Areas

The topography in the Capps and Chuitna coal fields includes areas of significant mass wasting potential due to water runoff, frost action, slope and other natural features. The ground surface is covered with many small hummocky hills indented with small cirques. The surficial features (patterned ground) indicate surface frost action is occurring primarily in the uplands. The presence of permafrost in the Capps coal field area is highly possible. During hand probes, several samples obtained below 5 feet in depth were very cold to the touch.

### ° Surficial Conditions at Mine Areas

The ground cover within the area of the Capps and Chuitna coal fields consists of a thin layer of moss, grasses, wild flowers and low woody plants. Field observations noted a cyclic build-up of surficial soils. The mosses are gradually covered by wind-blown sands and/or volcanic ash. Figure 3.18 illustrates a typical shallow soil profile of the Capps area. Soils tests show the sands to

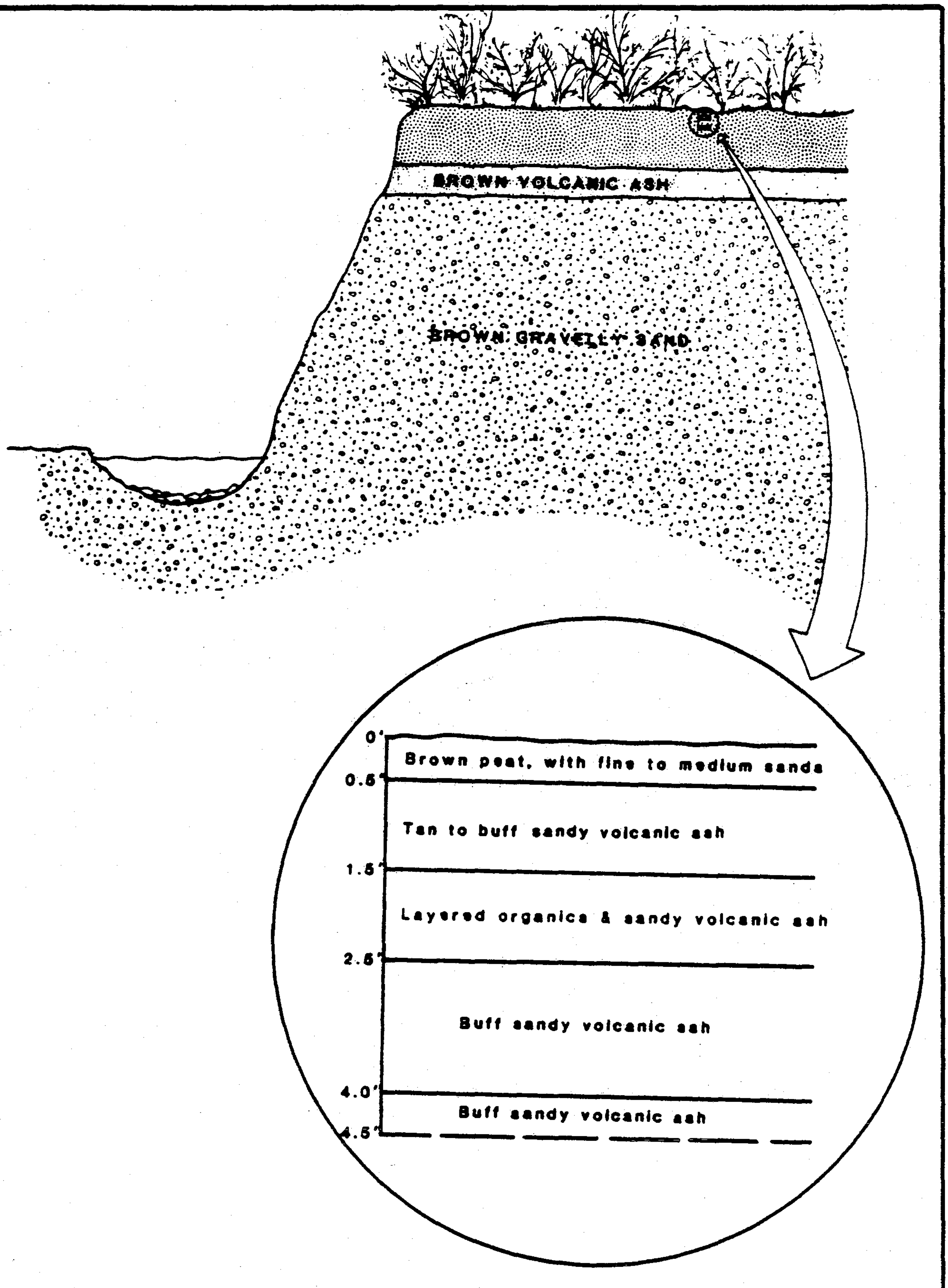



FIGURE 3.18. TYPICAL SOIL PROFILE OF CAPPS AREA, ALASKA

be well-sorted with 68% retained between the #40 and #200 screens. A grain size analysis of the ash shows 48.5% is sand and 41.6% is minus #200 grain size.

- Transportation Corridor

The transportation corridor traverses the upland tundra of the Capps Field area, passes through the transition zone between the tundra and mixed high brush where the Chuitna Field is located, and enters the lower elevation which is dominated by mixed high brush/spruce and hardwood forest area near tidewater.

The surface vegetation changes from grasses and moss to alders and grasses with root systems which extend 18 inches or more. The topsoil here has developed to a greater extent than the soils of the Capps area, however, it is still bisected with layers of sandy volcanic ash. Figure 3.19 shows a typical section/soil profile for the Chuitna Field area.

- Trafficability

The trafficability of the upland Capps coal field area is very poor. Layered organics and volcanic ash have been observed in recent field reconnaissance to range from a few feet to more than six feet in depth. In addition, the groundwater table is relatively high, having been located in several test probes at depths from 20 to 60 inches.

## Construction Materials

- Surficial Geology

Subsurface soils investigations were performed in the proposed plant and town sites and surrounding areas in order to observe the existing soil conditions, and to determine on-site aggregate

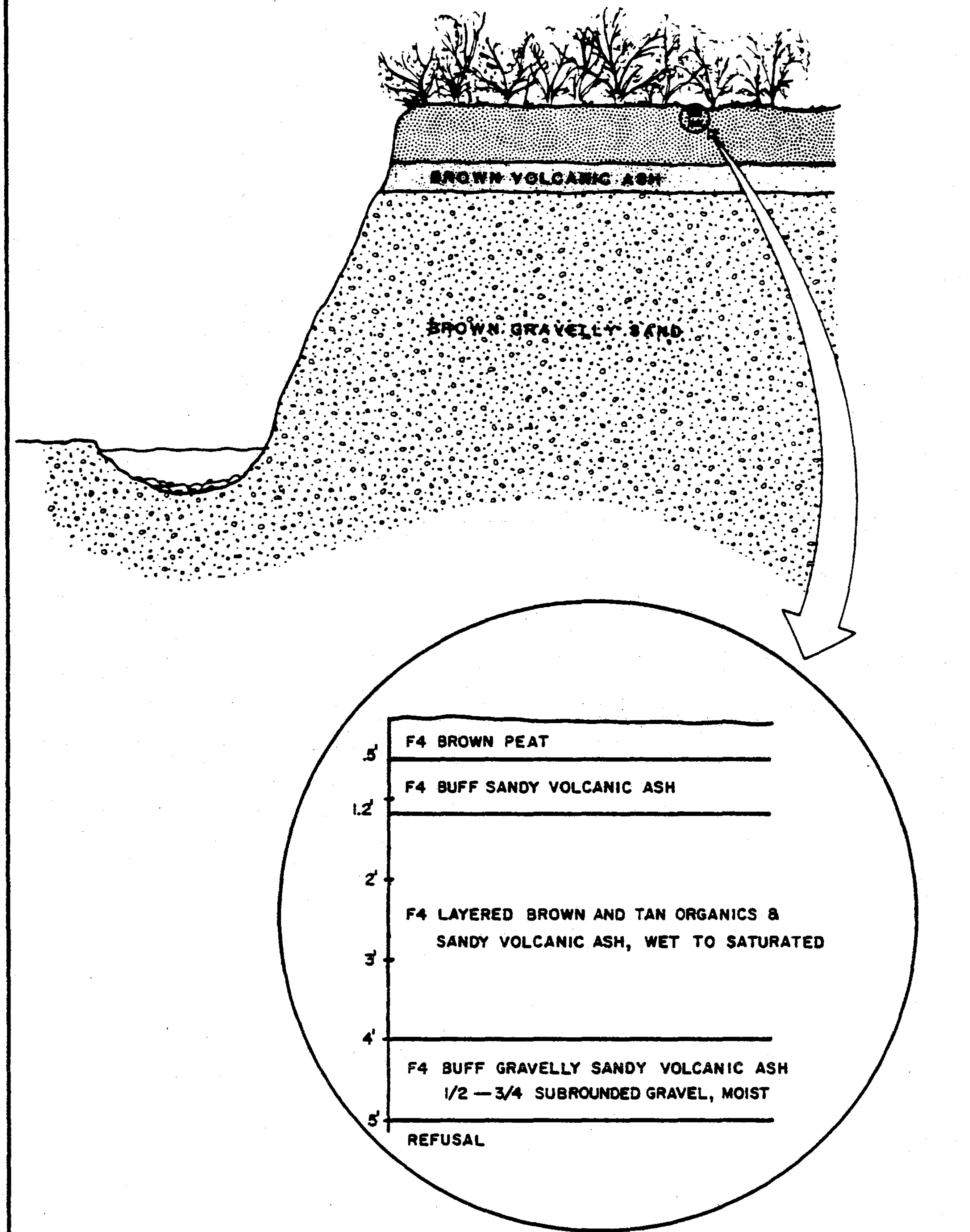



FIGURE 3.19 TYPICAL SOIL PROFILE OF CHUITNA AREA

sources. The investigation was confined to existing roads and accessible logging trails in the plant and town site areas. Random grab samples were also taken along the transportation corridor. Sufficient quantities of on-site aggregate resources for use in concrete, bituminus paving, railroad ballast, and classified fill do not appear to be present within the immediate plant or town sites. It is suspected there are moderate quantities of on-site aggregate, but the quantities are probably too small to be used for any major construction purposes.

The soils encountered in the proposed development areas are considered to be glacial in origin. The glacial deposits are generally divided into two types: Till, nonstratified drift, and moderate to well bedded diamicton; and stratified drift. The till is considered to be a direct glacial deposit and the stratified drift is considered to be deposited by a fluid medium less viscous than glacier ice, i.e. water or air.

Two distinct kinds of glacial till are found in the plant and town sites and surrounding areas. An upper layer of coarse, angular till was observed to depths of 0 to 8.5 feet, but is suspected to be deeper in some areas. It appears to be unsorted, virtually unweathered material containing all particle sizes. Boulders 10 feet or more in diameter are scattered erratically on the ground surface. Rock fragments are of all sizes, are angular to subangular, and contain some subrounded particle shapes. Lithologically, the parent material is primarily volcanic, ranging from non-visicular to visicular in texture, with little visible matrix. The upper soils often exhibit a silty sandy matrix, which may contain some organics leached from the surface organic soils.

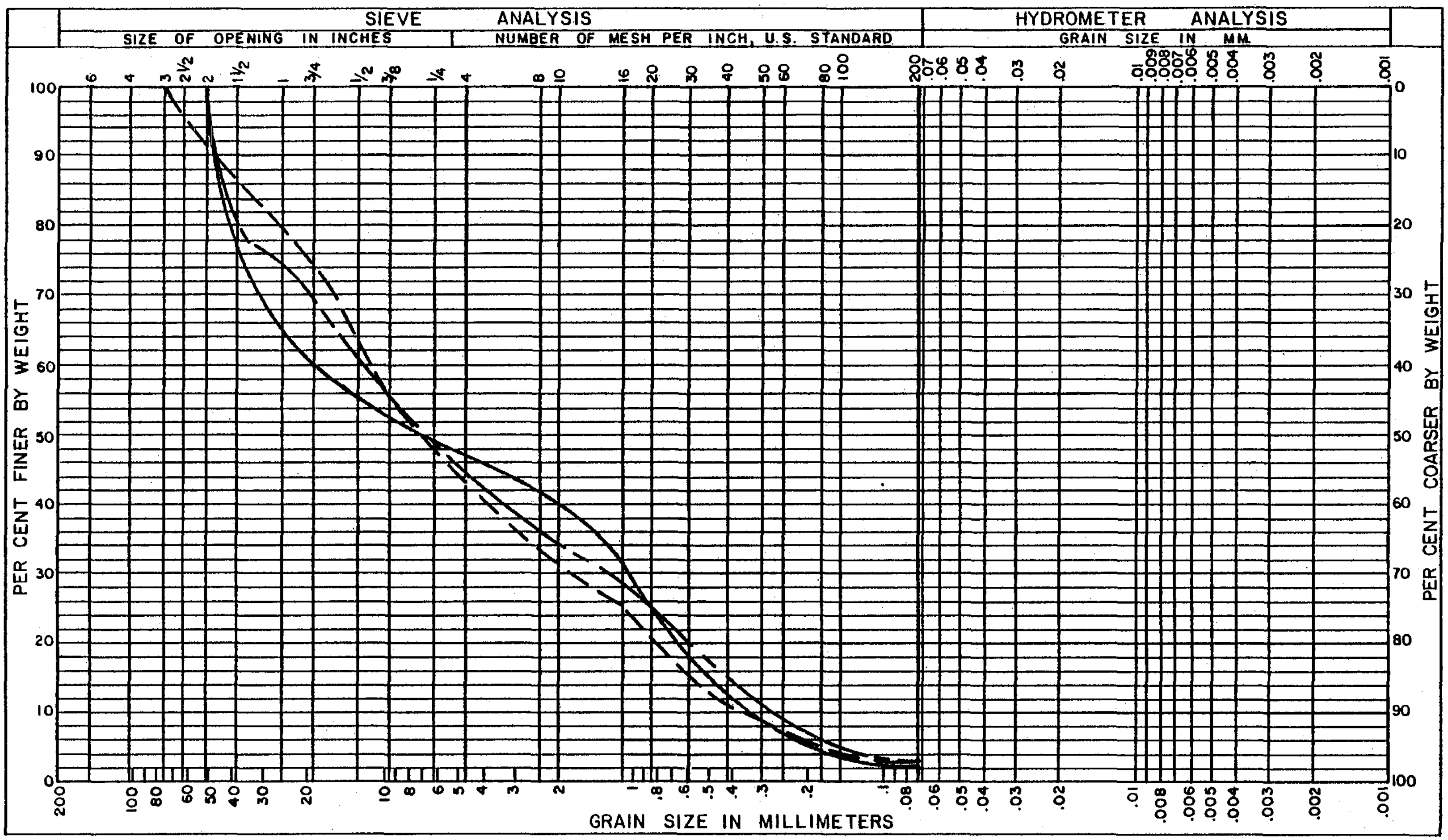
A second type of glacial till is found below the upper till. It is a poorly sorted, silty gravelly sand mixture, with occasional angular to subrounded cobbles and boulders. This till appears to have undergone a higher degree of weathering than the overlying till.

Various amounts of soil stratification were observed along road cuts and in pits. Generally the deep soil is considered to be non-stratified to moderately stratified and has been mapped as "ground moraine deposit -- primarily diamicton".

There are areas on the plant site where stratified tills are present. These deposits generally cap small knolls, eskers, and kames which are characteristic of the moraine topography. Most sites have already been scalped to build access roads for removing timber. The soil below this shallow surface material is a till composed of silty, gravelly sand. Poor accessibility caused by deep, soft peat prevented investigation of many of the potential aggregate source areas.

Random aggregate samples were taken at road cuts and existing gravel pits, both on and off the site, but no significant sources of aggregate were found. The search was extended to the Chackachatna River area and the lower reaches of the Chuitna River. The Chuitna River area has had little glacial activity and generally contains coarser material than the moraine areas.

Potential aggregate sources were examined as a part of this study. The Chakachatna riverbed and the accompanying old stream channels were considered. The sample tested was taken near the existing bridge, however similar material was observed about four miles east of the river. Other potential material sources include the existing pit at Tyonek, and Test Pit 6, where sample 1 which is representative of on-site material, was taken at a depth of 4 feet (Figure 3.7). Nearly unlimited quantities of material are expected to be present in the Chakachatna River area but on-site quantities are expected to be severely limited. Gradations of the samples tested are shown in Figure 3.20. The Chakachatna River sample was not entirely representative of the material in the field, because the natural deposit contains an abundance of large gravels and cobbles not reflected in the sample.




| KEY | LOCATION | SAMPLE NO. | DEPTH | UNIFIED CLASS. | FROST CLASS. | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|
| — — — — — | Tyonek Gravel Pit | -- | -- | GW | NFS | Sandy Gravel |
| ———————— | Chakachatna River Bridge | -- | -- | GP | NFS | Sandy Gravel |
| ———— — — | Plant Site | TP 6 Sa 1, @4' | -- | GP | NFS | Sandy Gravel |
| | | | | | | |

W.O. 12780

FIGURE 3.20 GRAIN SIZE DISTRIBUTION — GRADATION CURVE

A limited soils testing program was conducted in August 1981. Samples were obtained in the Capps Field area from exposed glacial till and volcanic ash. Grain size analyses were performed on the sand and volcanic ash, and Atterberg Limits were determined for the volcanic ash. In addition, a Los Angeles Abrasion Test (American Society for Testing and Materials [ASTM] C131-55, grading E) was performed on a surface grab sample of the glacially deposited volcanics in the Capps uplands.

The grain size analysis on the sand revealed a well-sorted sand with 68% retained between the #40 and #200 screens. This, in combination with field observations, indicates the mode of deposition was by wind. Because of the dark color of the sand and the surrounding dominant volcanic rock type, the sand is most likely derived from volcanic rocks and ash.

The grain size analysis of the volcanic ash reports 48.5% is sand and 41.6% is minus #200 grain size. An Atterberg test was run on the ash, and confirmed it to be non-plastic. Other volcanic ashes in the field were plastic.

The Los Angeles Abrasion Test on "glacial" till which had been reworked by surface runoff, reported a 15.6% loss by abrasion. This is considered a very acceptable percentage loss and suggests that this material could be used for a railroad ballast or for road construction. Figure 3.21 illustrates the results of the abrasion test.

- Concrete Aggregates

The Chakachatna River material shows the most favorable gradation of the three samples tested for both coarse and fine portland cement concrete aggregates. Table 3.1 shows the gradation of the three samples broken down on 1½" and #4 sieves. Both fractions of the test sample meet the appropriate ASTM C33 gradations.

Testing Exploration Chemical Materials Inspection

**ALASKA TESTLAB**

LOS ANGELES ABRASION ASTM C131-55

| Size Fraction | A | B | C | D | E | F | G | Grading Used | |
|---|---|---|---|---|---|---|---|---|---|
| 3" to 2-1/2" | | | | | 2500 gm* | | | | |
| 2-1/2" to 2" | | | | | 2500 gm* | | | | |
| 2" to 1-1/2" | | | | | 5000 gm* | 5000 gm* | | | |
| 1-1/2" to 1" | 1250 gm | | | | | 5000 gm* | 5000 gm | 1253.1 | |
| 1" to 3/4" | 1250 gm | | | | | | 5000 gm | 1252.2 | |
| 3/4" to 1/2" | 1250 gm | 2500 gm | | | | | | 1253.4 | |
| 1/2" to 3/8" | 1250 gm | 2500 gm | | | | | | 1249.9 | |
| 3/8" to 1/4" | | | 2500 gm | | | | | | |
| 1/4" to #4 | | | 2500 gm | | | | | | |
| #4 to #8 | | | | 5000 gm | | | | | |
| Total Weight | 5000 gm | 5000 gm | 5000 gm | 5000 gm | 10,000 gm | 10,000 gm | 10,000 gm | 5008.60 | Actual Wt. (A) |
| No. of Balls | 12 | 11 | 8 | 6 | 12 | 12 | 12 | 4158.6 | Wt. Ret #12 (B) |
| | | | | | | | | 850.0 | Loss A - B |
| | | | | | | | | 17.0 | % Loss $\frac{(A-B)100}{A}$ |

* Tolerance ± 2%/size fraction

Project: Beluga - Methanol Plant
Location: Tyonek
Client: CIRI/Placer - Amex
Pit Sampled: A2503
Date: 6/6/81

W.O. D12780
Tech. CJP

FIGURE 3.21

ABRASION TEST RESULTS

Table 3.1

FINE CONCRETE AGGREGATES, #4 MINUS

| Sieve | Percent Passing<br>Chakachatna River | Tyonek Pit | On-Site | ASTM C33 Specs |
|---|---|---|---|---|
| 4 | 100 | 100 | 100 | 95-100 |
| 8 | 87 | 80 | 82 | 80-100 |
| 16 | 68 | 59 | 66 | 50-85 |
| 30 | 38 | 34 | 46 | 25-60 |
| 50 | 19 | 16 | 27 | 10-30 |
| 100 | 9 | 10 | 11 | 2-10 |
| 200 | 5 | 8 | 4 | 0-5* |
| F.M. | 2.79 | 3.01 | 2.68 | 2.3-3.1 |
| Absorption | 2.9 | 3.6 | 3.3 | -- |
| Apparent Sp. G. | 2.81 | 2.71 | 2.76 | -- |

*0-3 is concrete subject of abrasion

| Sieve | Percent Passing<br>Coarse Concrete Aggregates, 1½" to #4 | | | ASTM C33 Size 467 Specs |
|---|---|---|---|---|
| 1½" | 100 | 100 | 100 | 95-100 |
| 1" | 60 | 86 | 87 | -- |
| 3/4" | 44 | 72 | 71 | 30-70 |
| ½" | 30 | 45 | 54 | -- |
| 3/8" | 16 | 30 | 32 | 10-30 |
| #4 | 0 | 0 | 0 | 0-5 |
| Absorption | 1.6 | 1.2 | -- | -- |
| Apparent Sp. G | 2.77 | 2.69 | -- | -- |
| L.A. Abrasion | 26 | 17 | -- | 50 Max. |

The oversized coarse gravel and cobbles would be wasted as a part of the concrete aggregate operation, but would probably be useful in some of the other products discussed below. The amount of material passing the #200 sieve in the Chakachatna River sample is only marginally within specifications. Washing of the sand or selective mining of the pit to decrease the amount of material passing the #200 sieve may be desirable to improve the efficiency of this material as concrete aggregate. Los Angeles abrasion loss on the coarse fraction of this sample is within specification limits, although higher than for some aggregates in the area.

The Tyonek pit material has grading deficiencies which would be a problem for production of portland cement concrete. It has a slight excess of coarse sand in the #4 and #8 ranges, and an excess of material passing the #200 sieve. It is slightly deficient in the medium sand fraction passing the #30 and retained on the #100. These deficiencies could be overcome by processing the sands through a classifying plant and wasting some of the unwanted sizes. In the coarse aggregate, the Tyonek pit material has an excess of material passing the 3/8-inch and retained on the #4. This (pea gravel) material decreases the economy of the concrete by increasing the cement content required to achieve a given strength level, and tends to cause poor finish-ability of the concrete. Therefore, if this source is used it is recommended that a large portion of the pea gravel size be wasted from the concrete aggregate. It may be possible to utilize some of the wasted pea gravel in other materials. The Tyonek pit material would probably be quite durable under abrasive conditions as indicated by its low loss in the Los Angeles abrasion test.

The on-site material as represented by the sample from Test Pit 6 typically is too silty for use as concrete aggregate. A test sample taken from an area with lower silt content than typical shows a gradation which could be processed to provide satisfactory concrete aggregates. The sand in that sample conforms to ASTM C33 specifications for concrete sand except that an excessive amount passes the #100 sieve. This deficiency could easily be corrected by washing the sand. The coarse fraction of this material has an excess of the pea gravel sizes, some of which would need to be wasted to provide a satisfactory concrete aggregate.

Coarse aggregate sizes other than 1½-inch maximum shown on Table 3.1 would also be practical to manufacture from the materials investigated. A 1½-inch maximum aggregate size would probably be economical to produce from the Chakachatna River material, while a finer coarse size, perhaps 3/4 to 1 inch nominal, would be more practical to produce with the Tyonek or on-site materials. It would also be possible to introduce crushed gravel into the coarse concrete aggregate. This would give a greater latitude in the potential gradations available, particularly with the Chakachatna River source.

No matter which source is selected for use as concrete aggregate, further testing should be performed to verify the acceptability of the source. Particles consist mostly of a mixture of coarse and fine-grain igneous rocks. Certain fine-grain igneous materials and glassy igneous minerals are alkali reactive. It is possible to compensate for alkali reactive constituents in aggregates if their presence is known beforehand. Therefore it is recommended that alkali reactivity tests be performed on any aggregate source considered for use. Also useful would be to produce some laboratory concrete test batches with materials tentatively selected for use. It would then be possible to check the workability of the concrete and the water demand, and to determine proper design strength levels for that aggregate source. If concrete placements which would be subjected to freeze-thaw action in a damp environment are contemplated, freeze-thaw tests of specimens of hardened concrete might also be considered.

° Asphalt Concrete Aggregates

Table 3.2 shows a typical aggregate grading for asphalt concrete. The material coarser than the #4 sieve in asphalt concrete consists mostly of crushed particles. The gradation of the coarse material could be controlled by controlling the crushing process, provided there is sufficient oversize material to provide a good crusher feedstock. The Chakachatna River source has abundant coarse gravel and cobbles that could provide large quantities of crusher feedstock. The other two sources would have smaller quantities of oversize material, but probably would have enough for production of asphalt concrete in limited quantities.

It is usually not practical to crush a fine asphalt aggregate to achieve a desired gradation, but it is necessary to find a material with a fine fraction graded within specifications or to blend several materials to obtain the desired gradation. None of the three sources contains a fine aggregate graded entirely to meet the specification shown on Table 3.2 for fine aggregate. The Chaka-

Table 3.2

TYPICAL ASPHALT CONCRETE SURFACE COURSE
(Asphalt Institute IVb)

| Sieve | Percent Passing |
|---|---|
| 3/4" | 100 |
| 3/2" | 80-100 |
| 3/8' | 70-90 |
| #4 | 50-70 |
| #8 | 35-50 |
| #16 | -- |
| #30 | 18-29 |
| #50 | 13-23 |
| #100 | 8-16 |
| #200 | 4-10 |

Material coarser than #4 sieve should be mostly crushed gravel.

chatna River fine aggregate is deficient in materials passing the #50, #100 and #200 sieves for use as an asphalt concrete aggregate. The Tyonek pit material is deficient in the sizes passing the #50 sieve and retained on the #200 sieve. The grade of the on-site material more closely approximates the asphalt specification, but is deficient in material passing the #200 sieve. Other on-site materials have more material passing the #200 so it is expected that a satisfactory blend could be achieved. If either the Chakachatna or the Tyonek material were used for asphalt concrete, it is recommended that a fine silty sand or sandy silt be blended with the natural material to produce a more desirable gradation for asphalt concrete. The exact blend would depend on which source is selected. The Tyonek pit material showed high resistance to abrasion using the Los Angeles abrasion test and would be expected to produce an asphalt concrete more resistent to traffic abrasion than would the Chakachatna material. The gradation on Table 3.2 is simply typical of what may be used for asphalt concrete. It may be worthwhile to test gradations outside that specification, as a wide range of gradations is capable of producing acceptable asphalt concrete.

- <u>Crushed Base Course</u>

Surfaces which are to be paved with asphalt concrete probably require a greater quantity of crushed base/leveling course than of aggregate for asphalt concrete. A typical gradation of base/leveling course is shown on Table 3.3. Since it is primarily a crushed product the gradation of the coarse material must be controlled by the crushing process. Efficient materials for processing into a base course would be those with a relatively high percentage of material coarser than the 3/4-inch screen. Use of sufficient quantities of coarse material would allow material from any of the three sources Chakachatna, Tyonek or on-site, to be processed into acceptable base course material. Some base course specifications may allow a larger maximum size than shown on

Table 3.3 and some allow a greater percentage passing the #200 sieve. No material with a "D" value less than 50 when tested for susceptibility to degradation during agitation in water according to Alaska Test Method T-13 should be used to produce base course.

- <u>Railroad Ballast</u>

Table 3.4 shows a typical gradation for railroad ballast. This is an open graded coarse aggregate containing a mixture of crushed and natural particles. Any of the three sources considered could be used as a raw material source for railroad ballast. If the Chakachatna River material were used, large quantities of coarse gravel and cobbles for crusher feedstock would be available, but the number of crushed particles in the finished product would probably be greater than required by the specification. If railroad ballast were being produced from either the Tyonek or on site source at the same time concrete aggregate were being produced, the oversize material wasted from the concrete aggregate could be crushed and utilized in the railroad ballast, while pea gravel sizes undesirable in the concrete aggregate could be wasted from the concrete aggregate and utilized in the railroad ballast as part of the uncrushed material.

The relative quantities of the different types of materials needed are important in selecting the most practical pit from which to borrow. The Chakachatna River material is expected to produce the largest quantity of coarse gravel and cobbles for crusher feedstock. The other sources would provide larger quantities of naturally rounded medium-size particles. If exceptionally large quantities of concrete were required, sands from any of the three sources could probably be processed through classification into an acceptable gradation. If the quantities of concrete would not justify importation of a classification plant, the Chakachatna River material shows the most favorable natural gradation of sand. Use

Table 3.3

TYPICAL BASE COURSE
(State of Alaska D-1 Specification)

| Seive | Percent Passing |
|---|---|
| 1" | 100 |
| 3/4" | 70-100 |
| 3/8" | 50-80 |
| #4 | 35-65 |
| #8 | 20-50 |
| #40 | 8-30 |
| #200 | 0-6 |
| Crushed Particles | 70% + #4 single face |

Source: DOTPF 1981 Standard Specifications for Highway Construction.

Table 3.4

TYPICAL RAILROAD BALLAST
(Alaska Railroad G-2)

At least 70% of material coarser than #4 seive should be crushed.

| Seive | Percent Passing |
|---|---|
| 1½" | 100 |
| 1" | 65-100 |
| ½" | 35-75 |
| #4 | 10-35 |
| #8 | 0-10 |
| #16 | 0-5 |
| Crushed Particles | 21-60 |

Source: Typical Alaska Railroad Construction Specification.

of waste materials from one product in another product can improve the economics of aggregate production, and could have an affect on selection of the pit site.

## GEOLOGIC HAZARDS

### Seismicity

The Cook Inlet-Susitna Lowlands, the setting for the proposed project, are included in a region of great seismic and volcanic activity associated with the subduction zone formed as the Pacific Ocean plate dips below the North American plate. Features of this collision zone include the arcuate Aleutian Island chain of volcanos and many, but not all, of the recorded large seismic events in Alaska.

Major fault systems have been identified in the general area Figure 3.22, and include the Aleutian Megathrust (subduction zone), Castle Mountain, Bruin Bay, Lake Clark, and Border Ranges faults. Each of these, as well as other more distant features, is capable of producing seismic events, but the frequency and magnitude associated with each system are not well known due to the relatively short length of record, which is generally the case throughout Alaska. Since 1899, nine Alaska quakes have exceeded Richter magnitude 8, and more than 60 have exceeded magnitude 7. Thirteen earthquakes of magnitude 6 or greater have occurred in the Cook Inlet region during that time. The general project area lies at the border between Zones 3 and 4 in the 1979 Uniform Building Code, but historical seismicity indicates a high level of seismic activity for all of upper Cook Inlet.

° Aleutian Megathrust

The subduction zone between the North American and Pacific Ocean tectonic plates is topographically expressed in the North

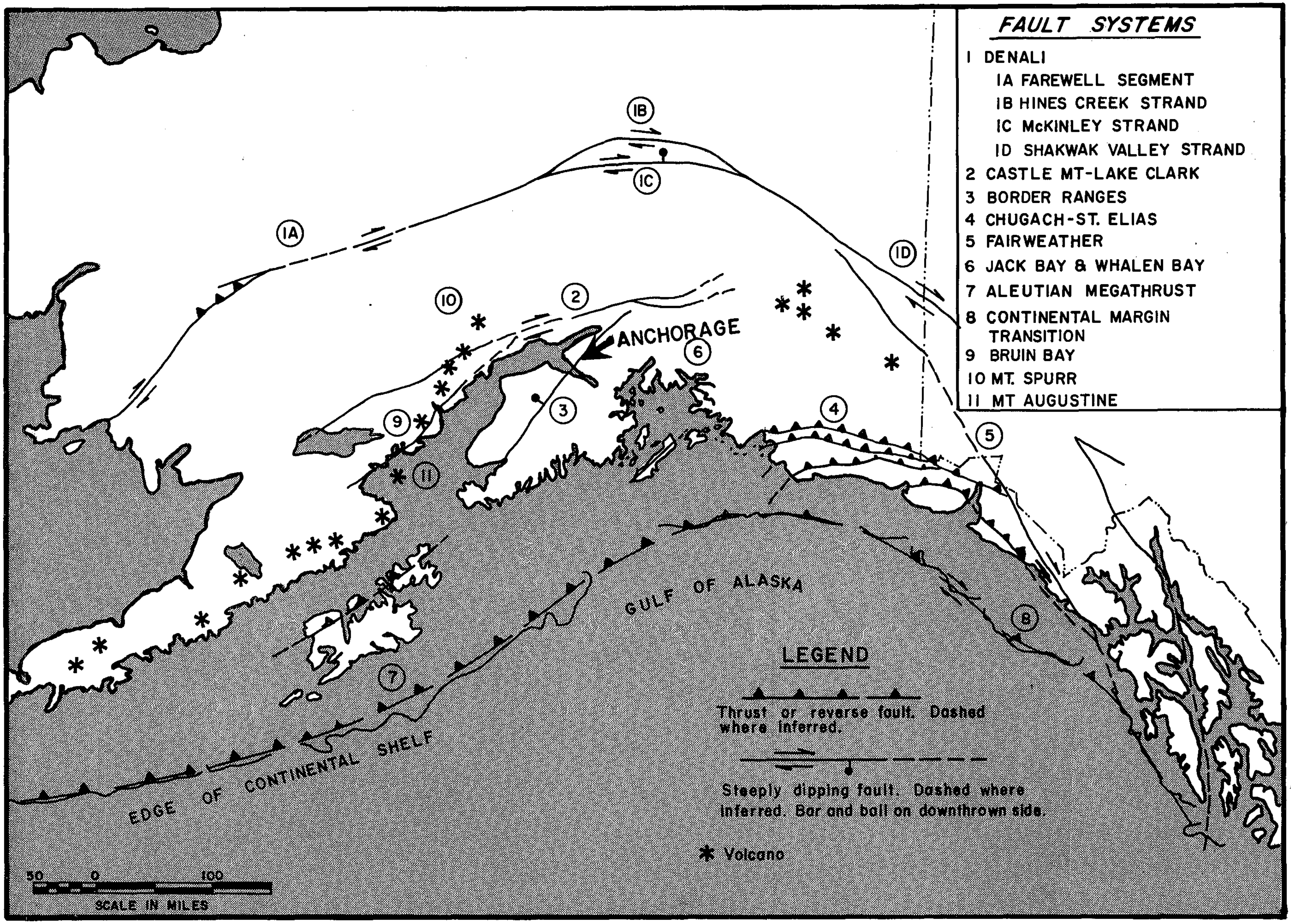



FIGURE 3.22 MAJOR FAULTS IN SOUTHCENTRAL ALASKA

Pacific by the arcuate Aleutian Island chain, the mountains which form the Alaska Peninsula, and the deep Aleutian oceanic trench. The subduction zone in this area of the Pacific is thought to be a shallow, north dipping (reverse fault) thrust zone termed a "megathrust". The unusually shallow (10°) angle of thrust is inferred from hypocentral locations and fault plane solutions of the earthquakes that continually express the tectonic realignment along the northern limits of the Pacific Ocean Plate. Although a simplistic interpretation of earthquake epicenters and topographic expression implies the Aleutian megathrust is a smooth circular arc with a radius of approximately 800 miles (1,280 kilometers) it is now believed that the arc is composed of relatively short straight line segments joined together at slight angles. It is further thought that these segments are tectonically independent. There has been a tendency for the hypocenters of large earthquakes to occur near one end of these blocks, and for the accompanying aftershocks to spread over the remaining portion, so that during large events strain is released over an entire segment of the megathrust zone, stopping abruptly at the discontinuity between individual segments.

Nearly the entire Aleutian Arc between 145°W and 170°E has ruptured in a series of great earthquakes ($M_L$ greater than 7.8) since the late 1930s. The most recent great event was the 1964 Prince William Sound earthquake, which was the largest ever recorded on the North American continent ($M_L$ = 8.3 to 8.6). It is believed that this activity is typical rather than atypical for the area, and that future earthquakes of magnitude 7.9 or larger can be expected along the megathrust.

Continual motion along the thrust system produces a large amount of regional subsidence and uplift due to plate warpage, and is responsible for the orogenesis (mountain building) for the region. The proposed plant site lies outside the zone of major vertical movement produced by the 1964 event. Although large displacements of 35 to 50 feet were noted elsewhere in Alaska, only about one foot of vertical displacement was noted by residents of Shirleyville, a small settlement near Granite Point.

- Castle Mountain Fault

The proposed plant site lies in an area which is near the ends or juncture of three major faults, the Castle Mountain, Bruin Bay, and Lake Clark faults. Continuity of these faults has been inferred by gravimetric methods, but no surface expressions tie them together.

The Castle Mountain Fault has been classified by various investigators as both a right-lateral strike slip fault and a steeply dipping reverse fault. Right-lateral slip was observed in Cretaceous units, and dip-slip motion has occured since Miocene time. Schmoll has indicated the fault was active east of the Susitna River in Holocene time, but Recent movement west of the river is unknown (Schmoll, et al , 1981).

The magnitude of earthquakes associtated with this fault generally is small ($M_L$ = 3.0 to 4.5), and their focal depths are shallow--generally less than 50km. However, it is thought that six recorded earthquakes with magnitudes greater than 6.0 have occurred on the fault. The maximum historical earthquake is believed to be 7.3 in 1943, but uncertainty exists concerning its location.

The Castle Mountain Fault is capable of producing a magnitude 8.0 earthquake based on its length of about 215 miles (exclusive of the Lake Clark Fault), but a probable maximum is 7.5.

- Bruin Bay Fault

It is postulated that the Bruin Bay Fault passes through the plant site and joins the Castle Mountain Fault through the Moquawkie

Contact. No surface lineaments are noted at the site, but Congahbuna Lake has been suggested as a surface feature of the fault (Schmoll, et al , 1981).

The activity of this fault system has not been established in Recent time, but Tertiary movement is suspected. More extensive investigations should be performed to determine its activity and location, since this is the closest fault to the proposed plant site. The length of the fault (320 miles) implies that it could produce seismic events with magnitudes greater than those associated with the Castle Mountain Fault; however, no Holocence activity is known.

- <u>Lake Clark - Lone Ridge Fault</u>

It is postulated that the Lake Clark Fault is a continuation of features similar to the Castle Mountain Fault. However, a gravimetric study indicates different tectonic blocks are involved. It is also postulated that the Lone Ridge lineament belongs to the Lake Clark system (Detterman, et al ). This ridge lies north of the Chuitna coal field and exhibits steep scarps.

- <u>Border Ranges Fault</u>

The Border Ranges or Knik Fault is located across Cook Inlet from the proposed site and forms a boundary of the Cook Inlet lowlands. A magnitude 7.0 earthquake has been estimated to be the maximum expected for the Border Ranges Fault, but little physical evidence is available concerning its activity. No fault movement has been documented for the past 10,000 years near Anchorage, suggesting that part of the fault is inactive.

- Seismic Design Considerations

Seismic considerations significantly affect the design of structures in the Cook Inlet region. Risk studies based solely on historic seismicity in the upper Cook Inlet region (Anchorage and vicinity) indicate peak rock accelerations of about 0.4g have a 10% chance of exceedence in 50 years, and peak rock accelerations of 0.17g have a 50% chance of exceedence in the same design period. These values have been calculated for Anchorage during previous investigations, but a regional study indicates that similar values should apply to adjacent areas including the plant site. The features which contribute to seismicity indicate that a 7.5 magnitude earthquake would be reasonable for a closely occurring earthquake, and an 8.5 earthquake may be expected from a distant earthquake attributable to the Aleutian Megathrust or other large fault. Frequency of these events for Anchorage is shown on Figure 3.23. The Castle Mountain and Bruin Bay faults probably could produce greater accelerations than the values given above, but these accelerations constitute the maximum credible accelerations at the site and have a low probability of occurrence. Boore (Boore, et al., 1978) indicates that peak accelerations of 0.8 to 1.0g would be expected from major activity on the nearby faults, such as the Castle Mountain or Bruin Bay fault.

Frequency contents of distant and near earthquakes would differ appreciably, but little information is available on the frequency content of Alaska earthquakes. However, comparison with California earthquakes indicates that "design earthquakes" should differ for near and distant sources, i.e. a higher frequency content for close earthquakes than for distant earthquakes. The peak rock acceleration may be used as a scale factor for design earthquakes from close or distant sources. However, the peak rock accelerations and design earthquakes were not determined during this investigation.

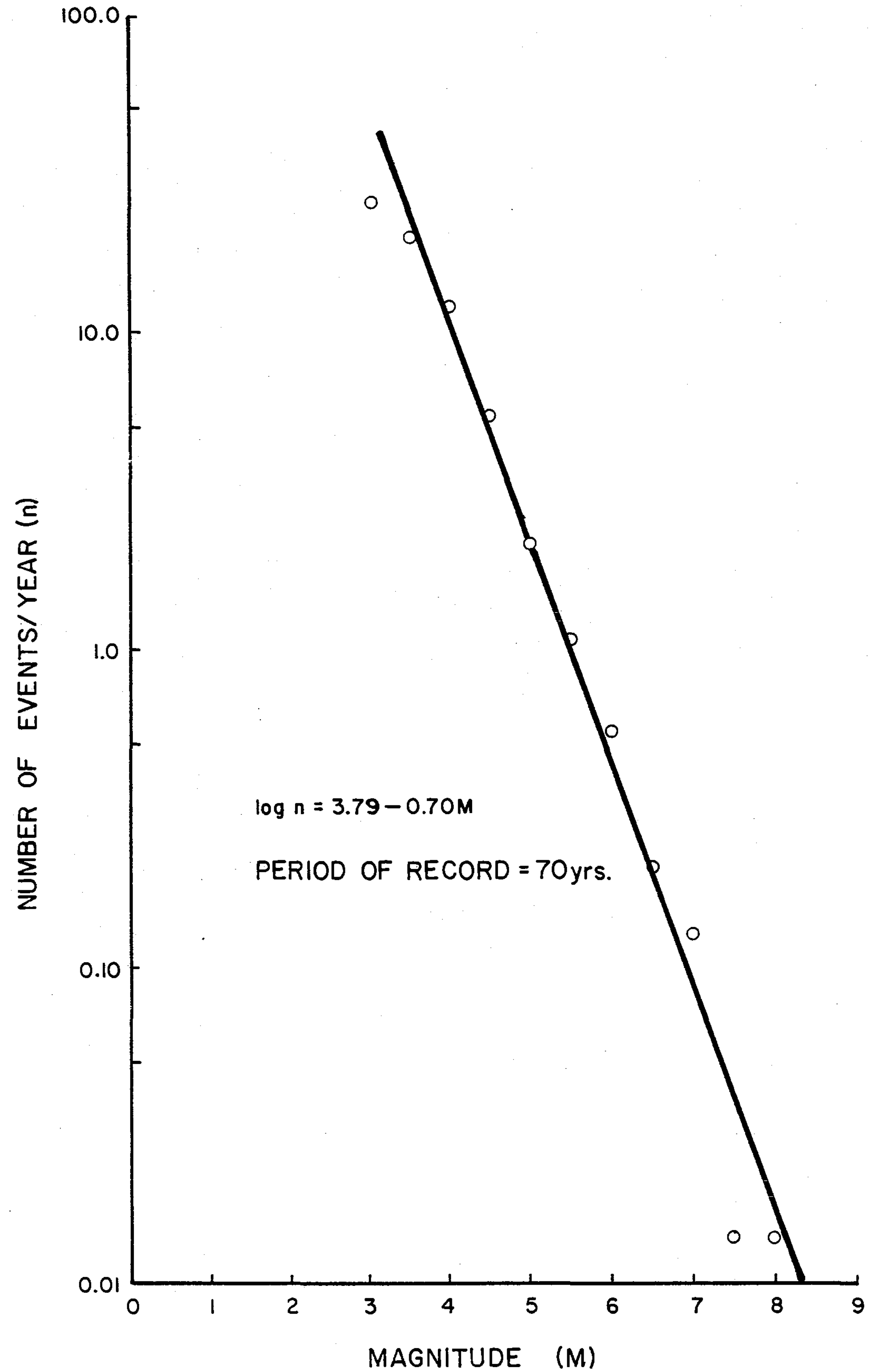



FIGURE 3.23 CUMULATIVE MAGNITUDE FREQUENCY RELATIONSHIP (ANCHORAGE REGION)

Peak ground acceleration is a function of the input rock acceleration, soil response, and the soil-structure interaction. The very dense soils which underlie the plant site indicate that surface motion would not differ largely from the input motion, but an investigation of ground motion should be performed for the site.

The dense soil will offer excellent protection against liquefaction or subsidence since it is already near its densest condition. Peat in the area may contribute to amplified ground movement during earthquakes if it is incorporated into foundations or if it underlies filled areas.

The effects of seismic motions may include some slope instability, but only in those areas which have been over-steepened by erosion. Bluff areas near the proposed plant site appear to have been relatively stable during the 1964 event except for areas along the beach and rivers which had been over-steepened by erosion. Slope failure did occur during the 1964 event along the steep bluffs northeast of the site. The proprietor of Shirleyville indicated that his house was damaged by an earthslide which occurred soon after the 1964 earthquake, but that the slope was stable during the event. Frost and water may have contributed to this phenomena of delayed slope failure. However, it must be concluded that many of the slopes in the area were not affected by the 1964 earthquake. The beach bluffs typically receed 2 to 3 feet per year due to erosion or due to shallow, slump type failures regardless of earthquake activity.

The bluffs adjacent to the plant site appear to be stable for all expected earthquake accelerations, provided large toe cuts are avoided and large loads are not applied at the top of bluffs. Some small, locally over-steepened slopes exist, but these areas could be avoided or cut to a stable configuration.

## Ground Failure

Local ground subsidence is not likely due to the dense state of the soil at the proposed plant site, but surface faulting along the Bruin Bay/Moquawkie Contact (Figure 3.22) could have severe consequences to development if it were to occur. Local investigations should be performed to determine the fault's activity and possibly the location and alignment of its surface expression. Since peat in this area is saturated, an investigation using trenching would be relatively difficult without extensive dewatering. The problems associated with surface faulting through developed areas could be avoided by restricting development in the area of possible ground faulting as inferred by linear features, such as Congahbuna Lake.

## Landslides

Landslides in the Beluga area often occur within the Kenai Formation. The soils consist of low-grade sedimentary sandstone, conglomerates, siltstone, and claystone. Most of the slides occur on steep slopes which are undercut by stream action and/or where frost action, surface and subsurface water, and gravity have contributed to slides. Some tectonic activity due to movement along the Castle Mountain Fault and earthquakes may also play a significant role in landslides in the area.

The Capps Glacier slide is a very large slide covering approximately five square miles. The land has a stepped slump topographic appearance. Many large coal blocks lie in a random orientation in relation to the surrounding insitu coal beds. The Capps Glacier slide is active with the most recent movement observed occurring adjacent to the top of the escarpment in Section 25, T14N, R14W, Seward Meridian.

A subsurface soils investigation performed by the USGS (Yehle, et al , 1980) indicated the strength index test on unconfined compressive strengths on a drill hole made in the Capps Field ranged from 0.20 to 4.20 MPa (29 to 609 psi) with an average of 1.74 MPa (252 psi). The test hole material ranged from soft soil to soft rock.

During field reconnaisance by DOWL Engineers (1981), the observable surface outcrops in landslide areas are low-grade sedimentary rock which is slightly to poorly cemented and friable. It appears to break down readily in water and is clearly affected by freeze-thaw cycles when surface water is present.

Along the Chuitna River and its tributaries, large and small slides are easily observed. Many slides are due to oversteepening of high-cut banks by stream action and surface runoff. Resistive beds of coal jut out from the face of the carved river banks. When enough underlying soil is eroded below a resistive bed, large blocks of coal fall into the stream channels.

Volcanos

Five active volcanos are found in the Cook Inlet region. The most recent eruptions were by Mr. Spurr in 1953 and Mt. Augustine in 1976. Mt. Spurr is located about 40 miles from the proposed plant site near the Capps Glacier. Mt. Augustine, located in south Cook Inlet near Kamishak Bay, is considered potentially explosively eruptive and is under observation by the USGS. The USGS should be able to provide warning if activity becomes imminent.

Volcanic deposits of 1 to 2 feet of ash from numerous eruptions were found in the vicinity of the proposed plant site, and these deposits are being mapped to determine historical volcanic activity in the region. The most recent ash fall at the proposed plant site occurred following the eruption of Mt. Augustine in 1976.

The volcanics in the Beluga area are Miocene or younger in age. The Capps upland is covered by a reported 0 to 100-foot thick cap of glacial till which is made up of silts, sands, gravel, cobbles and boulders. Most of the till is derived from extrusive and intrusive volcanics.

Many ash falls (nu´ees ardentes) have occurred. The eruption of Katmai, in 1912, 240 miles south of Beluga, produced an ash and sand flow of nu´ee ardente origin which formed sandy tuff 100 or more feet thick over 53 square miles. One such ash fall also covered an observable area of six miles, and likely much more, in the Beluga area. Flora prints of plant leaves are easily observed at the base of the ash fall. The ash fall has been described as a lappilli (composed of volcanic ejecta 4mm-32mm in diameter). Lappilli was observed, during field studies by DOWL Engineers, near the uplands at the 2,400-foot elevation and on banks of the Chuitna near Botts Creek at elevations of 750 to 800 feet. In both areas, the volcanic ash tuff overlies a coal bed ranging in thickness from a few feet to 7± feet where easily observed.

Tsunamis

Tsunamis are great sea waves most often caused by rapid vertical displacement of the ocean floor or submarine landslides. Two tsunamis have been recorded in lower Cook Inlet since 1883. Mt. Augustine errupted in 1883 and produced a 25-foot-high wave at English Bay; and the 1964 Prince William Sound earthquake produced a 4-foot-wave at Seldovia. These locations are 70 to 90 miles from the proposed site.

The restricted opening of Cook Inlet provides some degree of protection from incident tsunamis generated along the potential source areas along the Pacific Rim. In 1964, the Prince William Sound earthquake produced only a few feet of tidal disturbance inside Cook Inlet, although coastal areas such as Seldovia recorded some tsunami damage. Tsunamis generated in Cook Inlet may have severe impacts on coastal structures, but the plant site is at sufficiently high elevation to preclude tsunami damage.

### Permafrost

No permafrost was detected in any of the borings. In addition, surface reconnaissance indicates little evidence of shallow permafrost. It is also unlikely that this south-facing area has deep permafrost. Sample temperatures were at or above 42°F, but some sample heat gain is usually associated with auger drilling. The upland areas may have some permafrost present but this is not confirmed.

### Additional Geologic Hazards

Slope stability in the plant and town site areas is good, but slopes in the vicinity of the proposed construction dock are generally unstable and may require stabilization.

Other hazards were noted by Schmoll (USGS, 1980) in his preliminary report regarding the surficial geology of the area. Gravitational spreading of surficial deposits which produced graben-like features was noted along the Nikolai escarpment. However, this area is about 10 miles northwest of the proposed plant in an area of much steeper escarpments than found in the areas of the plant and town sites.

Volcanic clasts were observed within a few miles of the plant site and may indicate an unsuspected level of volcanic activity, or they may represent glacially transported volcanic debris. Additional investigation to determine the origin of this material should be considered.

The mountains north and west of the project site are extensively glaciated, among them being the Capps and Triumvirate glaciers. The glaciers present no foreseeable hazard to the higher portions of Nikolai margin, but the Triumvirate Glacier forms a dam creating Strandline Lake which then empties into Beluga River. Glacier dams can be unstable and have caused numerous floods, but a flood of this nature would not affect the proposed plant, town, or dock sites.

survey/soil investigation

upper Chuitna River area

vicinity Congahbuna Lake

upper Capps - exposed coal seam

# 4.0 HYDROLOGY

## GROUNDWATER

### Introduction

The availability of industrial quantities of groundwater in the study area is dependent on the existence of fairly extensive deposits of highly permeable granular materials which contact areas of high recharge capacity. The Chuitna River, although currently cutting its way through consolidated formations, may have some abandoned channel areas in which sufficient depths of gravels have been deposited so that a shallow groundwater or induced filtration situation may be developed. However, throughout the upland area from Nikolai Creek to the Beluga Lowlands the unconsolidated formations consist predominantly of impermeable glacial till with scattered and isolated deposits of sand -- ranging from silty sand to gravelly sand. As a result, production of previously drilled wells in the general area ranges from 0 to 50 gallons per minute (gpm). The only well of 500 gpm or more we know of in the Beluga area is at the Chugach Electric Association power plant. The vicinity of the Chakachatna River appears favorable for high groundwater production, perhaps 1,000 gpm or greater, due to extensive gravel deposits and sizable rivers to provide recharge. However, no production wells are known in that area. Information obtained by others drilling seismic shot holes in the Nikolai Creek flats area indicated that the Nikolai Creek area is underlain by gravel which might provide a substantial water source. A supply adequate for the proposed new town development may be available along the toe of the escarpment near the town site.

It is against this background that the water exploration program for this project was developed. The program included drilling two test wells, Test Well #1 in the Nikolai Creek Flats area and Test Well #2 within the proposed methanol plant site (Figure 4.1). An observation well, Well #3, was drilled near Test Well #1.

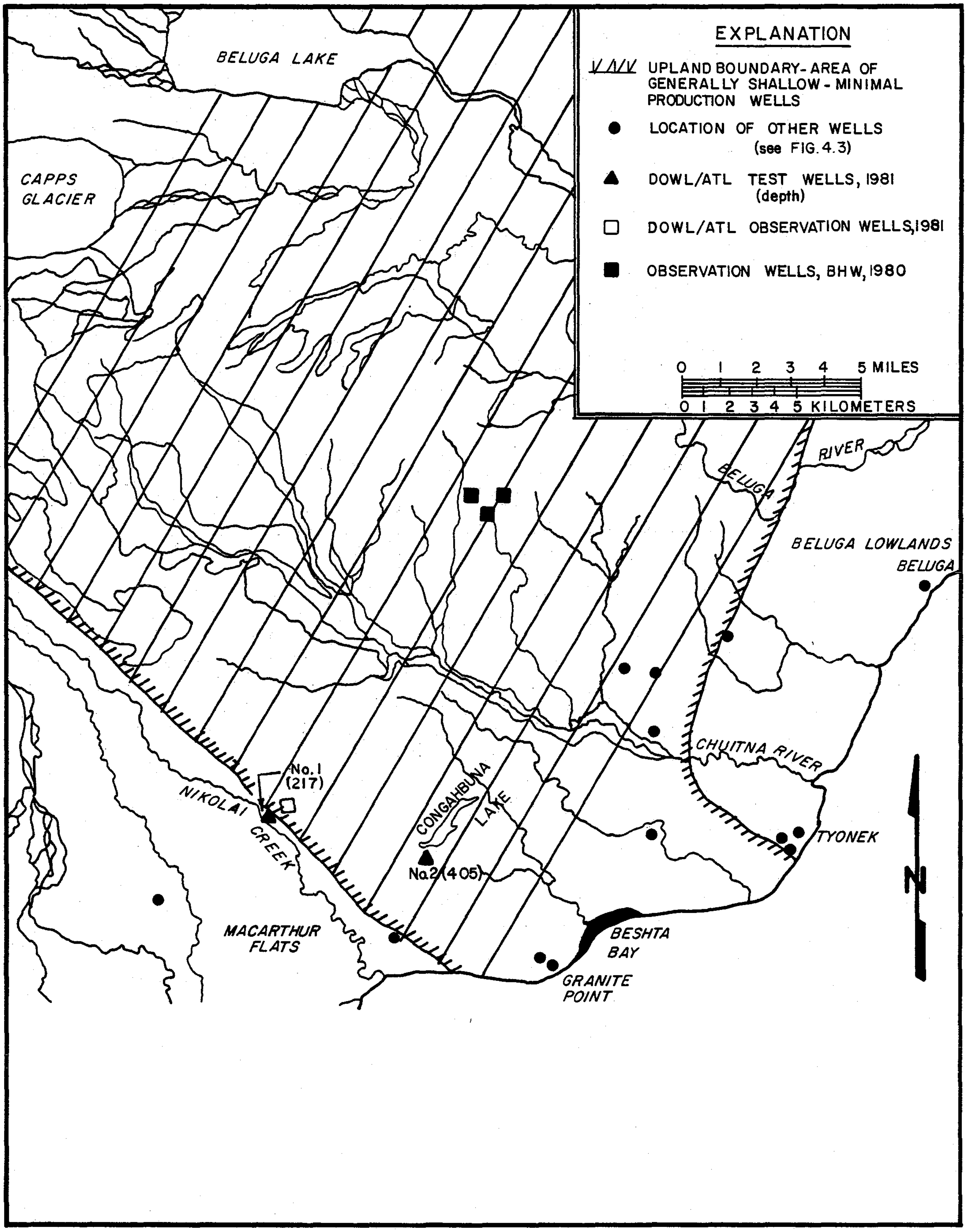



FIGURE 4.1 WELL LOCATIONS, GRANITE POINT AREA

Available Supply

° Nikolai Creek Flats

The vicinity of Nikolai Creek Flats appeared to be the most promising for development of high production wells within a reasonable distance of the proposed plant site. It did not appear that industrial quantities of groundwater could be obtained within a 2±-mile radius of the proposed plant site. However, it was felt that if an extensive shallow gravel or coarse sand aquifer existed in the Nikolai flats area, the creek would provide sufficient recharge to insure the long-term production of the formation. Since road construction would have been necessary to gain access to the flats nearer to the proposed town or plant sites, it was decided to drill the test well near the logging road bridge approximately six miles upstream from the plant site. It was felt that specific test information from this site could be combined with other generalized sources of subsurface information of the area to provide a reasonable indication of the groundwater potential in similar areas of the Nikolai flats nearer the proposed town and plant sites.

The primary objective of drilling in this area was to determine if relatively shallow aquifers exist which are recharged by Nikolai Creek; the drilling was to be shallow, less than 200 feet deep. Two holes were drilled, Test Well #1 and Well #3, which demonstrated that, at least in the area of the bridge, no such aquifer exists (Table 4.1). This verifies the surficial geologic mapping of the area done by USGS. The drilling did determine, however, that a series of predominantly fine-grain materials which are under considerable artesian pressure underlie the general area. These formations begin at a depth of 55± feet below the surface and extend beyond the maximum drilling depth of 217 feet. Although artesian leaks around the casings of Wells #1 and #3 were measured at 75 and 150 gpm, respectively, it was found that

Table 4.1

TEST WELL #1

SUMMARY OF DRILLER'S LOG

Drilled 5/16/81 to 5/19/81 - By M-W Drilling

| Depth (Feet) | Description |
|---|---|
| 0.0 - 0.5 | Fill |
| 0.5 - 24.0 | Silty Gravel with Water |
| 24.0 - 40.0 | Gravelly Silt - Dry |
| 40.0 - 48.0 | Silty Gravel - Damp |
| 48.0 - 133.0 | Silty Sand with Water - Flowing |
| 133.0 - 172.0 | Sandy Clay with Water - Flowing |
| 172.0 - 213.0 | Gravelly Sand with Water - Flowing |
| 213.0 - 217.5 | Silty Sand with Water - Flowing |

Screen was installed from 182 to 200 feet and the well was surged 22½ hours. The water would not clean up. The well was pumped one-half hour at 180± gpm with a drawdown to 150 feet. The estimated sustained well capacity at this depth interval is about 100± gpm. There was an artesian leak around the casing at 75± gpm which was unaffected by pumping from the screened interval. The leak was sealed by grouting. The static water level was calculated at 79 feet above the surface.

the formations were too fine and variable in gradation to be tapped by a naturally developed well. Although a screen was set in Well #1, a period of surging did not wash the fines from the formation sufficiently to perform a meaningful pump test.

It is possible that wells of 200 to 300 gpm capacity could be developed in these formations using an artificially gravel-packed construction method. The water in these formations is of very good quality (Figure 4.2) and has a static level 79 feet above the surface at Well #1.

- Plant Site

Because of the poor water production history and relatively shallow depths to bedrock reported in the upland area, Test Well #2 to be drilled on the plant site was intended primarily to prove firsthand that significant quantities are not available in that area. The well also could verify the shallow depth to bedrock. In fact, Test Well #2 was drilled to a depth of 405 feet without encountering bedrock (Table 4.2). This is deeper than bedrock was expected based on the information reported by Magoon, Adkinson and Egbert (USGS 1978) (Figure 4.3).

Test Well #2 was located near the Congahbuna drainage so that any shallow aquifers which may be associated with that drainage could be detected, as well as any deeper formations. The well did demonstrate that approximately 15 feet of good water-bearing formation exists at the depth of 40 to 55 feet. However, it is expected that the production potential of that aquifer would be relatively insignificant, being limited by the availability of excess water in the Congahbuna drainage system. This water-bearing formation was not tested. From 328 to 395 feet, a water-bearing silty gravelly sand was encountered which has a static water level (artesian pressure) approximately 25 feet above the surface. A screen was installed in that formation and a 24-hour pump test

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ANCHORAGE INDUSTRIAL CENTER
5633 B Street

ANALYTICAL REPORT

CUSTOMER DOWL Engineers SAMPLE LOCATION: Alaska

DATE COLLECTED 6-9-81 TIME COLLECTED: 10:00

SAMPLED BY --- SOURCE Well #2

REMARKS Beluga Methanol 6" Pipe, Filtered Sample

Artesian Flow Around Csg. —

From 85'± Level

FOR LAB USE ONLY

RECVD. BY LMG LAB # 7818-2

DATE RECEIVED 6-10-81

DATE COMPLETED 6-19-81

DATE REPORTED 6-19-81

SIGNED E. Yonkin

| | mg/l | | mg/l | | mg/l |
|---|---|---|---|---|---|
| []Ag, Silver | <0.05 | []P, Phosphorous | 0.17 | []Cyanide | |
| []Al, Aluminum | <0.05 | []Pb, Lead | <0.05 | []Sulfate | 2.3 |
| []As, Arsenic | <0.10 | []Pt, Platinum | <0.05 | []Phenol | |
| []Au, Gold | <0.05 | []Sb, Antimony | <0.10 | []Total Dissolved Solids | 83 |
| []B, Boron | <0.05 | []Se, Selenium | <0.10 | []Total Volatile Solids | |
| []Ba, Barium | <0.05 | []Si, Silicon | 12 | []Suspended Solids | |
| []Bi, Bismuth | <0.05 | []Sn, Tin | <0.05 | []Volatile Suspended Solids | |
| []Ca, Calcium | 11 | []Sr, Strontium | 0.08 | []Hardness as $CaCO_3$ | 41 |
| []Cd, Cadmium | <0.01 | []Ti, Titanium | <0.05 | []Alkalinity as $CaCO_3$ | 64 |
| []Co, Cobalt | <0.05 | []W, Tungsten | <1 | [] | |
| []Cr, Chromium | <0.05 | []V, Vanadium | <0.05 | [] | |
| []Cu, Copper | <0.05 | []Zn, Zinc | <0.05 | [] | |
| []Fe, Iron | <0.05 | []Zr, Zirconium | <0.05 | [] | |
| | | | | * * * * * * | |
| []Hg, Mercury | <0.10 | []Ammonia Nitrogen-N | | []mmhos Conductivity | 140 |
| []K, Potassium | 1 | []Kjedahl Nitrogen-N | | []pH Units | 7.5 |
| []Mg, Magnesium | 3.4 | []Nitrate-N | <0.1 | []Turbidity NTU | |
| []Mn, Manganese | <0.05 | []Nitrite-N | | []Color Units | 5 |
| []Mo, Molybdenum | <0.05 | []Phosphorus (Ortho)-P | | []T.Coliform/100ml | |
| []Na, Sodium | 12 | []Chloride | 3 | [] | |
| []Ni, Nickel | <0.05 | []Fluoride | <0.10 | [] | |

FIGURE 4.2 GROUNDWATER QUALITY

Table 4.2

TEST WELL #2

SUMMARY OF DRILLER'S LOG

Drilled 5/20/81 to 5/29/81 - By M-W Drilling

| Depth (Feet) | Description |
|---|---|
| 0.0 - 4.0 | Fill |
| 4.0 - 20.0 | Silty Gravel |
| 20.0 - 40.0 | Silty Gravel - Damp |
| 40.0 - 54.5 | Lose Gravel with Water - Blows 30gpm |
| 54.5 - 85.0 | Gravelly Clay - "Hardpan" |
| 85.0 - 92.0 | Silty, Sandy Gravel |
| 92.0 - 293.0 | Gravelly Clay with Some Boulders |
| 293.0 - 297.0 | Silty Coarse Sand with Water - Blows 3 gpm @ 293 |
| 297.0 - 328.0 | Gravelly Clay |
| 328.0 - 395.0 | Silty Gravelly Sand with Water |
| 395.0 - 405.0 | Clay |

Screen was installed from 355 to 385 feet and the well was surged for 21 hours, which was adequate to clean up the well. A 24-hour pump test at 149 gpm caused drawdown to 102± feet. The well was grouted at the surface (there was no artesian leak). The static level was calculated at 25± feet above the surface.

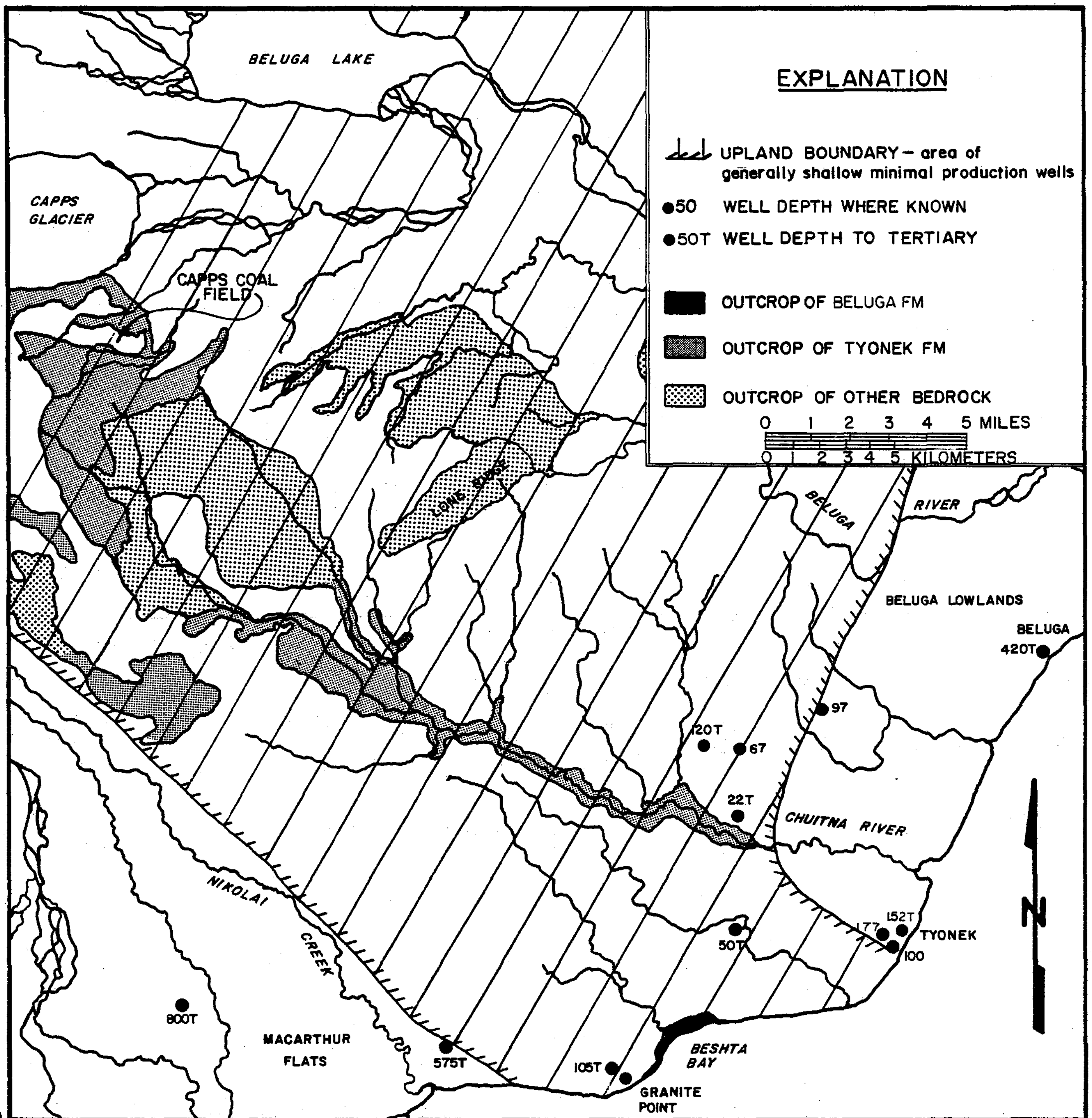



FIGURE 4.3

GRANITE POINT AREA
BEDROCK OUTCROPS AND DEPTH TO BEDROCK IN WELLS

was performed to determine the production potential. The test showed that the transmissivity (T) of the aquifer in the area is quite low (2,380 gallons per day per foot [gpd/ft]) (Figure 4.4). After 8 hours of pumping, the test also indicated that the cone of influence encountered a major impermeable boundary, reducing the effective T to about 840 gpd/ft. This formation could be used for minor intermittent demands of 100 gpm or less. It is unlikely that this water-bearing formation is extensive under the plant site location.

- <u>Existing Uses</u>

  Small domestic wells serve the Union Oil Company and ARCO facilities at Granite Point; the Kodiak Lumber Mill camp near the North Foreland, and the Chugach Electric Association facility at Beluga. None of these wells is near enough the proposed project to be influenced by withdrawals there. Other than these wells, the groundwater resources in the Beluga region are virtually untapped.

## SURFACE WATER

### <u>Existing Sources</u>

- <u>Lakes</u>

  Numerous shallow lakes dot the landscape between the Beluga River to the north and the Chakachatna River to the south (Figure 4.5). Of these, the largest is Congahbuna Lake located just north of the proposed plant site. Some consideration was given to the possible use of Congahbuna as a source of cooling water. A summary of the known information about the lakes of the Beluga region is contained in Table 4.3. Additional information on many of these lakes is being gathered as part of an ongoing field program.

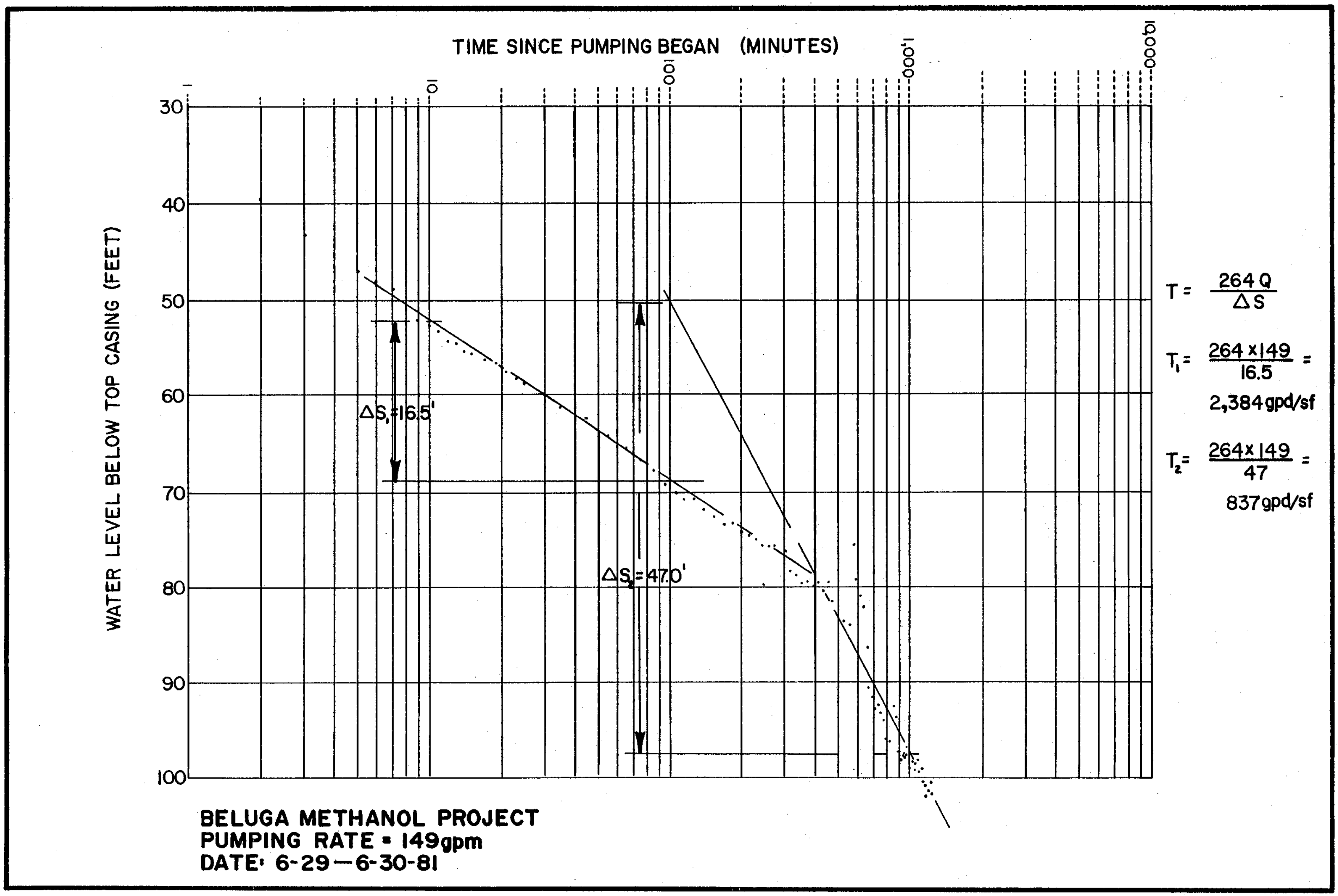



FIGURE 4.4 PUMP TEST OF WELL #2

Table 4.3

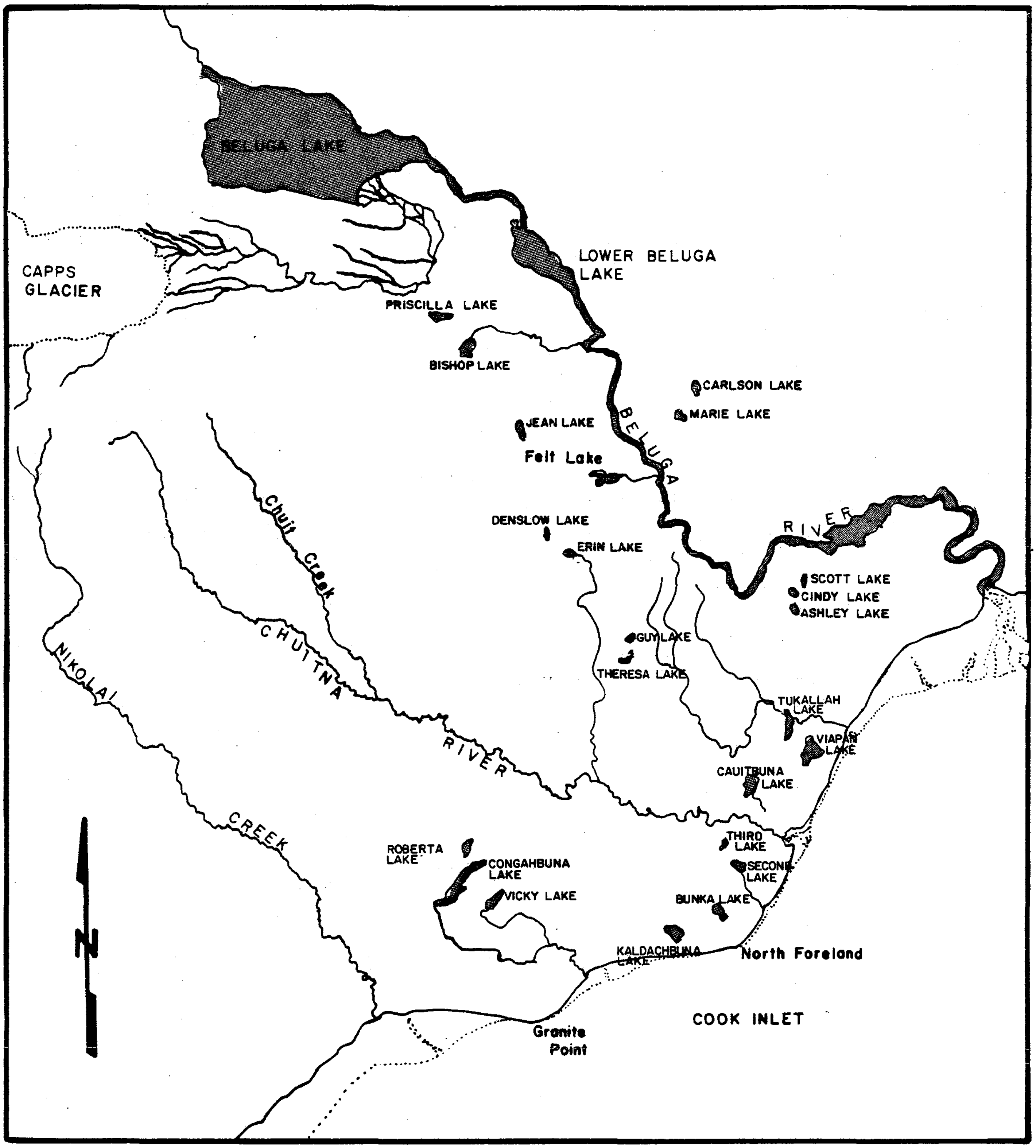
LAKES OF THE BELUGA REGION

| Name | Location | Area (mi.$^2$) | Area (Acres) | Chemical & Physical Characteristics: Date | Temp (°C) | pH | DO mg/ℓ | CaCO mg/ℓ | Secchi depth | Test Netting Results | | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ashley Lake | 61°8', 151°11+' | 00.07 | 44.8 | | | | | | | | | |
| Beluga Lake | 61°24', 151°36' | 16.97 | 10,860.8 | | | | | | | | | |
| Bishop Lake | 61°19', 151°25' | 00.18 | 115.2 | 6/12/75 | 11 | 6.7 | 17 | 17.1 | 12.5' | Rainbow<br>Dollies | 3<br>1 | |
| Bunka Lake | 61°4', 151°10+' | 00.06 | 38.4 | | | | | | | | | |
| Chuitbuna Lake | 61°7', 151°9' | 00.18 | 115.2 | | | | | | | | | |
| Cindy Lake | 61°8', 151°12' | 00.06 | 38.4 | | | | | | | | | |
| Congahbuna Lake | 61°4', 151°25' | 00.40 | 256.0 | 7/18/81 | 15.2 | 6.2 | 10.0 | | | | | |
| Denslow Lake | 61°14', 151°21' | 00.03 | 19.2 | | | | | | | | | |
| Erin Lake | 61°13', 151°19' | 00.07 | 44.8 | 7/18/81 | 15.4 | 6.4 | 9.4 | | | | | Depth 3.2 feet |
| Felt Lake | 61°16', 151°18' | 00.20 | 128.0 | | | | | | | | | |
| Guy Lake | 61°10+', 151°17' | 00.05 | 32.0 | | | | | | | | | |
| Jean Lake | 61°17', 151°21' | 00.08 | 51.2 | | | | | | | | | |
| Kaldachbuna Lake | 61°3', 151°14' | 00.21 | 134.4 | | | | | | | | | |
| Lower Beluga Lake | 61°21', 151°21' | 01.88 | 1,203.2 | | | | | | | | | |
| Mad Lake | 61°7+', 151°34' | 00.04 | 25.6 | | | | | | | | | |

Table 4.3
Continued

LAKES OF THE BELUGA REGION

| Name | Location | Area (mi.$^2$) | Area (Acres) | Chemical & Physical Characteristics: Date | Temp (°C) | pH | DO mg/ℓ | CaCO mg/ℓ | Secchi depth | Test Netting Results | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Priscilla Lake | 61°20', 151°27' | 00.09 | 57.6 | | | | | | | | |
| Roberta Lake | 61°5', 151°31' | 00.12 | 76.8 | 7/18/81 | 15.1 | 6.0 | 9.0 | | | | Depth 3.0 feet |
| Scott Lake | 61°7', 151°12+' | 00.05 | 32.0 | | | | | | | | |
| Second Lake | 61°5', 151°9+' | 00.07 | 44.8 | | | | | | | | |
| Theresa Lake | 61°10', 151°17' | 00.05 | 32.0 | | | | | | | | |
| Third Lake | 61°5', 151°10+' | 00.03 | 19.2 | | | | | | | | |
| Tukallah Lake | 61°8', 151°7' | 00.14 | 89.6 | | | | | | | | |
| Viapan Lake | 61°7', 151°6' | 00.30 | 192.0 | | | | | | | | |
| Vicky Lake | 61°3', 151°24' | 00.13 | 83.2 | 7/18/81 | 15.8 | 6.2 | 9.2 | | | | Depth 5.5 feet |
| Marie Lake | | 00.06 | 38.4 | | | | | | | | |




| FIGURE 4.5 | LAKES OF BELUGA AREA |
|---|---|

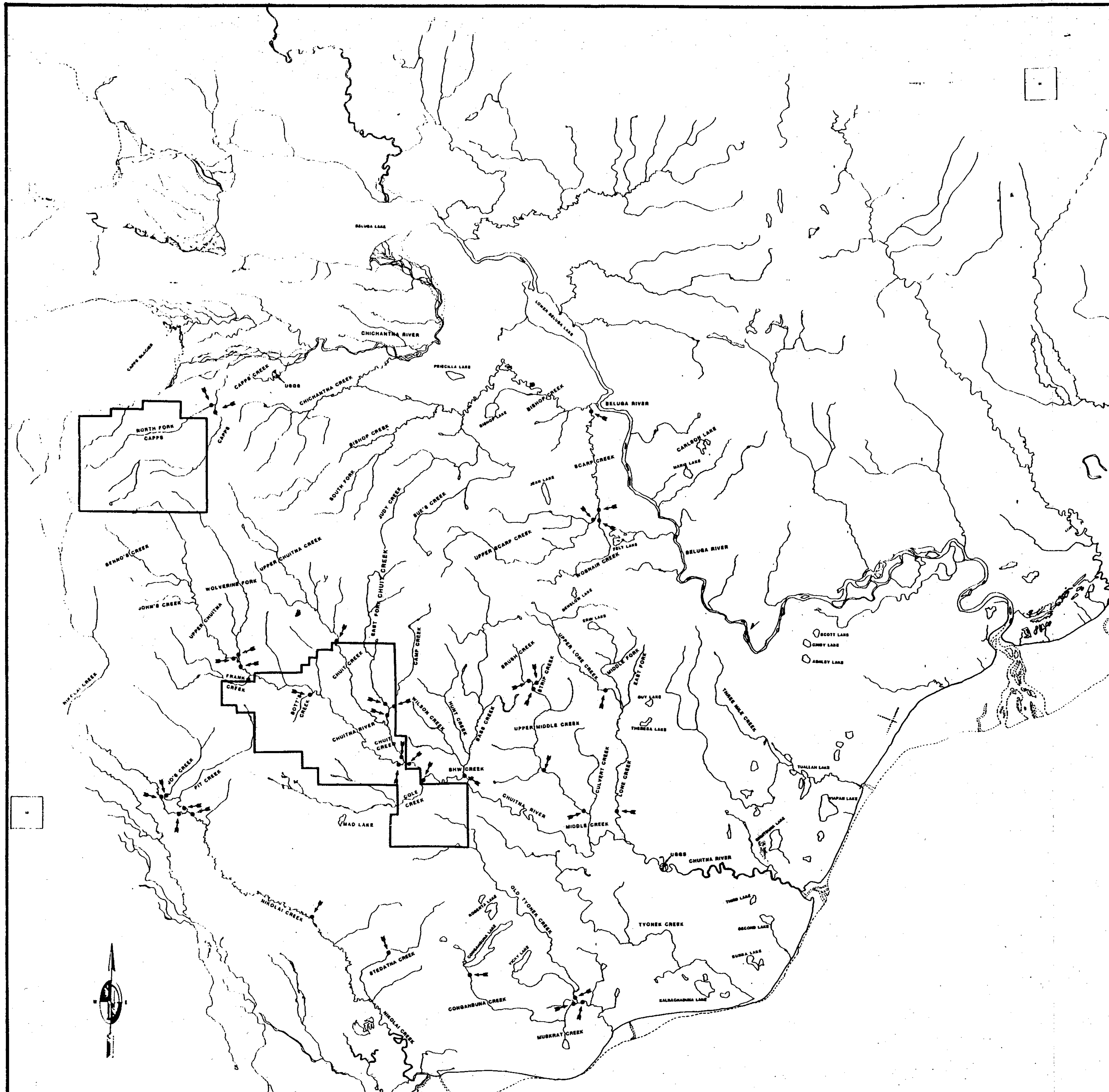
° <u>Streams and Rivers</u>

The most important properties of surface water are amount, chemical quality, suspended sediment content, and temperature. With few exceptions, data on surface water in the region is generally sparse.

While it is the Chuitna River that most likely would be directly affected by the project, the total project area includes several drainage systems including the Beluga, Chuitna and Nikolai. As part of the 1980-81 field program, staff gauges have been installed at numerous locations (Figure 4.6) and various measurements have been taken of discharge, water chemistry, and sediment content. Selected data on stream and river systems is shown in Table 4.4; stream flow data is shown in Table 4.5; selected discharge measurements are shown in Table 4.6; summary data on suspended solids is shown in Table 4.7; and selected water quality data is shown in Tables 4.8 through 4.11.

The current field program will permit the generation of rating curves for the various staff gauge locations and provide a first look at overall contributions of tributaries and groundwater flows to major stream courses. An example of such a rating curve for one stream is shown in Figure 4.7. Precipitation data and additional discharge measurements would be required before the hydrology of the region can be more accurately described.

Additionally, two sites (Nikolai Creek and Upper Chuit Creek) are being monitored for stream temperature and flows on an experimental basis using portable data recorders linked to temperature and pressure probes. If successful, this program expanded throughout the area of interest would permit a more detailed assessment of the hydrologic balance since simultaneous measurements throughout each of the drainage areas could be available. An example of the type of data being recovered from this program is shown in Figure 4.8.




## LEGEND

- STAFF GAUGE
- OTHER STATIONS
- USGS

STAFF GAUGE LOCATIONS - BELUGA REGION

FIGURE 4.6

Table 4.4

SELECTED DATA ON STREAM AND RIVER SYSTEMS

| NAME | Approximate Drainage Area (sq. mi.) | Approximate Length (mi.) | Estimated Annual Runoff (1000 acre ft.) | Estimated Flow (cu. ft./sec.) | Approximate Slope (ft./mi.) | Point of Discharge | Notes |
|---|---|---|---|---|---|---|---|
| BELUGA DRAINAGE | | | | | | | |
| Beluga River | | 26.8 | | | 9 | Cook Inlet | |
| Chichantna River | | 13.5 | | | 23 | Beluga River | |
| Capps Creek | | 3.5 | | | 71 | Chichantna River | |
| North Fork Capps Crk | | 4.7 | | | 410 | Capps Creek | |
| South Fork Capps Crk | | 5.4 | | | 335 | Capps Creek | |
| Chichantna Creek | | 6.3 | | | 167 | Chichantna River | |
| Bishop Creek | | 9.1 | | | 38 | Beluga River | |
| North Fork Bishop Crk | | 5.0 | | | 190 | Bishop Creek | |
| South Fork Bishop Crk | | 3.0 | | | 275 | Bishop Creek | |
| Judy Creek | | 5.5 | | | 137 | Sue's Creek | |
| Sue's Creek | | 7.6 | | | 128 | Bishop Creek | |
| Scarp Creek | | 7.6 | | | 79 | Bishop Creek | |
| Upper Scarp Creek | | 7.7 | | | 156 | Wobnair Creek | |
| Wobnair Creek | | 4.2 | | | 83 | Scarp Creek | |
| CHUITNA DRAINAGE | | | | | | | |
| Chuitna River | | 24.5 | | | 57 | Cook Inlet | |
| Lone Creek | | 4.6 | | | 43 | Chuitna River | |
| East Fork Lone Creek | | 2.2 | | | 34 | Lone Creek | |
| Middle Fork Lone Crk | | 3.7 | | | 89 | Lone Creek | |
| Upper Lone Creek | | 6.6 | | | 68 | Lone Creek | |
| Middle Creek | | 1.0 | | | 75 | Chuitna River | |
| Culvert Creek | | 3.6 | | | 35 | Middle Creek | |
| Upper Middle Creek | | 7.4 | | | 51 | Middle Creek | |
| Strip Creek | | 1.4 | | | 71 | Upper Middle Crk | |
| Brush Creek | | 1.7 | | | 162 | Upper Middle Crk | |
| BHW Creek | | 2.2 | | | 193 | Chuitna River | |
| Bass Creek | | 7.2 | | | 125 | BHW Creek | |
| Hunt Creek | | 4.1 | | | 146 | Bass Creek | |
| Wilson Creek | | 2.1 | | | 298 | BHW Creek | |
| Cole Creek | | 5.6 | | | 134 | Chuitna River | |

Table 4.4
Continued

SELECTED DATA ON STREAM AND RIVER SYSTEMS

| NAME | Approximate Drainage Area (sq. mi.) | Approximate Length (mi.) | Estimated Annual Runoff (1000 acre ft.) | Estimated Flow (cu. ft./sec.) | Approximate Slope (ft./mi.) | Point of Discharge | Notes |
|---|---|---|---|---|---|---|---|
| CHUITNA DRAINAGE Cont. | | | | | | | |
| Chuit Creek | | 8.6 | | | 94 | Chuitna River | |
| Camp Creek | | 4.0 | | | 181 | E. Fork Chuit Crk | |
| East Fork Chuit Creek | | 6.1 | | | 107 | Chuit Creek | |
| Upper Chuit Creek | | 4.5 | | | 22 | Chuit Creek | |
| Bott's Creek | | 1.2 | | | 375 | Chuitna River | |
| Frank Creek | | 3.6 | | | 139 | Chuitna River | |
| Upper Chuitna River | | 6.9 | | | 29 | Chuitna River | |
| John's Creek | | 1.9 | | | 263 | Upper Chuitna Riv | |
| Benno's Creek | | 3.6 | | | 194 | Upper Chuitna Riv | |
| Wolverine Fork | | 6.1 | | | 98 | Upper Chuitna Riv | |
| NIKOLAI DRAINAGE | | | | | | | |
| Nikolai Creek | | 27.9 | | | 97 | Cook Inlet | |
| Stedatna Creek | | 4.6 | | | 115 | Nikolai Creek | |
| Pit Creek | | 4.7 | | | 287 | Nikolai Creek | |
| Jo's Creek | | 5.0 | | | 280 | Nikolai Creek | |
| OTHER DRAINAGES | | | | | | | |
| Old Tyonek Creek | | 9.9 | | | 81 | Cook Inlet | |
| Congahbuna Creek | | 4.6 | | | 69 | Old Tyonek Creek | |
| Muskrat Creek | | .8 | | | 94 | Congabuna Creek | |
| Tyonek Creek | | 12.9 | | | 54 | Cook Inlet | |
| Indian Creek | | 1.4 | | | | Cook Inlet | |
| Three Mile Creek | | 7.7 | | | 52 | Cook Inlet | |
| S. Fork Three Mile Crk | | 8.8 | | | 34 | Three Mile Creek | |

Table 4.5

STREAM FLOW DATA (SELECTED STATIONS)
Point Discharge Measurement, Cubic Feet per Second (cfs)

| Station No. | Stream Gage Location | Latitude | Longitude | Nov. | May | June | July | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Capps | 61°19'05" | 151°40'54" | 17.3 | | 90.9 | -- | | | |
| 2 | Capps Creek | 61°19'00" | 151°40'43" | 16.4 | | 134.7 | -- | | | |
| 3 | Chuitna River below Wolverine Fork | 61°12'00" | 151°39'15" | 64.0 | | 375.9 | 140.82 | | | |
| 4 | Wolverine Fork | 61°12'05" | 151°39'17" | 14.8 | | 99.3 | 27.25 | | | |
| 5 | Chuitna River above Wolverine Fork | 61°12'03" | 151°39'28" | 45.1 | | 272.5 | 100.81 | | | |
| 6 | Congahbuna Creek above Old Tyonek Creek | 61°02'43" | 151°20'27" | 10.6 | 17.2 | 6.9 | 32.0 | | | |
| 7 | Old Tyonek Creek above Congahbuna Creek | 61°02'48" | 151°20'27" | 21.7 | 70.4 | 15.1 | 79.15 | | | |
| 8 | Old Tyonek Creek below Congahbuna Creek | 61°02'43" | 151°20'21" | 33.1 | 88.9 | 17.5 | 121.57 | | | |
| 9 | Congahbuna Creek, below Congahbuna Lake | 61°03'18" | 151°26'53" | 5.8 | 13.1 | 3.8[1]<br>2.8[5] | 9.97 | | | |
| 10 | Stedatna Creek at Culvert | 61°04'08" | 151°30'59" | 5.0 | 16.7 | 2.9 | 28.21 | | | |
| 11 | Nikolai Creek at Bridge | 61°05'05" | 151°35'54" | 152.8 | 136.0<br>204.7[5] | 245.5[1] | -- | | | |
| 12 | Upper Chuit Creek | 61°12'44" | 151°33'54" | 27.3 | | 155.3 | 91.17 | | | |

Table 4.5
Continued

STREAM FLOW DATA (SELECTED STATIONS)
Point Discharge Measurement, Cubic Feet per Second (cfs)

| Station No. | Stream Gage Location | Latitude | Longitude | Nov. | May | June | July | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Chuit Creek Mouth | 61°09'18" | 151°30'11" | 42.0 | 56.4 | 271.9 | 58.40 | | | |
| 14 | Chuitna River below Chuit Creek | 61°09'17" | 151°30'06" | 116.2 | 163.1 | | 209.87 | | | |
| 15 | Chuitna River above Chuit Creek | 61°09'16" | 151°30'11" | 72.8 | 100.0 (est.) | 500.0 (est.) | 167.39 | | | |
| 16 | BHW Creek Mouth | 61°09'00" | 151°26'40" | | 76.5 | 24.2 | 24.28 | | | |
| 17 | Lower Lone Creek | 61°07'51" | 151°17'57" (est.) | | 275.0 | 26.8 | -- | | | |
| 18 | Upper Lone Creek | 61°11'15" | 151°18'34" | | 80.2 | 12.5 | 12.99 | | | |
| 19 | Cole Creek Mouth | 61°08'46" | 151°29'16" | | 58.7 | 9.6 | 59.46 | | | |
| 20 | Pit Creek | 61°07'58" | 151°42'25" | | 43.3 | 12.9 | 8.75 | | | |
| 21 | Nikolai Creek above Pit Creek | 61°07'51" | 151°42'30" | | 97.2 | 45.6 | 23.35 | | | |
| 22 | Nikolai Creek below Pit Creek | 61°07'51" | 151°42'17" | | 136.9 | 57.4 | 28.94 | | | |
| 23 | Jo's Creek | 61°08'15" | 151°43'33" | | 19.9 | 30.3 | 8.32 | | | |
| 24 | Nikolai Creek Above Jo's Creek | 61°08'15" | 151°43'40" | | 73.1 | 18.0 | 15.99 | | | |
| 25 | Brush Creek | 61°11'32" | 151°22'45" | | | 2.5 | 4.15 | | | |

Table 4.5
Continued

STREAM FLOW DATA (SELECTED STATIONS)
Point Discharge Measurement, Cubic Feet per Second (cfs)

| Station No. | Stream Gage Location | Latitude | Longitude | Nov. | May | June | July | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|---|---|
| 26 | Strip Creek | 61°11'28" | 151°22'41" | | | 1.5 | 1.74 | | | |
| 27 | Upper Middle Creek | 61°11'24" | 151°22'46" | | | 4.2 | 5.62 | | | |
| 28 | East Fork Chuit above Camp Creek | 61°10'53" | 151°30'29" | | | 68.8 | 15.57 | | | |
| 29 | Camp Creek | 61°10'49" | 151°30'22" | | | 11.8 | 5.82 | | | |
| 30 | East Fork Chuit below Camp Creek | 61°10'45" | 151°30'25" | | | 78.3 | 19.61 | | | |
| 31 | Middle Creek near Lease Boundary | 61°09'27" | 151°22'35" | | | 11.3 | 16.43 | | | |
| 32 | Scarp Creek Mouth | 61°19'00" | 151°19'33" | | | 46.8 | 106.18 | | | |
| 33 | Wobnair Creek | 61°16'03" | 151°19'01" | | | 4.8 | 18.42 | | | |
| 34 | Scarp Creek above Wobnair Creek | 61°16'03" | 151°19'12" | | | 31.2 | 66.33 | | | |
| 35 | Scarp Creek below Wobnair Creek | 61°16'07" | 151°19'06" | | | 38.2 | 86.97 | | | |
| 36 | Frank Creek | 61°11'33" | 151°38'55" | | | | 67.63 | | | |
| 37 | Bolts Creek | 61°11'10" | 151°35'18" | | | | 5.7 | | | |

Table 4.6

SELECTED DISCHARGE DATA
Cubic Feet per Second (cfs)

| Station No. | Description | Water Year or Date | Drainage Area (sq. mi.) | Total Discharge (cfs) | Mean Discharge (cfs) | Maximum Discharge (cfs) | Minimum Discharge (cfs) | Comment |
|---|---|---|---|---|---|---|---|---|
| | Chuitna River (USGS gauge near Tyonek - 160 ft. above sea level) | 1979 | 131 | 147716 | 405 | 2370 | 45 | |

From USGS 1980: Period of record from October 1975.

Table 4.7

SUMMARY DATA ON SUSPENDED SOLIDS

Point Sample, Single Day Observation (mg/ℓ)

| Station No. | Description | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | North Capps Creek | | | | | | 41.0 | -- | | | | 2.5 | | |
| 2 | Capps Creek | | | | | | 480.0 | -- | | | | | | |
| 3 | Chuitna River below Wolverine Fork | | | | | | 11.0 | 5.0 | | | | | | |
| 4 | Wolverine Fork | | | | | | 14.0 | 1.7<br>3.3 | | | | 1.0 | | |
| 5 | Chuitna River above Wolverine Fork | | | | | | 12.0 | 8.5 | | | | 21.3 | | |
| 6 | Congahbuna Creek above Old Tyonek Creek | | | | | 3.2 | 0.65 | 3.3 | | | | 8.4 | | |
| 7 | Old Tyonek Creek above Congahbuna Creek | | | | | 19.0 | 2.1 | 6.3 | | | | 4.7 | | |
| 8 | Old Tyonek Creek below Congahbuna Creek | | | | | 18.0 | 2.2 | 7.3 | | | | | | |
| 9 | Congahbuna Creek below Congahbuna Lake | | | | | | 4.0 | 8.5 | | | | | | |
| 10 | Stedatna Creek @ Culvert | | | | | 8.4 | 1.1 | 2.2 | | | | 1.9 | | |
| 11 | Nikolai Creek @ Bridge | | | | | 19.0 | 5.9 | | | | | | | |
| 12 | Upper Chuit Creek | | | | | | 8.2 | 2.2 | | | | 2.0 | | |
| 13 | Chuit Creek Mouth | | | | | 3.6 | 10.0 | | | | | 3.6 | | |

Table 4.7
Continued

SUMMARY DATA ON SUSPENDED SOLIDS

Point Sample, Single Day Observation (mg/ℓ)

| Station No. | Description | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | Chuitna River below Chuit Creek | | | | | | | 18.0 | | | | | | |
| 15 | Chuitna River above Chuit Creek | | | | | | 22.0 | 32.0 | | | | | | |
| 16 | BHW Creek Mouth | | | | | | 1.3 | 3.7 | | | | | | |
| 17 | Lower Lone Creek | | | | | | 2.7 | 2.1 | | | | | | |
| 18 | Upper Lone Creek | | | | | 26.0 | 1.6 | 5.9 | | | | | | |
| 19 | Cole Creek Mouth | | | | | | .42 | 1.3 | | | | | | |
| 20 | Pit Creek | | | | | 180.0 | 7.5 | 2.6 | | | | | | |
| 21 | Nikolai Creek above Pit Creek | | | | | (5/5) 36.0<br>(5/4) 150.0 | 11.0 | 8.0 | | | | | | |
| 22 | Nikolai Creek below Pit Creek | | | | | (5/5) 36.0<br>(5/4) 130.0 | 13.0 | 9.8 | | | | | | |
| 23 | Jo's Creek | | | | | 25.0 | 9.4 | 3.0 | | | | | | |
| 24 | Nikolia Creek above Jo's Creek | | | | | 49.0 | 11.0 | 9.6 | | | | | | |
| 25 | Brush Creek | | | | | | | 3.1 | | | | | | |
| 26 | Strip Creek | | | | | | 72.0 | 110.0 | | | | | | |

Table 4.7
Continued

SUMMARY DATA ON SUSPENDED SOLIDS

Point Sample, Single Day Observation (mg/ℓ)

| Station No. | Description | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Upper Middle Creek | | | | | | | -- | | | | | | |
| 28 | East Fork Chuit above Camp Creek | | | | | | | .8 | | | | | | |
| 29 | Camp Creek | | | | | | 2.8 | 1.4 | | | | | | |
| 30 | East Fork Chuit below Camp Creek | | | | | | 4.8 | .5 | | | | | | |
| 31 | Middle Creek near Lease Boundary | | | | | | | 9.1 | | | | | | |
| 32 | Scarp Creek Mouth | | | | | | 36.0 | 71.0 | | | | | | |
| 33 | Wobnair Creek | | | | | | 7.7 | -- | | | | | | |
| 34 | Scarp Creek above Wobnair Creek | | | | | | | 6.3 | | | | | | |
| 35 | Scarp Creek below | | | | | | | 6.0 | | | | | | |
| 36 | Frank Creek | | | | | | | 8.7 | | | | | | |
| 37 | Bolts Creek | | | | | | | 4.4 | | | | | | |

Table 4.8

SELECTED WATER QUALITY DATA, NOVEMBER 1980

Point Sample, Single Day Observation

| Station No. | Description | Total Dissolved Solids (mg/ℓ) | Total Suspended Solids (mg/ℓ) | pH | Total Dissolved Iron (mg/ℓ) | Total Manganese (mg/ℓ) |
|---|---|---|---|---|---|---|
| | Capps Creek (South Fork) | 27.0 | 35.0 | | 0.19 | <0.05 |
| | Chuitna River (below Wolverine) | 28.0 | 5.4 | | ND | <0.05 |

Table 4.9

SELECTED WATER QUALITY DATA, MAY 1981

Point Sample, Single Day Observation

| Station No. | Description | Total Dissolved Solids (mg/ℓ) | Total Suspended Solids (mg/ℓ) | pH | Total Dissolved Iron (mg/ℓ) | Total Manganese (mg/ℓ) |
|---|---|---|---|---|---|---|
| | Jo's Creek | 50.0 | 19.0 | | 0.38 | <0.05 |
| | Cole's Creek | 21.0 | 16.0 | | 1.10 | 0.08 |
| | Pit Creek | 44.0 | 46.0 | | 0.46 | <0.05 |
| | BHW Creek | 29.0 | 6.6 | | 1.30 | <0.05 |
| | Chuitna (below Chuit) | 33.0 | 25.0 | | 1.20 | <0.05 |

Table 4.10

SELECTED WATER QUALITY DATA JUNE, 1981

Point Sample, Single Day Observation

| Station No. | Description | Total Dissolved Solids (mg/ℓ) | Total Suspended Solids (mg/ℓ) | pH | Total Dissolved Iron (mg/ℓ) | Total Manganese (mg/ℓ) |
|---|---|---|---|---|---|---|
| | Brush Creek | 63.0 | 2.2 | | 1.7 | 0.05 |
| | Strip Creek | 94.0 | 45.0 | | 1.6 | 0.17 |
| | Scarp Creek | 54.0 | 7.3 | | 0.70 | 0.05 |
| | Beluga River | 72.0 | 34.0 | | 1.9 | 0.06 |

Table 4.11

SELECTED WATER QUALITY DATA JULY, 1981

Point Sample, Single Day Observation

| Station No. | Description | Total Dissolved Solids (mg/ℓ) | Total Suspended Solids (mg/ℓ) | pH | Total Dissolved Iron (mg/ℓ) | Total Manganese (mg/ℓ) |
|---|---|---|---|---|---|---|
| | Chuitna Creek | 27.0 | 2.2 | 7.1 | .28 | <0.05 |
| | Strip Creek | 45.0 | 15.0 | 7.0 | .81 | 0.07 |
| | Brush Creek | 51.0 | 7.0 | 6.9 | .77 | <0.05 |

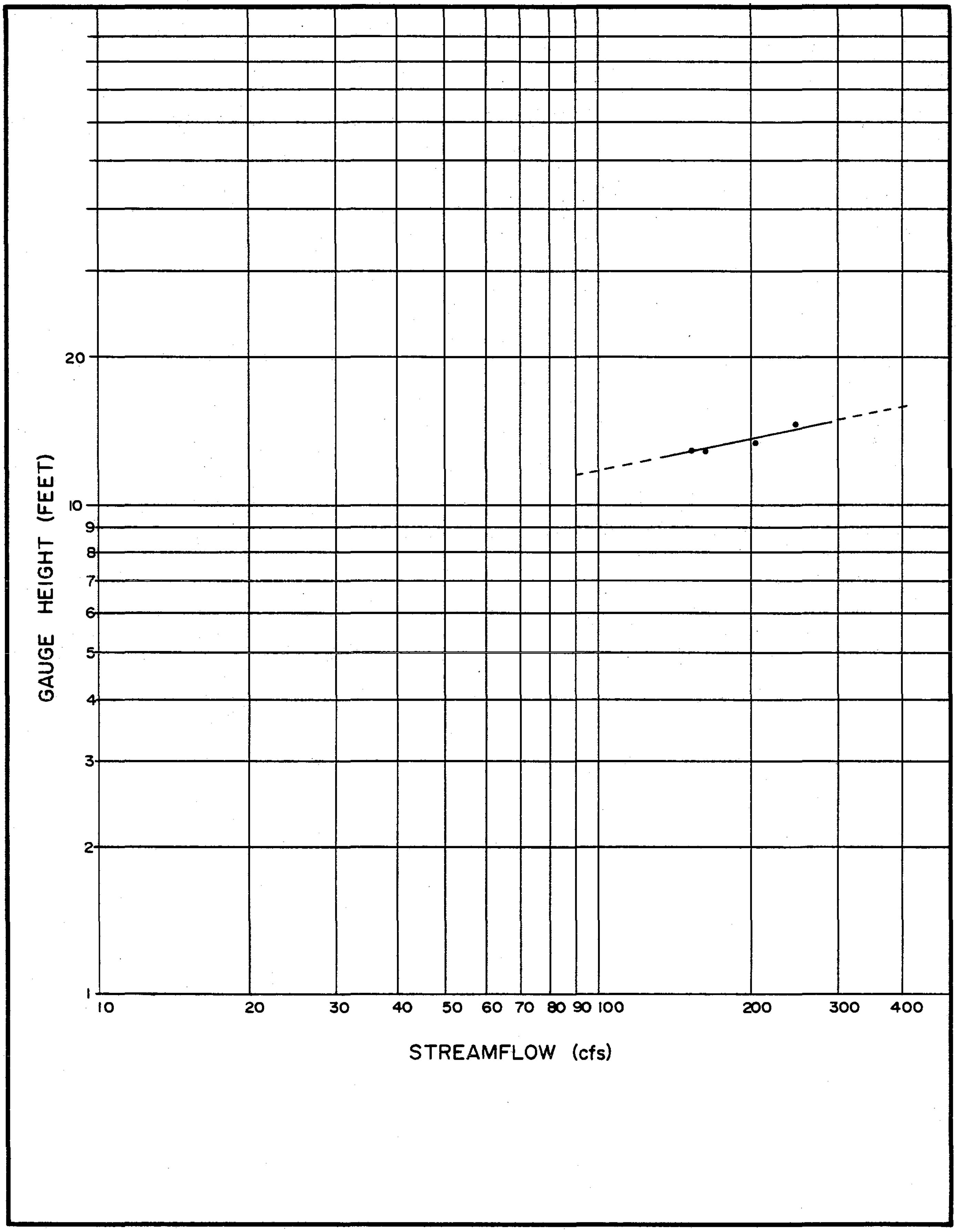



FIGURE 4.7 RATING CURVE FOR NIKOLAI CREEK (BRIDGE)

BELUGA HYDROLOGY STUDY
PREPARED BY DRYDEN & LARUE FOR DOWL ENGINEERS

PAGE 1
10-AUG-81

NIKOLAI CREEK    START TIME 06/03/81 12:00    (NIK064.POD)

| DATE | TIME | PRESSURE-INCHES H2O AVG | MIN | MAX | TEMPERATURE-DEG C AVG | MIN | MAX | STREAM GUAGE READING (FT) | FLOW (cfs) |
|---|---|---|---|---|---|---|---|---|---|
| 06/03/81 | 12:00 | 15.8 | 0.7 | 17.5 | 9.0 | 6.5 | 20.5 | | |
| 06/03/81 | 16:00 | 14.4 | 13.4 | 15.1 | 6.5 | 6.0 | 6.5 | | |
| 06/03/81 | 20:00 | 12.7 | 12.0 | 13.4 | 6.0 | 6.0 | 6.0 | | |
| 06/03/81 | 24:00 | 11.6 | 11.3 | 12.0 | 6.0 | 6.0 | 6.0 | 13.75 | 205* |
| 06/04/81 | 04:00 | 11.6 | 11.3 | 12.0 | 6.0 | 6.0 | 6.0 | | |
| 06/04/81 | 08:00 | 12.3 | 12.0 | 12.7 | 6.0 | 6.0 | 6.0 | | |
| 06/04/81 | 12:00 | 12.7 | 12.3 | 13.0 | 6.0 | 6.0 | 6.0 | | |
| 06/04/81 | 16:00 | 11.6 | 11.0 | 12.3 | 6.5 | 6.0 | 6.5 | | |
| 06/04/81 | 20:00 | 10.6 | 9.9 | 11.0 | 6.5 | 6.5 | 6.5 | | |
| 06/04/81 | 24:00 | 9.9 | 9.6 | 9.9 | 6.5 | 6.5 | 6.5 | | |
| 06/05/81 | 04:00 | 10.3 | 9.9 | 10.6 | 6.0 | 6.0 | 6.5 | | |
| 06/05/81 | 08:00 | 11.0 | 10.3 | 11.3 | 6.0 | 6.0 | 6.0 | | |
| 06/05/81 | 12:00 | 11.6 | 11.3 | 11.6 | 6.0 | 6.0 | 6.0 | 13.70 | 205** |
| 06/05/81 | 16:00 | 11.0 | 10.3 | 11.3 | 6.0 | 6.0 | 6.5 | | |
| 06/05/81 | 20:00 | 9.6 | 9.3 | 10.3 | 7.0 | 6.5 | 7.0 | | |
| 06/05/81 | 24:00 | 9.3 | 8.9 | 9.3 | 7.0 | 7.0 | 7.0 | | |

* from rating curve
** measured

FIGURE 4.8 TYPICAL DATA RECOVERED FROM *DATAPOD* EXPERIMENT (NIKOLAI CREEK)

The existing field program is being expanded to include more in situ water chemistry so that temperature, pH, dissolved oxygen, and conductivity measurements will be made each time a discharge measurement is taken or a stream gauge reading is made. A typical chemical analysis for one station on one day is shown in Figure 4.9.

Following the completion of the 1981 field program an evaluation of the program will be made and a scope-of-work for 1982 will be prepared. This scope-of-work will be coordinated with other field programs including the collection of climatic data and the initial analysis of groundwater with particular reference to the proposed mine areas.

Water quality for existing wells has been compared to that of the Chuitna River (Table 4.12). Additionally, sediment samples of numerous alluviums have been analyzed (Table 4.13).

Possible Use of Surface Waters

Congahbuna Lake has a surface area of some 256 acres with an average depth of some 6 feet (maximum depth of 16 feet). The size of this lake suggests that some consideration could be given to using the lake for a cooling pond to provide natural cooling of the thermal discharge from the plant. The impact on existing fisheries would obviously have to be carefully weighed. The lake would provide a holding time of approximately 25 hours assuming a 330,000 gpm discharge from the plant (lake volume is approximately 500 million gallons). The plant discharge would be 95°F. Analysis indicates that the surface area of the lake is not sufficient to provide cooling by natural means comparable to that which can be achieved by cooling towers.

Natural mechanisms that tend to dissipate heat from water surfaces would cool the thermal discharges to only 81°F in the colder winter

*CHEMICAL & GEOLOGICAL LABORATORIES OF ALASKA, INC.*

TELEPHONE (907) 279-4014 274-3364 ANCHORAGE INDUSTRIAL CENTER 5633 B Street

ANALYTICAL REPORT

CUSTOMER DOWL Engineers SAMPLE LOCATION: Alaska

FOR LAB USE ONLY

DATE COLLECTED 5-5-81 TIME COLLECTED: 1315 Hrs. RECVD.BY GY LAB # 7432-

SAMPLED BY EWT SOURCE Jc's Creek DATE RECEIVED 5-6-81

REMARKS DOWL Engineers - Beluga Methanol Project ATTN: rrd DATE COMPLETED 5-18-81

DATE REPORTED 5-18-81

SIGNED Archie L. Green

| | mg/l | | mg/l | | mg/l |
|---|---|---|---|---|---|
| []Ag,Silver | <0.05 | []P,Phosphorous | <0.05 | []Cyanide | |
| []Al,Aluminum | 0.33 | []Pb,Lead | <0.05 | []Sulfate | <1 |
| []As,Arsenic | <0.01 | []Pt,Platinum | <0.05 | []Phenol | |
| []Au,Gold | <0.05 | []Sb,Antimony | <0.10 | []Total Dissolved Solids | 50 |
| []B,Boron | <0.05 | []Se,Selenium | <0.01 | []Total Solids | 69 |
| []Ba,Barium | <0.05 | []Si,Silicon | 10 | []Suspended Solids | 19 |
| []Bi,Bismuth | <0.05 | []Sn,Tin | <0.10 | []Volatile Suspended Solids | |
| []Ca,Calcium | 2.5 | []Sr,Strontium | <0.05 | []Hardness as $CaCO_3$ | 17 |
| []Cd,Cadmium | <0.01 | []Ti,Titanium | <0.05 | []Alkalinity as $CaCO_3$ | 18 |
| []Co,Cobalt | <0.05 | []W,Tungsten | <0.05 | []Beryllium | <0.02 |
| []Cr,Chromium | <0.05 | []V,Vanadium | <0.05 | [] | |
| []Cu,Copper | <0.05 | []Zn,Zinc | <0.05 | [] | |
| []Fe,Iron | 0.38 | []Zr,Zirconium | <0.05 | [] | |
| | | | | * * * * * | |
| []Hg,Mercury | <0.001 | []Ammonia Nitrogen-N | <0.05 | []mmhos Conductivity | |
| []K,Potassium | <1 | []Organic Nitrogen-N | 0.58 | []pH Units | |
| []Mg,Magnesium | 2.3 | []Nitrate-N | 1.8 | []Turbidity NTU | 2.2 |
| []Mn,Manganese | <0.05 | []Nitrite-N | <0.01 | []Color Units | 20 |
| []Mo,Molybdenum | <0.05 | []Phosphorus (Ortho)-P | <0.05 | []T.Coliform/100ml | |
| []Na,Sodium | 2.4 | []Chloride | <1.0 | [] | |
| []Ni,Nickel | <0.05 | []Fluoride | <0.10 | [] | |

FIGURE 4.9 TYPICAL SURFACE WATER QUALITY ANALYSIS

Table 4.12

WATER QUALITY COMPARISON
GROUNDWATER & CHUITNA RIVER

| | Parameter | #1 Well Pad | #4 Chuitna River | #3 Beluga Station |
|---|---|---|---|---|
| | | (Concentration mg/ℓ) | | |
| Dissolved Species | Bicarbonate | 390.0 | 77.0 | 112.0 |
| | Calcium | 89.0 | 6.4 | 8.9 |
| | Chloride | 2.4 | 0.1 | 6.3 |
| | Copper | 0.001 | 0.002 | 0.004 |
| | Fluoride | 0.2 | 0.1 | 0.2 |
| | Iron | 6.2 | 0.4 | 1.5 |
| | Lead | 0 | 0.003 | 0 |
| | Magnesium | 16.0 | 3.8 | 4.6 |
| | Manganese | 1.1 | 0.09 | 0.06 |
| | Potassium | 7.6 | 1.5 | 2.7 |
| | Silica | 39.0 | 18.0 | 54.0 |
| | Sodium | 13.0 | 15.0 | 27.0 |
| | Sulfate | 2.2 | 2.9 | 8.9 |
| | Total Hardness | 290.0 | 32.0 | 41.0 |
| | Corrosion Index* | 0.02 | 0.05 | 0.20 |

*me/ℓ ($Cl^- + SO_4^{2-}$), Greater than 0.1 indicates corrosive tendency.

me/ℓ (Alkalinity as $CaCO_3$)

Table 4.13

SEDIMENT SAMPLES ANALYSES

| | Coarse Sand % | Medium Sand % | Fine Sand % | Silt % |
|---|---|---|---|---|
| 1. Alluvium, Chuitna River, below Wolverine Fork | 25 | 60 | 10 | 5 |
| 2. Tertiary sediments in valley wall, Chuitna River below Wolverine Fork | 40 | 30 | 25 | 5 |
| 3. Alluvium, Chuit Creek, just above Chuitna coal lease area | 40 | 50 | 7 | 3 |
| 4. Tertiary sediments in valley wall, Chuit Creek just above lease area | 20 | 20 | 50 | 10 |
| 5. Alluvium, Chuit Creek, near junction of Chuitna River | 65* | 30** | 4*** | 1 |
| 6. Alluvium, Capps Creek, near junction of North Capps Creek | 5 | 50 | 40 | 5 |
| 7. Sand dune, above Tertiary sediments in valley wall, North Capps Creek near junction with Capps Creek | 30 | 30 | 30 | 10 |
| 8. Alluvium, Stedatna Creek, in canyon below logging road | 50 | 20 | 25 | 5 |
| 9. Unconsolidated deposits, valley wall above Stedatna Creek in canyon | 20 | 15 | 50 | 15 |
| 10. Alluvium, Congahbuna Creek, at logging road crossing below lake | 60 | 20 | 17 | 3 |
| 11. Alluvium, Congahbuna Creek, near junction with Old Tyonek Creek | 50 | 30 | 15 | 5 |
| 12. Alluvium, Old Tyonek Creek, near junction with Congahbuna Creek | 40 | 25 | 32 | 3 |
| 13. Alluvium, Nikolai Creek, at logging road bridge | 55 | 30 | 14 | 1 |
| 14. Beach sand, Nikolai Creek, at logging road bridge | -- | 10 | 80 | 10 |

Coarse Sand = 0.02 - 0.08 inches diameter
Medium Sand = 0.01 - 0.02 inches diameter
Fine Sand = 0.0025 - 0.01 inches diameter
Silt = less than 0.0025 inches diameter

* Mainly quartz, lesser feldspar and dark minerals, angular to subround
** Mainly quartz
*** Mainly quartz and feldspar

months and to only 87°F in the colder winter months and to only 87°F in the warmest months. Spray coolers to provide for additional cooling do not appear to be cost effective when compared to the cooling towers. To provide the same degree of cooling as can be achieved by the proposed cooling towers would require a lake surface area of approximately 1,000 acres, nearly four times the area of Congahbuna Lake.

Further consideration should be given to developing a plant water source from Nikolai Creek in the vicinity of its junction with Stedatna Creek. An infiltration gallery in this location could conceivably provide adequate water to the plant without any impact on the upstream fishery.

Lone Creek

Chuitna River

## 5.0 ECOSYSTEMS

Due to the paucity of specific information available on the Beluga region, field investigations were undertaken in 1980 and 1981 to begin developing adequate baseline data. The major thrust of the field program was directed toward determining the presence or absence of fish in the numerous small creeks and tributaries of the region. Additional field observations of terrestrial and avian species were undertaken and are continuing.

An understanding of the resources of the general area requires that the study area extend well beyond the boundaries of the specific proposed project, so the field program encompasses an area extending from the Beluga River south to the Chakachatna River. The field program initially was designed to concentrate on the entire project area, and then as the season progressed more effort was placed on those areas that would have the most potential for impacts from the project, e.g. the mine areas and the transportation corridor. The field parties often were accompanied by one or more persons from state or federal resource agencies.

This chapter represents the synthesis of information derived from the existing literature, numerous conversations and meetings with agency personnel, and the preliminary results of the on-going field programs. No attempt has been made to narrow this synthesis to specific project-related activities due to the incompleteness of the field investigations. However, a general overview of the resources of the area is now possible and coupled with the continuing fall-winter observations will provide the basis for more detailed future programs.

This general area is far from pristine. Years of oil and gas exploration programs as well as logging activities and exploration related to the determination of coal reserves have resulted in numerous examples of surface disturbance.

## FRESHWATER AQUATIC ECOLOGY

### Existing Habitats

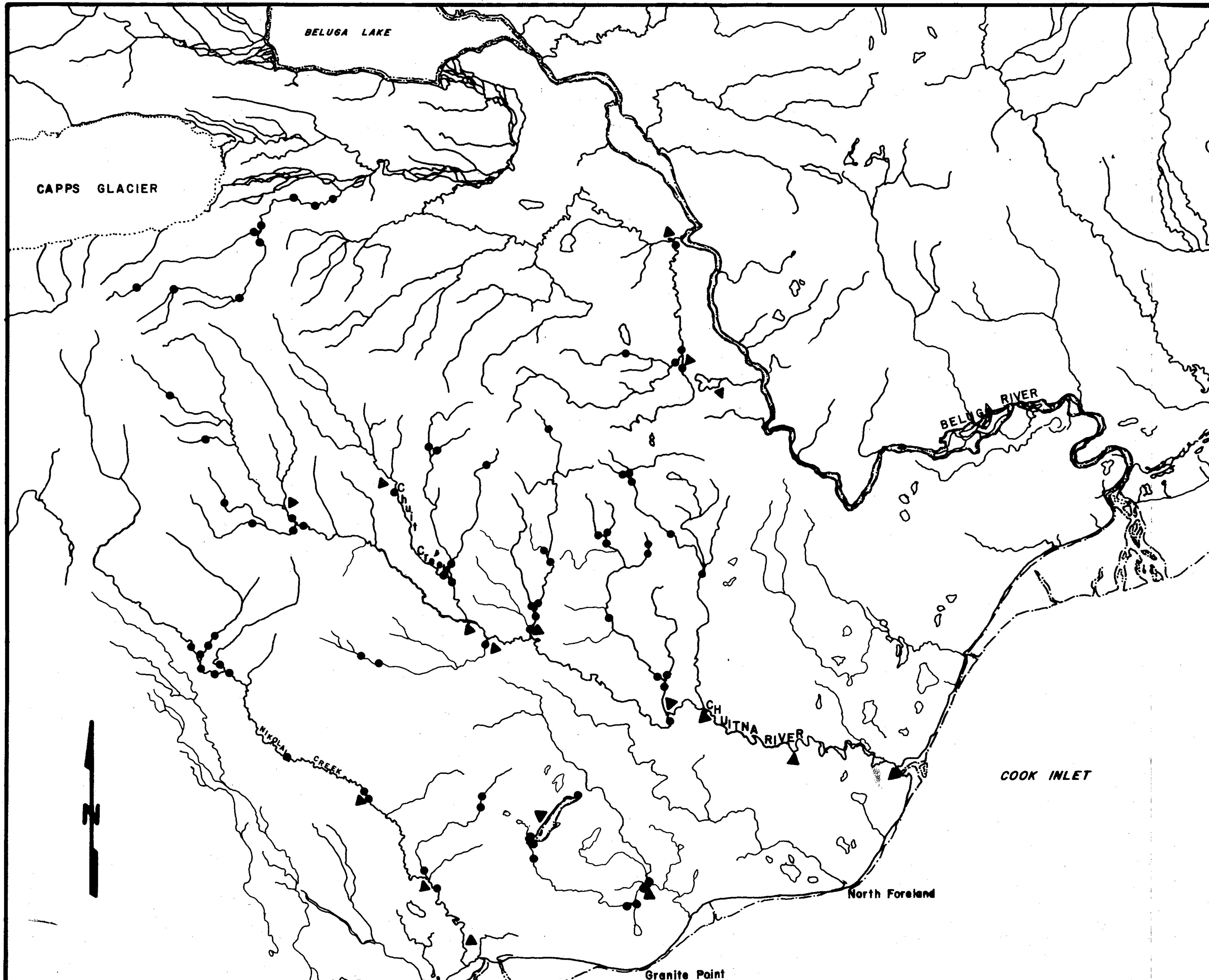
° Habitat Characterization

This section provides brief descriptions which characterize the general nature of the stream reaches in each drainage area where staff gauges and/or fish traps were located or where general field observations were made. General locations are shown in Figure 5.1. In many cases, these observations are limited to or pertain only to a single field excursion. This characterization of habitat is an on-going program.

#### BELUGA DRAINAGE

Beluga River: This glacial fed river begins at Beluga Lake, a 7-mile-long, 3-mile-wide lake located east of the toe of the Triumvirate Glacier and northeast of Capps Glacier. Both glaciers originate on the slopes of Mount Torbert. From Beluga Lake, elevation 246 feet, the river flows easterly nearly five miles before entering Lower Beluga Lake (elevation 243 feet), a narrow 3/4-mile wide lake nearly 2½ miles long. From this lower lake, the Beluga continues its easterly flow across the broad lowlands another 22 miles to Cook Inlet cutting banks into the glacial tills ranging from 10 to 150 feet or more in depth. The system supports runs of king, silver, sockeye and pink salmon. Dolly Varden also are present, and lake trout are found in Beluga Lake.

Headwaters of Scarp Creek: This stream reach has a relatively flat gradient meandering channel. The substrate is predominantly cobbles and gravel with some sand, and the stream channel is basically rectangular with vertical banks. Tall grass overhangs stream banks and covers the floodplain. Stream top widths aver-




GENERAL LOCATION SAMPLED BY TRAPPING AND BY ANGLING (MAY-AUG '81)

FIGURE 5.1

aged from 2 to 3 feet, with average depth 0.7 to 1 foot. Juvenile Dolly Varden and threespine sticklebacks were collected (1981).

Upper Scarp Creek: This reach is meandering with a moderate gradient. Riffles comprise approximately 30% of the stream, runs 30%, and pools 40%. The channel is generally rectangular. Stream top widths averaged 20 to 30 feet. Water depth in riffles was about 0.5 feet, runs 1 foot, and pools ranged from 2 to 4 feet. A discharge of 38 cfs was recorded on June 4, and flow probably ranges from 25 to 150 cfs during the ice-free season.

The substrate is gravel and small cobbles. Water is slightly peat stained. Stream bank materials are primarily silty sand, and banks are vertical and frequently undercut. Juvenile coho salmon, Dolly Varden, and rainbow trout were collected. Chinook and coho salmon fry were collected in this reach, as were adult rainbow trout (1981). Benthos collected included snails, midges, and blackfly, caddiesfly, and mayfly larvae.

Mouth of Scarp Creek: The stream in the lower reach is a moderate gradient meandering run. Few riffles and pools were evident in the vicinity of the staff gauge. The stream channel is generally rectangular but is parabolic at bends where the stream is cutting into steep banks 30 to 50 feet high. Stream banks are composed of silty sands and clay. The bank is slumping at several locations in the lower two miles. An active cut exposing clay deposits is coloring the water in the lower 1½ miles of the stream. Stream top widths were approximately 30 feet and depths averaged 1.5 to 2 feet. A discharge of 47 cfs was measured on June 4, and flow probably ranges from 30 to 350 cfs during the ice-free season.

The substrate is predominantly gravel and is 100% embedded in sand and silt. Much of the gravel was loose, indicating it was recently deposited. The floodplain is covered with alder and willow to water's edge. Some log debris was present along stream margins. Juvenile Dolly Varden, rainbow trout, and chinook salmon were collected (1981).

Wobnair Creek: This stream has a relatively flat gradient and sharp meanders near its mouth. Substrate is gravels and small cobbles. The banks are vertical with some undercutting and are composed of silts and sand. Predominant vegetation is willow and tall grass. Runs comprise 60% of the stream and pools 40%. The channel is generally rectangular. Stream top widths averaged from 7 to 10 feet with depths of 1 to 2 feet. A discharge of 5 cfs was measured on June 4, and flow probably ranges from less than 5 to 35 cfs during the ice-free season. Juvenile Dolly Varden and rainbow trout, coho and chinook salmon fry, and threespine sticklebacks were collected.

Headwaters Wobnair Creek: The headwaters of Wobnair above the beaver activity is a flat gradient meandering stream with gravel and cobble substrate. The floodplain and valley are relatively narrow. Stream top widths averaged 2 feet with depths to 1 foot. No discharge was measured, but flows are unlikely to exceed 5 cfs. Tall grass overhangs the bank and scattered spruce covers the floodplain. No fish were found here.

Below the highest set of beaver ponds the creek has a moderate to flat gradient. Substrate is basically gravel with some isolated boulders. This channel is generally rectangular with vertical banks, and this reach is predominantly a run with few pools. Pools were generally associated with remnants of old beaver dams. Several sets of active dams are present downstream. Stream top widths averaged from 5 feet, and average depth was 0.5 to 1 foot. Juvenile Dolly Varden and coho salmon were collected (1981). Stream flow probably ranges from 1 to 15 cfs during the ice-free season.

Chichantna River: This is a relatively large glacial stream with its source in Capps Glacier. The river, nearly 12 miles long with moderate to steep gradients, enters Beluga Lake over a broad silty delta.

Capps Creek: Capps Creek and its principal tributary, North Capps Creek, have their headwaters on a plateau at about 2,000-feet elevation, south of the Capps Glacier and just northwest of the upper headwaters of the Chuitna River. The creek flows northeast into the Chichantna River, joining it about three to four miles below Capps Glacier.

Both the south and north forks have their far upper headwaters covered by lapilli tuff and volcanic breccia, which contribute a small amount of volcanic sediment to the river's alluvium. The streams also pick up sediment from the Quaternary deposits, which contribute boulders, gravel, and silt to the system.

Both streams quickly become incised into the middle member of the Tertiary Kenai Formation which contributes clay, silt, sand, gravel, boulders, and coal lumps to the system. Each stream runs through about three miles of this formation.

Capps Creek and North Capps Creek then enter a deposit formed by landsliding and slumping of the middle member of the Kenai Formation and the Quaternary deposits that cover it, including sand dune deposits. These deposits contribute a variety of sediments to the river's alluvium, including clay, silt, fine sand, gravel, boulders, and coal lumps. Both streams run through this slump deposit for about three miles, with North Capps Creek joining Capps Creek about a mile before the end of the deposit.

The canyons at the confluence of Capps Creek and North Capps Creek are narrow and steep, with sidewalls about 150 feet high at a slope of approximately 45°. Many local slides occur on the canyon walls, involving the Tertiary and Quaternary sediments of the sidewalls. Overlying sand dunes as much as 20 feet thick were noted here. Many sites of slides were noted to also be the sites of water seeps from the canyon walls, which may have been the slide-triggering mechanism.

Capps Creek then enters a region of Quaternary and Recent glaciofluvial deposits of sand, gravel, and boulders, continuing for about three miles to the Chichantna River.

Capps Creek at Junction with North Capps Creek: Substrates are composed of very coarse boulder and cobble alluvium, with some sand and gravel. Fines appear to be predominantly sand of eolian origin (from nearby sand dunes that overlie the Tertiary sediments). Boulders are as much as 6 feet in diameter, many composed of granite. Stream gradient is moderately steep, with many riffles. Logjams found above the normal fall water stages indicate probable occasional flooding.

South Fork Capps Creek: Stream gradients are moderate to very steep. Steep gradients were characterized by almost continual waterfalls, cascades, or steep riffles; moderate gradients were described as intermittent cascades or riffles with some pools; and low gradients were characterized as entirely slow runs or very few riffles among slow runs. Streambed materials within the water course consist primarily of granite boulders and large pieces of coal, with gravels and sands filling the interstices. These streams consist almost entirely of riffles and rapids, but a few pool areas can be found at the outside of stream bends and among boulders at low flows.

Several high-water marks were observed 10 to 15 feet above the water surface elevation of November.

Both Capps and North Capps creeks are already incised in narrow, steep-walled canyons. Vegetation is primarily grass and devil's club with an alder brush overstory. Mass wasting is a common natural process within these canyons.

Although no major barriers to fish migration were observed along either stream, steep gradients may preclude passage and use by many species.

<u>Capps Creek (vicinity of USGS gauge)</u>: The gradient is gentle throughout this stream segment. The stream meanders at a moderate velocity throughout a glacial outwash type floodplain. Stream bank vegetation consists principally of a low alder and willow overstory with a tall grass understory. Some scattered large birch and cottonwood trees occur adjacent to the stream, and some moss-covered cobble and gravel banks with occasional spruce trees can also be seen. Overhanging alder shrubs and grassy banks occur along the lower several miles of Capps Creek.

The predominant substrate material is much smaller than that found in the upper reaches of Capps Creek. Substrate is principally cobbles and large gravels about 50% embedded in small gravels and sand. Some scattered coal pieces occur throughout the stream course, and some of the finer to medium-size gravel substrate is cemented with a heavy clay deposition.

High-water marks are evident 3 to 5 feet above the November 6 water surface elevation.

The stream is characterized as approximately 60% riffle, 40% pool in this section. Interspersed are numerous sandy gravel bars, with many silty clay deposits.

A juvenile Dolly Varden was observed (1980) in a backwater area along the left bank of the stream. Benthos, consisting primarily of caddiesfly larvae, was observed beneath 8- to 10-inch cobbles. No aquatic vegetation was observed.

Apparent signs of animal use included bear, fox, and otter tracks. Beaver sign is extensive throughout this area as evidenced by active lodges, newly created dams, and freshly cut shrubbery.

## CHUITNA DRAINAGE

Chuitna River: The upper Chuitna River and its principal tributary, Wolverine Fork, both head in a plateau at about the 2,000 feet elevation south of Capps Glacier. The river system flows southeastward into Cook Inlet. The streams initially course through Quaternary deposits overlying the plateau area, consisting of a discontinuous cover of glacial debris. Erosion of this cover contributes sediments consisting of gravel, silt, and some boulders to the streams.

Several of the upper, western tributaries to the Chuitna River have their far upper headwaters in an area covered by dark gray lapilli tuff and volcanic breccia. Alluvial sediments of this origin are found in small quantities throughout the Chuitna River.

The streams soon become incised into Tertiary sediments that underlie the area. Near their headwaters, the streams cut through the middle member of the Kenai Formation, consisting of a non-marine sequence of gray and light yellow claystone, siltstone, sandstone, and conglomerate, interbedded with sub-bituminous coal, and occasional layers of calcareous cemented siltstone. These sediments are poorly indurated and easily eroded, contributing clay, silt, sand, gravel, boulders, and coal lumps to the streams.

Within a few miles, the streams cross into the lower member of the Kenai Formation, consisting of light gray to light yellow pebbly sandstones and conglomerates. These sediments are also poorly indurated and easily broken down, contributing sand, gravel, and boulders to the streams. Both streams reenter Quaternary sediments for a few miles, then Wolverine Fork joins the Chuitna River in this section.

About six to seven miles downstream, the Chuitna River crosses the Castle Mountain Fault, reentering the middle member of the Kenai Formation and remaining in it for the next 15 to 16 miles. The Chuitna River is joined by Chuit Creek after running about four to five miles through this section. The canyon walls of the river in this section contain many large and small landslides and slump deposits, composed of the overlying Quaternary sediments, including sand dunes deposits, and the middle member of the Kenai Formation. These continually contribute clay, silt, sand, gravel, boulders, and coal lumps to the Chuitna River alluvium.

Many upper tributaries to the Chuitna River are blocked by waterfalls formed on coal seams, which appear to be the hardest strata in the area. These waterfalls may serve as barriers to fish migration.

The Chuitna River canyon at its confluence with Wolverine Fork is narrow and sidewall slopes average 35° to 40°. The walls are about 150 feet high and are composed of Tertiary conglomerate of a friable nature, consisting of sand, gravel, cobbles, and boulders up to several feet in diameter. Many slide deposits are found along the valley walls, composed of these Tertiary sediments and a shallow Quaternary cover.

At the confluence with Chuit Creek, the canyon of the Chuitna River is relatively broad, with walls about 150 feet high, and sidewalls of 35° to 40°. The walls here are composed of sandstone, claystone, and sub-bituminous coal, with the sandstone layer being somewhat conglomeratic in places, and including some discontinuous layers of well-indurated sandstone and concretions. Local slides, abundant in the area, are composed of these sediments. Water seeps are also common, often in conjunction with slides.

The lower four to five miles of the Chuitna River cuts through Quaternary sediments consisting of unconsolidated glacial outwash, sand and gravel. Slides are less common here. The canyon walls in the vicinity of the USGS gauging station are 60 to 70 feet high; sidewall slopes average about 25° to 30°. The valley then broadens and becomes gentler until reaching the Chuitna River delta about two miles northeast of the Village of Tyonek.

<u>Chuitna River just Below Wolverine Fork</u>: Substrates are composed of sand, gravel, cobbles, and boulders as much as 10 to 15 feet in diameter. Most boulders are composed of Tertiary sandstone, but some are granite. The sandstone boulders are fairly well indurated and contain some wood and coal fossils. The stream gradient is moderate.

<u>Lower Chuitna River (USGS gauge)</u>: Substrates are composed of sand, gravel, cobbles, and boulders as much as 2 to 3 feet in diameter. A large portion of the cobbles falls in the 6- to 10-inch range. Fines consist predominantly of medium sand. The stream gradient is low.

<u>Lone Creek at Upper Forks</u>: This stream reach has a moderate gradient with a cobble/gravel substrate. The stream channel is rectangular with vertical to undercut banks. Tall grasses are the predominant vegetation and overhang the banks. The tributary to Lone Creek has a steeper gradient 100 feet upstream from the mouth, and the substrate is predominantly cobbles.

Lone Creek's top widths averaged 5 to 7 feet, with depths ranging from 0.5 to 1.5 feet in this reach. It was comprised of 75% pool/

run and 25% riffle. No discharge was measured in this reach. Juvenile Dolly Varden and coho salmon were collected; Dolly Varden fry were also observed in this reach.

Upper Lone Creek: This reach has a meandering channel with a moderate to flat gradient. Stream banks are nearly vertical, with some slumping into the stream channel. Stream top widths averaged from 20 to 25 feet with an average depth of 1 to 1.5 feet. A discharge of 13 cfs was measured on June 4, and flow probably ranges from 5 to 200 cfs during the ice-free season.

The substrate is predominantly gravel and small cobbles partially embedded in sand. Banks are covered primarily by alder and willow with a grass understory. Several side channels and cutoff meanders are present in this reach, as well as log debris in pools and along margins.

This stream reach supports a rich benthic community, and the stream bottom is covered with green filamentous algae. Juvenile Dolly Varden and coho salmon, and rainbow trout and chinook salmon fry were collected (1981). A beaver dam upstream of the staff gauge supports juvenile Dolly Varden and coho salmon. Adult Arctic lamprey were observed in this area (1981). A surber sample was collected over large gravel and included water mites, midges, and larval forms of mayflies, caddiesflies, stoneflies, and danceflies.

Lower Middle Creek: Lower Middle Creek has a moderate gradient and basically a riffle/run sequence. It consists of approximately 20% pool, 50% run, and 30% riffle. The channel in this portion of the stream is basically triangular. The average stream top width was 30 feet, with average depths ranging from 0.4 to 0.7 feet. Discharge was not measured at this site.

Substrate is composed mainly of cobbles and boulders with small, isolated gravel and sand deposits probably associated with road construction. Riparian vegetation consists of cottonwood trees with an understory of alder and willow. Some log debris was present in the pools. Juvenile Dolly Varden, coho salmon, and chinook salmon, and pink and coho salmon fry were collected in this reach (1981).

A moderate to steep gradient tributary (Culvert Creek) enters Middle Creek in this reach. Dolly Varden and coho salmon juveniles were collected downstream of the culvert (1981).

<u>Middle Creek (near the BHW Chuitna lease boundary)</u>: This stream reach is characterized by a moderate to flat gradient and a very meandering channel. It consists of approximately 50% pool, 30% riffle, and 20% run. The channel was rectangular and the stream width averaged 10 to 15 feet in riffle areas and 15 to 20 feet in pool areas. Average depth in riffles was 0.3 to 0.6 feet, and pools averaged from 1.5 to 2 feet. A discharge of 1 cfs was measured on June 3.

Gravel and sand were the predominant substrate material. The nearly vertical banks are composed of silts and sands, and were undercut on bends. Stream banks are covered with tall grasses and a little log debris was present in the stream channel. Juvenile Dolly Varden, rainbow trout, and chinook and coho salmon were collected in this reach; an adult Arctic lamprey was also collected (1981).

<u>Upper Middle Creek</u>: This reach has a moderate gradient with approximately 30% pool, 20% riffle, and 50% run. This channel is basically rectangular with average top widths of 10 to 15 feet. Water depth of runs and pools averaged from 0.5 to 1 foot and 1 to 2 feet, respectively. A discharge of 4.2 cfs was measured on June 3.

The substrate consists of gravels and cobbles embedded in silts and sands. There are large deposits of silt and sand in pool areas. Stream banks are nearly vertical with undercutting on bends and are composed of silt and sands. Tall grasses and an occasional willow cover the banks. Juvenile Dolly Varden and coho salmon were collected in this reach (1981).

Strip Creek: Strip Creek is a flat gradient tributary of Middle Creek. The stream is an incised meandering run. Pools are present in meander bends but probably comprise only 15% of the stream. Few riffles were noted. The top width of this small stream averaged 3 feet, and the average depth was 1 foot. A discharge of 1.5 cfs was measured on July 3, and flow probably ranges from 1 to 25 cfs during the ice-free season. This system is probably influenced by groundwater.

The substrate is primarily silts and sands. Stream banks are composed of similar materials and were nearly vertical to undercut, with tall grasses covering them. Juvenile Dolly Varden, coho salmon, and coastrange sculpins were collected in this creek (1981).

Brush Creek: Brush Creek is a moderate gradient stream which combines with Strip Creek to form Middle Creek. It is composed of 30% pool, 20% run, and 50% riffle. The channel is generally rectangular with near vertical banks. Stream top widths averaged from 7 to 10 feet. Water depth in the pool areas was generally 1 to 1.5 feet and in riffle areas was from 0.2 to 0.7 feet. Much of this stream probably freezes solid during the winter. A discharge of 2.5 cfs was measured in June and flow probably ranges from 1 to 50 cfs during the ice-free season.

Substrate is primarily cobbles and boulders. Stream bank material is a glacial till which supports a dense growth of alders. Juvenile Dolly Varden, coho salmon, and coastrange sculpins were collected here (1981).

Chuit Creek: Chuit Creek has its headwaters on a plateau at about 2,000 feet elevation south of the Capps Glacier, about three miles east of the headwaters of the Chuitna River. The stream flows southeastward about 10 miles to its confluence with the Chuitna River. The stream initially flows through Quaternary glacial deposits of gravel, silt, and boulders. The stream shortly becomes incised into the middle member of the Tertiary Kenai Formation, consisting of poorly indurated claystone, siltstone, and conglomerate, interbedded with sub-bituminous coal and occasional layers of cemented siltstone. These sediments contribute clay, silt, sand, gravel, boulders, and coal lumps to the stream.

Within less than a mile the stream crosses into the lower member of the Kenai Formation, consisting of pebbly sandstones and conglomerates. These contribute sand, gravel, and boulders to the river. About six miles downstream, Chuit Creek crosses the Castle Mountain Fault and reenters the middle member of the Kenai Formation, remaining in it for about five more miles until its confluence with the Chuitna River.

Chuit Creek canyon, within the Chuitna coal lease area, is a relatively gentle canyon with sidewalls about 150 feet high and averaging about 30°. Landslides occur here, but appear to be fewer than along the Chuitna River. Just north of the lease area, the sediments in the sidewalls consist of poorly indurated gravelly sand, with cobbles up to 5 inches in diameter. Near the confluence with the Chuitna River, the sidewalls are composed of poorly indurated sandstone, with some lenses of well indurated sandstone and occasional concretions. They grade downward into claystone, which overlies thick, platy sub-bituminous coal.

Chuit Creek (just above Chuitna lease area): Substrate is sand, gravel, and cobbles as much as 10 inches in diameter. Gradient is moderate and very few boulders are evident.

Chuit Creek (near junction of Chuitna River): Substrate is sand, gravel, cobbles, and many boulders, as much as 1 to 2 feet in diameter. Stream gradient is moderate.

Chuit Creek Area: Chuit Creek stream gradients are moderate (primarily riffles with occasional pools or runs) as this creek meanders through a relatively wide canyon. Riparian vegetation is predominantly low willow thickets and grass at the higher elevations. Spruce, birch, and cottonwood trees occur in the floodplain near the mouth of Chuit Creek. The stream is primarily riffles and runs with some (approximately 10%) pool areas. Several beaver ponds occur in the floodplain. The substrate materials are principally gravels and small cobbles in the upper reaches grading toward large cobbles and isolated boulders near the mouth. No barriers to fish migration are evident along this stream.

East Fork of Chuit Creek: This stream is relatively straight and has a moderately steep gradient. It consists primarily of riffle/run/rapid sequences with less than 5% pools. The channel is basically triangular with an average stream top width of 35 to 40 feet. Average water depths were 1.5 to 2 feet. A discharge of 78 cfs was measured below the confluence of Camp Creek in June. Stream flow probably ranges from 20 to 300 cfs during the ice-free season.

The substrate is predominantly large cobbles and boulders. Alder and willow thickets grow to the water's edge, with some cottonwoods scattered throughout the narrow floodplain. No log debris was observed in the channel. Juvenile Dolly Varden were collected in the vicinity of the staff gauges (1981).

Camp Creek: This stream has a steep gradient and consists primarily of riffles/rapids. The channel is primarily triangular with an average top width of 10 feet. Depths averaged 0.5 to 1 foot.

A discharge of 12 cfs was measured in June and flow probably ranges from 5 to 30 cfs during the ice-free season.

The substrate is predominantly large cobbles and boulders. Alders and willows cover the stream banks and overhang the stream. No log debris was observed in the channel. Juvenile Dolly Varden and rainbow trout were collected (1981).

Frank Creek: This stream reach (elevation 16,000 feet) has a moderate gradiant with 30% pool, 30% riffle and 40% run. Top width averaged 10 to 12 feet with average depths of 0.8 feet in pools, 0.3 feet in riffles and 0.5 feet in runs. Substrate is composed of small to medium gravels. The stream channel is rectangular with nearly vertical banks approximately 3 to 4 feet high. The stream banks were composed of sand and silt and supported willows and tall grasses. Some mass wasting was evident farther downstream where the stream cuts into a high bluff. One of the few beaver dams present was located upstream. The floodplain is covered with grasses and has several large marshy areas. High-water marks were apparent 6.5 feet above the stream bottom.

Upper Chuitna River (above Wolverine Fork): The stream gradient in this area is moderate, with a substrate consisting predominantly of large cobbles and boulders with a gravel-sand base. Considerably more sand- and silt-size particles occur in the Chuitna River above the confluence with Wolverine Fork.

The water courses in this area wind through distinct canyons where vegetation consists of grassy or muskeg meadows or patchy low willow and alder areas. Some active landslide areas are visible on the Chuitna above the confluence with Wolverine Fork, but the streams are clear and contain little sediment.

No barriers to fish migration are evident in this area. The substrate material appeared suitable for spawning by salmonids.

## NIKOLAI DRAINAGE

Nikolai Creek: Nikolai Creek has its headwaters on the plateau south of Capps Glacier, in a small lake about 2¼ miles south of the glacier, and about a mile west of the upper headwaters of Capps Creek and the Chuitna River. The creek flows off the plateau in a narrow valley and then crosses a small, flat area before plunging into a canyon cut through the Nikolai escarpment. The canyon is cut into Quaternary glacial debris consisting of gravel, silt, and boulders.

The creek then follows a course southeastward along the foot of the Nikolai escarpment for about 18 miles to empty into Trading Bay. Near the logging road crossing, slightly more than a mile west of Stedatna Creek, the creek is cutting only a few feet into Quaternary and Recent glaciofluvial sediments of sand and gravel. At the bridge, the creek banks are about 2 feet high, and composed principally of sand. Substrate is silt, sand, gravel, and small cobbles as much as 3 inches in diameter. Stream gradient is low. Stream banks at this point consist of find sand.

Nikolai Creek (vicinity of logging road bridge): The gradient of Nikolai Creek is very slight. The river meanders extensively through a muskeg floodplain, and banks are alternately characterized by thick muddy banks or grass-covered clayey banks. Clumps of alder and some individual spruce trees are scattered along the stream course. Substrate is principally clayey sand in the low-energy deposition areas; in other areas with higher velocities, considerably larger materials, specifically small to medium cobbles, are predominant. Considerable quantities of branches and twigs are found lying on or embedded in the clayey banks along the stream. Beaver sign is extensive in this area, as evidenced by the newly cut willow branches. Some man-made pollution enters this stream in the form of suspended silts and clays, as well as log debris, from upstream logging operations.

Stedatna Creek: Stedatna Creek begins in a muskeg flat about two miles northwest of Congahbuna Lake and flows southwest to its confluence with Nikolai Creek. The creek flows over the Nikolai escarpment, cutting a canyon about 50 feet deep into Quaternary deposits in the escarpment, consisting of gravelly sand with boulders up to 8 feet in diameter. Substrate is sand, gravel, cobbles, and boulders as much as 6 feet in diameter.

The stream gradient just above the logging road is moderate, and large boulders and cobbles are scattered throughout the stream course. Although this stream reach had been channelized in association with construction of the logging road, some grass lines the banks. Most of the riparian shrubbery and trees have been removed. The substrate is a heterogeneous mix ranging from sands through large boulders. Habitats upstream and downstream consist principally of a meandering stream cascading over cobbles and boulders. The stream passes through a cottonwood/birch/spruce forest with an alder and grass understory. This segment is approximately 20% pool, 80% riffle. No suitable salmonid spawning sites are apparent in the area.

Steep cascades downstream from the logging road crossing, as well as the culverts beneath the road, may create definite fish migration barriers. However, an adult rainbow trout was captured upstream from the culvert in 1981.

Pit Creek: This stream has clear water and the lower quarter mile has a moderate gradient with approximately 10% pools, 20% riffles, and 70% runs. The channel is rectangular with very steep banks. Few scour holes or undercut banks are apparent. Stream top widths averaged from 10 to 12 feet with an average depth of 1 foot. A discharge of 13 cfs was measured on June 1, and flow probably ranges from 10 to 50 cfs during the ice-free season.

The substrate is predominantly gravels and cobbles embedded in silts and sands. The substrate is tightly packed and has the appearance of being cemented together. Tall grass overhangs the banks and scattered alders and cottonwoods cover the floodplain. Dolly Varden and coho salmon juveniles and chinook salmon fry were collected in this reach (1981).

Upstream of River Mile 0.25 the gradient steepens and the stream is predominantly riffles. The substrate contains larger material, including large cobbles and boulders. A surber sample collected over large cobbles included water mites, midges, and larval forms of mayflies, caddiesflies, stoneflies, blackflies, snipeflies, and false craneflies.

Jo's Creek: This stream has clear water and the lower half mile has a moderate to flat gradient with 40% pools, 50% runs, and 10% riffles. The channel is rectangular with almost vertical banks. Several scour holes are present along the banks. Stream top widths averaged from 15 to 20 feet with an average depth of 1.5 feet. A discharge of 30 cfs was measured on June 1, and flow probably ranges from 5 to 60 cfs during the ice-free season.

The substrate is predominantly gravels and small cobbles with some fines. The substrate appeared cleaner and was composed of smaller particle sizes than those present in Pitt Creek. Tall grass overhangs the stream banks, and scattered alders and cottonwoods cover the floodplain. Little log debris was present in the stream. Juvenile Dolly Varden and coho salmon and Dolly Varden fry were collected (1981). A surber sample collected over small cobbles included larval forms of mayflies, stoneflies, caddiesflies, crane-flies, and false craneflies.

Above River Mile 0.5 the gradient steepens and the stream becomes riffle/run/rapids. Substrate particle sizes increase to large cobbles and boulders.

## CONGAHBUNA

Congahbuna Creek: Congahbuna Creek is a small creek that begins in Congahbuna Lake and flows southeast and north to its confluence with Old Tyonek Creek about one to two miles above Beshta Bay. The creek runs principally through a region of peaty soils and muskegs, underlain by Quaternary sands and gravels. The substrate near the stream junction is silty fine sand, but upstream a few hundred yards the substrate is gravelly. The stream gradient is low. At the junction of Congahbuna Creek and Old Tyonek Creek, the substrate is sand, gravel, and some cobbles as large as 2 inches in diameter. The stream gradient is low. Stream bank materials at this site consist of silt and fine sand.

Muskrat Creek: Muskrat Creek is a small creek that begins in a small lake just north of Granite Point and flows north for slightly more than a mile to its confluence with Congahbuna Creek. Its course is predominantly across muskeg flats underlain by Quaternary sand and gravel. The substrate is silty fine sand with organic material and is stained red. The stream gradient is low (almost imperceptible).

Both Muskrat Creek and Congahbuna Creek meander slowly through a muskeg bog. Stream bank vegetation is principally tall grass, which overhangs the stream providing extensive cover. Muskrat Creek, which originates in a small lake about three-quarters of a mile to the south is a tea-colored stream with a bottom comprised of organic silty-sand material. The entire course of this tributary appears to be one long slow run, with no true riffles or pools. However, the uppermost section of this stream near the lake from which it originates was not observed. Congahbuna Creek is also tea-colored and is characterized by a long slow run, and an organic silty-sand substrate. Submerged grass is also visible. Downstream from the confluence with Muskrat Creek, Congahbuna Creek develops a series of riffles and pools in a near 50:50 ratio.

Old Tyonek Creek: Old Tyonek Creek begins in a small lake, about two miles southeast of the confluence of Chuit Creek and the Chuitna River, and runs about nine miles to Cook Inlet, emptying into the sea at Beshta Bay. The creek's entire course is through Quaternary glaciofluvial deposits of sand, gravel, and boulders. The creek valley is relatively flat with low banks 6 to 10 feet in height. Substrate is sand, gravel, and cobbles as much as 3 inches in diameter. The stream gradient is low.

Tall grass extensively overhangs the stream banks. Small patches of willow and alder thickets with scattered birch, cottonwood, and spruce trees provide the primary overstory. The substrate type is a medium to fine gravel embedded in sand. Isolated patches of armored substrate are present. Flooding is evidenced by a water mark about 5 to 8 feet above the water surface. Stream banks are deeply undercut, and some sloughing of bank materials was observed. With the slight gradient present throughout the stretch below Congahbuna Creek, the river exhibits a ratio of about 60% run/pool to 40% riffle providing excellent spawning habitat.

° Fishes

A comprehensive survey of the seasonal use, distribution and abundance of fish in the Beluga region has not been performed. Four species of Pacific salmon are known to inhabit the Chuitna River system and the mainstream of the Chuitna is an important king salmon spawning stream. The occurrence of the fifth species, the sockeye, is questionable though it may be found near the mouth of the Chuitna. Figure 5.2 displays a preliminary overview of the species distribution and spawning areas. The

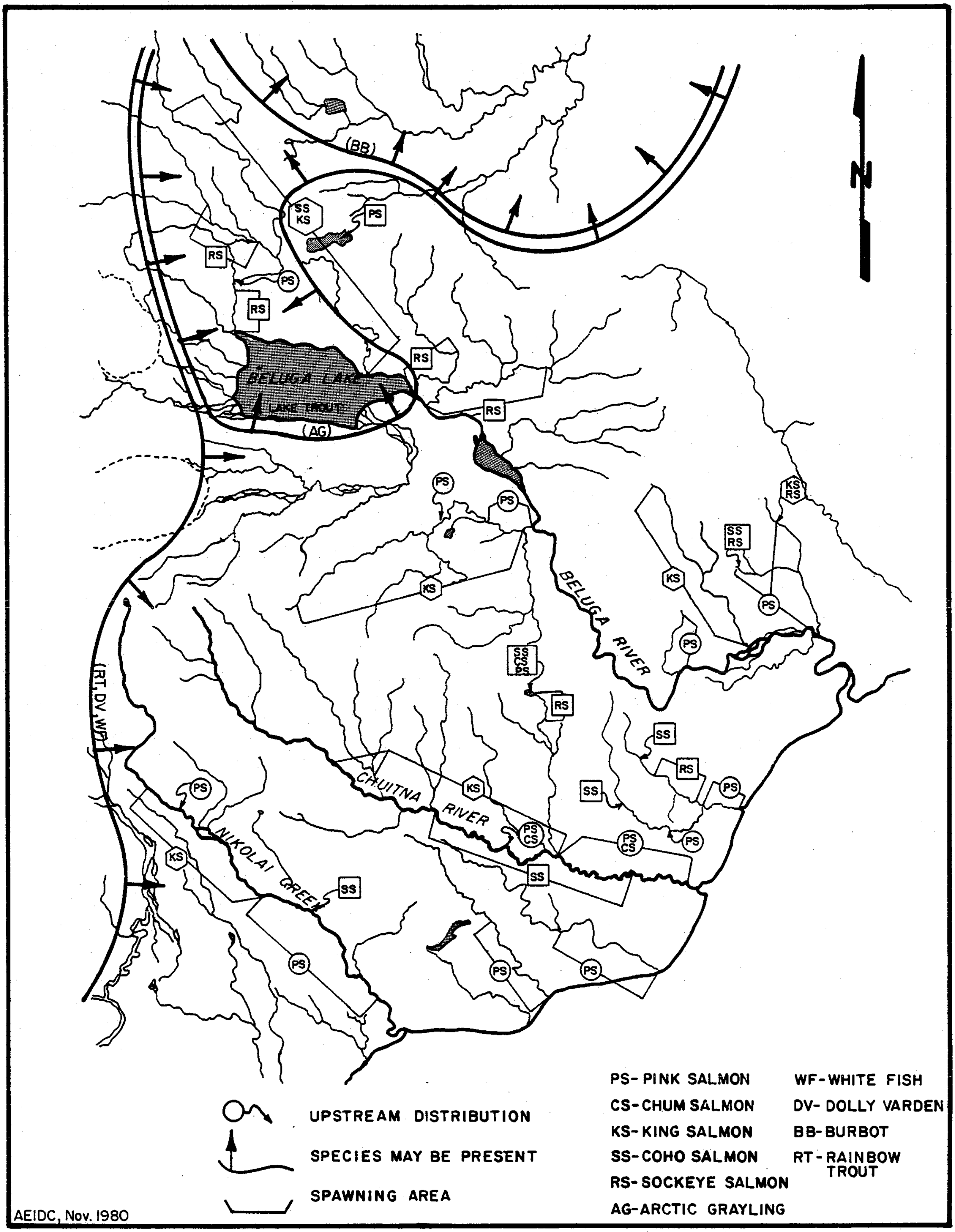



FIGURE 5.2 SPECIES DISTRIBUTION AND SPAWNING AREAS

completion of the 1981 field program will provide further insight into both distribution and habitat utilization.

Chuit Creek is a known king salmon spawning area, and both pink and chum salmon spawn in the Chuitna from Lone Creek to the mouth of the river. Estimates of the abundance of the annual return to the Chuitna system are:

| | |
|---|---|
| Pinks | 100,000 even years |
| Chums | 20,000 odd years |
| Coho | few |
| Kings | 5,000 |
| Rainbow Trout | ? |
| Dolly Varden | ? |

Nikolai Creek provides spawning for king, coho, and pink salmon and pink salmon also spawn in Old Tyonek Creek. Nikolai Creek is known for its rainbow trout and Congahbuna Lake supports a resident rainbow population.

The various Pacific salmon of Cook Inlet are discussed in some detail later in this section under Marine Species, and Table 5.1 provides a summary of selected life history data.

Table 5.2 illustrates the type of data being obtained from the 1981 field program relative to determining the presence or absence of species. Emphasis during this period was to determine the presence or absence of juveniles and observe the return of adult fish to the system. No outmigration or preemergent work was accomplished in 1981.

Table 5.3 is a checklist of the probable freshwater species of the Beluga region (not all species have been confirmed by this program).

Table 5.1

LIFE HISTORY DATA FOR FIVE SPECIES OF PACIFIC SALMON*

| | Chinook (King) | Pink | Sockeye (Red) | Coho (Silver) | Chum (Dog) |
|---|---|---|---|---|---|
| Freshwater habitat | Large Rivers | Short Streams | Short Streams & Lakes | Short Streams & Lakes | Short & Long Streams |
| Length of time young stay in fresh water | 3 to 12 mos. | 1 day or less | 1 to 3 yrs. | 1 to 2 yrs. | Less than 1 mo. |
| Length of ocean life | 1 to 5 yrs. | 1-1/3 yrs. | ½ to 4 yrs. | 1 to 2 yrs. | ¼ to 4 yrs. |
| Year of life at maturity (years) | 2 to 8 | 2 | 3 to 7 | 2 to 4 | 2 to 5 |
| Average length at maturity (inches) | 36 | 20 | 25 | 24 | 25 |
| Range of length at maturity (inches) | 16 to 60 | 14 to 30 | 15 to 33 | 17 to 36 | 17 to 38 |
| Average weight at maturity (pounds) | 22 | 4 | 6 | 10 | 9 |
| Range of weight at maturity (pounds) | 2½ to 125 | 2 to 9 | 1½ to 10 | 3 to 30 | 3 to 45 |
| Principal spawning months | Aug - Sept | July - Sept | July - Sept | Sept - Dec | Sept - Nov |
| Fecundity (number of eggs) | 5,000 | 2,000 | 4,000 | 3,500 | 3,000 |
| Principal spawning habitats | Sands & gravels (coarse) | Silts & small gravel | Fine to large gravels | Fine to coarse gravels (5 cm) | Fine gravels (2.5 cm) |
| Principal rearing habitat | Cool, clear streams | Estuarine | Lakes & ponds | Pools in streams | Streams |

* Exceptions to these general descriptions occur frequently.

Table 5.2

SELECTED FISH TRAPPING DATA
NIKOLAI DRAINAGE (JUNE 1981)

| Location | Date | Species Captured | |
|---|---|---|---|
| Nikolai Creek | 6/6 | Adult Chinook Salmon | (8)* |
| | 6/2 | Juvenile Chinook Salmon | (4) |
| | 6/2 | Juvenile Coho Salmon | (24) |
| | 6/2 | Coho Salmon Fry | (2) |
| | 6/6 | Adult Rainbow Trout | (10)* |
| | 6/2 | Juvenile Rainbow Trout | (3) |
| | 6/2 | Juvenile Dolly Varden | (25) |
| | 6/2 | Coastrange Sculpin | (13) |
| | 6/2 | Threespine Stickleback | (1) |
| Jo's Creek | 6/2 | Chinook Salmon Fry | (1) |
| | 6/2 | Juvenile Coho Salmon | (2) |
| | 6/2 | Juvenile Dolly Varden | (3) |
| | 6/2 | Coastrange Sculpin | (2) |
| Pitt Creek | 6/2 | Chinook Salmon Fry | (2) |
| | 6/2 | Juvenile Coho Salmon | (2) |
| | 6/2 | Juvenile Dolly Varden | (3) |
| Stedatna Creek | 6/2 | Juvenile Chinook Salmon | (1) |
| | 6/2 | Juvenile Coho Salmon | (4) |
| | 6/2 | Juvenile Dolly Varden | (4) |

*by angler (hook & line)

Table 5.3

CHECKLIST OF THE FRESHWATER FISH OF BELUGA AREA*

| | |
|---|---|
| Pacific Lamprey | Entosphenus tridentatus |
| Arctic Lamprey | Lampetra japonica |
| Green Sturgen | Acipenser medirostris |
| Pacific Herring | Clupea harenque pallasi |
| American Shad | Aloza sapidissima |
| Pygmy Whitefish | Prosopium coulteri |
| Round Whitefish | P. cylindraceum |
| Rainbow Trout | Salmo gairdneri |
| Lake Trout | Salvelinus namaycush |
| Dolly Varden | S. malma |
| Sockeye Salmon (red or blue back) | Oncorhynchus nerka |
| Coho Salmon (silver) | O. kisutch |
| King Salmon (chinook) | O. tshawytscha |
| Chum Salmon (dog) | O. keta |
| Pink Salmon (humpy) | O. gorbuscha |
| Arctic Grayling | Thymallus arcticus |
| Pond Smelt | Hypomesus olidus |
| Surf Smelt | H. pretiosus |
| Eulachon (hooligan) | Thaleichthys pacificus |
| Longrose Sucker | Catostomus catostomus |
| Burbot | Lota lota |
| Saffron Cod | Elegimus graccilis |
| Threespine Stickleback | Gasterosteus aculeatus |
| Ninespine Stickleback | Pungiltius pungitius |
| Slimy Sculpin | Cottus cognatus |
| Coastrange Sculpin | C. aleuticus |
| Pacific Staghorn Sculpin | Clinocottus acuticeps |
| Starry Flounder | Platichthys stellatus |

* Including anadromous species and the marine species of brackish estuaries.

Figure 5.2 shows the location of all reaches sampled by trapping and angling during the period May to early August 1981. In addition, aerial observations were made on numerous streams at various times during the field season (Table 5.4 is an example) and all of the streams within the study area, with the exception of those in the Bishop Creek System, have been examined in part both from the air and the ground. Figure 5.3 shows those areas where adult king salmon wre observed in July and August 1981.

° Invertebrates

Only preliminary studies of the benthic invertebrate community have been undertaken by the USGS and only general sampling of these communities is part of the 1981 field program. Table 5.5 illustrates the results from basket samples taken at two stations of the Chuitna River by the USGS.

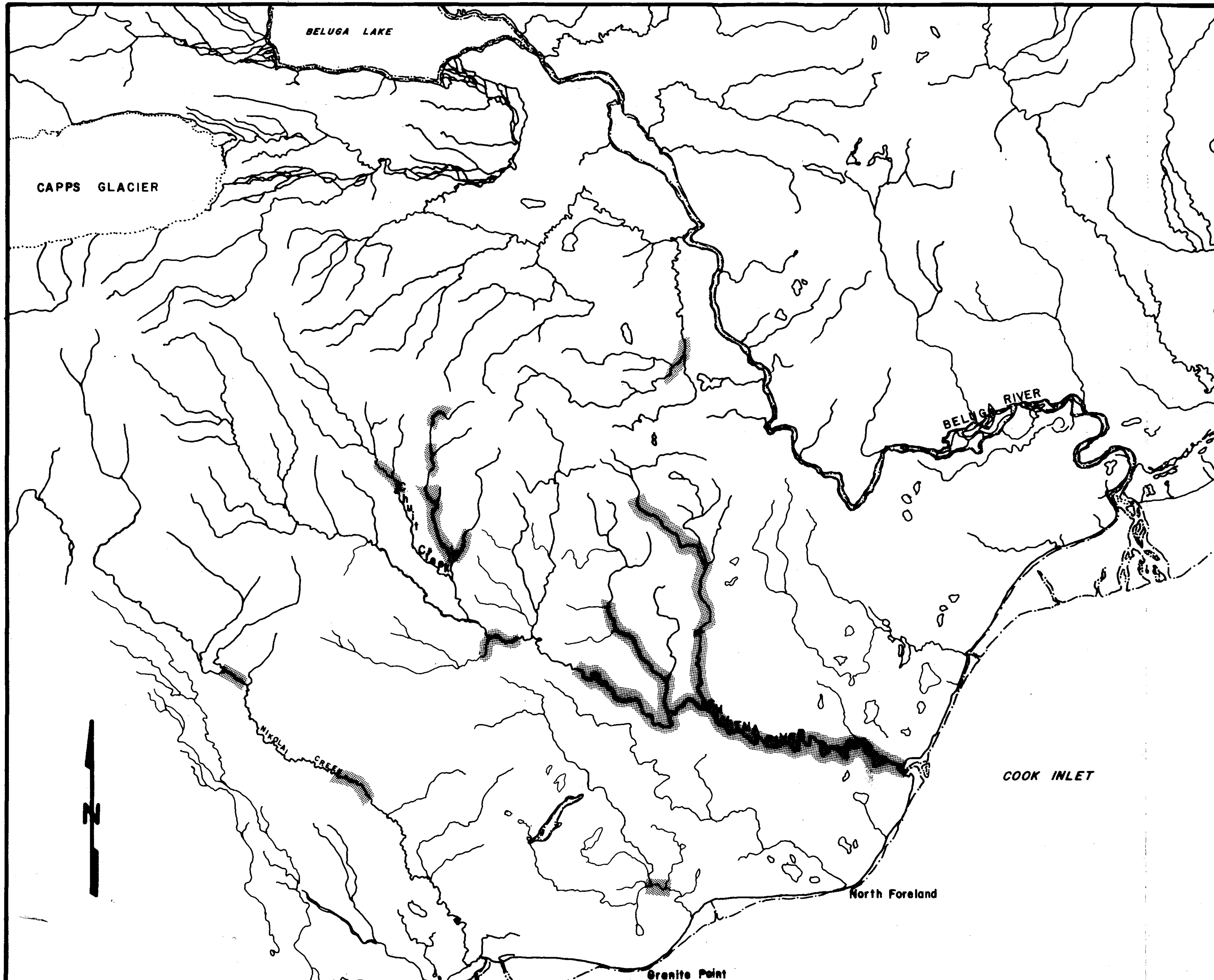
## TERRESTRIAL ECOLOGY

### Existing Vegetation

A generalized vegetation map adapted from the map, "Major Ecosystems of Alaska" prepared by the Federal-State Land Use Planning Commission in 1973, is shown in Figure 5.4. Terrestrial vegetation in the region includes four general vegetative types:

- upland spruce - hardwood forest
- high brush
- wet tundra
- alpine tundra

The upland spruce - hardwood forest is a fairly dense, mixed forest of white spruce, paper birch, quaking aspen, black cottonwood and balsam poplar occupying major portions of the benchland in the re-




LEGEND

AERIAL OBSERVATIONS OF ADULT KING SALMON

AREAS WHERE ADULT KING SALMON WERE OBSERVED

(JULY-AUGUST, '81)

FIGURE 5.3

Table 5.4

CHINOOK SALMON AERIAL SURVEY

August 3, 1981*

| LOCATION | NUMBER |
|---|---|
| Chuitna River below mouth of Lone Creek | 71 |
| Lone Creek | 207 |
| Middle Creek | 26 |
| Cole Creek | 2 |
| Frank Creek | 2 |
| East Fork of Chuit Creek | 32 |
| Nikolai Creek above Jo's Creek | 0 |
| Jo's Creek | 0 |
| Pitt Creek | 0 |
| Camp Creek | 3 |

* By helicopter; observers JB, JT and RD.

Table 5.5

BENTHIC INVERTEBRATE COMMUNITY

Analysis of Basket Samples
Chuitna River Near Tyonek

| | 10/18/77 #50 | 3/29/78 #60 | Sampling Dates Station Number |
|---|---|---|---|
| INSECTS | | | |
| Ephemeroptera nymphs (May Flies) | | | |
| Baetis sp | -- | -- | |
| Ephemerella doddsi | -- | -- | |
| Ephemerella inermis | 2 | -- | |
| Ephemerella sp | -- | 1 | |
| Plecoptera nymphs (Stone Flies) | | | |
| Capnia sp | -- | -- | |
| Hastaperla brevis | -- | 6 | |
| Isoperla ebria | -- | 2 | |
| Isoperla sp | -- | 6 | |
| Pteronarcella badia | -- | -- | |
| Taenionema nigripenne | -- | -- | |
| Taenionema sp | -- | 3 | |
| Zapada cintipes | 2 | 6 | |
| Zapada frigida | -- | 3 | |
| Trichoptera larva (Caddis Flies) | | | |
| Apatania sp | -- | -- | |
| Arctopsyche ladogensis | -- | 2 | |
| Brachycentrus sp | 1 | 4 | |
| Ecclisomyia sp | -- | -- | |
| Glossosoma sp | -- | -- | |
| Homophylax sp | -- | -- | |
| Molanna sp | -- | 1/1P | |
| Onocosmoecus sp | 4 | 7 | |
| Psychoglypha subbarealis | -- | -- | |
| Rhyacophila sp | -- | -- | |
| Diptera larva (True Flies) | | | |
| Tipulidae larva (Crane Flies) | | | |
| Dicranota sp | -- | 1 | |
| Hexatoma sp | -- | -- | |
| Limnophila sp | -- | -- | |
| Ormosia sp | -- | -- | |

Table 5.5
(Continued)
BENTHIC INVERTEBRATE COMMUNITY

| | 10/18/77 | 3/29/78 | Sampling Dates |
|---|---|---|---|
| | #50 | #60 | Station Number |
| Simuliidae larva (Black Flies) | | | |
| Prosimulium sp | 3 | 1 | |
| Similium sp -- | -- | | |
| Chironomidae larva (midges) | | | |
| Arcto or Conchapelopia sp | -- | -- | |
| Brillia sp | -- | -- | |
| Cladotanytarsus sp | -- | -- | |
| Conchapelopis sp | -- | -- | |
| Cricotopus sp 3 | -- | -- | |
| Diamesa sp 1 | 1 | 1 | |
| Diamesa sp 2 | -- | -- | |
| Eukiefferiella sp | 7 | 17 | |
| Micropsectra sp | 3 | -- | |
| Orthocladius sp | 1 | -- | |
| Polypedilum sp | -- | -- | |
| Potthastia sp | -- | -- | |
| Procladius sp | -- | 2 | |
| Rheotanytarsus sp | -- | -- | |
| Tanytarsus sp | -- | 8 | |
| Trissocladius sp | -- | -- | |
| Thienemanniella sp | -- | 6 | |
| Ceratopogonidae larva (Biting Midges) | | | |
| Palpomyia sp | -- | -- | |
| Empididae larva (Dance Flies) | -- | -- | |
| Psychodidae larva (Moth Flies) | | | |
| Pericoma sp | 1 | 2 | |
| MISCELLANEOUS ORGANISMS | | | |
| Acari (Water Mites) | | | |
| Limnesia sp | -- | -- | |
| Sperchon sp 1 | -- | -- | |
| Total Number of Organisms | 25 | 80 | |
| Total Number of Taxa | 10 | 19 | |
| Number of Taxa - Insects Only | 10 | 19 | |
| Total Number of Insects | 25 | 80 | |
| Diversity Index - Insects Only | 3.00 | 3.79 | |
| Pooled: Total Number of Insects | 105 | | |
| Pooled: Diversity Index - Insects Only | 3.92 | | |

P Indicates pupa stage.

gion extending from sea level to more than 1,000 feet in elevation. Black spruce generally occupies areas of poor drainage; pure stands of white spurce and mixed stands of cottonwood and poplar often occur along stream courses. Successional stages following fire are birch on the east- and west-facing slopes with aspen following willow on south-facing slopes. Either of these stages provides good browse for moose. Some Sitka spruce occur as far north as the southern slopes of Mt. Susitna and some small stands are found near Tyonek. Sitka spruce hybridize with white spruce making identification difficult. Some mountain hemlock is also found in the vicinity of Tyonek. The endemic spruce beetle, *Dendroctonus rufipennis*, has destroyed thousands of acres of forest in the Beluga region. Principal species include:

| | |
|---|---|
| White spruce | *Picea glauca* |
| Black spruce | *Picea mariana* |
| Quaking aspen | *Populus tremuloides* |
| Paper birch | *Betula papyrifera* |
| Black cottonwood | *Populus balsamifera trichocarpa* |
| Balsam popular | *Populus balsamifera balsamifera* |
| Willow | *Salix* |
| Alder | *Alnus* |
| Rose | *Rosa* |
| High-bush cranberry | *Viburnum edule* |
| Lingenberry | *Vaccinium vitis-idaea minus* |
| Raspberry | *Rubus* |
| Currant | *Ribes* |

The dominant species in the high brush vegetative type range from dense willows to dense alder. This type occupies a wide variety of soil types and often occurs as pure thickets in coastal lowlands and floodplains. Occasional trees including aspen, birch, and spruce may be present but are generally widely scattered. Principal species include:

| | |
|---|---|
| Sitka alder | Alnus crispa sinuata |
| Green alder | Alnus crispa |
| Thinleaf alder | Alnus incana tenuifolia |
| Devil's club | Echinopanax horridum |
| Willow | Salix |
| Currant | Ribes |
| Blueberry | Vaccinium |
| Raspberry | Rubus |
| Soapberry | Shepherdia canadenus |
| Lingenberry | Vaccinium vitis-idaea minus |
| Spirea | Spirea beauverdiana |
| Thimbleberry | Rubus parviflorus |
| Salmonberry | Rubus spectabilis |
| Dogwood | Cornus |

The wet tundra vegetative type is generally a mat of vegetation occurring along tidal flats and other flat areas near sea level. This vegetative mat is dominated by sedges and cottongrass with scattered woody and herbaceous plants occurring on drier sites above the water table. Principal species include:

| | |
|---|---|
| Sedges | Carex |
| Cottongrass | Eriophorum |
| Lyme grass | Elymus arenarius |
| Pendant grass | Arctophila fulva |
| Bur reed | Sparganium |
| Mare's tail | Hippuris |
| Rushes | Juncus |
| Willow | Salix |
| Dwarf birch | Betula nana exilis |
| Labrador tea | Ledum palustre groenlandicum |
| Cinquefoil | Potentilla fruiticosa |
| Lingenberry | Vaccinium vitis-idaea minus |
| Bog cranberry | Oxycocus microcarpus |

Alpine tundra is generally found at the higher elevations and is comprised primarily of low mat plants, both shrubby and herbaceous. Principal species include:

| | |
|---|---|
| Resin birch | Betula glandulosa |
| Dwarf birch | Betula nana exilis |
| Arctic willow | Salix arctica |
| Crowberry | Empetrum nigrum |
| Labrador tea | Ledum palustre groenlandicum |
| Mountain heather | Phyllodoce |
| Rhododendron | Rohododendron lapponicum |
| Dwarf blueberry | Vaccinium caespitosum |
| Alpine blueberry | Vaccinium uliginosum alpinum |
| Alpine bearberry | Arctostaphylos alpina |
| Mountain avens | Dryas |
| Moss campion | Silene acaulis |
| Arctic sandwort | Minuartia arctica |
| Cassiope | Cassiope |
| Alpine azalea | Loiseluria procumbens |
| Sedges | Juncus |
| Lichens | |
| Mosses | |

A more detailed vegetation map of the region is currently being prepared by the U.S. Forest Service Laboratory of the Pacific Northwest Experiment Station as part of the Susitna Basin Project. It is anticipated that this map will be available in 1982. The classification system being utilized is unique for the project and is based on Viereck and Dyrness's 1980 "A Preliminary Classification System for Vegetation of Alaska". A modified vegetation map based primarily on the laboratory's preliminary photo-mapping is shown in Figure 5.5. This system classifies existing, not potential, vegetation and begins with four formations for terrestrial vegetation - forest, tundra, shrub, and herbaceous vegetation.

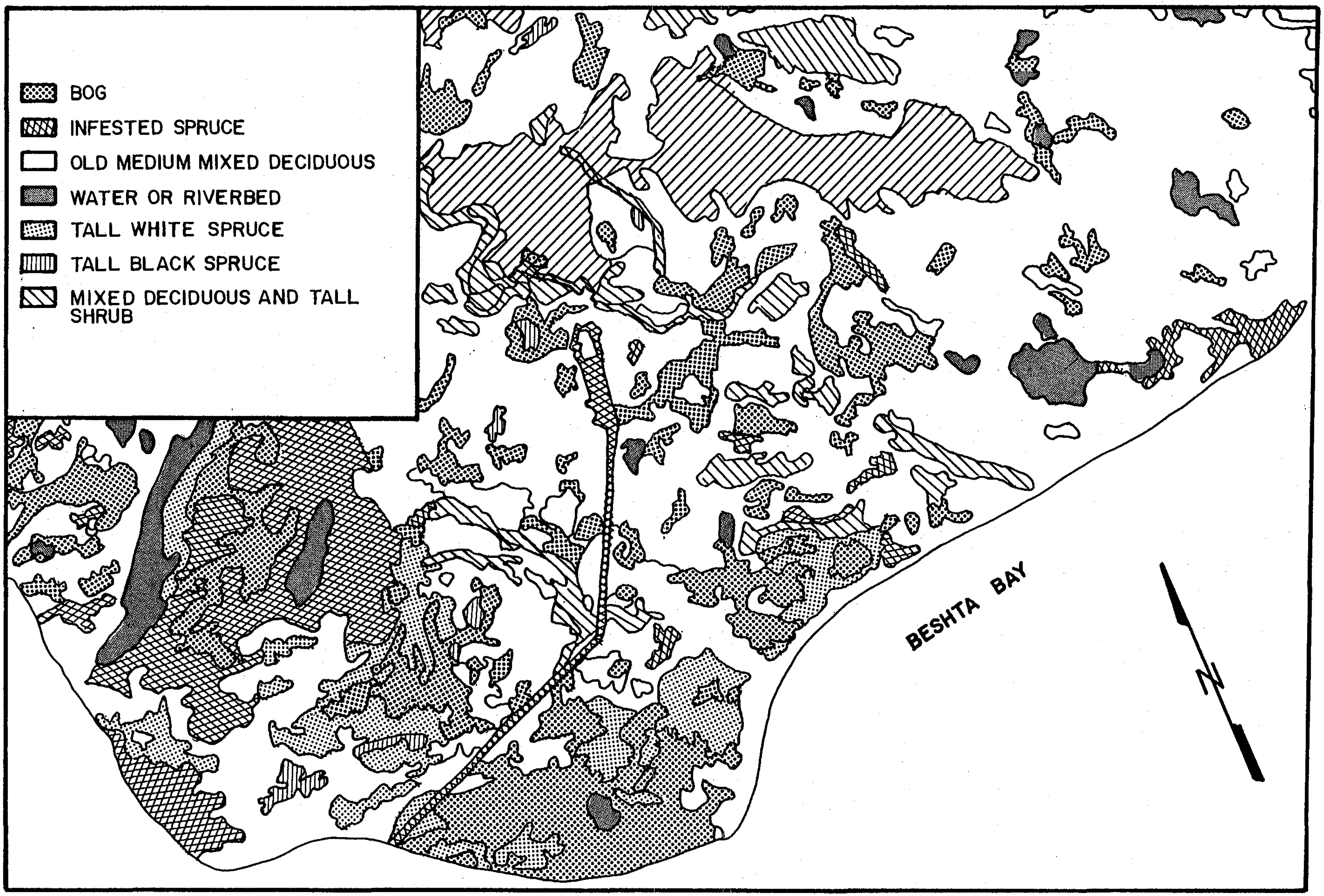



FIGURE 5.5 PRELIMINARY PHOTO INTERPRETATION VEGETATION MAP

Based on Murray's 1980 list of "Threatened and Endangered Plants of Alaska", only one species, the pale poppy Papaver alboroseum which is often found in alpine tundra, is known to occur in the region.

The plant communities described above will ultimately be related to successional stages and such regulating factors as altitude, soil and groundwater conditions, wildlife, and man's activities, as part of a continuing characterization of terrestrial habitats. Much of the necessary baseline data will result from the 1981 field activities of the SCS. It is anticipated that surficial soils data and ground-truth confirmation of photo vegetation types will be available in 1982.

### Wetlands

Wetlands constitute a large portion of the general area. The COE (Regulatory Program, July 19, 1977, Part 323, Section 323.2) provides the following definition:

> c) The term "wetlands" means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient 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.

The U.S. Fish and Wildlife Service has mapped portions of western Cook Inlet at a scale of one inch to the mile as part of the National Wetlands Inventory. This inventory has been curtailed by budgetary constraints and it is not known when such information for the general project area will become available.

The COE has made a preliminary wetlands determination in the Beluga area and that determination is shown in Figure 5.6.

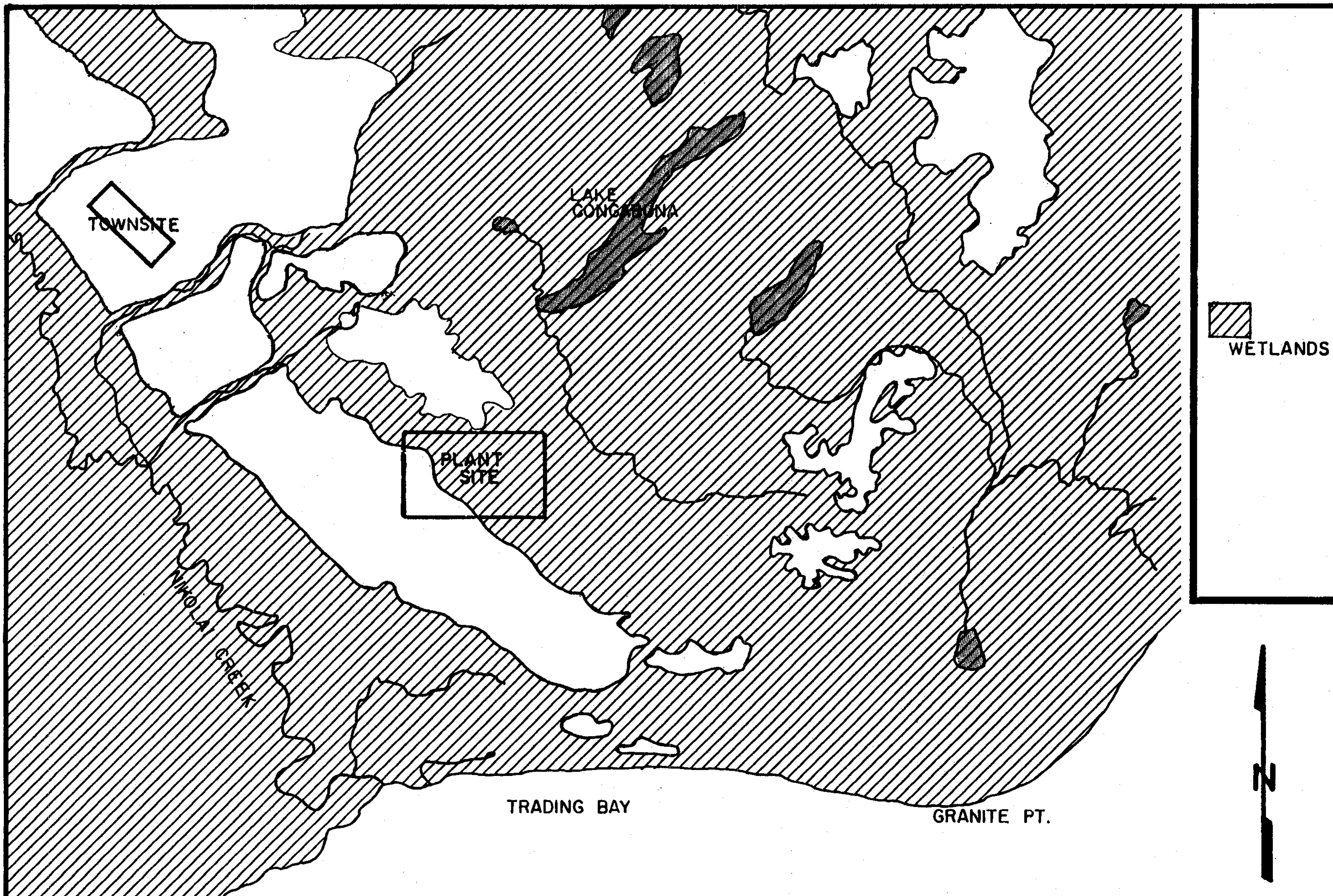


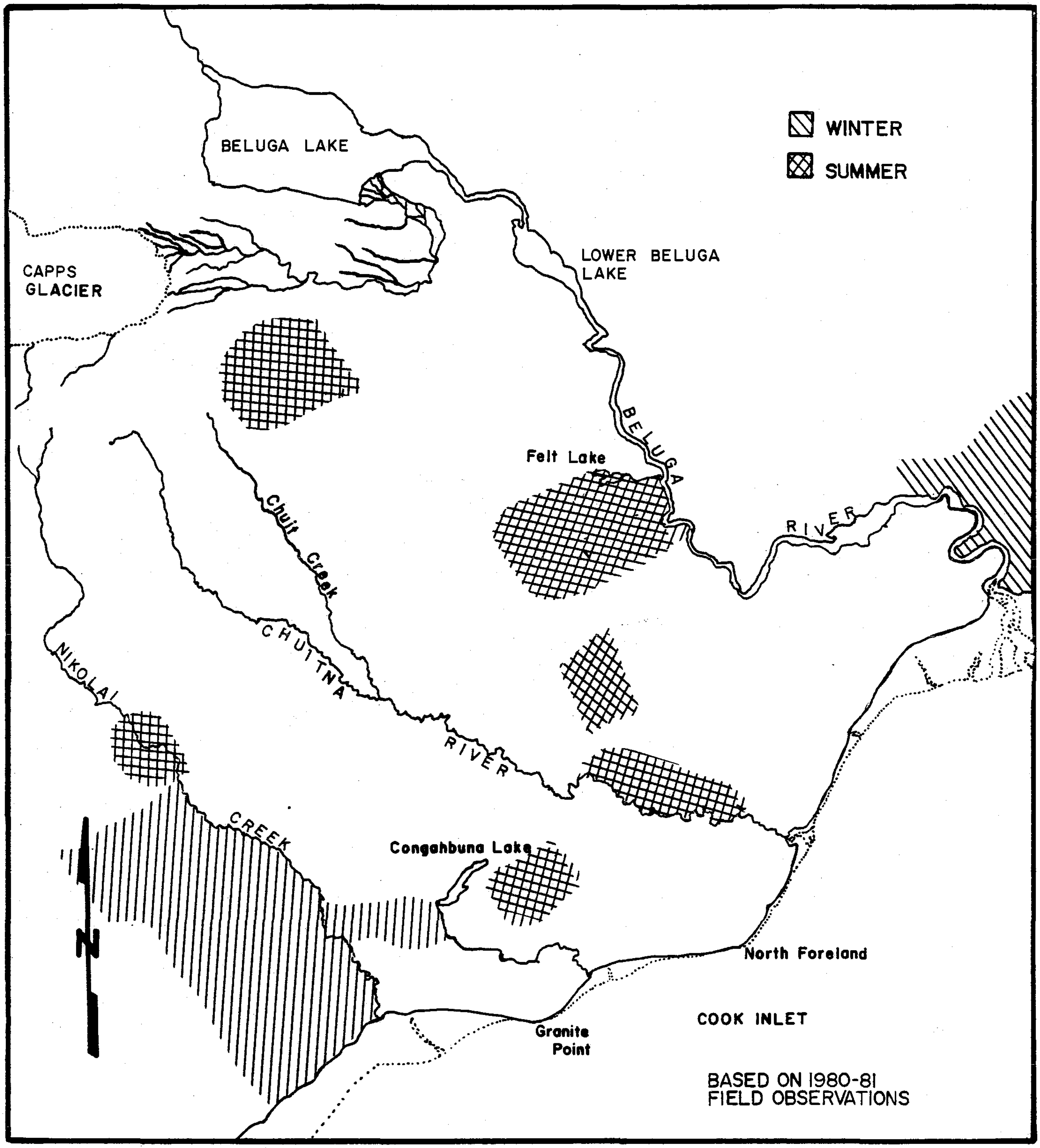

FIGURE 5.6 PRELIMINARY DETERMINATION OF WETLANDS

The above wetland classifications or determinations will not of themselves portray wetland resources in sufficient detail to assess environmental impacts of site specific activities. Different types of wetlands vary in value, extent, and associated use by wildlife and this will be assessed on a site specific basis.

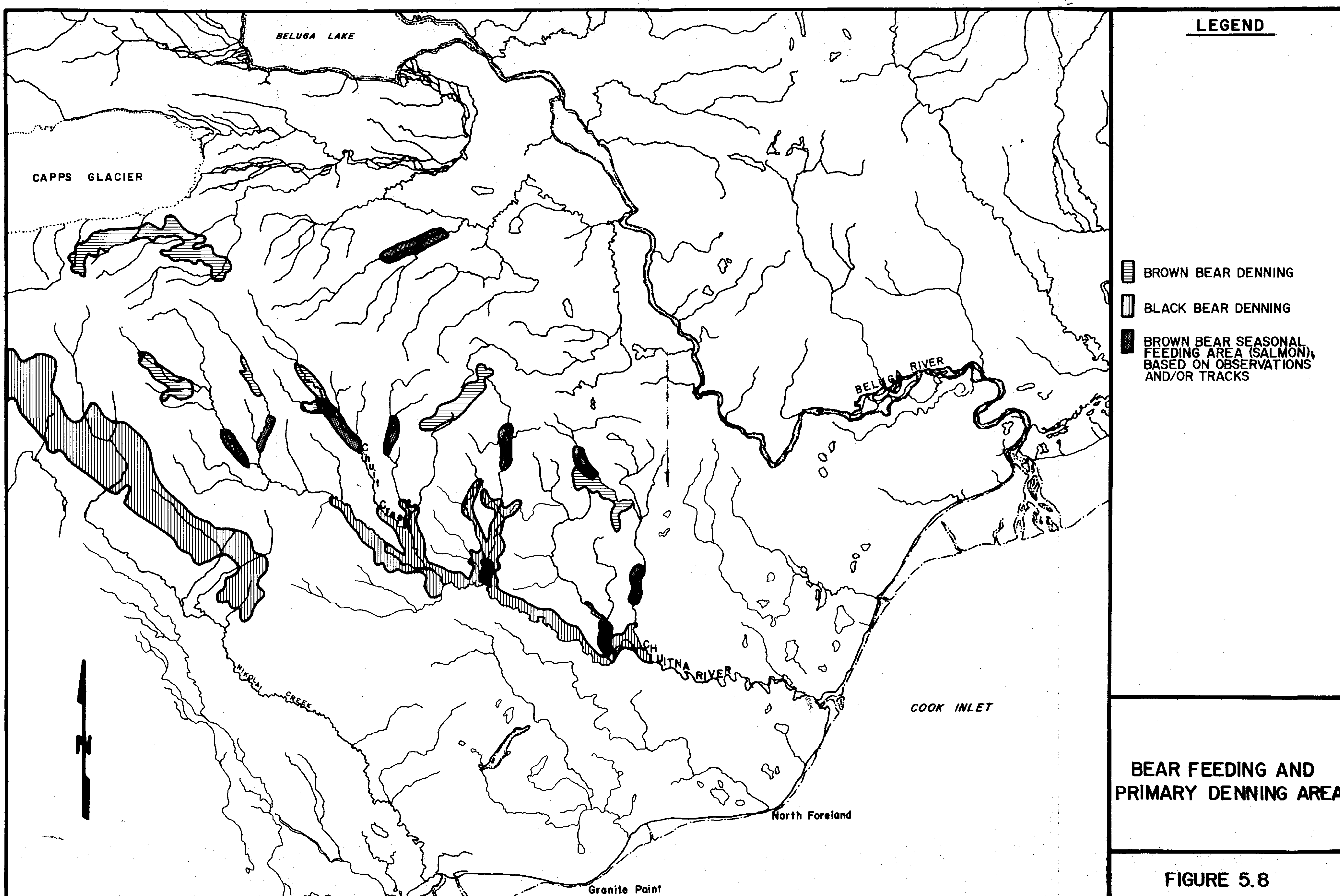
Existing Mammal Populations

The brown bear (*Ursus arctos*), the black bear (*Ursus americanus*), and the moose (*Alces alces*) are the principal species of large mammals found within the general project area. All three species can be considered common and widespread throughout the area. Moose are often locally abundant; most bears are transient using the area on a seasonal basis. Seasonal concentrations of moose are shown in Figure 5.7; known seasonal feeding areas along salmon streams for bears are shown in Figure 5.8 as are primary denning areas. Other denning areas most likely occur within the region, as do other feeding areas along streams supporting seasonal runs of Pacific salmon. The wolf (*Canis lupus*) is not common within this area but has been observed in the Trading Bay State Game Refuge. Three wolves were also observed in the Capps area in August 1981 above the headwaters of Wolverine Fork.

Brown bears reach minimum breeding age at 4½ to 6½ years of age; most males reach sexual maturity at 4 to 6 years (average 5½). The bears mate in May or June and cubs are born the following February or March. Denning in the study area probably begins in November, with younger and pregnant female bears denning earlier. Most bears remain in their dens until May, although they may emerge for brief periods if disturbed or during stretches of mild weather. The cubs remain with the sow for two years and are then abandoned in the third year before the sow breeds again. Litters of cubs and yearlings contain, on the average, slightly more than two cubs. A postnatal mortality differential between cubs and yearlings makes this "average" somewhat questionable.




| FIGURE 5.7 | SEASONAL CONCENTRATION OF MOOSE |
|---|---|




BEAR FEEDING AND PRIMARY DENNING AREA

FIGURE 5.8

Brown bears usually leave their dens in May and may move to the lower elevations or even onto the beaches, feeding on animal carcasses cast up during the winter storms. More typically, the bears remain at mid-elevations for various reasons both sociological and physiological. Inland bears may opportunistically utilize "moose yards" for winter kills and prey on moose calves at the calving grounds. As spring progresses, green vegetation becomes the principal diet, and as the snow retreats, the bears follow the spring growth to higher ground. Green vegetation, with occasional small mammals, carrion, roots, and other plant materials, form the mainstay of the diet until berries and salmon become available during the summer. Soon after they reach the spawning streams, salmon become the primary component of their diet, and the bears remain near the streams throughout the summer, supplementing their diet with plants and berries. After the salmon runs are complete, brown bears feed largely on berries, roots, and green vegetation, and occasional small mammals and carrion.

° <u>Brown Bear Denning</u>

Brown bears prepare dens by digging into hillsides usually at an altitudinal range of 300 to 750 meters (m) (1,000 to 2,500 feet). This zone provides certain environmental conditions favorable to winter denning including moderate, ambient temperatures during cold intervals, a relatively stable snowpack that insulates the den cavity, and an interwoven complex of vegetation that supports the snowpack (drifting) and den cavity (soil binding by root systems).

Dens generally have a single entrance, a chamber, and in some cases, a connecting tunnel. They are occupied from October or November until April or May and when abandoned, thawing and erosion soon cause them to collapse. Rocky caves and natural cavities may be appropriated or modified for use and reuse as winter dens.

Denning habitat of brown bears may be delineated by subjectively evaluating the principal criteria leading to site selection: elevation and slope, soil/rock substrate, and vegetation. The best snow conditions during the denning period are generally at intermediate elevations. Higher levels above the vegetation zone (635 m or 2,000 ft plus) tend to have erratic and unstable snow conditions characterized by massive drifting, wind scouring, icing, heavy crusting and avalanches, and provide marginal denning opportunities. Sea level temperatures are above freezing later in the winter and snow cover may not be sustained at lower elevations. Temperatures at the 300 m (1,000 ft) level may average lower than at sea level and, therefore, permit the snowpack to increase in depth. Later, during spring, lower temperatures at higher elevations permit snow cover to remain longer than at lower elevations. The insulating property of snow has been recognized as an essential element of successful denning of polar and brown bears (Craighead and Craighead 1972; Lentfer and Hensel 1978, Lentfer et al. 1972). Intermediate levels also provide a warmer air stratum compared to lower and higher elevations since temperature inversions prevail during midwinter cold snaps in calm conditions. Site preference probably is also a function of slope as an incline aids in excavation--soil material can be easily deposited downhill from the den entrance. An incline also provides site drainage during thaws and spring snowmelt.

Suitable soil condition is a major criterion for den site selection. Generally of shallow depth, alpine soils are easily pulverized and lack the cohesive properties of soils found at lower elevations. At upper elevations dens supported by subsurface freezing are likely to collapse during warm periods and be abandoned prematurely. Although suitable soil conditions occur at lower elevations, site selection at this level may be precluded by colder temperatures during midwinter cold snaps, reduced insulation qualities of snow, and insufficient drainage during snowmelt.

Den site selection appears to be related to the subalpine ecotone delineated by the upper limit of woody vegetation types, notably alder, willow, and dwarf birch. Root penetration by these and large herbaceous plants bind the soil and provide added support to the den cavity. At intermediate elevations vegetation affords concealment and enhances security. Standing vegetation also retains and stabilizes the snowpack by retarding wind erosion. Snow accumulation on semi-brushy sites seals the den entrance, inhibiting air transfer, and provides an insulative layer covering the entire den. Usable and marginal denning habitats in the Beluga area were delineated through direct aerial observation of bears, dens, and related signs, together with the site selection criteria described by Spencer and Hensel (1980). Three possible den sites were located in the upper reaches of the Wolverine Fork and the Chichantna drainages and in the Chuitna drainage. Actual occupancy of these sites was not verified by ground inspection. Distribution of tracks and bear sightings noted late in the period of den emergence indicated that denning activity is remarkably more intensive in the headwaters of the Chichantna River, and in hilly areas of North Capps Creek, and the mainstem of upper Capps Creek where the gentle relief the the plateau slopes abruptly and drainage systems form intervening gullies and steep-walled canyons. Considerable post-denning activity was noted in the upper Chuitna drainage, to a lesser degree in the upper Chuit drainage, and along the upper edge of the Nikolai escarpment. Most brown bear activity in the Beluga area is probably associated with this escarpment and steep slopes paralleling the upper Chuitna and its major tributaries where elevation exceeds 300 m (1,000 ft). At this altitude the snowpack is probably of sufficient depth, composition and duration to accommodate most of the brown bear denning occurring in the Beluga area. Canyons and tributary slopes provide good drainage and adequate shrub/herbaceous coverage are an added inducement for brown bear denning in these areas. Slopes and drainages near the Capps Glacier lack suitable soil and vegetation condition to be considered usable denning habitat. Rocky land outcroppings and large boulders along the bottom edges of tributary canyons may provide natural den sites for brown bears, but these situations appear to be limited in number.

Much of the Beluga area, because of its elevated plateau character and lowland tree cover, is unusable or marginal denning habitat for brown bears. That portion of the plateau stretching from Nikolai escarpment to Lone Ridge north to the Capps Glacier is of such gentle grade, sparse vegetation cover and gravelly sandy soils to virtually preclude denning. Approximately 20% of the delineated brown bear habitat is situated in the North Capps Creek lease area.

° <u>Brown Bear Movement and Activity Patterns</u>

The locations of established bear trails were noted on topographic maps from aerial and field observations. When there is no snow cover, such trails are prominent features on the landscape, patterns of which indicate the level and direction of movements to and from activity areas. Depending upon biological needs and habitat conditions, brown bears utilize two or more activity areas, which can be viewed merely as different portions of an all-encompassing range. Distances between activity areas also vary, since one or several drainages may be part of a year-around range of an individual bear.

The location of principal trail systems relates to topographic obstacles and cross country distance and/or access to activity areas, particularly those associated with seasonal food gathering. In the Beluga area, topography limits movements to and from adjacent areas. The high glaciated mountains preclude movements north of the moraine plateau. The extensive lowland marsh between Nikolai and the Chakachatna drainges deter westward movement because brown bears traveling across lowland areas have a proclivity to avoid open terrain. Logging operations in and around this sector also affect movement in this area. The absence of any established trails or recent signs indicative of traveling bears in this area supports this observation. To the east, the relatively large and fast-flowing Beluga River probably restricts brown bear movements parallel to the mountain range or Cook Inlet. The region's geomorphology limits the degree of interchange between brown bear subpopulations resident to the north side of Cook Inlet. Brown bears may, therefore, be considered in the Beluga area as a relatively discrete population with minimum interchange between adjacent subpopulations.

Feeding and socializing (breeding behaviorism) as distinct activities greatly influence the extent to which brown bears move. Individual tracks and bear sightings made during the post-denning (breeding) period indicated bears traverse the upper reaches of the plateau at an altitudinal range of 350 to 700 m (1,200 to 2,300 ft). Considerable movement activity of an exploratory nature was noted to occur along the eastward edge of the plateau in the headwaters of Bishop and Scarp creeks, and headwaters of the Chuitna and Wolverine Fork.

In the Nikolai area, a major travel route (Pit Creek) was found to connect the upper Chuitna and Nikolai drainages. The absence of any permanent bear trails across the marshy areas west of Nikolai Creek supports the supposition of limited population interchange.

- <u>Black Bears</u>

Black bears are generally considered open forest animals which tend to avoid both the denser forest and large open areas; this may not be typical of the southcentral portion of the range where black bears are found throughout the study area along principal stream courses. Primary denning habitat for black bears occurs along the Nikolai escarpment and forested portions of the upper Chuitna and Lone Creek drainages. It is estimated that less than 15% of the primary habitat for black bear denning occurs within the overall project area and even less in specific site locations.

Black bear usually reach maturity in their third year, although some females may not breed until they are 5 or 6 years of age. They mate in June or July and the cubs, usually two to three per litter, are born in the den in midwinter. Black bears in the study area generally emerge from their dens in May, though females with their cubs may emerge later and den earlier than others. Cubs are generally weaned by the next September after their birth, but may remain with a lactating sow for another winter.

Black bears eat a wide variety of plant and animal material. During the spring, grasses, sedges, and horsetail (Equisetum) make up the bulk of their diet. During the summer and early autumn, berries make up the larger portion of the diet. Black bears in general are less dependent on salmon runs than brown bears, but in the study area, concentrations along salmon streams indicate that salmon is an important component of the summer diet. In the fall, vegetation again becomes more important in the diet as salmon and berries become less and less available.

- Moose

Moose range throughout the study area and calve during the spring in areas of muskeg or swamps. One or two calves are the norm. Bulls and cows with calves from previous years usually summer on higher ground, and in early to mid fall move down the hills to lower elevations. Wintering grounds usually are in the lowlands and river valleys and may hold dense aggregations of moose in "moose yards". "Yarding" occurs primarily in response to heavy snow cover and difficult feeding conditions.

Moose eat a variety of vegetable matter including browse (woody plant stems, buds, leaves, bark, and twigs), lichens, fungi, grasses, and forbs (non-woody annual and perennial plants other than grasses). The percentage of each of these components in the diet is determined for the most part by its seasonal availability. Birch, which constitutes a large percentage of the diet, does not provide sufficient nutrition to support the moose for sustained periods.

Moose reportedly eat alder and willow preferentially throughout the year, but the quantity of these plants available to the moose is usually less than sufficient to comprise the bulk of the diet. Low browse, forbs, and other plant material are essential to moose diets. Typically, vegetation on the best moose range is in the earlier seral stages (i.e., 5 to 25 years old) of plant succession. Much of the area logged in recent years is now in excellent browse condition, particularly along the Nikolai escarpment.

Aerial observation of big game is continuing as part of the ongoing 1981 field program. Table 5.6 shows the results of a 2-day observation period in early June. Table 5.7 shows the results of the 1980 moose survey conducted by ADF&G.

Seasonal distribution of bears, moose, and other mammals can only be generally described considering the limits of the past and ongoing field studies. A more comprehensive mapping effort will be required to quantify the impacts on habitat of the project. The status and discreteness of both the moose and bear populations require additional field evaluation. Predator-prey relationships for big game and other species have not been described.

- Other Mammals

Other mammals known or considered to be present within the study area are:

| | |
|---|---|
| Red Fox | Vulpes fulva |
| Mink | Mustela vison |
| River of Land Otter | Lutra canadensis |

Table 5.6

MOOSE/BEAR OBSERVATIONS (AERIAL) JUNE 1-4, 1981

| Date 1981 | Obs. No. | Obs. | Location | Altitude | Brown Bear | Black Bear | Adult | Sub-adult | Uniden-tified | Females w/cubs | Females w/Yearling | Males | Females | Females w/calves | Uniden-tified |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/1 | - | H | Lower Chuitna | 300 | | | | | | | | | 1 | | 1 |
| 6/2 | 1A | T | Lower Capps Crk | 500 | | 1 | | | 1 | | | | | | |
| 6/2 | 1B | H | Lower Chuitna | 300 | | | | | | | | | | 1(2) | |
| 6/3 | 2H | H | Mid-Chuitna | 1,000 | | 1 | | | 1 | | | | | | |
| 6/3 | 3H | H | Mid-Chuitna | 500 | | | | | | | | 1 | | | |
| 6/3 | 4H | H | Lower Chuitna | 150 | | 1 | | | 1 | | | | | | |
| 6/3 | 5H | H | 3 Mile Creek | 250 | | | | | | | | 1 | | | |
| 6/3 | 6H | H | East Fork Chuitna | 600 | | 1 | | | 1 | | | | | | |
| 6/3 | 7C | H | S. Side Chichantna | 300 | 1 | | | | 1 | | | | | | |
| | 8C | H | Wolv. Crk E. Side | 1,500 | | | | | | | | 2 | 1 | | |
| | 9C | H | Upper Chichantna | 1,000[1] | | | | | | | | | | | |
| | 10C | H | Upper Chuitna | 1,300 | | 1 | | | 1 | | | | | | |
| | 11C | H | Lower Chuitna | 800 | | 1 | | | 1 | | | | | | |
| | 12C | H | Lower Chuitna | 200 | | | | | | | | | | 1 | |
| | 13C | H | Upper Chakachatna | 1,900 | 3 | | | | | 1(2) | | | | | |
| | 14C | H | Straight Creek | 500 | | 1 | | 1 | | | | | | | |
| | 15C | H | Straight Creek | 300 | | | | | | | | 1 | 2 | | 2 |
| | 16C | H | Upper Nikolai | 2,000 | 1 | | 1 | | | | | | | | |
| | 17C | H | Upper Chuit | 1,600 | | 1 | | 1 | | | | | | | |
| | 18C | H | Mid-Chuitna | 800 | | 1 | 1 | | | | | | | | |
| | 19C | H | Mid-Chuitna | 800 | | | | | | | | 1 | | | |
| | 20C | H | Lower Chuitna | 200 | | 1 | | | 1 | | | | | | |
| | 21C | H | Upper Wolverine | 1,700[1] | | | | | | | | | | | |
| | 22H | H | Mid-Chuitna | 375 | | 1 | | | | | | | | | |
| | 23C | H | Nikolai Creek | 900 | | 3 | | | | 1(2) | | | | | |
| | 24C | H | East Chuitna | 350 | | 1 | | | 1 | | | | | | |

Table 5.7

1980 MOOSE SURVEY

Area: Lone Ridge, Beluga Drainage, Chuitna Drainage

Observer: J. Didrickson, ADF&G (Palmer)

Total Moose: 151 (139 adults, 12 calves)

| | | | | |
|---|---|---|---|---|
| Age-Sex Ratios: | Bulls - | 33 large,<br>11 yearlings | Cows - | 85 w/o calves<br>8 w/calves<br>2 w/2 calves |
| | | 44 Total | | 95 Total |

Period of Observation: December

| | |
|---|---|
| Red Squirrel | Tamiasciurus hudsonicus |
| Lynx | Lynx canadensis |
| Snowshoe or Varying Hare | Lepus americanus |
| Flying Squirrel | Glaucomys sabrinus |
| Muskrat | Ondatra zibethica |
| Beaver | Castor canadensis |
| Wolverine | Gulo luscus |
| Porcupine | Erethizon dorsatum |
| Least Weasel | Mustela rixosa |
| Ermine or Shorttail Weasel | Mustela erminea |
| Mouse Weasel | Mustela nivalis |
| Marten | Martes americana |
| Coyote | Canis latrans |
| Ground Squirrel | Citellus undulatus |
| Collared Pika | Ochotna collaris |
| Hoary Marmot | Marmota caligata |
| Brown Lemming | Lemmus trimucronatus |
| Northern Bog Lemming | Synaptomys borealis |
| Red-backed Vole | Clethrionomys rutilus |
| Tundra Vole | Microtus oeconomus |
| House Mouse | Mus musculus |
| Meadow Jumping Mouse | Zapus hudsonius |
| Masked Shrew | Sorex cinereus |
| Dusky Shrew | Sorex obscurus |
| Water Shrew | Sorex palustris |
| Little Brown Bat | Myotis lucifugus |

Population estimates for the above are not available, however the area has historically supported a relatively large harvest of fur-bearers, particularly beaver and wolverine. Beavers are active throughout the region and have a significant impact on the head-waters of nearly every stream within the system. An aerial count of active lodges is anticipated as part of an on-going field program to be conducted in the fall of 1981.

- General Sensitivity to Changed Conditions

Populations of large mammals change in response to natural biologic, geologic, and climatic events and in response to human activities. Pressures from human activities are generally related to economic development. Direct pressures also occur when habitats are altered or their uses are denied by segmentation or other means. Habitat may be altered or destroyed by fire, clearing, logging, road building, or other construction and resource extraction activities. Segmentation divides a habitat into tracts too small to be used effectively by a population. The noise and activity associated with development also may prevent utilization of a habitat. Many diverse habitat types within the range of a species may be occupied at least occasionally by a particular species. One or more of these types termed "critical habitats" may be of particular importance and their extent may limit the population. Critical habitats may be areas used for denning, wintering, calving, or feeding. Use of a critical habitat may vary widely from year to year depending on a variety of factors. Critical habitats for many species have been defined.

Denning areas, spring feeding areas, and salmon streams are probably the most critical habitats for brown bears. Most of the salmon streams support brown bear concentrations and may be considered critical habitat during the salmon runs. The future of the brown bear inevitably will be determined by human encroachment into bear habitat. Within the study area, brown bears probably are more vulnerable to the secondary effects of development, especially increased access by hunters and increased incidental confrontations, than to the more direct modifications of habitat associated with resource development.

Factors determining black bear mortality are well known, and hunting and other human activities generally become the major limiting factors in accessible areas. Loss of habitat to development, loss of access to salmon streams and berry patches, harassment (both intentional and inadvertent) by outdoor recreation and transportation activities, and the incidence of nuisance bears that must be destroyed will increase as human populations and bear populations interface more frequently. Small, discrete black bear populations may be especially vulnerable to over-harvest. In the study area, where black bear populations infrequently are isolated from one another, the bears are less vulnerable to the effects of human activities. Black bears usually inhabit open woodlands, avoiding extensive open areas and the larger tracts of dense forest. Where human contact has not been encouraged, habitat preference and native wariness permit black bears to withstand considerable human pressure.

Winter mortality of moose, including deaths associated with starvation and losses to predators caused by the weakened condition of the moose and loss of mobility in deep snow, are the major factors limiting natural moose populations. Winter mortality is determined primarily by food availability, which in turn is determined by competition for the food resources and by the depth, duration, and hardness of the snow. Adverse winter conditions first affect the calves, then the cows, and finally the bulls. Mortality in extremely harsh years may be nearly 100%. Predation by bears, wolves, and human hunters also may affect populations. Accidental kills by automobiles may be important locally, and traffic mortality increases when roads and railroads are constructed through prime ranges or across migration routes. Secondary effects of development, particularly increased access for hunters, would have the greatest impact on existing moose populations.

## Existing Avian Populations

Little information is available on terrestrial avian populations for the Beluga area. Ornithological records primarily reflect lists published by various observers. Year-round populations of terrestrial birds are represented by relatively few species, including raven, chickadee, redpoll, Canada and Steller's Jay, magpie, and several woodpeckers. Species diversity and abundance increase markedly in the summer. Table 5.8 represents a list of birds which can be expected to be found in the Beluga region. The list includes year-round residents, migratory species (excluding waterfowl, shorebirds and seabirds) and accidental or occasional sightings. Known nesting sites (cranes, eagles, swans) based on 1981 field observations are shown in Figure 5.9. Included in Figure 5.9 are swan and eagle nests sighted during a June 2, 1981 flight of the Upper Cook Inlet Oil and Gas Lease Units by personnel of ADF&G.

Nesting habitat (current and potential) will be mapped eventually as part of an overall habitat mapping scheme. The relationship between project development and operation relative to adjacent refuge lands must be carefully considered particularly if the DF&G were to undertake any enhancement programs to encourage additional summer utilization of the lands.

Amphibians

The only amphibians known from the region are the rough-skinned newt, Taricha granulosa, and the wood frog, Rana sylvatica. The rough-skinned newt is a relatively large brown salamander (up to 6 inches in length) found near small ponds and lakes throughout the spruce forests near the coast. The wood frog is a small (up to 3 inches) light brown or gray frog, with a prominent dark eye mask, found in or near the shallow ponds of both the lowland forest and wet tundra. Both the rough-skinned newt and the wood frog are active during daytime (diurnal).

Table 5.8

TERRESTRIAL BIRDS

| Common Name | Scientific Name | Occurrence S/S/F/W |
|---|---|---|
| Goshawk | Accipiter gentilis | U/U/U/U * |
| Sharp-shinned Hawk | Accipiter striatus | C/U/C/U * |
| Red-tailed Hawk | Buteo jamaicensis | R/R/R/+ * |
| Rough-legged Hawk | Buteo lagopus | R/+/R/+ |
| Golden Eagle | Aquila chrysaetos | R/R/R/R * |
| Bald Eagle | Haliaeetus leucocephalus | C/C/C/C * |
| Marsh Hawk | Circus syaneus | C/U/C/R * |
| Osprey | Pandion haliaetus | R/R/R/- * |
| Gyrfalcon | Falco rusticolus | R/R/R/R * |
| Peregrine Falcon | Falco peregrinus | U/R/U/R * |
| Merlin | Falco columbarius | R/R/R/R * |
| American Kestrel | Falco sparverius | R/-/R/+ |
| Spruce Grouse | Canachites canadensis | U/U/U/U * |
| Willow Ptarmigan | Lagopus lagopus | U/U/U/U * |
| Rock Ptarmigan | Lagopus mutus | C/C/C/C * |
| White-tailed Ptarmigan | Lagopus leucurus | R/R/R/R * |
| Sandhill Crane | Grus canadensis | C/R/C/- * |
| Rock Dove | Columba livia | C/C/C/C * |
| Great Horned Owl | Bubo virginianus | C/C/C/C * |
| Snowy Owl | Nyctea scandiaca | R/+/R/U |
| Hawk Owl | Surnia ulula | U/U/U/C * |

S/S/F/W = Summer, Spring, Fall, Winter

C = Common
U = Uncommon
R = Rare
+ = Casual or accidental
- = Not known to occur
* = Known or probable breeder

Table 5.8
Continued
TERRESTRIAL BIRDS

| Common Name | Scientific Name | Occurrence S/S/F/W |
|---|---|---|
| Great Gray Owl | Strix nebulosa | R/R/R/R * |
| Short-eared Owl | Asio flammeus | C/C/C/R * |
| Boreal Owl | Aegolius funereus | U/U/U/U * |
| Saw-Whet Owl | Aegolius acadicus | R/R/R/R * |
| Rufous Hummingbird | Selasphorus rufus | C/C/C/- * |
| Belted Kingfisher | Megaceryle alcyon | U/U/U/U * |
| Common Flicker | Colaptes auratus | +/R/U/- |
| Yellow-bellied Sapsucker | Sphyrapicus varius | +/-/+/- |
| Hairy Woodpecker | Picoides villosus | U/U/U/U * |
| Downy Woodpecker | Picoides pubescens | U/U/U/U * |
| Black-backed Three-toed Woodpecker | Picoides arcticus | +/-/-/- * |
| Northern Three-toed Woodpecker | Picoides tridactylus | R/R/R/R * |
| Eastern Kingbird | Tyrannus tyrannus | -/+/+/- |
| Alder Flycatcher | Empidonax alnorum | U/U/U/- * |
| Western Wood Pewee | Contopus sordidulus | -/R/R/- * |
| Olive-sided Flycatcher | Nuttallornis borealis | R/R/R/- * |
| Horned Lark | Eremophila alpestris | R/R/R/- |
| Violet-green Swallow | Tachycineta thalassina | C/C/C/- * |
| Tree Swallow | Iridoprocne bicolor | C/C/C/- * |
| Bank Swallow | Riparia riparia | U/U/U/- * |
| Rough-winged Swallow | Stelgidopteryx ruficollis | +/+/-/- |
| Barn Swallow | Hirundo rustica | C/C/C/- * |
| Cliff Swallow | Petrochelidon pyrrhonota | U/U/U/- * |
| Gray Jay | Perisoreus canadensis | R/R/R/R * |
| Steller's Jay | Cyanocitta stelleri | C/C/C/C * |
| Black-billed Magpie | Pica pica | C/C/C/C * |

Table 5.8
Continued
TERRESTRIAL BIRDS

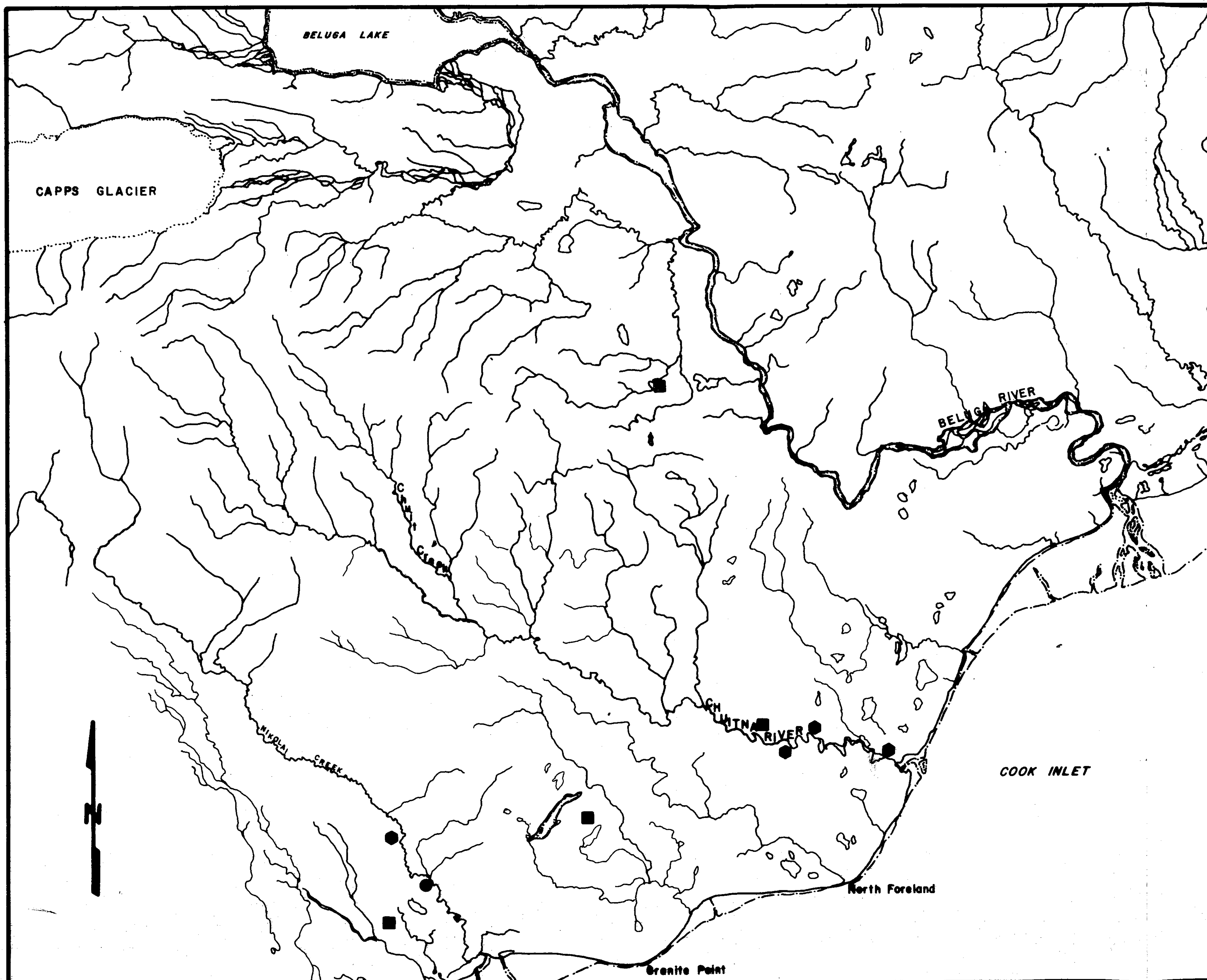
| Common Name | Scientific Name | Occurrence S/S/F/W |
|---|---|---|
| Common Raven | Corvus corax | C/C/C/C * |
| Northwestern Crow | Corvus caurinus | C/C/C/C * |
| Black-capped Chickadee | Parus atricapillus | U/U/U/U * |
| Boreal Chickadee | Parus hudsonicus | R/R/R/R * |
| Chestnut-backed Chickadee | Parus rufescens | C/C/C/C * |
| Red-breasted Nuthatch | Sitta canadensis | R/R/U/R * |
| Brown Creeper | Certhia familiaris | U/U/U/U * |
| Dipper | Cinclus mexicanus | C/C/C/C * |
| Winter Wren | Troglodytes troglodytes | U/U/U/U * |
| American Robin | Turdus migratorius | C/C/C/R * |
| Varied Thrush | Ixoreus naevius | C/C/C/U * |
| Hermit Thrush | Catharus guttatus | C/C/C/- * |
| Swainson's Thrush | Catharus ustulatus | U/U/U/- * |
| Gray-cheeked Thrush | Catharus minimus | U/U/U/- * |
| Wheatear | Oenanthe oenanthe | R/R/R/- * |
| Townsend's Solitaire | Myadestes townsendi | R/R/R/- * |
| Golden-crowned Kinglet | Regulus satrapa | U/U/U/U * |
| Ruby-crowned Kinglet | Regulus calendula | C/C/C/+ * |
| Water Pipit | Anthus spinoletta | C/C/C/- * |
| Bohemian Waxwing | Bombycilla garrulus | U/U/U/R * |
| Northern Shrike | Lanius excubitor | U/U/U/U * |
| Starling | Sturnus vulgaris | R/-/R/R |
| Tennessee Warbler | Vermivora peregrina | +/-/-/- |
| Orange-crowned Warbler | Vermivora celata | C/C/C/- * |
| Yellow Warbler | Dendroica petechia | U/U/U/- * |
| Yellow-rumped Warbler | Dendroica coronata | U/U/U/- * |
| Townsend's Warbler | Dendroica townsendi | U/U/U/- * |
| Blackpoll Warbler | Dendroica striata | R/R/R/- * |

Table 5.8

Continued

TERRESTRIAL BIRDS

| Common Name | Scientific Name | Occurrence S/S/F/W |
|---|---|---|
| Northern Waterthrush | Seiurus noveboracensis | R/R/R/- * |
| Wilson's Warbler | Wilsonia pusilla | C/C/C/- * |
| Red-winged Blackbird | Agelaius phoeniceus | R/R/R/- * |
| Rusty Blackbird | Euphagus carolinus | U/R/U/R * |
| Brambling | Fringilla montifringilla | -/-/+/+ |
| Bullfinch | Pyrrhula pyrrhula | -/-/+/+ |
| Pine Grosbeak | Pinicola enucleator | U/U/U/U * |
| Gray-crowned Rosy Finch | Leucosticte tephrocotis | U/U/U/R * |
| Hoary Redpoll | Carduelis hornemanni | R/-/-/R |
| Common Redpoll | Carduelis flammea | C/U/U/C * |
| Pine Siskin | Carduelis pinus | C/C/C/U * |
| Red Crossbill | Loxia curvirostra | R/R/R/R * |
| White-winged Crossbill | Loxia leucoptera | U/U/U/U * |
| Savannah Sparrow | Passerculus sandwichensis | C/C/C/- * |
| Dark-eyed Junco | Junco hyemalis | U/U/U/U * |
| Tree Sparrow | Spizella arborea | U/R/U/R * |
| Chipping Sparrow | Spizella passerina | +/-/+/- |
| Harris' Sparrow | Zonotrichia querula | +/-/+/- |
| White-crowned Sparrow | Zonotrichia leucophrys | U/R/U/R * |
| Golden-crowned Sparrow | Zonotricha atricapilla | C/C/C/R * |
| White-throated Sparrow | Zonotricha albicollis | -/-/+/+ |
| Fox Sparrow | Passerella iliaca | C/C/C/R * |
| Lincoln's Sparrow | Melospiza lincolnii | C/C/C/+ * |
| Song Sparrow | Melospiza Melodia | C/C/C/C * |
| Lapland Longspur | Calcarius lapponicus | U/R/U/+ * |
| Snow Bunting | Plectrophenax nivalis | U/R/U/R * |




KNOWN NESTING SITES (ACTIVE, 1981)

FIGURE 5.9

## MARINE ECOLOGY

### Intertidal and Shallow Subtidal Habitats

The intertidal and shallow subtidal environments present in upper Cook Inlet vary significantly from area to area. Figure 5.10 illustrates the diverse habitats present along the northwest shore of Cook Inlet near the proposed project. The intertidal area from the Beluga River south through Trading Bay contains broad expanses of gravel and sand as well as extensive mud flats. From the sandy reaches just south of the Beluga River, the intertidal zone becomes mud to below Three-mile Creek. Gravel exists at the delta of the Chuitna River, however mud flats are present north of Tyonek. The gravel returns south of Tyonek through North Foreland. Mud flats are again present to just north of Granite Point (Beshta Bay), gravel with mixed boulders exist at Granite River, and then the area becomes broad mud tidal flats (Trading Bay) disected by the flow of Nikolai Creek.

The oceanographic conditions vary significantly on each side of the inlet, and to a lesser extent on a site specific basis anywhere along the west side of the inlet. This is a major reason for variations in diversity of intertidal and shallow subtidal habitats.

° Mud Flats

The productivity and species diversity on the broad mud flats of upper Cook Inlet are generally low. In addition, the subtidal species density and diversity in these areas are also low. The limiting factors to productivity in areas dominated by mud flats are the high suspended sediment levels, low light penetration, and climatic variables. In winter months the surface sediments freeze during low tide.

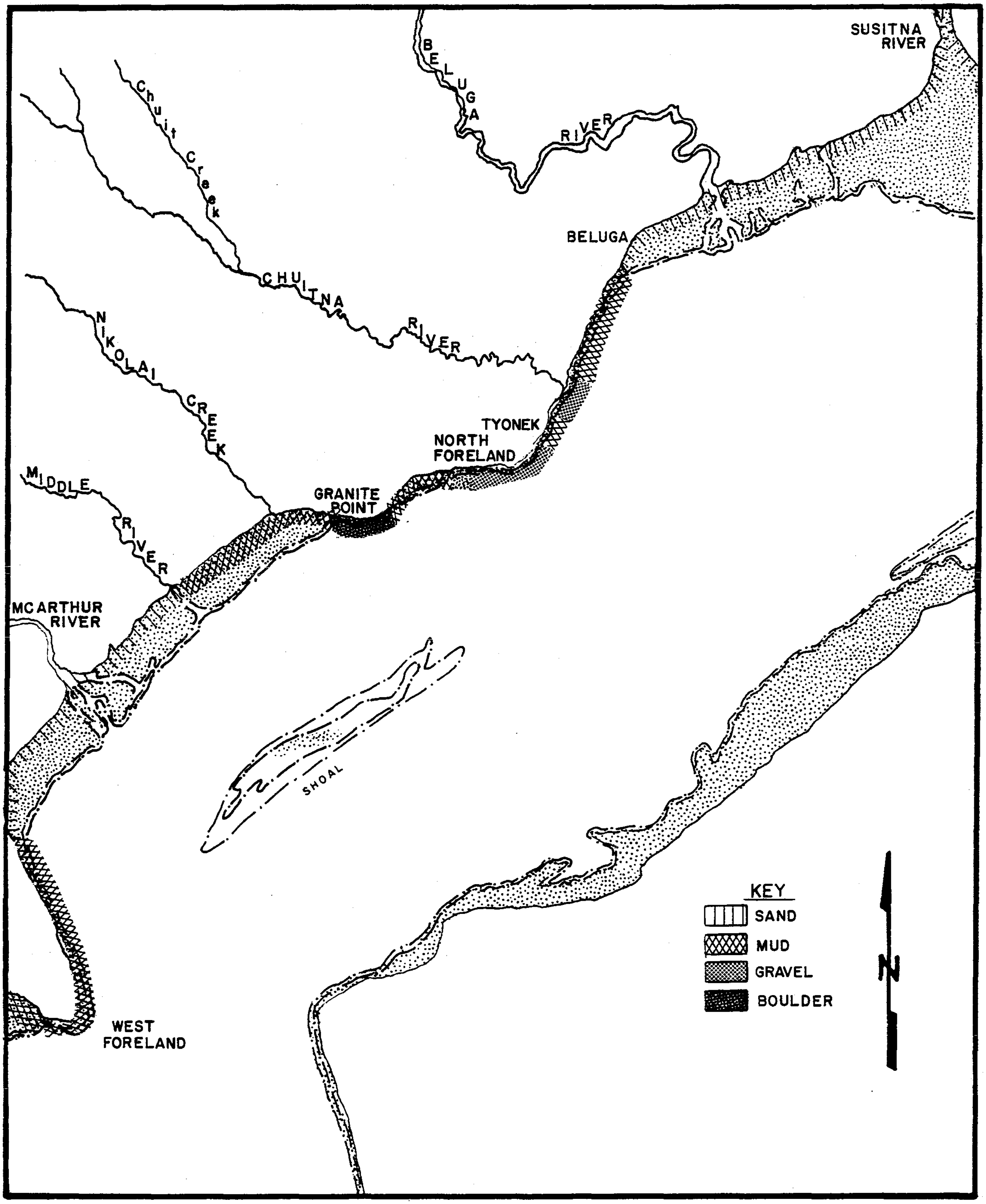



FIGURE 5.10 HABITAT TYPES, COOK INLET SHORELINE

The fauna within the intertidal/shallow subtidal area of mud flats is dominated by pelecypods (clams), primarily Macoma balthica and Mya sp., and polychaete worms (Nephtys, Etcone, Potamilla, Spio) of minor importance, and the clams Clinocardium, the basket cockle, and Pseudopythina, the common clam. There is substantial vertical distribution of the faunal assemblages in the mud flats. Figure 5.11 shows the distribution of the major organisms in the mud flats.

Predation is strong, with diving ducks, gulls and shorebirds being the major predators. A number of transient predators also depend on the infauna. These predators include crab, flatfish, cottids, and some Pacific salmon. Several migratory bird species utilize the mud flats, including the western Sandpiper and Dunlins during spring migration. The Greater Scaup, Old squaw, Surf scoter and Black scoter feed extensively on the mud flats in the winter. A generalized food web for mud flat environments is shown in Figure 5.12.

## Gravel and Cobble Substrate

The gravel and cobble intertidal and subtidal areas support moderate densities of gammaride amphipods (Anisogammarus confervicolus) and the isopod Gnorimosphaeroma oregonensis.

In addition, barnacles (Balanus sp.) and mussels (Mytilus edulis) are present during spring, summer and fall. They are preyed upon by nudibranch (Onchidoris balamellata) and snails (nucella emarginata). The barnacles and mussels seldom survive the winter and thus are replaced yearly.

Other important predators include the rock sandpiper, a winter predator; dungeness crab (lancer magister); helmet crab (Telmessus cheiragonus); gray shrimp (Crangon alaskensis ; sand lance (Ammoclytes hexapterus); Pacific staghorn Sculpin (Leptocotuss

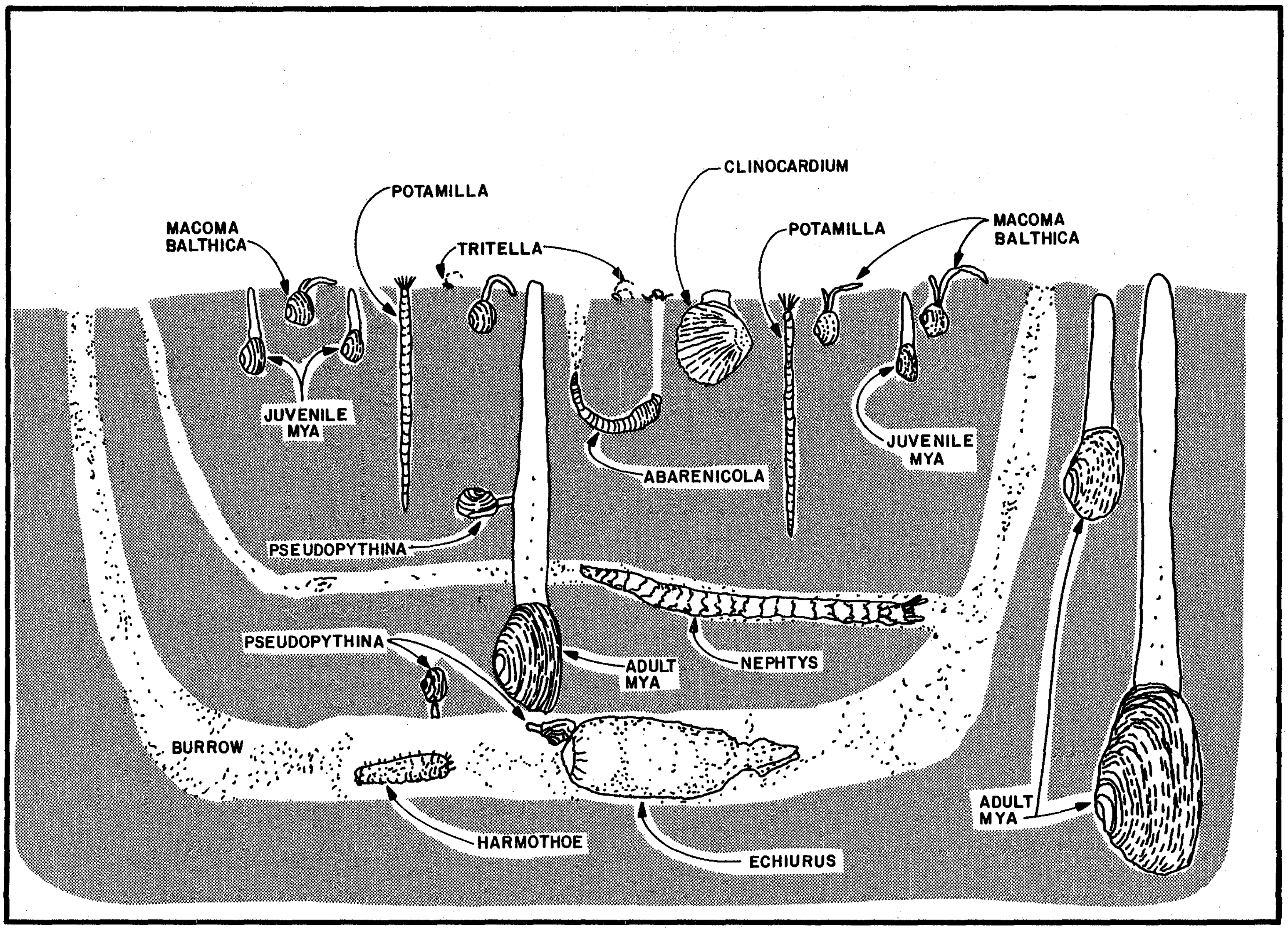



FIGURE 5.11 DISTRIBUTION OF ORGANISMS IN MUD FLATS

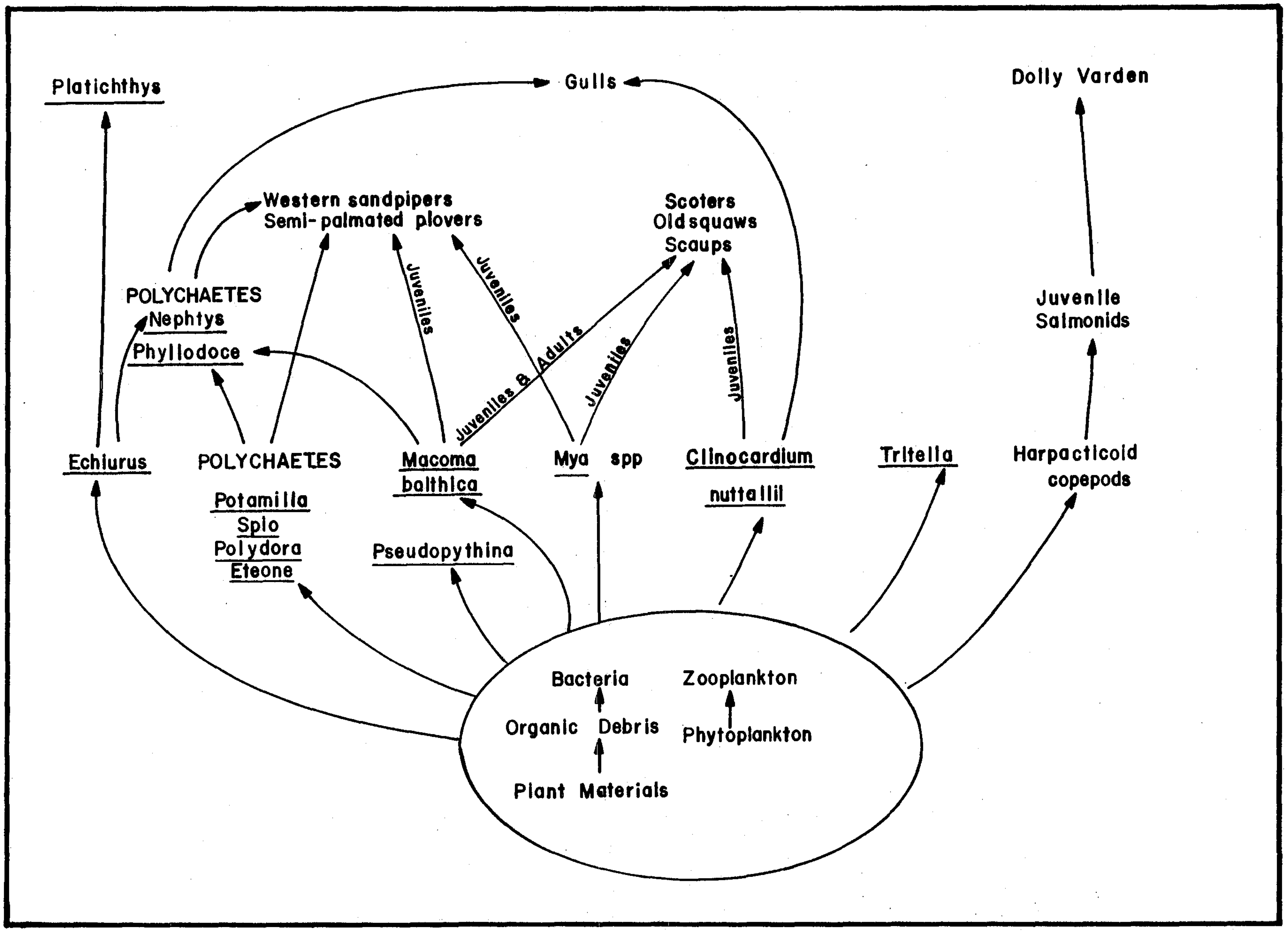



FIGURE 5.12 GENERALIZED FOOD WEB FOR MUD FLAT

armatus); starry flounder (Platichthys stellatus); and flathead sole (Hippoglosgoides classodon).

Granite Point Intertidal and Shallow Subtidal Investigation

A July 1981 investigation of the shallow subtidal and intertidal area in the vicinity of Granite Point revealed that the benthic community at all the sampled stations was dominated by the pink clam (Macoma balthica). Three transects with three intertidal stations (high, low and midtide) and one subtidal station were established. The intertidal flats from the airport to Granite Point grades from a fine, muddy clay near the airstrip to gravelly sand toward Granite Point, and grades to coarse sand and gravel at increasing distances from the shoreline. The results of this investigation are summarized in graphic form in Figure 5.13

Marine Species

° Fisheries

Fish populations in upper Cook Inlet in close proximity to the Trading Bay/Beluga River area include anadromous species (salmon and eulachon), resident species (flounder and sculpin), migratory species (halibut), and shellfish. Of commercial importance in upper Cook Inlet are four of the the five species of Pacific salmon. These salmon are also important sport fish.

The five Pacific salmon species found in upper Cook Inlet are:

| | |
|---|---|
| King (chinook) salmon | Oncorhynchus tshawytscha |
| Sockeye (red) salmon | O. nerka |
| Silver (coho) salmon | O. kisutch |
| Chum (dog) salmon | O. keta |
| Pink (humpback) salmon | O. gorbuscha |

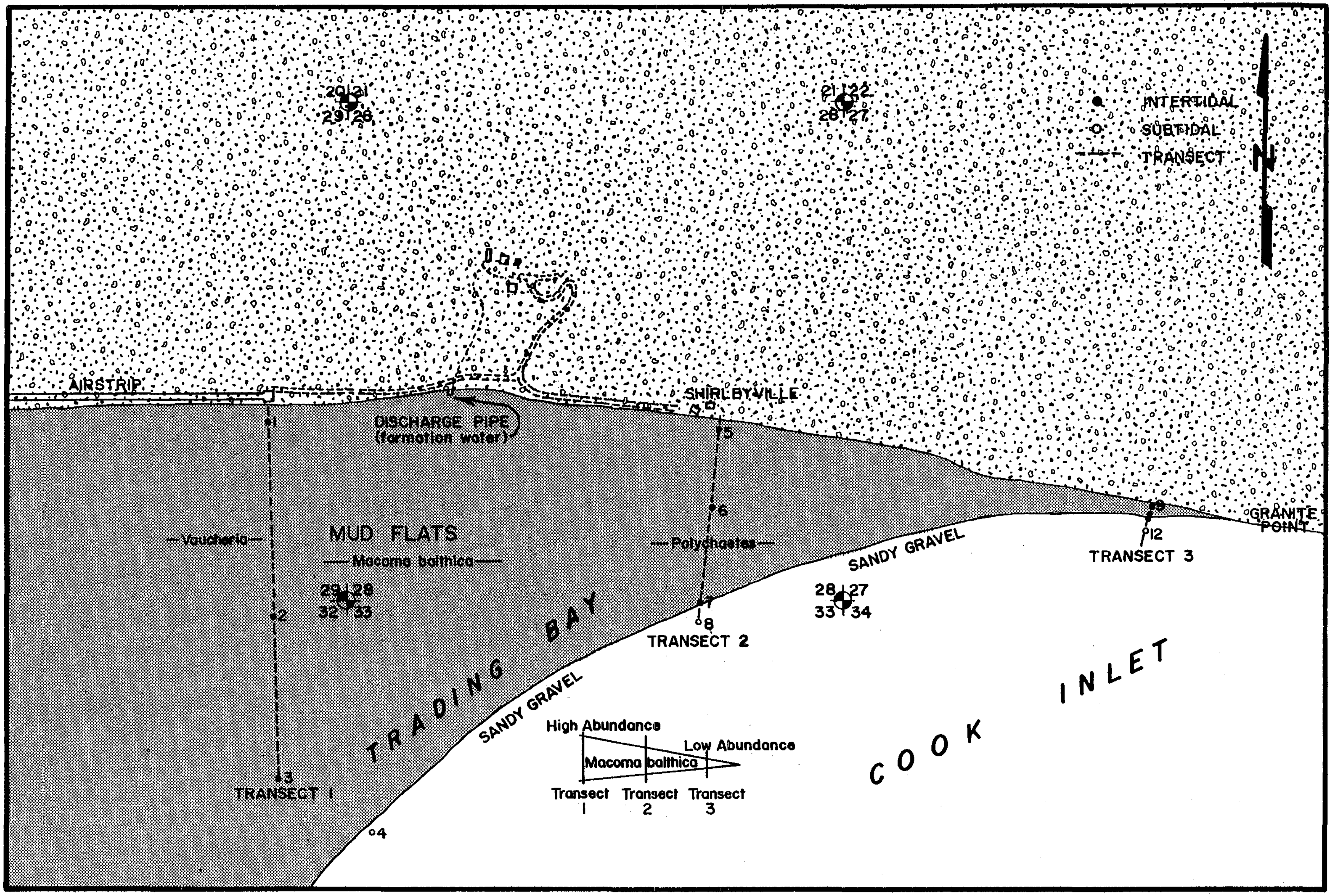



FIGURE 5.13 GRANITE POINT INTERTIDAL AND SHALLOW SUBTIDAL SPECIES ASSEMBLAGES

The general life histories of the five species of Pacific salmon in Cook Inlet is summarized in Table 5.9, as well as under Fresh-water Fishes and in Table 5.1. Exceptions to these general features occur frequently. The relationship between salmon and the freshwater streams in the Beluga area is important in that the fish use the freshwater streams only to carry on reproductive and early life stage functions. Adult fish migrate from the marine environment to spawn and then die. Young salmon (fry) inhabit the freshwater streams for a short time, migrate to the sea where they grow rapidly into adults, and return to natal streams to spawn. Early development may also occur there. Some salmon remain in fresh water for 2 to 3 years; Dolly Varden may remain for as long as 4 years.

The different salmon species remain in fresh water varying lengths of time and also return to spawn at different times of the year. The general timing of the life history stages for each of the five species is shown in Table 5.10. The adult fish migrate to fresh water, then the female prepares the nest (redd) and generally spawns with only one male. Several males may be in attendance but usually only the dominant male will spawn with the female. It is estimated that early-run spawners deposit approximately 3,700 eggs each, while late-run spawners deposit approximately 4,100. The eggs are covered with upstream gravel, and the females guard the nest as long as possible but die soon after spawning. Hatching usually occurs in February to March, depending primarily on water temperature. The alevins (yolk sak fry) remain in the gravel for 2 to 3 weeks and then emerge as free-swimming, actively feeding fry. Some fry migrate immediately to the sea, however, most remain in the gravel areas near stream banks. Few lakes in the Beluga area are accessible to salmon. Most remain in fresh water for at least one year before moving out to sea. The life cycle of the king and silver salmon are illustrated in Figures 5.14 and 5.15.

Table 5.9

PACIFIC SALMON IN ALASKA-LIFE FEATURES

| Species of Salmon | Time Spent in Fresh Water after Emergence From Gravel | Time at Sea Years | Age at Spawning Years | Average Weight of Adults Pounds | Average Eggs per Female Thousands |
|---|---|---|---|---|---|
| Chum (dog) | Less than 1 month | 2-4 | 3-5 | 8 | 3.0 |
| Pink (humpback) | Usually less than 1 month | 1 | 2 | 4 | 2.0 |
| Silver (coho) | 12-36 months | 1 | 3-4 | 9 | 3.5 |
| Red (sockeye) | 12-36 months | 1-4 | 3-6 | 6 | 3.5 |
| King (chinook) | 3-12 months | 1-6 | 3-7 | 20 | 8.0 |

Table 5.10

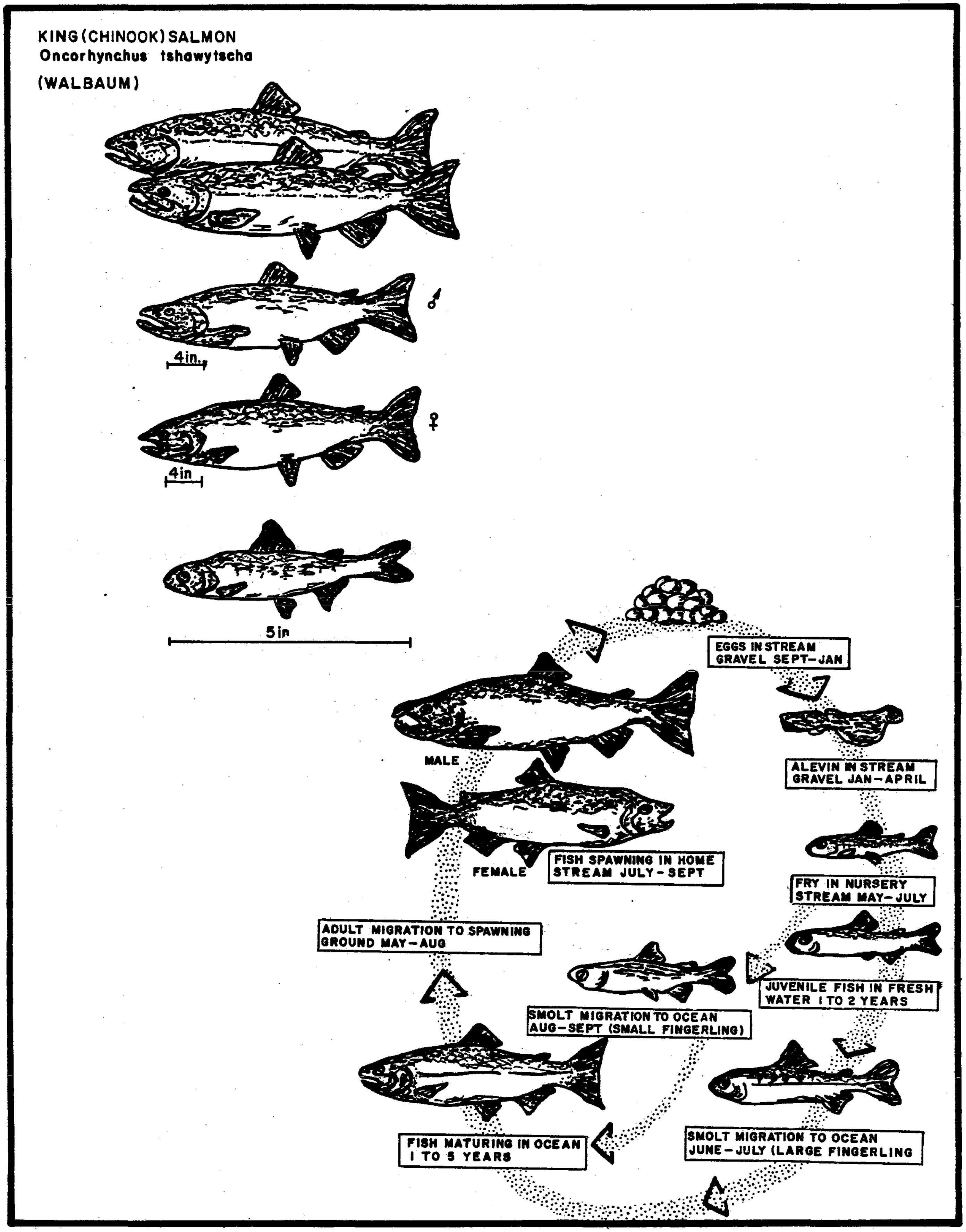
GENERAL SALMON RUN TIMING INFORMATION
FOR NORTHERN COOK INLET STREAMS

| Species | Life History Stage* | Activity | Dates |
|---|---|---|---|
| Chinook Salmon | Adults | Enter fresh water | May 15 - July 15 |
| | | Spawning | June 20 - Aug. 15 |
| | Juveniles | Outmigration | Apr. 15 - July 15 |
| Sockeye Salmon | Adults | Enter fresh water | May 20 - Aug. 15** |
| | | Spawning | Aug. 1 - Nov. 15 |
| | Juveniles | Outmigration | Apr. 15 - Aug. 1 |
| Coho Salmon | Adults | Enter fresh water | July 10 - Nov. 1*** |
| | | Spawning | Aug. 1 - Feb. 1 |
| | Juveniles | Outmigration | Apr. 15 - July 15 |
| Pink Salmon | Adults | Enter fresh water | June 20 - Aug. 15*** |
| | | Spawning | July 10 - Sept. 1 |
| | Juveniles | Outmigration | Apr. 15 - June 10 |
| Chum Salmon | Adults | Enter fresh water | July 1 - Sept. 1*** |
| | | Spawning | Aug. 1 - Oct. 1 |
| | Juveniles | Outmigration | Apr. 15 - July 10 |

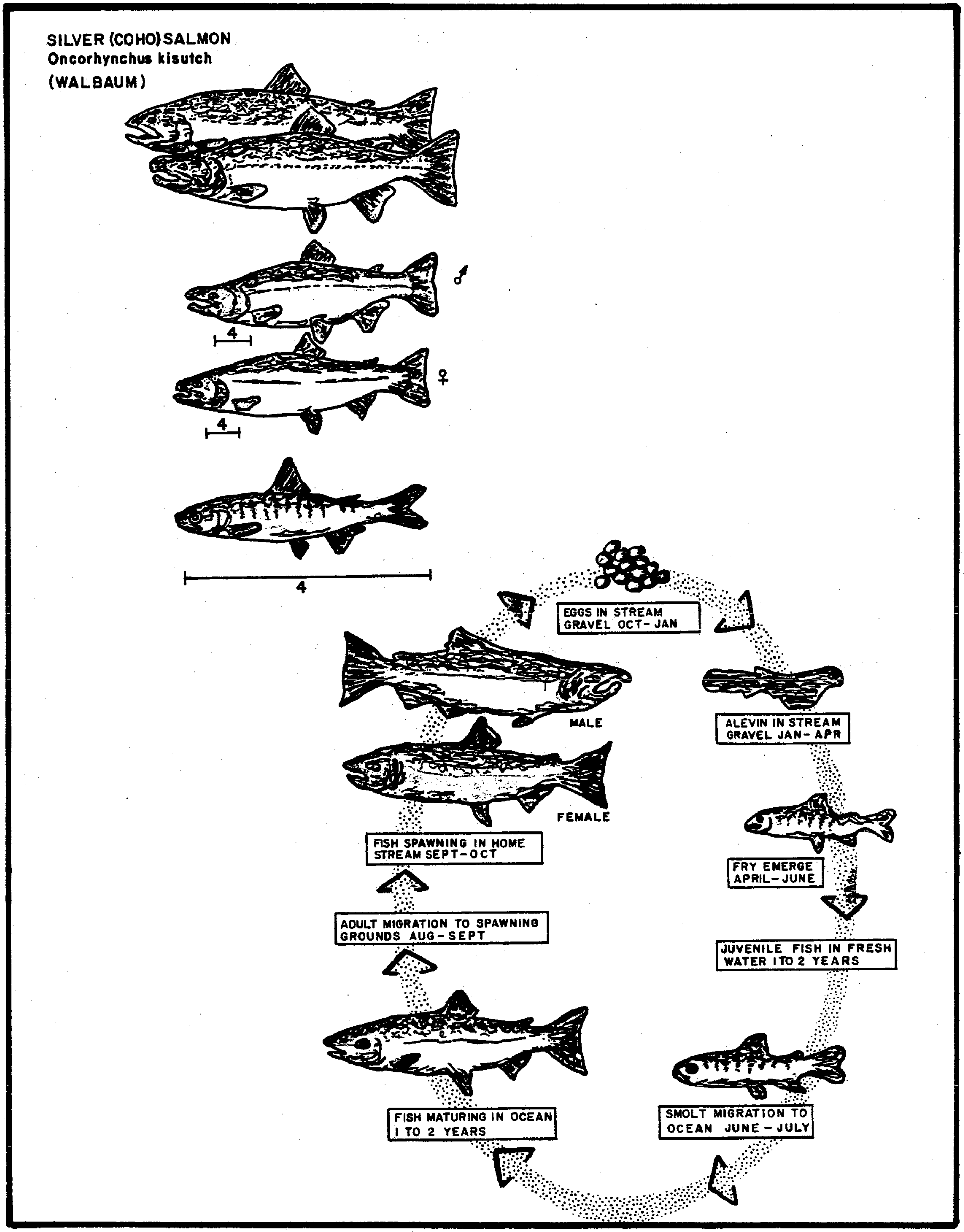
* Juvenile chinook, sockeye, and coho salmon are present in streams or lakes year round.

** Even numbered years.

*** Odd numbered years.




| FIGURE 5.14 | LIFE CYCLE OF KING SALMON |
| --- | --- |




| FIGURE 5.15 | LIFE CYCLE OF THE SILVER SALMON |
|---|---|

The spawning substrate for these salmon varies somewhat by species. Silver (coho), pink (humpback) and chum (dog) prefer a substrate of medium-size gravel, while red (sockeye) prefer fine gravel or sand and king salmon (chinook) prefer coarse gravel.

Young chinooks and cohos feed mainly on insects, including fly and beetle larvae and juveniles (dipterous larvae, trichopteran, and coleopteran juveniles). Other species of salmon fry also serve as an important food source for the coho. Sockeye feed on zooplankton.

Several factors relative to incubation are important to the survival of local salmon populations:

Access to Spawning Sites: Most basic to hatch success is the ability of migrating salmon to reach the spawning sites.

Freedom from Disturbance: Once the redds are established and eggs are deposited, disturbance may increase egg mortality.

Predation by Other Animals - Invertebrate organisms that invade the redds or other fish which feed on dislodged eggs are the major predators.

Diseases: Infection by aquatic fungi increases egg mortality.

Water Quality and Quantity: If the water contains deleterious chemicals and is not adequately oxygenated, is of unsuitable temperature, or does not flow properly around the eggs or larvae, significant mortality results. Proper stream flow, permeability of gravel, and dissolved oxygen concentrations are critical to salmon survival. Foreign substances in the water including siltation of streams has been demonstrated to severely diminish productivity.

Other factors such as adequate rearing habitat, food sources, holding areas, and spawning habitat are also important.

Dolly Varden (char) are widely distributed throughout Cook Inlet. They also migrate from the marine environment to fresh water to spawn. Upstream movement usually begins in late July or August and continues through November. Spawning usually occurs in gravelly streams with a fairly stong current. Unlike the Pacific salmon, Dolly Varden do not die after spawning. Development to hatching requires about 130 days, and the young remain in the gravel for 60 to 70 days. Dolly Varden usually spend three to four years in the creek before going to sea.

Eulachon (hooligan), a small anadromous smelt, is found in abundance in upper Cook Inlet. However, the only known run of eulachon in the Beluga area is at the Beluga River. Eulachon runs begin about May 15 and peak toward the end of May. The eggs hatch in 2 to 3 weeks and the young move downstream immediately.

Resident marine fish found in upper Cook Inlet are primarily flounder, sculpin, and cod. Their distribution is widespread, however their population densities are unknown. They are of little commercial or subsistence importance.

Migratory marine fish include the halibut, which are primarily found in lower Cook Inlet (Kalgin Island and south). Most halibut winter offshore in the Gulf of Alaska. Herring also can be found in fairly large numbers in lower Cook Inlet, and are very rarely found in upper Cook Inlet.

Shellfish, including king crab, dungeness crab, tanner crab, several species of shrimp, clams, oysters, and scallops are all found in commercial quantities in Cook Inlet. Most of these shellfish are found predominantly in lower Cook Inlet, south of the

Forelands. Clams, however, are common in tidal flats in upper Cook Inlet, including Trading Bay.

Commercial Fisheries: Commercially important species of fish in Cook Inlet include salmon, halibut, herring, shrimp and crab. The commercial fishing industry (harvesting and processing) is an important source of income and employment. The yearly and mean catches for the period 1973 to 1977 of the various fisheries in Cook Inlet are shown in Table 5.11.

Salmon: The salmon fishery in Cook Inlet is the most important commercial fishery. There are three distinct Cook Inlet salmon fisheries, defined by gear type (purse seine, drift gill net, and set gill net). Upper Cook Inlet areas support primarily gill net fishing. The salmon harvest in recent years has increased substantially due to improved fishery management, enhancement and rehabilitation programs. Annual harvest weight for 1980 was estimated to be 20.4 million pounds (0.224 metric tons), with a real value of $18 million. Harvest projections for the year 2000 are for approximately 28.2 million pounds (12,778 metric tons) with a value of $30.5 million.

The beach area from the northern end of Trading Bay in the vicinity of Shirleyville to the Beluga River is heavily utilized by set net fishermen including many residents of Tyonek. Based on the experience of set net fishermen on the eastern side of Cook Inlet, construction and operation of dock facilities has little impact on set net fishing.

Herring: The Cook Inlet herring fishery is primarily a roe herring fishery. The herring fleet is dominated by purse seiners whose principal employment is in other fisheries. The season is concentrated in a few days between May and mid-June because the roe is of marketable quality for only a very brief period. The average annual catch is approximately 6.4 million

Table 5.11

COOK INLET FISHERIES
1973-1977

Catch in 1,000 Pounds

| Year | Salmon | Herring | Halibut | King Crab | Tanner Crab | Dungeness Crab | Shrimp |
|---|---|---|---|---|---|---|---|
| 1973 | 14,418 | 3,184 | 3,972 | 4,349 | 8,509 | 330 | 4,897 |
| 1974 | 10,341 | 5,389 | 1,930 | 4,602 | 7,661 | 721 | 5,749 |
| 1975 | 18,045 | 8,298 | 3,935 | 2,886 | 4,952 | 363 | 4,752 |
| 1976 | 23,298 | 9,696 | 3,418 | 4,954 | 5,935 | 119 | 6,208 |
| 1977 | 36,012 | 6,435 | 3,249 | 2,027 | 5,650 | 76 | 5,144 |
| Mean | 20,443 | 6,600 | 3,300 | 3,764 | 6,541 | 322 | 5,350 |

pounds (2,919 metric tons) with a real harvest value of approximately \$1.3 million.

Halibut: The Cook Inlet halibut fishery is dominated by a small fleet which consists of boats that are often primarily participants in other fisheries, and which fish in protected waters. Many of these boats are less than 35 feet (10.7 meters) in length. The season is between May and August, and is broken into several 2-week periods. Harvest weight and real harvest value of halibut for 1980 are approximately 0.6 million pounds (254 metric tons) and \$400,000.

King Crab: The Cook Inlet king crab fishery is dominated by boats smaller than in many other Alaska crab fleets. The typical boat lengths are between 25 and 45 feet (7.6 and 13.7 meters). They generally have a crew of three or four and participate in the fishery from August through March. The harvest for 1980 was approximately 3.7 million pounds (1,667 metric tons) with a real market value of \$4.6 million.

Tanner Crab: The tanner crab season is from December through May, and many of the boats participate in both king and tanner crab fishing because of the succession of seasons. The 1980 catch weight was approximately 5.2 million pounds (2,350 metric tons) with a real market value of \$1.9 million.

Dungeness Crab: The Cook Inlet dungeness crab fleet consists of boats that typically are 26 to 35 feet (7.9 to 10.7 meters) in length, and have a crew of two. They participate in the dungeness crab fishery from May through December. The annual harvest has fluctuated significantly in recent years, however, more favorable market conditions are expected to stabilize the fishery in the future. Catch statistics and real market value for 1980 are 500,000 pounds (204 metric tons) and \$300,000.

Shrimp: There are two shrimp fisheries in Cook Inlet, a trawl fishery and a pot fishery. The trawlers range in length from less than 25 feet to more than 80 feet (7.6 meters to 24.4 meters), and have a crew of three. They participate in the fishery from June through March. Although several times as many boats participate in the pot fishery as in the trawl fishery, the trawl fleet harvests the majority of the annual catch. The pot boats range in length from less than 25 to 45 feet (7.6 meters to 13.7 meters). They generally have a crew of two, and are active throughout the year.

The shrimp fisheries are well developed and have well defined resources. The 1980 harvest of all species amounted to approximately 5.6 million pounds (2,540 metric tons) with a real market value of $1.7 million.

Razor Clams: The Cook Inlet razor clam fishery has been small and sporadic for a number of years. The latest large harvest occurred in 1962 when just less than 200,000 pounds (91 metric tons) were taken. During the five years the fishery was active between 1969 and 1977, the annual harvest averaged less than 24,000 pounds (11 metric tons) and the number of boats in the fishery typically did not exceed three. With the exception of 1972 when a dredge was also used, the hand shovel has been the sole gear type. Although increases in resource abundance, increasingly favorable market conditions, the development of more efficient types of gear, and improved programs for the certification of beaches as a source of clams for human consumption are expected to stimulate renewed activity in this fishery, the razor clam fishery is expected to remain an almost insignificant portion of the Cook Inlet commercial fishing industry.

<u>Sport Fishery</u>: The Cook Inlet area supports a diverse and important sport/recreational fishery. Most sportfishing is for

the five Pacific salmon species. The east side of Cook Inlet (Kenai Peninsula) is the most intense sport fishery, however, the west side of the inlet also supports a lucrative sport fishery. The primary streams utilized for this purpose are in the Susitna drainage.

The major streams in the Beluga area capable of supporting a sport fishery are Nikolai Creek, Chuitna River and the Beluga River. However, there are no catch statistics concerning sport fish harvests from any of the streams or rivers in the Beluga area. Access to these streams would be primarily by float plane or limited wheel plane traffic. Fish harvested for sport/recreation are the five species of Pacific salmon, rainbow trout, Arctic grayling, Dolly Varden, and eulachon.

Sport fish regulations administered through the state Department of Fish and Game restrict the number of fish taken within a 24-hour period. The bag limit for any combination of salmon, trout, grayling and char under 16 inches in length (or 20 inches for king salmon) is 10 per day. Taking king salmon longer than 20 inches is limited to one per day with a maximum of only two in possession. Taking any combination of the other salmon species more than 16 inches in length is limited to three per day.

Subsistence Fishery: Subsistence fishing is of importance to the local residents of the Beluga area (Tyonek). Local Natives use the shoreline of Cook Inlet in the summer and fall to gather a large portion of the food in their diets. The marine resources gathered include clams, cockles, and bottomfish. Of primary importance during the summer months, however, is the harvesting of spawning salmon and smelts.

Methods of harvesting salmon vary. The primary harvest methods utilize drift gill net fishing, beach set nets, and seine net fishing. The drift gill net floats on the water's surface and drifts with the tide, intercepting salmon traveling toward the freshwater streams. Set nets are fished from the beach and are comprised of a small mesh lead net attached to the gill net. Salmon encounter the lead net as they swim along the beach and are led out to the gill net where they become entrapped. Leads are permanently anchored to shore. Seine fishing, although seldom used in upper Cook Inlet, utilizes a length of net to encircle and trap schools of fish.

Subsistence catch records are not generally available and very little specific data concerning subsistence fisheries is available for the Beluga region.

Current marine resource utilization in Cook Inlet is shown in Figure 5.16.

- Birds

Marine birds or seabirds have been defined as birds which, during some part of their life cycle, come in contact with the marine environment. This broad definition includes the migratory waterfowl as well as pelagic species. Primary marine bird habitat within upper Cook Inlet includes offshore waters (more than three nautical miles from land), inshore waters (within three nautical miles of land), steep rock or rubble beaches, sea cliffs, intertidal beaches, and coastal floodplains such as wetlands.

Approximately 180 species of birds are known to inhabit the Cook Inlet region. About 105 to 110 of these species are regarded as being associated with the marine or coastal environment. There is very little qualitative or quantitative information available for pelagic and coastal birds inhabiting Cook Inlet, especially in the Trading Bay to Beluga River region. Non-site-specific information which is available refers to environment types as described above.

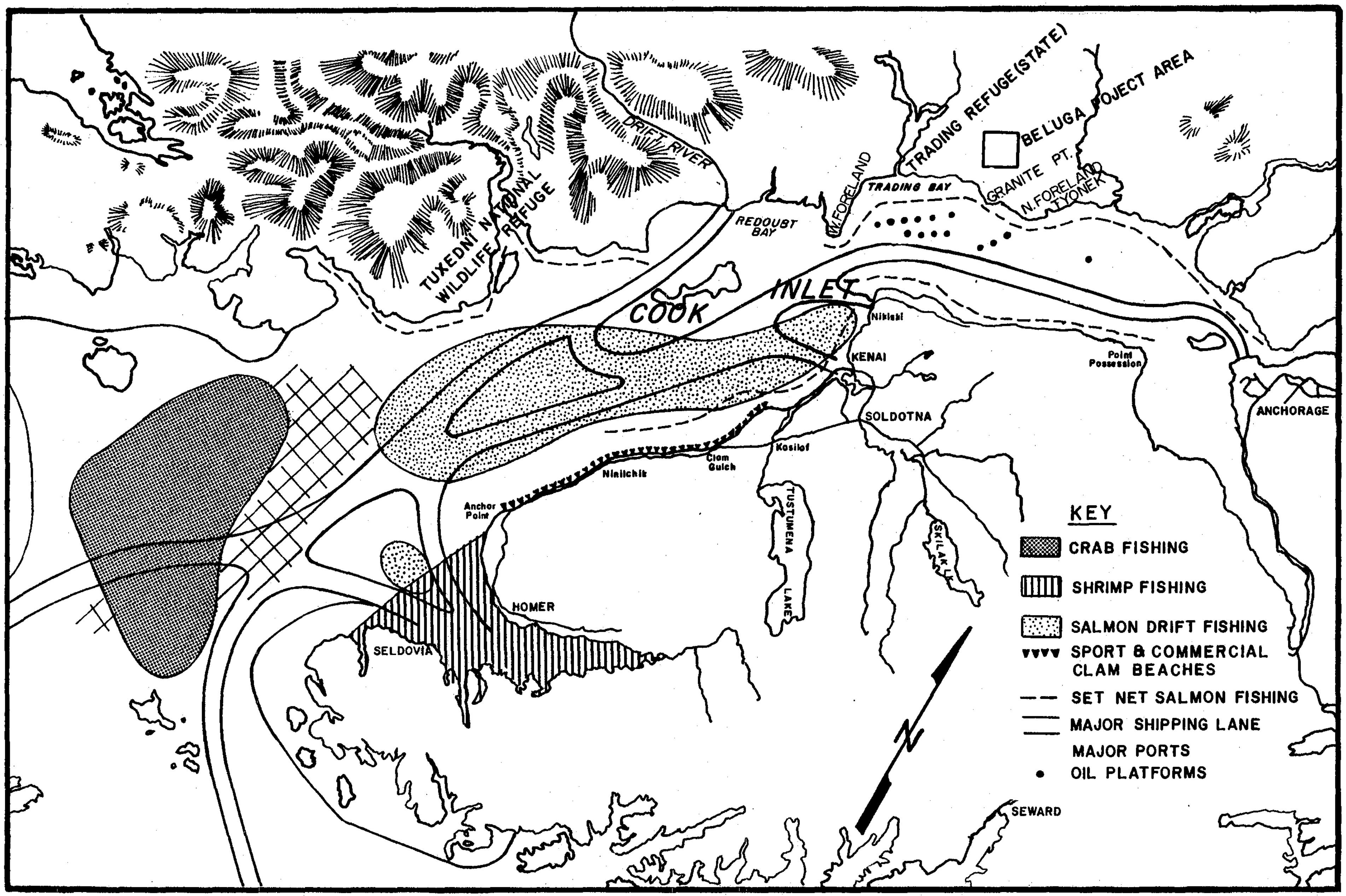



FIGURE 5.16 RESOURCE USE IN THE COOK INLET AREA

Cook Inlet is a geographical funnel for migrating birds moving to and from the interior, North Slope, and west coast Alaska breeding areas. The highest bird populations occur in Cook Inlet's wetlands during the spring migration period when the area is used by more than 1.25 million ducks and geese (primarily lesser Canada and snow), about 25,000 whistling and trumpeter swans, several thousand cranes, and millions of shorebirds.

Pelagic areas in the upper inlet receive less bird use than areas closer to the mouth of the inlet. During migration and summer periods it appears that selected nearshore areas, estuaries, wetlands, and bays receive significant use by waterfowl and shorebirds.

Coastal wetland areas are important as nesting, resting, and feeding habitat to several species of birds. Trading Bay is a prime wetlands area and supports a diverse waterfowl population. Highest waterfowl populations occur in Cook Inlet's wetlands in spring when they are used by several thousand lesser Canada and snow geese, ducks, and occasional swans and cranes. The fall build-up of waterfowl in the inlet's wetlands begins in early August and peaks in late September. During the fall migration period about 0.75 million ducks and geese utilize wetland areas in Cook Inlet. The fall buildup of waterfowl in the inlet's wetlands begins in early August and peaks in late September.

Sea ducks, shearwaters, murres, gulls, puffins, guillemots, murrelets, and cormorants are the principal seabirds in offshore waters. These birds also inhabit inshore waters, where they nest on sea cliffs or rocky shores. Many of the sea ducks and gulls nest and feed in the sea beach tidal flat and coastal floodplain habitats. Geese and dabbling ducks (puddle ducks), and shorebirds, including black oystercatchers, plovers, snipe, trunstones, sandpipers, yellowlegs, dunlin, dowitchers, surfbirds, and others, also nest and feed in these two wetland habitats.

Pelagic areas in Cook Inlet during the winter months appear to receive comparatively little bird use. During winter months icing conditions in the inlet, in part, regulate the distrubution of wintering birds, i.e., there are fewer birds in areas of moderate to heavy ice cover. Since icing conditions are usually more severe on the west side of the inlet comparatively fewer birds would be present on the west side than on the east side. The most abundant coastal wintering birds were sea ducks, larids, and shorebirds, with very few alcids present.

Seabirds, sea ducks, and shorebirds generally feed on marine animals such as molluscs (gastropods, pelecypods, and cephalopods), crustacea (amphipods, schizopods, and copepods) and several species of fish. Carrion, birds, other marine invertebrates and plants are also utilized by several species of birds.

The largest seabird colony in close proximity to the study area is located in Tuxedni Bay on Chisik and Duck islands about 120 miles (182 km) south of Anchorage and on the west side of Cook Inlet. Together the bay and islands comprise the Tuxedni National Wildlife Refuge which was established in 1909 by Executive Order. Approximately six seabird colonies are located in Tuxedni Bay, four are located on Chisik Island, one is on Duck Island, and two are on the adjacent mainland. Black-legged kittiwakes and murres are particularly numerous in Tuxedni Bay.

Table 5.12 is a list of migratory waterfowl, shorebirds, and seabirds which can be expected to be found in the Trading Bay/ Beluga region.

- Mammals

Numerous marine mammals inhabit or have been reported in Cook Inlet, but only a few species inhabit upper Cook Inlet. Harbor seals (Phoca vitulina) move up and down the west side of the inlet

Table 5.12

WATERFOWL, SHOREBIRDS AND SEABIRDS

Waterfowl and Shorebirds

| Common Name | Scientific Name | Occurrence S/S/F/W |
|---|---|---|
| Common Loon | Gavia immer | C/U/C/U * |
| Yellow-billed Loon | Gavia adamsii | U/R/R/U |
| Arctic Loon | Gavia arctica | C/U/C/C * |
| Red-throated Loon | Gavia stellata | C/C/C/U * |
| Red-necked Grebe | Podiceps grisegena | C/U/C/C * |
| Horned Grebe | Podiceps auritus | C/U/C/C * |
| Pied-billed Grebe | Podilymbus podiceps | +/+/+/+ * |
| Great Blue Heron | Ardea herodias | U/U/U/U * |
| Whistling Swan | Olor columbianus | C/R/C/R |
| Trumpeter Swan | Olor buccinator | C/C/C/U * |
| Canada Goose | Branta canadensis | C/C/C/U * |
| Brant | Branta bernicla | C/R/R/+ |
| Emperor Goose | Philacte canagica | R/+/R/U |
| White-fronted Goose | Anser albifrons | C/R/C/+ * |
| Snow Goose | Chen caerulescens | C/-/C/- |
| Mallard | Anas platyrhynchos | C/C/C/C * |
| Gadwall | Anas strepera | C/U/C/U * |
| Pintail | Anas acuta | C/C/C/U * |
| Green-winged Teal | Anas crecca | C/C/C/R * |
| Blue-winged Teal | Anas discors | R/R/R/+ * |

S/S/F/W = Summer, Spring, Fall, Winter

C = Common
U = Uncommon
R = Rare
+ = Casual or accidental
- = Not known to occur
* = Known or probable breeder

Table 5.12
Continued
Waterfowl and Shorebirds

| Common Name | Scientific Name | Occurrence S/S/F/W | |
|---|---|---|---|
| Northern Shoveler | Anas clypeata | C/C/C/U | * |
| American Wigeon | Anas americana | C/C/C/U | * |
| Redhead | Aythya americana | R/R/R/+ | * |
| Ring-necked Duck | Aythya collaris | R/R/R/R | |
| Greater Scaup | Aythya marila | C/C/C/C | * |
| Lesser Scaup | Aythya affinis | R/+/R/R | |
| Common Goldeneye | Bucephala clangula | C/U/C/C | * |
| Barrow's Goldeneye | Bucephala islandica | C/C/C/C | * |
| Bufflehead | Bucephala albeola | C/R/C/C | * |
| Oldsquaw | Clangula hyemalis | C/U/C/C | * |
| Harlequin Duck | Histrionicus histrionicus | C/C/C/C | * |
| Steller's Eider | Polysticta stelleri | C/+/U/C | |
| Common Eider | Somateria mollissima | U/U/U/U | |
| King Eider | Somateria spectabilis | U/-/U/U | |
| White-winged Scoter | Melanitta deglandi | C/C/C/C | * |
| Surf Scoter | Melanitta perspicillata | C/C/C/C | |
| Black Scoter | Melanitta nigra | C/U/C/C | |
| Common Merganser | Mergus merganser | C/C/C/C | * |
| Red-breasted Merganser | Mergus serrator | C/C/C/C | * |
| Semipalmated Plover | Charadrius semipalmatus | C/C/C/- | * |
| Killdeer | Charadrius vociferus | R/R/R/- | * |
| American Golden Plover | Pluvialis dominica | C/+/C/- | |
| Black-bellied Plover | Pluvialis squatarola | C/U/C/- | |
| Hudsonian Godwit | Limosa haemastica | U/U/U/- | * |
| Bar-tailed Godwit | Limosa lapponica | R/-/R/- | |
| Marbled Godwit | Limosa fedoa | R/-/+/- | |
| Whimbrel | Numenius phaeopus | C/U/C/- | |
| Bristle-thighed Curlew | Numenius tahitiensis | +/-/+/- | |
| Upland Sandpiper | Bartramia longicauda | +/-/+/- | |

Table 5.12
Continued
Waterfowl and Shorebirds

Waterfowl and Shorebirds

| Common Name | Scientific Name | Occurrence S/S/F/W | |
|---|---|---|---|
| Greater Yellowlegs | Tringa melanoleuca | C/C/C/- | * |
| Lesser Yellowlegs | Tringa flavipes | C/C/C/- | * |
| Solitary Sandpiper | Tringa solitaria | U/R/U/- | * |
| Spotted Sandpiper | Actitis macularia | C/C/C/+ | * |
| Wandering Tattler | Heteroscelus incanus | C/U/C/- | * |
| Ruddy Turnstone | Arenaria interpres | C/R/U/- | |
| Black Turnstone | Arenaria melanocephala | C/U/C/R | |
| Northern Phalarope | Phalaropus lobatus | C/C/C/+ | * |
| Red Phalarope | Phalaropus fulicarius | C/R/C/- | |
| Common Snipe | Gallinago gallinago | C/C/C/R | * |
| Short-billed Dowitcher | Limnodromus griseus | C/C/C/- | * |
| Long-billed Dowitcher | Limnodromus scolopaceus | C/-/C/- | |
| Surfbird | Aphriza virgata | C/U/C/U | * |
| Red Knot | Calidris canutus | C/-/R/- | |
| Sanderling | Calidris alba | U/U/U/R | |
| Semipalmated Sandpiper | Calidris pusilla | U/R/U/- | |
| Western Sandpiper | Calidris mauri | C/U/C/- | |
| Least Sandpiper | Calidris minutilla | C/C/C/- | * |
| White-rumped Sandpiper | Calidris fuscicollis | +/-/+/- | |
| Baird's Sandpiper | Calidris bairdii | U/-/U/- | |
| Pectoral Sandpiper | Calidris melanotos | C/-/C/- | |
| Sharp-tailed Sandpiper | Calidris acuminata | -/-/R/- | |
| Rock Sandpiper | Calidris ptilocnemis | C/-/C/C | |
| Dunlin | Calidris alpina | C/R/C/U | * |
| Pomarine Jaeger | Stercorarius pomarinus | C/R/C/- | |
| Parasitic Jaeger | Stercorarius parasiticus | U/C/C/- | * |
| Long-tailed Jaeger | Stercorarius longicaudus | R/R/R/+ | |
| South Polar Skua | Catharacta maccormicki | -/R/R/- | |

Table 5.12
Continued
Seabirds

| Common Name | Scientific Name | Occurrence S/S/F/W | |
|---|---|---|---|
| Black Oystercatcher | _Haematopus bachmani_ | C/C/C/U | * |
| Glaucous Gull | _Larus hyperboreus_ | R/R/R/R | |
| Glaucous-winged Gull | _Larus glaucescens_ | C/C/C/C | * |
| Herring Gull | _Larus argentatus_ | C/U/C/U | * |
| Thayer's Gull | _Larus thayeri_ | R/R/R/R | |
| Ring-billed Gull | _Larus delawarensis_ | R/R/R/R | |
| Mew Gull | _Larus canus_ | C/C/C/C | * |
| Bonaparte's Gull | _Larus philadelphia_ | C/C/C/+ | * |
| Black-legged Kittiwake | _Rissa tridactyla_ | C/C/C/U | * |
| Sabine's Gull | _Xema sabini_ | U/R/U/- | |
| Arctic Tern | _Sterna paradisaea_ | C/C/C/- | * |
| Aleutian Tern | _Sterna aleutica_ | U/U/U/- | * |
| Common Murre | _Uria aalge_ | C/C/C/C | * |
| Thick-billed Murre | _Uria lomvia_ | R/R/R/R | * |
| Pigeon Guillemot | _Cepphus columba_ | C/C/C/C | * |
| Marbled Murrelet | _Brachyramphus marmoratus_ | C/C/C/C | * |
| Kittlitz's Murrelet | _Brachyramphus brevirostris_ | C/C/C/U | * |
| Ancient Murrelet | _Synthliboramphus antiquus_ | U/U/U/U | * |
| Cassin's Auklet | _Ptchoramphus aleuticus_ | R/R/R/- | |
| Parakeet Auklet | _Cyclorrhynchus psittacula_ | U/U/U/- | * |
| Rhinoceros Auklet | _Cerorhinca monocerata_ | R/R/R/- | * |
| Horned Puffin | _Fratercula corniculata_ | U/U/U/R | * |
| Tufted Puffin | _Lunda cirrhata_ | C/C/C/R | * |

as far as and often up the Susitna River. Of the 13 species of whales reported from Cook Inlet, only the beluga (or white) whale (Delphinapterus leucas) is found in upper Cook Inlet. While the sea otter (Enhydra lutris) populations are reported to be increasing within the inlet, no sea otters have been reported within the specific area of interest though they have been observed in the vicinity of Trading Bay and at Ninilchik on the eastern shore of the inlet.

The following marine mammals have been reported for lower Cook Inlet in addition to those indicated above:

| | |
|---|---|
| Northern Fur Seal | Callorhinus ursinus |
| Steller Sea Lion | Eumetopias jubuta |
| Dall Porpoise | Phocoenoides dalli |
| Harbor Porpoise | Phocoena phocoena |
| Sperm Whale | Physeter catodon |
| Minke Whale | Balaenoptera acutorostrata |
| Gray Whale | Eschrichtius robustus |
| Humpback Whale | Megaptera novaeangliae |
| Fin Whale | Babenoptera physalus |
| Pacific Right Whale | Balaena glacialis |
| Sea Whale | Balaenoptera boraelis |
| Stejneger's Beaked Whale | Mescoplodon stejnegeri |
| Goose Beaked Whale | Ziphius cavirostris |
| Giant Bottlenose Whale | Berardius bairdi |
| Blue Whale | Balaenoptera musculus |
| Northern Pacific White-sided Dolphin | Lagenorhynchus acutus |

The beluga whale in upper Cook Inlet feed primarily on salmon, both adults and smolt. The Cook Inlet population of beluga has been estimated to be on the order of 300 to 500 animals and is believed to be a discrete population. These whales generally feed from the bottom to mid-water levels and are known to move into the mouths and often up the mainstem of major rivers (including the Beluga River) to feed on outward migrating salmon. In addition to salmon, belugas are known to eat smelt, flounder, sole, sculpin, lamprey, squid, shrimp, and mussel. In Cook Inlet, belugas have been reported as far north as Ship Creek (Anchorage) and the vicinity of Girdwood, pursuing runs of hooligan.

Reproduction in belugas probably takes place in late May or June with a 12-month gestation period. The calf generally remains with the mother for several years following an eight-month lactation period.

In recent years, both the Minke whale and the beaked whale have been observed in Kenai and Anchorage where, for unknown reasons, individuals have been beached at low tides.

### Trading Bay State Game Refuge

The Trading Bay refuge (Figure 5.17) was established in 1976 to protect and perpetuate waterfowl and big game habitat. The refuge is approximately 169,000 acres in size including tidal and submerged lands as well as uplands. The refuge boundaries border on the project area in the vicinity of both the proposed town and plant sites and includes the main stem of Nikolai Creek.

The refuge has been the scene of exploration activities for oil and gas; is crossed by the Cook Inlet Pipe Line; and portions of the refuge have been logged by Tyonek Lumber Company. The latter activity has resulted in bridge crossings of Nikolai Creek and the Chakachatna River and numerous gravel roads that are still utilized by the lumber company. The eastern shore of Chakachatna River is a primary gravel source for commercial development in the area. In addition, one test water well has been drilled as part of the 1981 field program in the vicinity of the Nikolai Creek bridge crossing. The DF&G has recently completed (1981) a waterfowl survey of the Trading Bay area. Nikolai Creek is an important fishery, and the

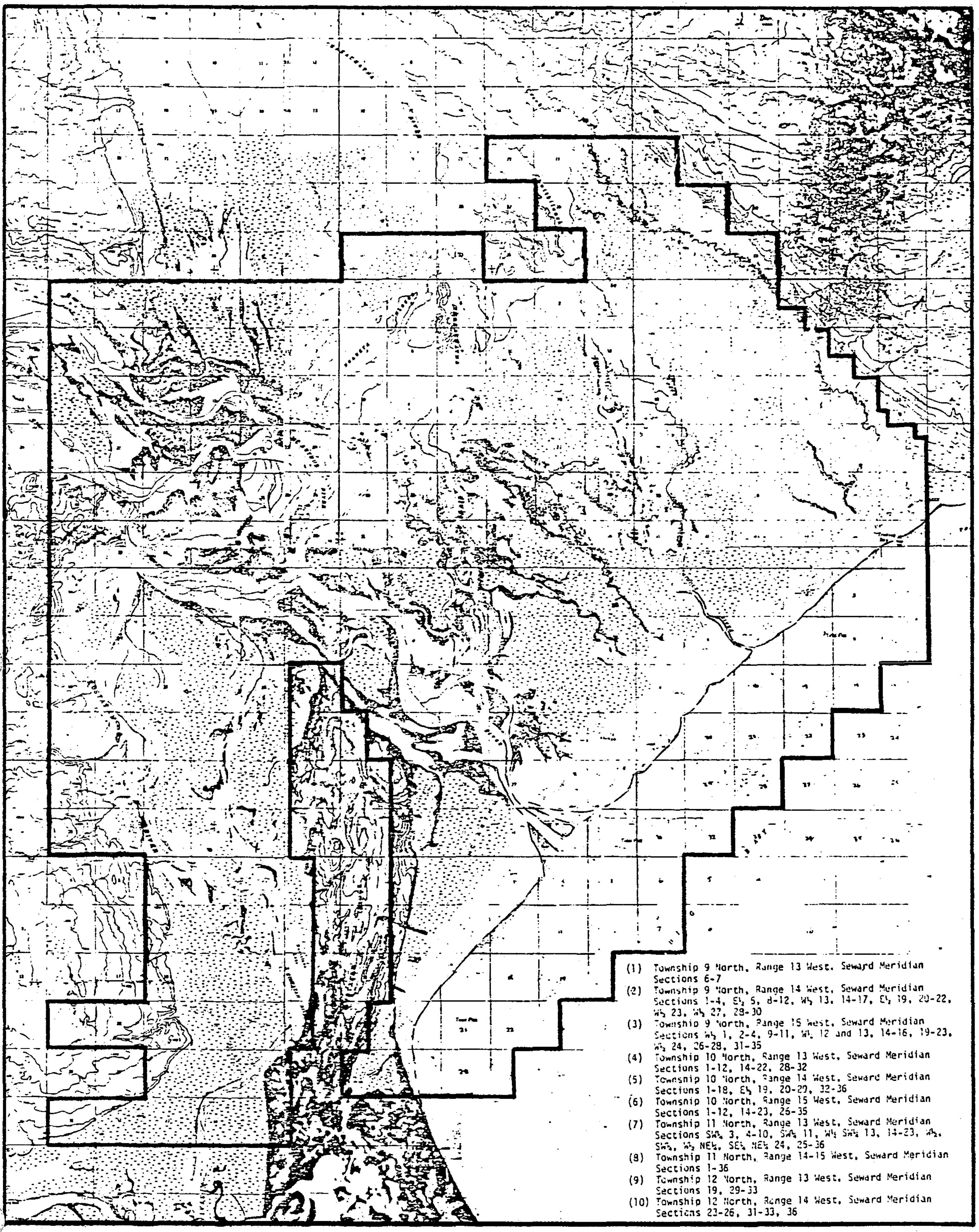



FIGURE 5.17 TRADING BAY STATE GAME REFUGE

area between the Chakachatna River and Nikolai Creek is an important moose wintering area. It would appear from the available browse that the current moose population is far below the carrying capacity of the land. Swans, sandhill cranes, and eagles nest along the general stream course of Nikolai Creek. Road access to the Nikolai drainage makes this area accessible to and important to local residents of the area.

surficial soil pit

upper Capps

fish trapping/stream surveys

John's Creek

BELUGA FIELD PROGRAM 1981

sub-tidal sampling

soils investigation

fish trapping

stream surveys

# 6.0 CLIMATOLOGY AND AIR QUALITY

## CLIMATIC CONDITIONS

The Cook Inlet area in general is in a transitional climate zone between the continental climate of the Interior and the maritime climate more common to the coastal areas farther south. The Aleutian and Alaska mountain ranges to the northeast of the project area are effective in preventing the large, extremely cold air masses that typically settle in the Interior Basin from causing comparably frigid conditions along the inlet during winters. The Kenai and Chugach ranges which run in a northeastern direction to the south of the project area protect the inlet from advection of moist air from the Gulf of Alaska, and from potentially heavy precipitation. The higher elevations experience colder temperatures, more precipitation and stronger winds than the low-lying coastal areas.

The four seasons are not well defined in the region. Winter generally begins mid-October and lasts until mid-April. Monthly average temperatures vary between 10° and 30°F during this season. However, temperatures fall well below freezing, with the possibility of some inland locations reaching -50°F. The total annual snowfall ranges between 70 and 100 inches with December, the coldest month, receiving the greatest snowfall. The difference in expected snowfall between the inlet shore and the higher elevations of the Capps Field is probably reflected by the above stated range in total snowfall. Springtime occurs from mid-April to June when the average daily temperatures rise from 30°F in April to near 50°F in June. Precipitation is lowest in the spring with monthly averages around 1 inch. During the summer precipitation increases rapidly. About 40% of the total annual precipitation falls between mid-July and the end of summer. July is also the warmest month of the year with the average daily temperature near 55°F. Autumn is brief, accompanied by a decrease in precipitation. Most precipitation occurs as rain early in the season and snow later, although snow may predominate throughout the season at the higher elevations. Temperatures also fall rapidly during this short season; monthly average temperatures for September and October differ by 15°F.

The bar charts on Figure 6.1 summarize monthly variations in average daily temperatures, average daily temperature ranges, and precipitation for the part of the Cook Inlet Basin in which the proposed project is located. The average values shown should be considered as generally occurring for the entire area from the plant site to the coal fields.

These charts are based on isopleth maps prepared by the U.S. Environmental Data Service from data taken at weather stations associated with the National Oceanic and Atmospheric Administration. Figure 6.2 shows the locations and activities of these stations. Stations represented by double circles monitor wind speed and direction, sky cover and cloud ceiling heights in addition to measuring temperatures and precipitation. Knowing these parameters would make it possible to calculate how much dilution of air pollution concentrations occurs as a function of the meteorology or atmospheric conditions. Wind profiles for the Kenai and Anchorage stations indicate that a general wind pattern exists for the entire inlet region. However, local variations in wind profiles and turbulent diffusion are expected in the project area due to the effects of terrain roughness. The rough surface should increase mechanical turbulence allowing for the atmosphere to be well mixed during periods of high winds. During the winter, winds from the north/northeast are dominant and as summer approaches the prevailing winds are from the south/southwest. The annual average wind speed at both Kenai and Anchorage is approximately 7 mph. Monthly average wind speeds range from 4 to 9 mph at Anchorage. Figure 6.3 illustrates wind roses for Kenai, Anchorage, and the Phillips Petroleum's Platform "A" located approximately 5 miles due east of Tyonek.

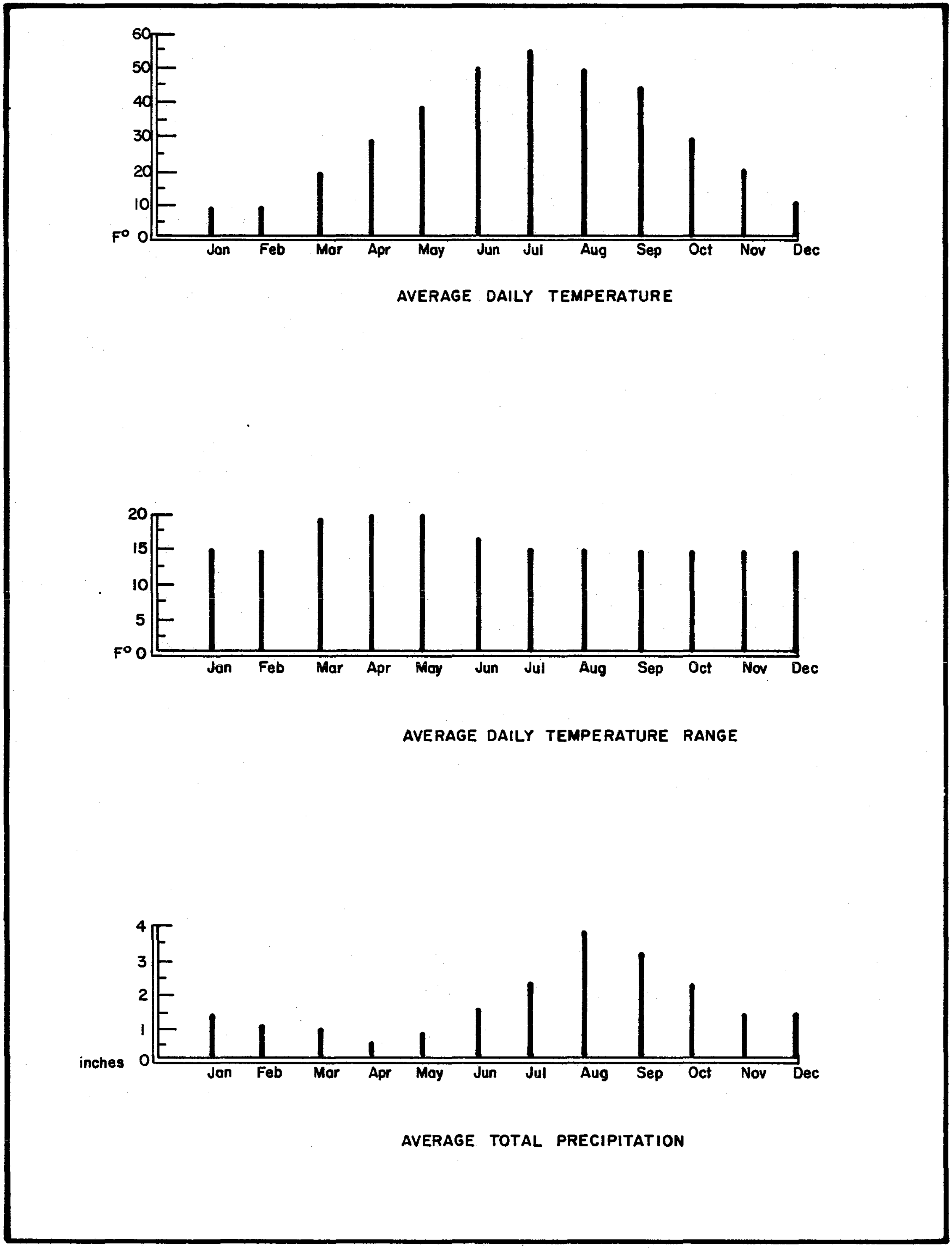
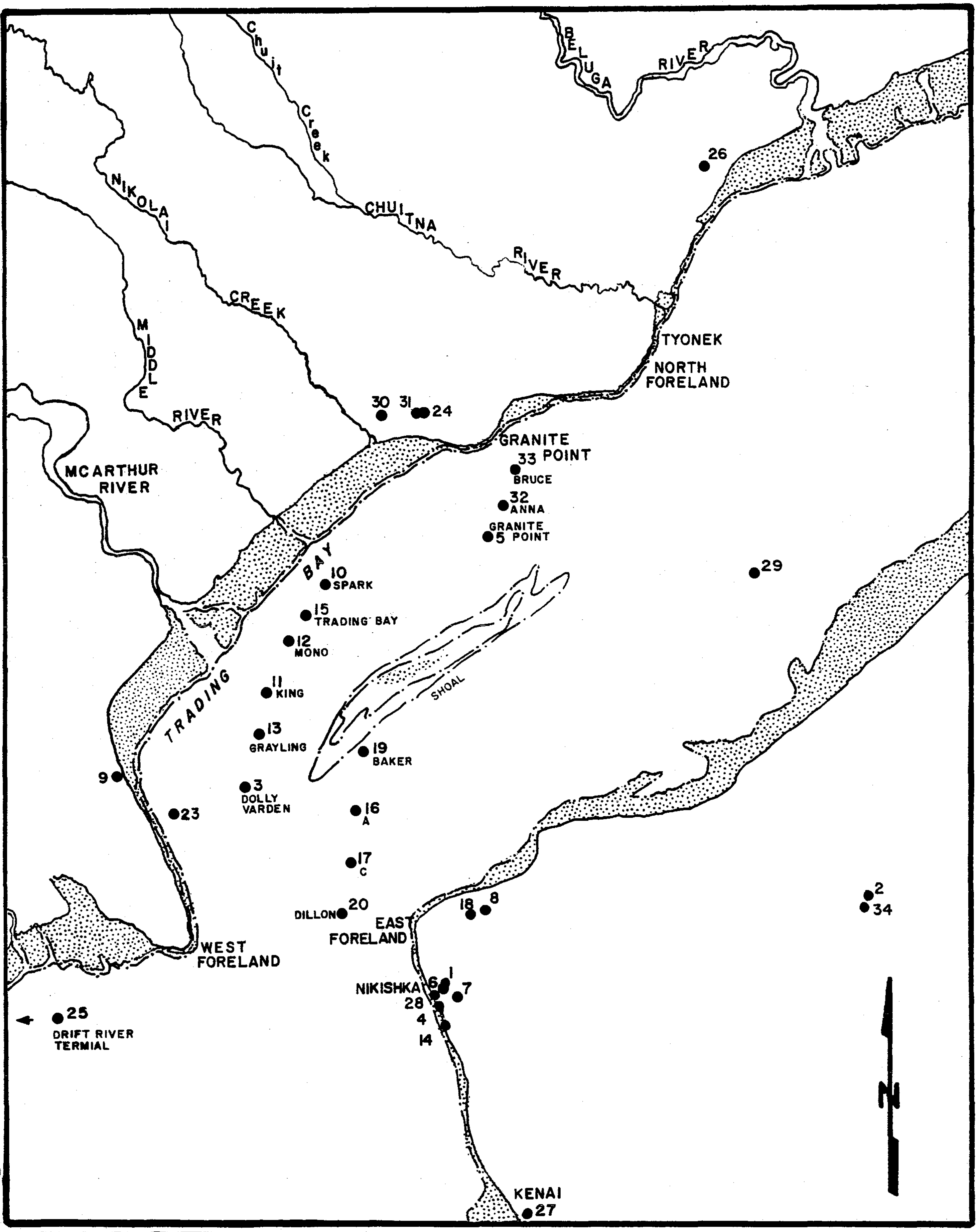
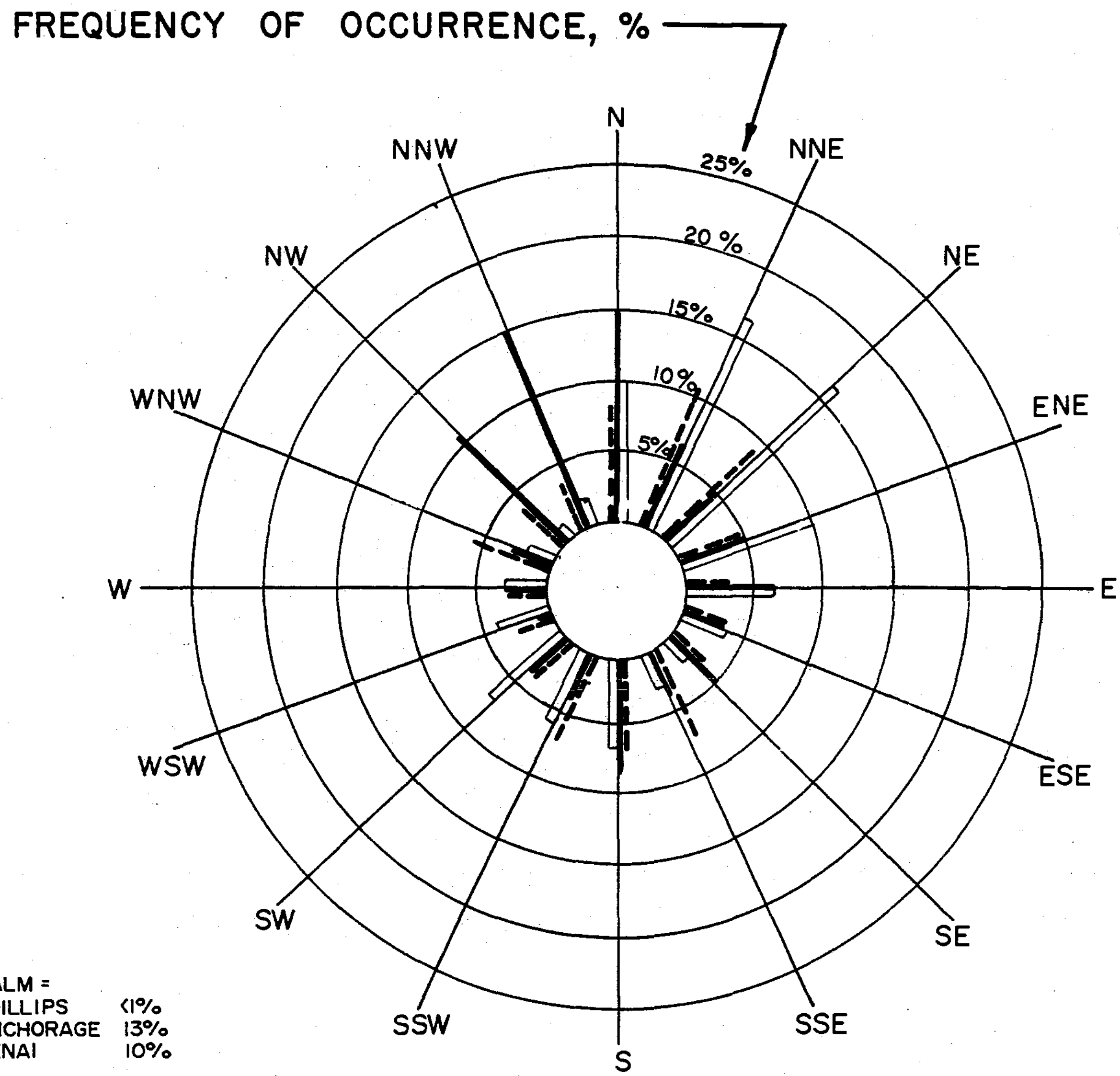



FIGURE 6.1 REPRESENTATIVE CLIMATIC CONDITIONS FOR PROJECT AREA




| FIGURE 6.2 | LOCATIONS OF WEATHER MONITORING STATIONS |
|---|---|




| LOCATION | SYMBOL | SEASON | DATA PERIOD | NUMBER OF OBSERVATION DAYS |
|---|---|---|---|---|
| PHILLIPS PLATFORM | ——— | ANNUAL | 74 - 79 | 2 |
| ANCHORAGE | ▬ ▬ ▬ ▬ | ANNUAL | 51 - 60 | 24 |
| KENAI | ▭ | ANNUAL | 64 - 70 | 8 |

NOTE: KENAI ROSE HAS CALMS DISTRIBUTION BETWEEN THE 1 - 3 & 4 - 6 KNOT GROUPINGS.

FIGURE 6.3 WIND ROSE

Observations from the Kenai and Anchorage stations are used to describe the turbulent structure of the atmosphere. Wind speed, time of day, cloud cover and cloud ceiling height data are combined with estimates of the intensity of solar radiation to classify the atmosphere into one of six atmospheric stability categories designated by the letters A through F. Stability Class A represents the most turbulent conditions and is associated with strong solar radiation input and dominating convective currents. Stability Class F describes very stable air absent of convection currents. For Kenai, the annual frequencies of occurrence of the various stability classes are: Class A - 0%, Class B - 1%, Class C - 10%, Class D - 62%, Class E - 9%, Class F - 18%. This distribution reflects the rather common occurrence of cloudy skies (Class D). It also suggests that the dispersion of contaminants released into the atmosphere will be controlled most of the year by wind speed and roughness of the ground surface. This is discussed in more detail in Section 15.0 AIR QUALITY.

Other aspects of the climatology that should be noted are:

| | |
|---|---|
| ° Possible sunshine | Less than 50%, annual average |
| ° Sky (cloud) cover (sunrise to sunset) | 70% annual average occurrence, 40% annual average full coverage |
| ° Mean daily solar radiation | 225 Langleys, annual average |
| ° Precipitation greater than 0.01 inches | Less than 120 days, annual |
| ° Shortest day | 5½ hours |
| ° Longest day | 19½ hours |
| ° Heating degree days (base 65°F) | 10,864, annual average total (Anchorage) |

## EXISTING AMBIENT AIR QUALITY

National and Alaska Ambient Air Quality Standards set maximum levels of several pollutants: Ozone, carbon monoxide, surfur dioxide, total suspended particulates, hydrocarbons, nitrogen dioxide and lead. The Clean Air Act as Amended August 7, 1977 (PL 95-95) defines three classifications for areas which meet these standards: Class 1 areas are considered to have pristine air quality with the allowance for minimal introduction of additional air pollutants; Class II areas, in which pollution will be allowed to increase to accommodate moderate industrial growth; and Class III areas which are the most heavily industrialized. Some areas are specifically defined in the regulations as mandatory Class I Areas (40 CFR 81 Subpart D). The Cook Inlet Air Quality Control Region is designated a Class II Attainment Area for all criteria pollutants. The Tuxedni National Wildlife Refuge, about 80 miles southwest of the project area, is a mandatory Class I Area (40 CFR 81.402). Anchorage, approximately 75 miles east/northeast of the proposed plant site, is one of two areas of Alaska in nonattainment with the ambient air quality standards for carbon monoxide. The Prevention of Significant Deterioration (PSD) permit program administered by EPA limits the amount of controlled pollutants which can be emitted by a new source in order to ensure that the ambient air quality standards are not violated in any area which could be affected by the new source.

## ATMOSPHERIC EMISSION SOURCES

The actual air quality on the western shore of Cook Inlet near Tyonek is not known. Several sources of emissions of particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides and hydrocarbons are scattered throughout the onshore area, with a number of offshore oil and gas platforms concentrated in the Nikishka/Kenai area. Nitrogen dioxide emissions are greatest, with products of combustion representing the majority from both offshore and onshore pollutant emission sources. The impact of these existing sources on ambient air quality tends to be very localized with the highest regional concentrations occurring where source congestion is greatest. The most congested areas include Trading Bay and Salamatof, and even in these areas separation between individual sources is good

(Dames and Moore, 1978). For these reasons, air quality within the area is expected to be well within the National and Alaska Ambient Air Quality Standards. These existing sources will have to be considered in evaluating the impact that new sources would have on ambient air quality, especially if the new sources are expected to have their maximum impact to the immediate south of the site.

Visibility is occasionally a problem throughout the inlet area. At Anchorage, the visibility is one-half mile or less 5% of the time during December and January, primarily due to fog. The Alaska Department of Environmental Conservation may, in its discretion, require any person proposing to build or operate an industrial process, fuel burning equipment, or incinerator in areas of potential ice fog to obtain a permit to operate and to reduce water emissions ( 18 AAC 50.090). In addition, snowfalls frequently decrease visibility to less than 3 miles.

# 7.0 OCEANOGRAPHY

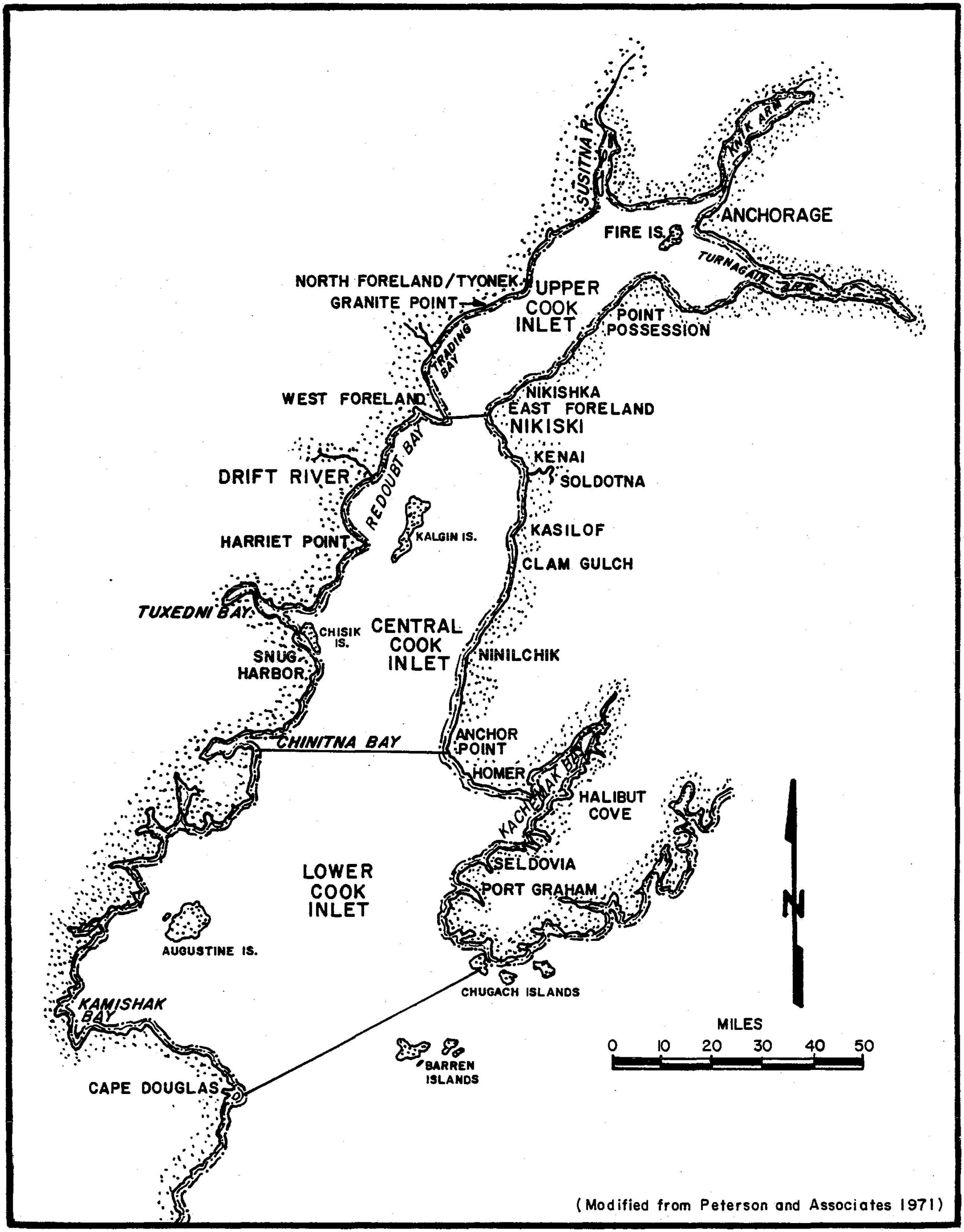
## PHYSICAL OCEANOGRAPHY OF COOK INLET

Cook Inlet is a large tidal estuary in Southcentral Alaska which flows into the Gulf of Alaska. The estuary lies between latitudes 50° and 61° 30' north and longitudes 149° and 154° west. The inlet is more than 150 nautical miles long and 50 nautical miles wide at the mouth. At its northern tip Cook Inlet divides into Turnagain Arm (43 nautical miles long) and Knik Arm (45 nautical miles long).

The inlet is bordered by more than 100 square miles of tidal marsh, found primarily in the Susitna flats at the northwest end and in Trading and Redoubt bays on the northwest side of upper Cook Inlet.

For discussion purposes, the inlet is divided into lower, central, and upper regions (Figure 7.1). The lower division extends from the mouth to an east-west line from Chinitna Bay to Anchor Point. The upper region lies north of an east-west line from East Forelands to West Forelands. Granite Point, the site for the proposed methanol plant, lies just north of Trading Bay in upper Cook Inlet; the Drift River Terminal is in Redoubt Bay on the west side of central Cook Inlet.

The Cook Inlet environment is diverse, and water quality varies greatly from the mouth of the inlet to the head. The tidal range in Cook Inlet is one of the largest in the world. The upper portion of the inlet is a shallow silt-laden basin. At the Forelands the maximum depth is approximately 75 fathoms (450 feet). Below the Forelands, the bottom slopes to a depth of more than 100 fathoms (600 feet) at the mouth.




| FIGURE 7.1 | DIVISIONS OF COOK INLET |
|---|---|

## Tides and Currents

The tides in Cook Inlet are semidiurnal with a marked inequality between successive low waters. At the mouth of the inlet the mean diurnal tidal range is 13.7 feet. The range increases to 19.8 feet at Kenai and 29 feet at Anchorage. At the ends of both Knik and Turnagain arms, the tidal range exceeds 35 feet. These mean ranges can be exceeded during the spring and fall equinox periods by more than 5 feet. The time lag between high water at the mouth and at Anchorage is about 4.5 hours. It has been estimated that the time lag at Drift River is approximately 2 hours at low tide and 1.7 hours at high tide.

The following tidal ranges are applicable for the central and upper portions of the inlet. These ranges vary slightly for the Tyonek/ Beluga area.

Table 7.1

COOK INLET TIDAL RANGES

| | KENAI (ft.) | ANCHORAGE (ft.) | BELUGA (ft.) |
|---|---|---|---|
| Estimated Highest Tide | 27.0 | 36.0 | -- |
| Mean Higher High Water | 20.7 | 30.0 | 21.00 |
| Mean High Water | 20.0 | 29.0 | 20.40 |
| Mean Tide Level | 11.1 | 15.5 | 11.25 |
| Mean Low Water | 2.1 | 2.2 | 2.10 |
| Mean Lower Low Water | 0.0 | 0.0 | 0.0 |
| Estimated Lowest Tide | -6.0 | -4.9 | -- |

The extreme tides in the inlet create strong currents. The average maximum tidal currents range from 1 to 2 knots in lower Cook Inlet, 4 to 6 knots between the Forelands, and 2 to 3 knots near Anchorage. Current direction is determined by bathymetry. Higher velocities for currents vary within the inlet; however, the high velocities are associated with flood tides. In the Tyonek area, current velocities have an estimated range from 3 to 6 knots.

## CIRCULATION

The circulation of waters within Cook Inlet has been extensively studied. Generally waters from the Gulf of Alaska flow into Cook Inlet through the Kennedy Entrance between the Chugach Islands and Cape Douglas. The waters must pass a steep entrance ramp into the inlet, causing upwelling. The nutrients and plankton from the Gulf of Alaska are carried into the inlet creating an area of high productivity in the lower inlet/Kachemak Bay region.

The waters from the gulf move northward along the east side of the inlet and across the inlet at Anchor Point. Waters also flow into Kachemak Bay, and eddies are created at the mouth of the bay. Minor quantities of water move northward past the forelands and into the upper inlet. Turbid water from the upper inlet mixes with the clear water from the gulf north of Anchor Point. Because of the vast difference in the density between waters of the upper inlet and those from the Gulf of Alaska, lateral mixing is slow. However, the rapid currents and tidal action keep the waters of the inlet well mixed vertically. Lateral mixing produces convergence zones in which denser saline waters flow under less saline waters and produce rip tides. These rip tides produce considerable horizontal shear. Circulation patterns and main rip tide locations are illustrated in Figure 7.2.

### Upper Cook Inlet

The waters of upper Cook Inlet mix with each tidal cycle. This is due to the large tidal fluctuations and the shallow sea bottom. In

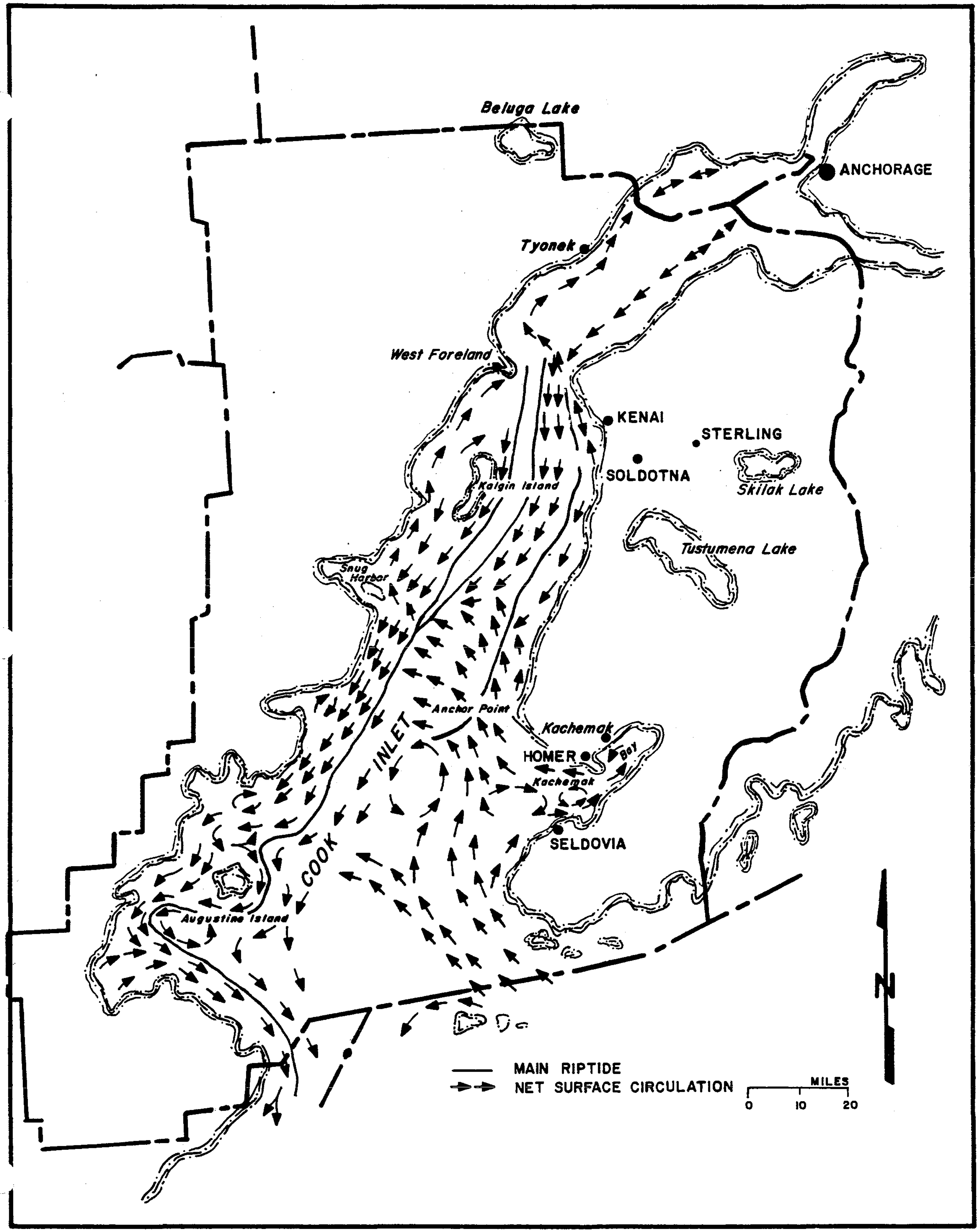



FIGURE 7.2 NET SURFACE CIRCULATION

the spring and summer a large amount of fresh water flows into the upper inlet from major tributaries including the Beluga, Susitna, Little Susitna, Matanuska, Knik, Eagle, Twenty-mile, Placer, Resurrection, and Swanson rivers. The increase in fresh water volumes causes a net outward movement of upper inlet waters of as much as a mile each tidal cycle. In the winter, however, when runoff is greatly reduced, there is practically no net outflow from the upper inlet.

### Middle Cook Inlet

The middle inlet is characterized by saline oceanic water moving northward along the eastern shore, and the outward movement of fresh runoff water from the upper inlet along the western shore. Lateral separation of these waters is maintained.

### Lower Cook Inlet

In the lower inlet a vertical stratification of the water masses occurs. The denser, colder, more saline oceanic waters underlie the warmer, less saline waters of the inlet. As the inlet becomes shallower to the north the dense oceanic waters are forced upward and mix with the inlet waters.

## WATER CHEMISTRY

The waters of Cook Inlet change chemical make-up seasonally, due primarily to variations in the volume of freshwater inflow. During summer, large quantities of nitrate, nitrite, silicate, and suspended sediments are carried into the inlet from rivers, streams and other runoff sources. During the winter, with decreased freshwater inflow, there is an increased intrusion of oceanic water, and salinity, phosphate and ammonia concentrations increase.

### Salinity

The salinity of Cook Inlet varies with the season due to increased freshwater runoff in summer. During May through September the increased discharge from rivers and streams and other runoff sources decreases the salinity of the upper inlet. At Anchorage salinity varies from 6 to 15 parts per million (ppm) during the summer. In the winter, freshwater inflow is reduced and the intrusion of more saline oceanic waters is evidenced by an increase in salinity. The salinity of waters near Anchorage in the winter usually is approximately 20 ppm. At the mouth of the inlet, however, the salinity values remain relatively constant at 32 ppm. The salinity in the Beluga/Tyonek area varies between 10 and 20 ppm in the summer months.

As a result of the increased freshwater inflow, the Alaska current and the Coriolis effect, the water on the eastern side of Cook Inlet tends to be more saline than on the western side.

### Temperature

The temperature of waters varies with season from below 32° to 60°F (0° to 15°C) in the upper inlet. The lower inlet is affected by the intrusion of warmer waters from the Gulf of Alaska and thus the waters range in temperature from 48° to 50°F (9° to 10°C). During the winter, the upper inlet loses enough heat to form ice on the water's surface and also loses heat throughout the vertical column. However, during spring, freshwater inflow and warm air temperatures melt the ice and the water temperature rises.

### Suspended Sediments

Discharges of fresh water from the major rivers which flow into Cook Inlet carry large amounts of suspended sediment. The Susitna River and other rivers flowing into Knik Arm represent 70 to 80% of the total sediment flow into the inlet. As with temperature and salinity, suspended sediment loads vary seasonally. This is due to the large amount of glacially derived sediments which combine with sediments in the summer and fall runoff waters.

In the upper inlet the small-size particles, clays and silt-size particles are kept in suspension by strong tidal action. The heavier particles are deposited at the mouths of the streams and rivers. The distribution of sediments within the inlet is shown on Figure 7.3.

Concentration of suspended sediments varies within the inlet from negligible at the mouth to 3,000 micrograms per liter ($\mu g/\ell$) in Knik Arm. In the Beluga/Tyonek area the concentration varies from 250 to 1,000 $\mu g/\ell$.

Nutrients

Nutrients are introduced into the estuarine environment of Cook Inlet through both natural and man-made sources. Total concentration of nutrients is found to gradually increase with distance toward the mouth of the inlet. Nutrients of importance include ammonia, nitrite, nitrate, phosphate and silicate. The increase of these nutrients in the southern portion of the inlet causes an increase in productivity. Marine biological resources increase dramatically. Low levels of nutrients associated with high turbidity in the upper inlet are responsible for the near absence of plankton.

Ammonia concentration decreases northward toward Knik and Turnagain Arms, however, ammonia concentrations do not fluctuate seasonally. Sources of ammonia input to Cook Inlet include oceanic entrainment, freshwater inflow, precipitation and man-made sources. Of these, oceanic entrainment provides more than 80% of the ammonia in the inlet. Ammonia is used by phytoplankton and is one of the first elements decomposed by bacteria. Concentration of ammonia in the upper inlet ranges from 0.5 to 2.0 $\mu g/\ell$.

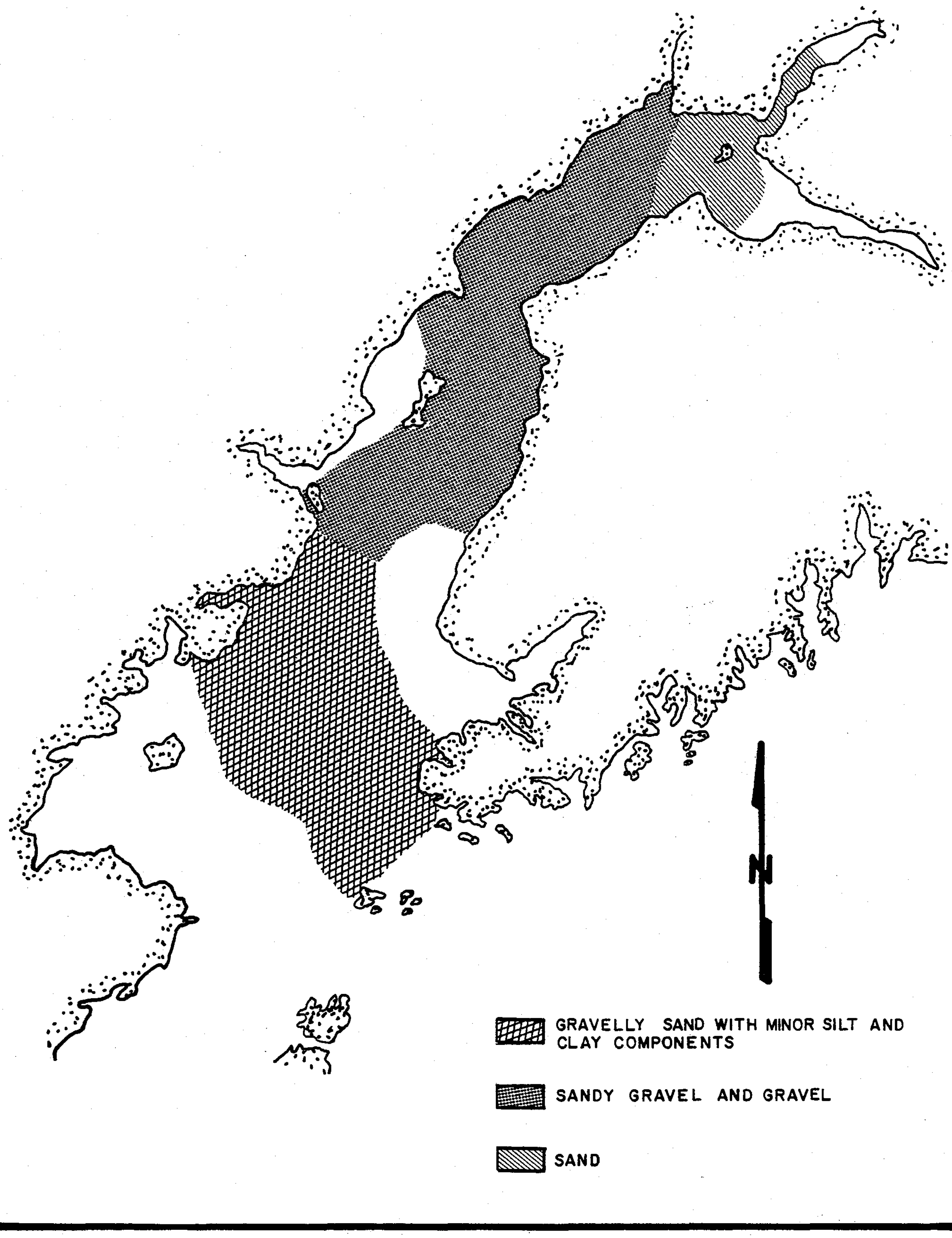



FIGURE 7.3 BOTTOM SEDIMENTS IN COOK INLET

Nitrite concentration in the inlet varies from 0.02 to 0.52 μg/ℓ. There is a gradual increase in concentration seaward.

Nitrate concentration increases from below detectable limits at the mouth to 23.5 μg/ℓ near the head of the inlet. The increase in concentration can be attributed to higher freshwater inflow, lower biological activity, and higher municipal waste inputs.

Phosphate-phosphorus concentration ranges from 1 μg/ℓ at the ocean entrance to approximately 2.3 μg/ℓ between Anchor Point and Kalgin Island, then decreases to about 0.7 μg/ℓ in Knik Arm. The high amounts of freshwater inflow at the head of the inlet reduce the phosphate concentration.

Silicate concentration is directly related to the concentration of suspended sediments and thus decreases in concentration toward the mouth of Cook Inlet. Concentration ranges from 82 μg/ℓ near Knik Arm to 9 μg/ℓ at the ocean entrance.

Dissolved oxygen saturation levels for Cook Inlet range from 6.5 to 9.5 μg/ℓ. These levels may decrease slightly during winter months in upper Cook Inlet when there is an ice cover. Dissolved oxygen is necessary for aerobic marine life. Dissolved oxygen saturation value increases with decreasing temperature and salinity and decreases with suspended sediment concentration. The high suspended sediment concentration in the upper inlet also may cause a slight decrease in the dissolved oxygen saturation level. The high level of turbulence and strong currents throughout the inlet, however, help maintain the dissolved oxygen level at or near saturation.

pH values in Cook Inlet vary seasonally and with location. The pH can vary from 7.7 near the head of the inlet to 8.4 at the mouth.

## SEA ICE

Heavy ice normally accumulates in upper Cook Inlet around mid-December, exists in greatest quantities during the colder months of December and January, and remnants may be present through mid to late April. Sea ice in Cook Inlet is found primarily north of the Forelands and generally moves with the currents southward toward warmer waters. The extent of the ice coverage depends on the severity of the winter and the prevailing winds.

Temperature and snow cover control ice growth in the inlet. When air temperatures are extremely low and snow cover marginal for extended periods of time, the ice cover will be thicker and more extensive than usual.

Ice in the inlet takes many forms. Usually the ice is floe ice, which in periods of extremely low ambient temperature and little or no snow cover can increase in thickness by as much as 1 inch per day, forming cakes or pans of ice. The pans have a normal thickness of 2 to 4 feet but may attain thicknesses of 6 to 8 feet under uncommonly severe conditions. Tidal action moves the pans of ice back and forth in the upper inlet causing small pieces to break off and form individual pieces of stranded ice, called "Stamukhi". Shorefast ice forms in shallow intertidal areas such as tidal flats. Tidal action deposits large blocks of ice on the beach or along the shoreline. The blocks of ice then freeze to the underlying mud. These blocks of ice are exposed to air and submerged with water during the tidal cycle and build mats of ice, 6 to 10 feet in thickness. Piles of ice may break off and go adrift during periods of extreme high tide and enter other ice floes in the inlet. Ice piles such as these can be dangerous to the smaller ships, tugs, and barges which operate within northern Cook Inlet.

Sea ice tends to accumulate along the western shoreline of Cook Inlet due to prevailing winds and currents. Ice formed in upper Cook

Inlet has a lower salinity due to freshwater discharges into the inlet, and would tend to be harder than ice found in lower Cook Inlet and the Gulf of Alaska. These freshwater discharges also carry large amounts of suspended sediments of which a large part is glacial flour. The ice which contains these sediments would tend to break more easily than ice which doesn't. This would in part mitigate the ice hardness due to the lower salinity of upper Cook Inlet.

Ice occasionally causes difficulties with shipping within Cook Inlet. With the decrease in demand for freight to be shipped during the winter and the possibility of sustaining damage to the vessel as a result of impacts with ice flows, most tug and barge operations generally terminate in upper Cook Inlet from mid-November to late March. The average tug length in Cook Inlet is approximately 120 feet, and none of the tugs or barges is strengthened for ice conditions.

Though ice must be acknowledged as a factor important to navigation and berthing of ships in Cook Inlet, it has not caused significant difficulties to the large vessel trade. Anchorage, at the head of Cook Inlet where ice accumulation is greatest, is the port of call for an average of two to three Totem Ocean Trailer Express and Sea-Land Service Company ships weekly throughout the year, with 15 to 20 Chevron USA ships using the port facilities yearly. These ships have extra plating to prevent damage due to the ice, with the exception of the two ships operated by Totem. Totem's marine manager feels their fine-line ships have a greater tendency to cut through the sea ice than do the wider ships. Totem's vessels have not sustained damage due to ice floes which has required repair ahead of the regular maintenance schedule.

Servicing of the many oil platforms within Cook Inlet also continues throughout the winter months without significant difficulties due to the sea ice. The Alaska Husky, a 182-foot ship operated by Amoco Production Company, transports fuel, water, and miscellaneous supplies to and from two of the three oil platforms nearest Granite Point, the Bruce and the Anna, twice weekly with little difficulty and without an accelerated maintenance schedule. None of the above companies has ever had a ship cancelled due to the ice in Cook Inlet. An occasional short delay has been experienced, waiting for the tidal action to wash the ice from the berthing area for a more facile entry. Past experience indicates tankers transporting methanol from Drift River should have no significant trouble with ice in Cook Inlet.

## PORTS

There are 6 ports or terminal facilities within the inlet. These include Seldovia, Homer, Kenai/Nikiski, Ninilchik, Drift River, and Anchorage. Anchorage, at the head of Cook Inlet, is the most ice-affected location within the inlet. Anchorage is also the largest of the ports and is a modern, year-round facility that handles more than one million short tons of cargo per year. The Nikiski port handles primarily out-bound petroleum products including crude, residuum, finished products and liquified natural gas (LNG). Another major product is urea, which is shipped primarily to Japan.

The ports of Kenai, Homer, Seldovia and Ninilchik are primarily small boat harbors and support the fishing industry in lower Cook Inlet. The Drift River Terminal is a single-berth fixed-platform offshore loading facility which transfers crude oil from the offshore platforms aboard tankers for transport to refineries.

## 8.0 ARCHAEOLOGIC & HISTORIC SITES

A paucity of archaeological investigations in the area requires that an understanding of the history and prehistory be gleaned from regional sources of information.

### ETHNOHISTORY AND SETTLEMENT PATTERNS

#### Settlement Patterns

The area is currently inhabited by the Tanaina Athapaskan Indians, speakers of the Upper Inlet dialect of the Dena´ina language of the Na-Dene speech family. Archaeological evidence indicates that the ancestral Na-Dene moved across the Bering Strait into the present State of Alaska by the tenth millenium B.C., near the end of the final great glacial period. They continued to spread east and south during the period of deglaciation, and diversification of the Pacific Athapaskan subfamily is considered to have been completed by about 1000 A.D. It is further considered that the earlier inhabitants of the Cook Inlet area were Pacific Eskimo or their direct ancestors, and they were occupying the area at least seasonally beginning before and lasting until after 1000 A.D., with the Tanaina moving into Knik Arm, specifically, between 1650 and 1780 A.D.

A complex relationship between the people and the land can be described for the inhabitants of Cook Inlet. Location along the food-rich sea coast enabled the fairly settled way of life known as Central-Based Wandering: A community that spends part of each year wandering in the performance of subsistence activities, and the remainder of the year at a settlement, or central-base. The settlement patterns of the Northern Athapaskans, as well as of the Pacific Eskimos, also can be characterized by a sedentary seasonal settlements-complex. This is one in which the year is divided into a winter season during which little resource exploitation occurs and the people gather at their winter settlements, and a hunting and fishing season from the spring to the fall when people are scattered in small hunting, sealing or fishing camps. In the case of the Tanaina on Cook Inlet, it is probable that people gathered at the seashore or riverbanks in concentrated settlements during the fishing seasons or sea mammal hunting seasons, and in the intermittent seasons task groups moved about to hunt wild game, trap, etc.

The socio-territorial relationships of historic and prehistoric inhabitants of Cook Inlet can be broken down into three segments. The local band was a community body resident in one locale, and structured around family ties. The regional band was oriented toward an extensive exploitive territory with regard to its biotic resources. The sites of these resources and routes of access to the sites determine the stations and movements of various groupings. The task groups were short-term groupings of people specifically created for exploitive activities. Task groups formed in the Cook Inlet area could have been a male trapping pair or trio, a trapping party of a few families, a moose hunting party or camp, a fish camp, a berry gathering party, or a trading party. It is apparent that the settlement patterns were determined by and changed according to the ecological potentiality of the locale, combined with the exploitive ability of the human occupants.

## Dwellings

Aboriginal Tanaina dwellings were characteristic of those of the Pacific Eskimo, and were also built on Kodiak Island, the Aleutian Islands, and Prince William Sound. The winter house, known as a "barabara" in Russian and "nichil" in Dena´ina was rectangular, and semi-subterranean, excavated to a depth of two to four feet. It fits in the category of the Third Period of Kachemak Bay. The dwelling which extended "five trees long" was constructed with split vertical logs, and had four or five fireplaces and a smoke hole at the top. To the main part of the barabara, or winter house, one or more secondary rooms were added, for sleeping rooms (depending on the number of families sharing the dwelling), a sweat house, and possibly a menstrual lodge. These were excavated to the depth of the main lodge. Floors of the sweat house and sleeping rooms were rough hewn planks and the remaining floors were spread with grass. A narrow, semi-subterranean shed served as an entrance way. The summer houses, used also for fish smoking, were simplified versions of the winter houses. Excavation was to two feet, length was a maximum of 20 feet, and three corner posts sufficed.

Petroff (1880) and Porter (1890) report that by 1880 house construction had changed and a log dwelling erected entirely above ground replaced the barabara. The dwelling was divided into an outer room for cooking and rough labor, and an inner room for sleeping.

Secondary dwellings, constructed for short-term use such as on hunting expeditions, were of various types. The semi-spherical "beaver house" made of bent alders covered with birch bark or skins was common. Another type was the lean-to, or one-sided lodge. This was also constructed from covered alder poles.

## Caches

The Tanaina in the Tyonek Upper Inlet area constructed two types of storage caches. One was an underground cache constructed similarly to the winter house, however the roof was lower and the whole house was sunken and covered with earth. The caches were generally situated some distance from the village and the main advantage of this type was that they could not easily be detected and therefore were protected from Eskimo raids. At the Kijik site on the west shore of Lake Clark west of Cook Inlet, 29 small, deep depressions thought to have been caches were noted. Storage pit depressions were also found on the northwestern Kenai Peninsula. The more common log building, situated on a platform and raised on poles, was also utilized in the Tyonek area.

## Burial

According to Osgood (1937), the dead, along with their essential possessions, were disposed of by cremation in the Tyonek area. The ashes were then wrapped in birch bark and hung in a tree. A method known to have been used by the Eskimo in Alaska south of the Bering Strait was box burial. In Tyonek, the dead were also known to have been cremated and placed, with possessions, in a box on posts. By 1805 only the rich were cremated, and by the late 1800s, due to Russian influence, cremation was no longer practiced. Grave offerings continued, however, and burials were frequently in structures resembling miniature houses.

Hieromonk Nikita visited in 1881 a grave of a former local chief at Tyonek. A small house in the shape of a chapel, equipped with a door and a window, had been constructed over the grave. Inside the structure was a table, food, clothes, a gun, a razor and other items, many of European descent, that a wealthy Tanaina would value. Petroff (1880) also witnessed a burial house at Tyonek filled with Russian samovars, rifles, blankets and other costly items.

## Material Culture

Osgood (1937) states that it is probable that metal working, to the extent of pounding crude copper into useful shapes, was a custom of the Upper Inlet Tanaina. Dumond and Mace (1968) concurred that at least in late prehistoric times copper was used by the Natives in Southcentral Alaska. Copper objects were attributed to the late prehistoric sequence at Kachemak Bay, and Captain James Cook reported that the Cook Inlet Natives had spears and knives with copper blades. Prince William Sound and the Copper River were the nearest sources of native copper. The Athapaskans of Cook Inlet used to travel the Matanuska River and cross the 12-day portage to the Tazlina River where they traded with the Copper River Indians.

It is a point of conflict whether the Tanaina were producers of pottery. Osgood (1937) reports that the pottery sherds discovered by Jacobsen at an abandoned village called Soonroodna, on the south shore of Kachemak Bay, are evidence that the Tanaina had pottery, and he concludes that they made it themselves. He states, however, that his informants have no memory of the Tanaina ever having made pottery. It is considered that pottery users in the Naknek drainage and on the Pacific were Eskimos. In addition, two gravel-tempered sherds excavated by DeLaguna at Kachemak Bay are thought to represent the last of the Pacific Eskimos residing there before the arrival of the Tanaina. In addition, pottery sherds recovered in 1966 at Fish Creek on Knik Arm, which were associated with Pacific Eskimo occupation were of relatively thick, gravel tempered ware, globular form, with a rim identical to those from the Naknek drainage from a time between 1000 and 1500 A.D. Therefore, it can be expected that there is at least a sporadic occurrence of later pebble tempered pottery along the shores of Cook Inlet (Dumond 1969), and it can be concluded that there is stronger evidence in favor of pottery representing the Eskimo culture, than its replacement Tanaina culture.

The uncovering of a coal labret (lip ornament) at the same Fish Creek site substantiates the evidence of Eskimo occupation of the area. Captain James Cook stated that the Tanaina of Tyonek in 1778 used fewer lip ornaments and more nose ornaments than the Eskimo of Prince William Sound. Nose and ear ornaments were made of beads and carved bone.

A simple pointed harpoon with blades attached, nine feet one inch long, was collected at Tyonek. This was utilized for sea otters, seals and porpoises. A spear-thrower with a hook on the end is thought to have been used in the area. The bow had a guard and no sinew backing. Roughly hewn pieces of wood, slightly curved at the striking end, were used as clubs to kill seals and for dispatching sea otters after they were drawn alongside the kaiaks with harpoons.

The aboriginal man's knife was generally made of stone, two inches wide, eight inches long, and pointed. The handle was narrowed for grasping. The woman's knife was fashioned after the Eskimo ulu, a semi-ovaloid blade of stone set lengthwise in a handle. Adzes were made from hard stone, and scrapers from beaver teeth, mussel shells, and stone. No saw-like implements are known.

The foregoing list describes some of those tools used by the Tanaina Athapaskans of the Tyonek area. Frederica DeLaguna's exhaustive archaeological investigation in Cook Inlet, particularly in Kachemak Bay, can offer clues as to what cultural remains might be found in the study area. Her collection contains a large proportion of stone objects due to their resistence to decay. Bone and wood objects are highly susceptible to destruction by salt water. The stone industry of the early Kachemak Bay culture is characterized by the importance of chipping. This emphasis subsides as polished slate takes its place. Notched stones appear in the second period, as do grooved stones. Stone types commonly found in the later stages are the slate awl, slate mirror and decorated stone lamp.

In the bone industry, the Thule Type I harpoon head is most important in the First Period. In later periods the barbed dart head replaces it in importance, and incised decorations on bone objects become more common. The labret is found even from the earliest periods, and the double pointed bird bone awl, bone scrapers, red shale beads and rectangular bone and shell beads appear in the later stages.

Pottery and copper are uncommon, and are restricted to the last stage of the Third Period.

## European Contact and Trade

The first documented contact between Pacific Drainage Athapaskans and Europeans occurred in 1778 when, searching for the northwest passage, Captain James Cook sailed into the inlet that now bears his name. Toward the close of that century other English navigators visited and traded with the coastal Tanaina.

In 1786 the Russians settled at St. George on the Kenai Peninsula and 13 years of struggle between various trading companies ensued. Finally, in 1799 the Russian American Company was formed and maintained a monoploy. Trade with the Russians was merely an elaborated form of trade patterns that had been occurring between the Indians and Eskimos before contact with the Russians. From the Russians the Tanaina received iron, beads, clothing and furnishings in exchange for furs.

At the time of the sale of Alaska to the United States, the assets of the Russian American Company were purchased and the Alaska Commercial Company was founded. A trading station was established at Tyonek at that time. The Western Fur and Trading Company also opened a post north of Tyonek at Ladd near the mouth of the Chuitna River. Tyonek is considered the earliest permanent settlement on upper Cook Inlet. Petroff reported 117 inhabitants in the town in his 1880 census report. A post office was opened in 1897.

Gold fever drew hundreds of prospectors to upper Cook Inlet, and in May 1898, 300 prospectors were reported camping on the beach at Tyonek. Large boats would go up the inlet in the summer, and touch at Tyonek. There, people would change to small boats and dories to reach Turnagain Arm. The Indians were used as guides and for manual labor.

In 1899, Captain Edward F. Glenn of the Twenty-fifth Infantry commanded the Cook Inlet Exploring Expedition which was based in Tyonek. The goal was to explore, survey, establish, and mark the trail from Tyonek to various locations. The routes were to be eventually made available to the public, and information was gathered regarding topographical features, feasible routes for railroad construction, sites for military reservations, the location and condition of natives encountered, etc. Expeditions were dispatched in the directions of the mouth of the Tanana River, Sushitna station, Circle City, and Eagle City.

According to the register of accounts for the Alaska Commercial Company, 16 types of skins were traded in 1884. The trading station's clerks kept a daily diary of events in the town and reported that there was much travel between towns by the inhabitants, and game was particularly scarce.

Historic and Prehistoric Sites

DeLaguna (1934) notes four archaeological sites near the study area (Figure 8.1). The modern village of Ladd is situated on the ancient site, Ts'ui´tna, from which the name of the river Chuit is probably derived. The town has been called Ladd since 1895, when it was a trading post and fishing station. Near the current site of Tyonek is the old village site, Qa´qesle. In the woods at the top of the hill behind the village site are the houses where the Tanaina lived for fear of raids by the Kodiak Eskimo. Old Tyonek is called Ta'naq and the site of Tsila´xna is at a small stream south of Granite Point. In addition, the site of Tobona, meaning "people of the beach," is located two miles south of Tyonek. Californsky's Fish Camp is along the beach 5½ miles southwest of Tyonek. Located about two miles southeast along the beach from the Kodiak Lumber Mills camp at North Foreland is a native cemetary, and on the bluff in front of McCord's cabin is evidence of prehistoric habitation. One-and-a-quarter miles inland on a road near the mouth of Tyonek Creek is Lake Batunglyashi. The lake, according to oral tradition, is the site of the last Indian war. Located within the modern town of Tyonek are many historic sites.

Proposed construction would avoid the land located within the boundaries formerly designated as the Moquawkie Reservation. The only

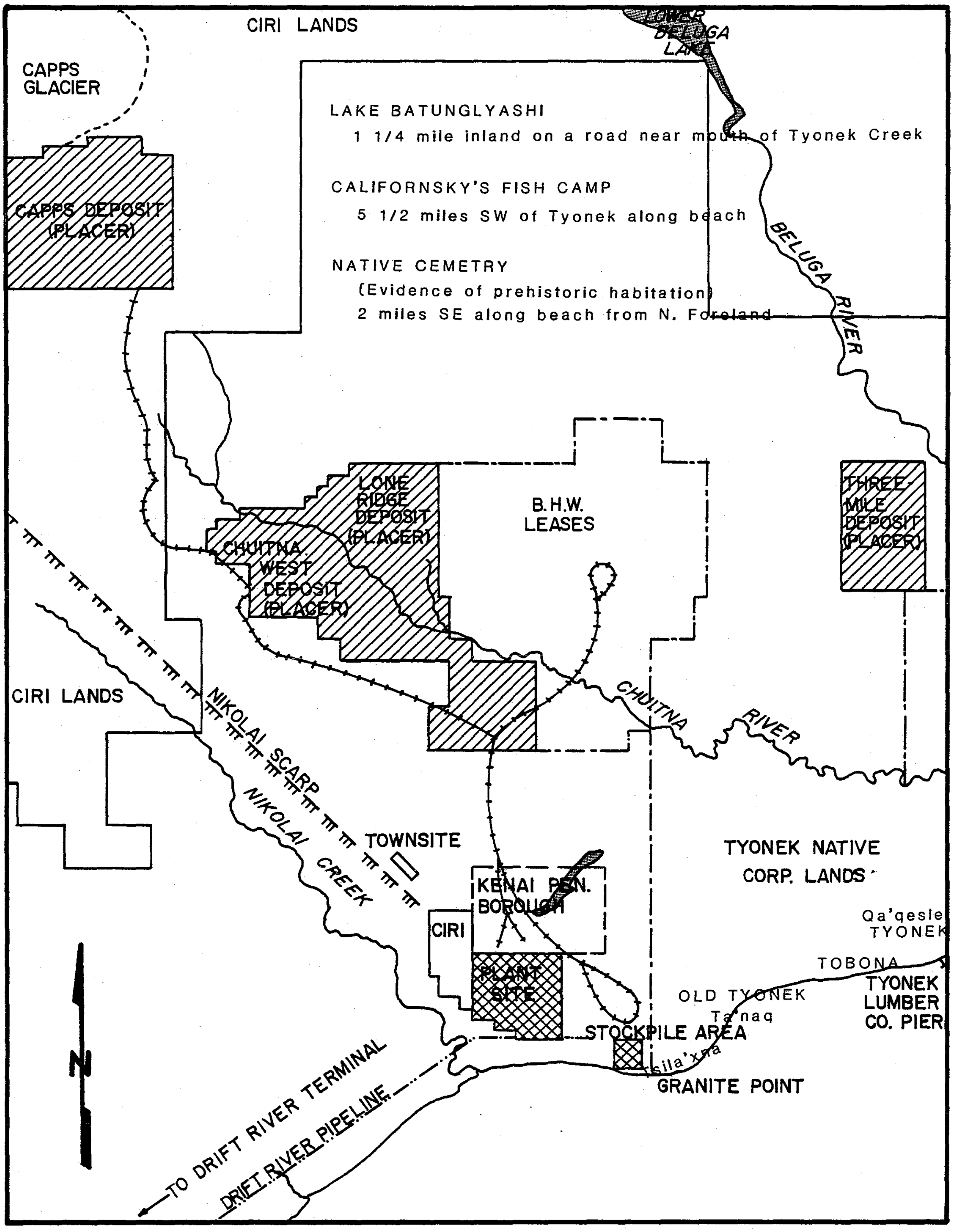



FIGURE 8.1 ARCHAEOLOGIC & HISTORIC SITES

site that lies outside these boundaries and within the study area is the Village of Ladd.

## ARCHAEOLOGIC SITES

The area of study has been inhabited by two distinct cultures, the Pacific Eskimo, and more recently, the Tanaina Athapaskan Indian. Any major excavation in the proposed town or plant sites should be preceeded by an archaeological reconnaissance to determine the presence or absence of historic or prehistoric sites.

Dr. James Kari, of the Alaska Native Language Center at the University of Alaska, Fairbanks, has accumulated a vast knowledge of placenames for the Tanaina territory, many of them located away from the coastline. It would appear that the Tanaina may have been more than just coastal dwellers. More than 75 placenames have been identified in the Tyonek area, thus indicating that there exists a whole range of sites that are significant either mythologically or historically to the Tyonek people that cannot be evidenced archaeologically.

Two factors have placed a limit on the possibility of survival of prehistoric and historic sites in the study area. It has been ascertained archaeologically that the Tanaina Athapaskans were predominantly coastal dwelling people. It is also evident that the violent tidal action of the inlet has been constantly eroding the shoreline. It is possible, therefore, that artifacts, or even entire prehistoric settlements situated on the extreme coastline, may have been washed away by now. This phenomenon has been encountered on the northwestern Kenai Peninsula. It has been estimated that between 1953 and 1974 the bluff in areas between the North Foreland and Tyonek and between Ladd and Three Mile Creek had retreated two feet per year. In addition, the bluff around Granite Point is characteristic of a zone highly susceptible to erosion. Also, the study area has been crossed with numerous lumber roads and seismic investigation trails, thus increasing the probability that sites may have been destroyed and historic trails may have been obscured.

## 9.0 OTHER FRAGILE LANDS

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 directed the Secretary of the Interior to establish a permanent regulatory procedure for surface coal mining and reclamation operations. The regulatory program is intended to control adverse environmental impacts stemming from activity in and around surface coal mines. Although neither the federal program nor state program has been instituted in the State of Alaska at this time, a surface mining regulatory program is imminent and it is assumed it would resemble the present federal regulatory program. An integral part of the present federal program is the establishment of criteria for the evaluation of permit applications to determine if a proposed mine area should be declared suitable or unsuitable for surface coal mining operations. None of the criteria deals with the determination as to whether reclamation is technologically and economically feasible under the Act. This is discussed further in the volume of this report dealing with mining plans. The other criteria deal with compatibility of the proposed mining operation with the following outlined environmental elements. The remainder of this section discusses each of these elements with reference to key land management criteria presented in the federal program.

### FRAGILE OR HISTORIC LANDS

Fragile lands, according to SMCRA, are geographic areas containing natural, ecologic, scientific or aesthetic resources that could be damaged or destroyed by surface coal mining operations:

> Examples of fragile lands include valuable habitat for fish or wildlife, critical habitats for endangered or threatened species of animals or plants, uncommon geologic formations, National Natural Landmark sites, areas where mining may cause flooding, environmental corridors containing a concentration of ecologic and aesthetic features, areas of recreational value due to high environmental quality, and buffer zones adjacent to the boundaries of areas where

surface coal mining operations are prohibited under Section 522(e) of the Act and 30 CFR 761.

Within these proposed mining areas there are no critical wildlife habitat areas or endangered or threatened plant species. There would, however, be a general loss of noncritical vegetation and wildlife habitat. There are valuable fish habitats in the areas adjoining the proposed mining locations, however, with proper precautions and controlled mining activities effects on these streams could be minimized. Due primarily to its inaccessibility, this land currently receives essentially no recreational use. The local Native population constitutes the only significant hunting and fishing activities. It is expected that the proposed mining activities could be conducted acceptably as envisioned by the federal regulatory program.

## NATURAL HAZARD LANDS

Natural hazard lands according to SMCRA means:

> geographic areas in which natural conditions exist which pose or, as a result of surface coal mining operations, may pose a threat to the health, safety or welfare to people, property or the environment, including areas subject to landslides, cave-ins, large or encroaching sanddunes, severe wind or soil erosion, frequent flooding, avalanches in areas of unstable geology.

No lands of this type exist within the proposed mine area which would render a mining operation incompatible with this criteria. The nearest lands representing this definition would be the unstable bluffs of the Chuitna River Gorge. Due to natural erosion there are bluff areas that are subject to periodic slides but the area is sufficiently removed from the mine areas as to not be impacted by mining activities.

## RENEWABLE RESOURCE LANDS

These are lands in which "the mining operations could inflict a substantial loss or reduction of long-range productivity of water supply or of food or fiber products." This area is not known as or utilized for a watershed or a water source. It also would fall outside of the timber harvest area, as it is at or above tree-line in nearly all locations. A mine site would not be incompatible with this criteria.

## LAND PLANNING

The contemplated mining activity is compatible with existing land use plans or programs. The proposed mine sites are located in the second most extensive untapped coal reserve in Alaska. The area has largely been controlled by the State of Alaska under a leasing policy encouraging energy development. A portion of the area now is owned by CIRI Native corporation, which encourages energy development through resource oriented policies. Mining operations in the Chuitna and Capps coal field areas are considered consistent with the intended land use and industrial development in this area.

# 10.0 EXISTING SOCIAL AND ECONOMIC ENVIRONMENT

## WEST COOK INLET DEVELOPMENT

### Employment Activities and Population

Currently, employment is created by three commercial developments on the west side of Cook Inlet. These are the crude oil processing and transportation facilities that serve offshore fields in Cook Inlet, the Kodiak Lumber Mills (KLM) Tyonek Timber Division chip mill, and the Chugach Electric Association (CEA) gas-fired generator station at the Beluga gas field. Total regular on-site employment from these sources is now about 100, although seasonal construction and maintenance work can increase the work force to two or three times that number.

There is only a minor residential population outside the Village of Tyonek, mostly at the Three Mile Creek subdivision near the CEA power plant and near Granite Point.

In addition to employment associated with the above commercial development, a few nonlocal fishermen work commercial set net sites along the west Cook Inlet coast during the six-week salmon season in midsummer. Also, occasional geophysical work and exploratory drilling in the area create sporadic local employment.

Granite Point and Trading Bay are landfall sites for submarine crude oil pipelines that serve several production platforms in Cook Inlet. At these sites the crude oil undergoes initial processing and metering. It is then transported by pipeline to the marine terminal at Drift River where it is stored and loaded aboard tankers for transport to U.S. refineries. The two processing plants and the marine terminal require a total of about 55 operators. However, summer maintenance and repair work involve additional temporary labor at the sites. The work force lives in dormitories and rotates regularly between the facilities and Anchorage. Families do not live at the processing plants or the terminal.

The KLM chip mill was built in 1975 on land leased from the Tyonek Indians to process a large volume of timber infested with spruce bark beetle. At the height of operations, the mill employed 200 people. Currently, however, it is operating year-round with fewer than 20 people because of a decline in the Japanese chip market. The work force lives in dormitory and single-family housing at the plant site. It does not rotate at regular intervals to Anchorage or Kenai.

The Chugach Electric Association operates a large natural gas-fired generation facility approximately 16 miles from the Village of Tyonek. This facility provides the base load generating capacity for the Anchorage area. It has a regular operations and maintenance work force of approximately 30 people, but construction and special maintenance and repair work cause significant fluctuation in the local labor force (the dining room capacity is approximately 250).

## Land Ownership, Status and Use Restrictions

Land ownership in Alaska is complicated and continuing to evolve. Land conveyances under the Alaska Native Claims Settlement Act (ANCSA) and the Statehood Act are not yet complete; and disputes remain over land rights of the state, boroughs and Natives. However, these issues have been resolved in the vicinity of the proposed project.

Since ownership is integral with land use development rights, land use planning questions are also discussed in this section. The Department of Natural Resources, Planning Section, has the authority to be the lead state agency in preparing an overall land use plan for the area. The Kenai Peninsula Borough likely would assist in developing the plan and policies to guide specific actions proposed by industry, particularly in regard to land it owns in the vicinity of the proposed plant and town sites. The land management policies of CIRI will also be of significant influence on the area because of its substantial land holding in and adjacent to the project area.

Land Ownership and Status

Major land holdings in the area include ownership of both the surface and subsurface estates. In some cases both rights are held by the same owner and in others, by different owners. The latter case produces potential conflicts where revenues obtained from sale of mining rights are not conferred to owners of surface rights.

Key ownerships in the area are vested in the following state and private organizations:

State of Alaska
Cook Inlet Region, Incorporated
Tyonek Native Corporation
Kenai Peninsula Borough

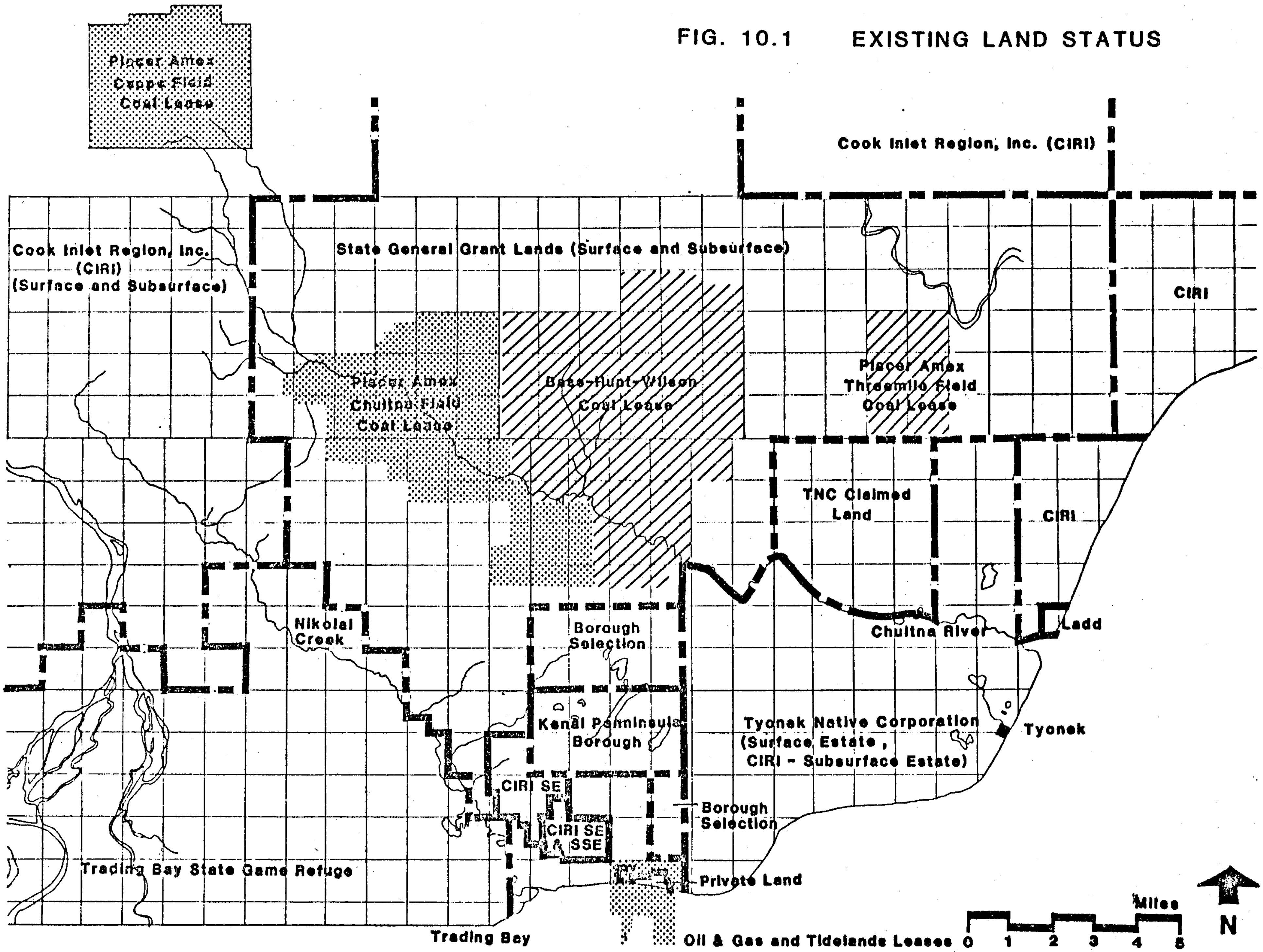
Other smaller holdings such as Native Allotments, the Native Village of Tyonek, Inc., and other Native lands subject to reconveyance under Section 14(c) of ANCSA are not discussed here.

Blocks of land owned by these organizations are shown in Figure 10.1, along with subsurface mining leases.

- State of Alaska

  A substantial portion of the Beluga coal district is patented state land, excluding the Capps Field area that would be developed by this proposal. These lands were transferred by the federal government under the 1958 Statehood Act (General Grant Lands), and the 1956 Mental Health Enabling Act (Mental Health Lands,

FIG. 10.1 EXISTING LAND STATUS



providing a State General Fund revenue base on which to meet needs of the Mental Health Program). In 1978 the state redesignated Mental Health Lands to General Grant Lands, to allow municipalities to select land, of which not less than 30% is to be disposed for private ownership. This redesignation does not affect any prior leases, permits, or easements. The redesignation also allows the state to dispose of lands to private parties more easily than was possible under its status as Mental Health Lands. The third major category of state lands on the west edge of the district is the Trading Bay State Game Refuge, established in 1976.

The state Department of Natural Resources (DNR) classifies General Grant Lands and tidelands in this vicinity into one of four categories: Resource Management Lands, Industrial Lands, Reserved Use Lands, and Material Lands. This system describes a capacity for use or multiple use which can be modified for the public interest. Once lands have been classified, they may be disposed (by lease, sale, grant or exchange) to municipalities or private parties.

- <u>Resource Management Lands</u>

Most of the state land in the Beluga coal district is classified as Resource Management Lands, portions of which are in the following uses: coal prospecting and leasing, mining permits, timber sales, and oil and gas leasing. Two Placer Amex leases and the Bass-Hunt-Wilson (BHW) lease are located on Resource Management Lands (the Capps Field is located on land owned by CIRI).

Kodiak Lumber Mills is authorized to harvest timber from 223,000 acres until August 1983. About 6 million board feet of spruce-beetle-infested trees are to be harvested. Numerous primary and secondary logging roads have been built on state, CIRI, and TNC land in the area in association with these activities under authority of 20-year leases between Kodiak Lumber Mills, CIRI, and

Tyonek Native Corporation and the state. No public rights-of-way are associated with these logging roads.

The Trading Bay State Game Refuge is a separate category from Resource Management Lands. Established by the state legislature in 1976, this refuge and the Susitna Flats Game Refuge east of the Beluga coal district are managed by the state Department of Fish and Game (DF&G). Pre-existing rights-of-way for roads and pipelines are excluded from the refuges, and will become part of the refuges when permits or applications expire.

- <u>Industrial Lands</u>

  Specific facilities such as the CEA power plant near Tyonek are operated as Industrial Lands, subject to Kenai Peninsula Borough building and zoning codes. These sites may only be used for the designated purposes. Most of Sections 27 through 30, T11N R12W, including tidelands along Trading Bay are also classified as Industrial Lands.

- <u>Reserved Use Lands</u>

  Reserved Use Lands are set aside for such public uses as expansion of town sites and new town sites. Small sites in the Beluga area are being used for creek access, barge landing sites (e.g., Beluga River), and other DF&G requests.

- <u>Material Lands</u>

  Material Lands are administered by the DNR to sell sand, gravel and other materials located on state-owned tidelands and uplands. The Department of Natural Resources can influence the location of coal port and transshipment facilities through its ownership of tidelands. The state land in the Beluga area which was transferred to CIRI or TNC includes sand, gravel and other materials as part of their estate.

The DNR will have an important role in guiding coal-related development because of its management responsibilities for extensive state holdings in the area. In addition to its aforementioned control of tidelands and surface minerals, DNR also regulates temporary access and rights-of-way across state land and the appropriation and use of surface water and groundwater. It will ultimately prepare a land use plan to guide the department in reclassifying state land for the proposed project.

- <u>Cook Inlet Region, Inc. (CIRI)</u>

The regional Native corporation holds both surface and subsurface title to much of the inland area of the Beluga coal district. The Placer Amex Capps lease is within this area. CIRI also owns approximately 3,000 acres adjoining and including a portion of the proposed plant site. As a profit-oriented corporation, CIRI is encouraging coal development in the area. It was granted a 300-foot wide, unspecified location right-of-way easement to connect its holdings in the Capps Field to the beach at the eastern edge of Trading Bay. The corporation also holds subsurface rights to the land whose surface rights are held by the Tyonek Native Corporation.

Revenues from subsurface development rights are distributed to stockholders of CIRI, TNC, and other Native corporations.

- <u>Tyonek Native Corporation (TNC)</u>

Tyonek Native Corporation, the village corporation created under ANCSA, has surface title to the 27,000-acre former Moquawkie Indian Reservation, as well as other lands north of the Chuitna River. Its claim to about 11 sections of state land north and west of the Chuitna River (known as the Moquawkie Reserve Lands) is in litigation.

Potential developers in the area negotiate with TNC for surface use and with CIRI for subsurface use of the TNC lands. TNC has leased land to Kodiak Lumber Mills for the chip mill.

Tyonek Native Corporation is opposed to rights-of-way and easements across its lands (DCED - Land Tenure, 1978). After passage of the ANCSA in 1971, the village corporation attempted to obtain title to its former Moquawkie Reservation lands, but objected to the number of public easements proposed by the federal government. Easements are discussed later in this section under Transportation and Power Infrastructure.

- Kenai Peninsula Borough

  The borough owns eight sections of land that include most of Congahbuna Lake (with the exception of State Special Use Lands immediately around the lake, and a smaller lake to the east). The proposed construction camp site and a portion of the proposed transportation corridor are located on borough land. This area also has been considered as a possible alternative town site for a permanent community. The borough has not yet developed policies on lease of its land for industrial or community development (Battelle, 1979).

Land Development Planning Authority

In addition to the management responsibilities associated with land ownership described above, other governmental and private corporations have jurisdiction over land use in the area. This section discusses these responsibilities with particular reference to control of land use and transportation access.

Agencies and organizations which will guide development in the Beluga coal district, in addition to those discussed above include:

Governor's Coal Policy Group
State Beluga Interagency Task Force
Kenai Peninsula Borough
Village of Tyonek, Inc.

- <u>Governor's Coal Policy Group</u>

  This cabinet-level group will provide the governor's office with recommendations in three areas: possible royalty and severance taxes on mining (none exist at present); state response to industry requests to provide infrastructure; and land reclamation. The governor will review coal policies with industry before adoption. Legislation may not be required. For example, the Alaska Industrial Development Authority may be a logical state instrument for provision of certain infrastructure. This public corporation assists in providing low-interest loans for industrial projects.

- <u>Beluga Interagency Task Force</u>

  This technical group is responsible for assisting the governor's policy group on energy development in the Beluga area. At present it is primarily an interagency informational forum. It is chaired by the Department of Commerce and Economic Development (supported by its own Division of Energy and Power Development) and includes departments of Environmental Conservation, Natural Resources, Community and Regional Affairs, and Fish and Game, as well as the Office of the Governor Division of Policy Development and Planning (DPDP). The Department of Community and Regional Affairs will address issues of public facilities and services with respect to possible town site development.

- <u>Kenai Peninsula Borough</u>

  Overall planning and zoning responsibility for the Beluga area rests with the Kenai Peninsula Borough. Although no specific land use plan has been developed, its Draft Coastal Management Plan (September 1978) proposes a special management district and recommendations for the area. Development within this district, or Area Meriting Special Attention (AMSA), could be governed by a comprehensive development program. The proposed program would be coordinated with state and other agencies and approved by the Alaska Office of Coastal Management. At this time, however, the status of the coastal development planning for the borough is in doubt. The borough assembly adopted a resolution to rescind the state act on which the plan is based, and there is no apparent schedule for finalization of the draft plan.

Eventually, borough involvement would include reviewing plans for town site development including zoning, subdivisions, schools, solid waste and other permits. Only subdivision review is now required in the Beluga area, entirely designated as "unrestricted" use in its Comprehensive Plan. The Tyonek Village Council believes borough planning, zoning and subdivision authority does not extend over any activities in the vicinity of its land (Battelle, 1979).

° <u>Tyonek Village Council (Native Village of Tyonek, Inc.)</u>

The village tribal council is the federally chartered local government of Tyonek. Its influence over development on Native lands, however, extends beyond the village itself.

With passage of ANCSA, the Moquawkie Indian Reservation was extinguished. Tyonek Native Corporation now has surface rights and Cook Inlet Region, Inc. has subsurface rights within the former reservation. Generally, the council represents residents of the village when they feel that policies of TNC and CIRI don't necessarily represent the interests of the people of Tyonek. In particular, the village council believes it still can control access to lands within the former reservation which TNC and CIRI might want to see developed for profit. Regardless of legal authority, TNC has deferred to the village council on local land management questions, particularly in the immediate vicinity of the village. Additional discussions of community governance, life-style and attitudes on industrial development are provided later in this section under TYONEK VILLAGE.

## Transportation and Power Infrastructure

Some existing roads in the area would be improved to serve a portion of the project, with some extensions required to the mine and dock locations. The existing airstrip at Granite Point probably would not be used except during very early stages of project start-up. The existing KLM chip mill dock at the North Foreland is too distant to conveniently receive heavy cargo, and probably would not be available for general use.

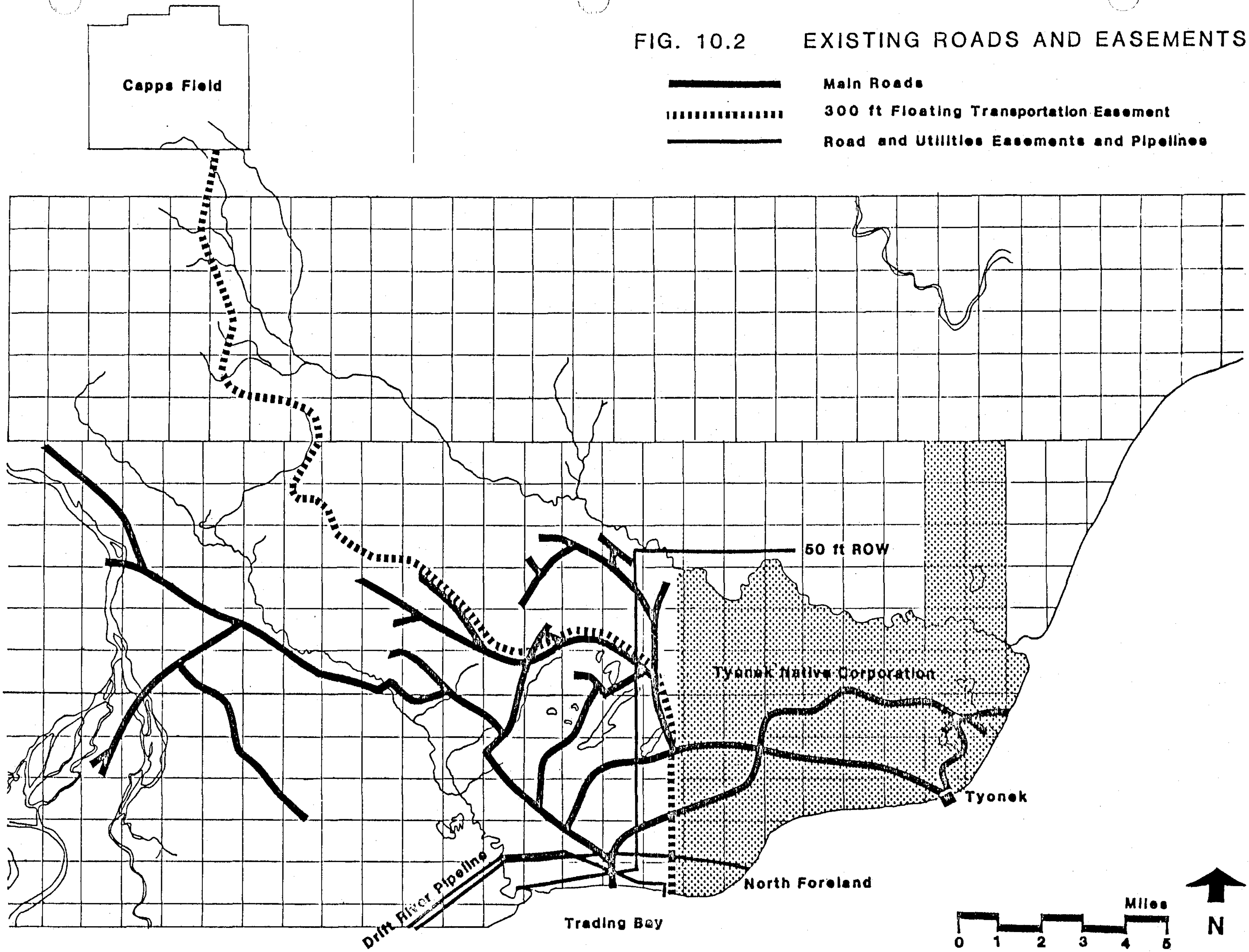
### ° Existing Roads and Easements

A network of gravel-surface logging roads crisscrosses the area between the Capps Glacier and the coast. Of the approximately 100 miles of primary and secondary roads, the main logging roads extend about 16 miles northwest of Congahbuna Lake, to within eight miles of the Capps Field (Figure 10.2).

These roads were built to serve KLM timber harvest agreements. No public right-of-way is allowed on these roads. Agreements exist between KLM and the state for use of logging roads on state land west of TNC land. The timber harvest agreements on TNC land expire in 1983, when timber harvests are expected to terminate altogether (DCED - Transportation, 1978).

A 27½-mile, 300-foot wide unspecified location transportation corridor easement between the Capps Field and the eastern edge of Trading Bay has been granted by the State Department of Natural

## FIG. 10.2 EXISTING ROADS AND EASEMENTS



Resources, on land obtained by CIRI. Portions of the existing logging roads may fall within this easement.

Other road rights-of-way include section line easements on all state land or land transferred to others by the state. Although section line easements do not necessarily allow for access due to topographic constraints, they do allow for public right-of-way access across the land. These easements allow for a 100-foot right-of-way between sections.

At the request of TNC, no section line easements or other easements for transmission lines, rail lines, or roads exist on TNC land. Thus any new road, rail or power line proposed between the project area and the Beluga area or east to developed portions of the Matanuska-Susitna Borough which passed through TNC land would probably be very difficult to obtain, given the present position of the corporation. Plans for the CIRI/Placer Amex project do not anticipate a need for any such easements. A 65-mile road connection between the coal district and Wasilla, and an equally long rail connection between the district and the Alaska Railroad near Houston, have been discussed, although neither is anticipated for this project.

A 200-foot development setback and a 100-foot recreation easement are in effect along the Chuitna River and other streams (outside of TNC land). These easements were established by the state DNR, Division of Lands.

With respect to obtaining access across CIRI or state land in the project area, no difficulties are anticipated. The DNR reviews right-of-way applications on state land.

o <u>Airports</u>

There are no airports with a capacity to handle landings of heavy cargo planes in the immediate project vicinity. Airstrips which could be used in early stages of project development include the beach strip at Granite Point and two 900-foot strips at Capps Field. The Granite Point airstrip is about 3,500 feet in length, with a gravel surface.

The closest airport with a good surface and landing lights is the 3,500-foot Tyonek Airport. Like other privately owned airstrips in the vicinity, the Tyonek Airport is restricted to planes with prior landing privileges. The village tribal council in Tyonek wishes to control visits by planes to the village in the same way the village corporation, TNC, wishes to restrict road access across its lands.

- Docks

The only dock near the proposed project with the potential for use during early stages of project development is owned by Kodiak Lumber Mills and is located 7 miles northeast of Granite Point at the North Foreland. This dock is 1,466 feet long, with 685 feet of berthing space at a mean low water depth of 36 feet. The largest ship to dock at North Foreland was 601 feet long and 45,000 metric tons (Battelle, 1979). Use of the dock would require permission, not only from Kodiak Lumber Mills, but also from Tyonek Native Corporation for use of the existing road across TNC land to the project area.

The dock that is proposed to receive and ship the methanol is located approximately 40 miles southwest of the proposed project area on the west side of Cook Inlet near Drift River. This facility, the Cook Inlet Pipeline Drift River Terminal, includes a single-berth fixed-platform offshore loading facility that will accommodate up to 70,000 DWT tankers. This facility will accommodate a maximum 810-foot LOA vessel. This facility is further described in Volume II of this report in the section on pipe transportation and ship loading.

- Power

The closest power source to the proposed plant and town sites is about 16 miles northeast at Beluga. This gas-fired plant owned by Chugach Electric Association supplies power to the Village of Tyonek, the KLM chip mill and others, via a transmission line near the coast.

Kenai Peninsula Borough Services

The entire project area lies within the Kenai Peninsula Borough, but is isolated from the other borough settlements by Cook Inlet.

Under state law, boroughs exercise powers within their jurisdictional boundaries, both inside and outside of home rule and general law cities. Borough powers extending to the project area include education, planning, platting and land use regulation, and air and water pollution control. Borough service areas can be established for unincorporated areas to provide public safety, solid waste or other services.

The only existing school serving the area is the Bob Bartlett School in Tyonek (discussed later in this section under Community Facilities and Infrastructure). The borough builds schools, establishes curriculum (with local input) and hires teachers. Although the school operating budget is a local responsibility, 50% of operating costs were paid by the state last year. It is not known if state funding will continue. Under a bill likely to pass the 1981 Legislature, all local school construction debt (rather than the current 80%) would be paid by the state. The borough would continue to bond for school construction and would be reimbursed by the state. The proposed legislation forbids 100% reimbursement for such special facilities as swimming pools, hockey rinks and teacher housing.

Planning and zoning and subdivision powers are provided on an areawide basis. The borough establishes a planning commission which prepares a comprehensive plan and/or plans for incorporated cities. Theoretically, the borough could prepare the comprehensive plan for a new town at Beluga if the town became an incorporated first- or second-class city. In practice, this is unlikely because the Kenai Peninsula Borough intends to transfer planning and zoning powers to cities, while retaining control of platting, subdivision approval and transportation facilities.

The borough may collect property, sales and use taxes levied within its boundaries. Taxes levied by an incorporated city shall be collected by the borough and returned entirely to the city. The Kenai Peninsula Borough is proposing a July 1981 - July 1982 budget with a 2.5 mill rate. If increased state funding of schools is not forthcoming, the borough mayor estimates that a 1 mill increase could be required (Atkinson, 1981). At the same time, municipal assistance grants of $1.4 million authorized by the state for next year would allow the borough to end personal property tax (on boats, cars, airplanes, etc.) and reduce real property tax.

Other West Cook Inlet Coal Development

Another coal development project in the Beluga area is coal export from leases held in the Chuitna Field by the Bass-Hunt-Wilson (BHW) venture. The BHW leases are shown in Figure 10.1. Development plans prepared in April 1980 (Bechtel, 1980) suggest production of 7.7 million short tons of coal per year, shipped via a deepwater port at Granite Point to Far East and West Coast destinations. Associated facilities include a town site within the lease area for 1,300 personnel and a conveyor or rail system to carry the coal to a tidewater stockpile.

A 7,700-foot wharf would be built to channel depth for 100,000 DWT carriers. Alternatives to the Granite Point location include a new

8,000-foot wharf near the village of Ladd, about 12 miles southeast across TNC land, or use of the existing 3,500-foot wharf owned by Kodiak Lumber Mills, Inc.

A six-year time frame from engineering to commencement of mining operations was envisaged in the April 1980 feasibility report, although its schedule for development may be adjusted in light of an agreement establishing a joint venture to develop the BHW lease. In an agreement approved by the state DNR in August 1981, the Diamond Shamrock Corporation joined with BHW leaseholders for the purpose of developing engineering, marketing and mining plans for the coal field. The venture is to be managed through Diamond Alaska Coal Company, a wholly owned subsidiary of Diamond Shamrock.

The BHW operations are largely independent of those planned by CIRI/Placer Amex. Town site, dock and transportation concepts currently are completely separate. As these projects reach advanced planning stages, it is expected that the owners will explore ways these infrastructure facilities can be shared to reduce capital costs.

## TYONEK VILLAGE

### Background

Tyonek is the only settlement on the west coast of Cook Inlet. It is a long-standing community of about 270 Tanaina (Athapaskan) Indians. The village and 27,000 acres surrounding it were withdrawn as an Indian reservation in 1915. However, the residents of the village voluntarily surrendered the reservation status of their land to participate in the land selection benefits of the Alaska Native Claims Settlement Act of 1971.

Like other Indian villages, Tyonek was a traditional community oriented to seasonal subsistence pursuits. When opportunities for commercial trapping and fishing developed in the twentieth century, villagers participated in them to the extent the local resource base would permit. Thus, the fortunes of the village were tied to the cyclic fluctuations of fish and game. Poverty and the threat of starvation were ever-present. In the winter of 1955, an emergency airlift of food was necessary to save the villagers from famine. Housing and living conditions generally were substandard, like those of numerous other remote Native villages in Alaska.

The life-style of Tyonek was radically altered in 1964 when the village received $12.9 million in bonus bids for the competitive sale of oil and gas leases on its land. The money was used to upgrade village housing and community facilities, and to invest in Anchorage real estate and other commercial ventures.

Tyonek's sudden prosperity did much to improve the living conditions of village residents, but it caused new stresses within the community and did nothing to solve familiar problems of culture change faced by Tyonek residents. The oil revenue replaced the remaining physical vestiges of traditional village life, but provided no new spiritual or cultural substance.

Thus, the "identity crisis" of the Tyonek villagers, caught in a conflict between the values and life-styles of traditional Indian and modern white societies, was exacerbated by the oil lease windfall.

The history of Tyonek's investment activities is long and often unhappy. Exploratory drilling failed to discover oil in commercial quantities, so a steady stream of royalty income has not supplemented the one-time bonus bid lease payments. Financial setbacks and reversals have plagued the Tyoneks, so that early investments do not now provide a continuous source of direct support or indirect subsidy to village residents.

Both Braund and Behnke (1980) and Battelle (1979) report that the Tyonek village residents are suspicious of outsiders and prefer to have non-Natives avoid the village. The presence of non-Natives in the vicinity of the village is discouraged, especially if it involves the attendance of non-Native children at the Tyonek school, which occurred during the height of the chip mill operation.

Community Facilities and Infrastructure

Tyonek's facilities adequately serve the needs of its approximately 270 residents. Compared with many Native villages in Alaska, Tyonek has good housing, water and sewer systems and educational and health facilities. A substantial portion of the $12.9 million lease sale revenue was used to improve village living conditions (Battelle, 1979).

- Housing and Utilities

  Lease revenue was used to provide a new house for each family in Tyonek. Fifty-nine prefabricated, one- to five-bedroom units were barged from Seattle. Today there are about 60 frame dwellings and six mobile homes. All homes are owned by the Native Village of Tyonek, Inc. Many of the ranch-style prefabricated units have not stood up well to Alaska conditions and are in need of new insulation and rehabilitation. Twenty-seven HUD-financed houses were planned for construction in 1979, but additional housing for those wanting their own homes is still needed.

  Village homes are heated by electricity, which is provided free by Chugach Electric Association under an agreement which will expire when the village has used a total of 50 million kilovolt hours (about 1982-1984). Then homes will be converted to oil-fired furnaces to use fuel purchased from Kodiak Lumber Mills (Battelle, 1979). Because of past power failures and fuel shortages, some residents wish for a return to wood heat.

The Kodiak Lumber Mills camp, located about two miles from the village, has six 20-person bunkhouses, five 3-bedroom modular homes, about 12 trailers and six duplexes -- capable of accommodating a total of about 200 people.

Oil lease money also provided funding for new gravel roads in Tyonek and a village water system. Roads are laid out in an orderly fashion to accommodate additional housing development. A lake water source was developed in 1976 after a high iron content was found in well water. The new system has apparent problems with chlorination, and a low lake level in winter. The Public Health Service is investigating alternative water sources.

Wastewater disposal is by septic tanks and cesspools. Some of the steel septic tanks installed in 1965 are rusting. Soils are gravel base and are adequate for subsurface disposal.

The village has a community building which houses a store, shop facility, guest house, medical center, and the village offices. The town also has a gas station.

- <u>Education</u>

The village school is the one facility which some village residents feel they have the least control over. They fear that children of coal field and plant workers might attend their school in large enough numbers to make Native children a minority in the school.

The Bob Bartlett School, serving grades K-12, is financed and managed by the Kenai Peninsula Borough School District. Enrollment is about 100 students, and capacity is about 240 students. The school has four regular classrooms, a home economics unit, and a portable classroom. There are 10 full-time teachers, who move in to teach temporarily. Two local residents provide supplementary education in cultural affairs, funded by the federal

Johnson-O'Malley program. The amount of funding is keyed to the number (not proportion) of Native students in the school. The Native Village of Tyonek oversees the program.

The borough school board would determine whether students from families employed by this proposed project would attend the Tyonek school. When the KLM chip mill was in full operation, about 20 students were bussed to the village to attend the school. In deciding how best to meet the educational needs of all students, the board would consider the wishes of Tyonek residents in light of districtwide program requirements and funding.

- Public Safety

The Alaska State Troopers provide public services outside of incorporated cities. A constable serves Tyonek, the chip mill, and the oil and gas facilities at Trading Bay. He is based at the Beluga power station. Tyonek has no plans to incorporate as a second-class city.

The addition of a full-time officer is not expected until population increases justify it in another 10 or 20 years. Additional staff can be added on a short-term basis to meet seasonal needs. Industry can also be expected to provide its own internal security.

There is no publicly provided fire protection in the area. It is not known what firefighting equipment is available at Tyonek. Industry would, however, provide its own firefighting equipment and capability.

Health care is available at a small clinic in the community building at Tyonek. The facility is staffed by a resident Licensed Practical Nurse who provides medical and dental care. The U.S. Public Health Service also provides a community health aide (and alternate). Emergency medical care is received at the Alaska Native Medical Center in Anchorage.

Emergency services and hospital care from the health aide are available to non-Natives on an emergency basis only. Emergency evacuations are handled by the state troopers using private charter planes. The U.S. Air Force also handles some emergency evacuations. The Kenai Peninsula Borough provides service to the area from a 32-bed hospital in Soldotna.

## Employment

Employment in Tyonek is scarce. With the exception of a few permanent jobs associated with the operation of the school, work in the village is part-time and seasonal. In recent years, a significant amount of work has been derived from government activities and programs. Thus, Tranter (1972) observed: "Tyonek, even with its good fortune of the 1960s, does not significantly differ from the prevailing employment patterns found in Alaska's Native village society found elsewhere in the state."

A survey of employment in Tyonek in the spring of 1979 revealed that 54 people had a full-time or part-time job. Seventy percent of them worked in government-related programs, including state and federal education and health programs and the federal Comprehensive Employment and Training Act (CETA) program. In addition, eight people worked at the KLM chip mill, four worked with a petroleum exploration crew drilling for natural gas on village lands, and four worked in Anchorage on the construction of modular houses that would be brought to the village (Braund & Behnke, 1980). Little of this employment represents permanent full-time jobs. Most is temporary, and the government-related work is dependent upon annual program appropriations.

Thirty-three limited entry fishing permits are held by Tyonek residents (three salmon drift gill net permits and 30 salmon set gill net permits). The Cook Inlet salmon season is open for two days per week for a six-week period from July to mid-August. Salmon stocks in Cook Inlet have been rebuilding slowly after long years of decline, and the fishery is increasingly lucrative to purse seiners and drift gill net fishermen. However, because Tyonek villagers are predominantly set-net fishermen, and because the runs in the vicinity of the village are not especially strong, commercial fishing is still a marginal enterprise for many residents who participate in it.

The record of village employment in the nearby chip mill is informative for what it suggests about the prospects of villagers benefiting from employment opportunities created by development in the Beluga coal fields. This record is summarized by Braund and Behnke (1980):

> When Tyonek Timber Company, a subsidiary of Kodiak Lumber Mills, constructed a chip mill near the village, many residents hoped the plant would provide permanent jobs for villagers after production began in 1975. The chip mill is located on former reservation land once owned by the village but now owned by the village corporation (Tyonek Native Corporation). From time to time, Tyonek Timber Company employs villagers, but the majority of the workers are transients housed near the facility. Apparently, Tyonek Timber Company did not intend to hire a high percentage of non-Native transients, but many problems developed between the mill and the villagers.
>
> From the industry point of view, the main difficulty was keeping employees who would report to work each day. Flexible work hours were arranged, but apparently absenteeism and drinking problems plagued production, and with a $30 million investment which was losing money each year, Tyonek Timber Company needed a crew of dependable loggers and mill operators. The villagers, who required specialized training for the jobs, often became disillusioned with the training program. Also, they felt that work schedules were constraining and interfered with more traditional and acceptable activities such as hunting and fishing. The growing presence of outsiders near their village was viewed with suspicion and concern. Some villagers complained that they were harrassed by non-Natives at the plant. Others felt the pay was too low when compared to union jobs. A shortage of gas in the village made it difficult to get to and from the timber mill. Possibly one villager summed up the problem when he said, "Natives aren't loggers." The net result is that in a village where unemployment is of primary concern

industry builds a lumber mill within a few miles, and for various reasons, unemployment remains a problem.

Thus, it apparently cannot be assumed that the creation of local employment opportunity will necessarily result in substantial village employment. Many of the same factors that affected village employment in the chip mill could also affect employment in a nearby coal mining and industrial plant operations.

## Community Attitudes Toward Development

Attitudes of Tyonek residents toward major new commercial development in the vicinity of their village are discussed in Braund and Behnke (1980) and Battelle (1979). In general, there seems to be little enthusiasm for local development that will result in an increase of the non-Native population of the area. New employment opportunity has general appeal among the villagers, of course, but even this attraction of development is tempered by the realization that full-time employment entails sacrifice of the slower-paced traditional life-style of commercial fishing, seasonal subsistence pursuits, and occasional wage employment.

There is nothing unusual about ambivalence on the part of a small rural town toward the prospect of dramatic change by a major resource development project; but in most cases, the promise of economic prosperity is stronger than the urge to protect traditional life-styles. In the case of Tyonek, however, the villagers may perceive that the disadvantages of development seem to outweigh the hope of benefits. Available data suggest that a majority of village residents would oppose creation of a major new town on the west side of Cook Inlet. A community profile and community attitudes survey are being prepared by a consultant to the Alaska Department of Community and Regional Affairs.

## CONSTRUCTION AND OPERATIONS REQUIREMENTS

### Background

The Beluga Methanol Project is comprised of the following basic components: a coal mining operation; a rail and road linkage to a coal-to-methanol plant; a pipeline for the methanol to an existing transshipment point; a separate cargo dock; an airport; construction camp; and permanent new town. Assumptions about project manpower requirements and the ultimate projected population of the town were derived by CIRI/Placer Amex in consultation with CIRI/Holmes and Narver, Inc. Separate estimates are provided for construction and operations/maintenance manpower requirements for the mining operation, construction camp, methanol plant, airport, and permanent town.

These figures should be taken as general estimates sufficient for preliminary facility planning and cost estimating. Because of its remote location, the project would require a high degree of self-sufficiency. Since few public facilities or services would be required or impacted, there was only limited consultation with governmental agencies regarding facility requirements. Nevertheless, experience with other remote community and support facilities in Alaska suggests that the proposed project realistically meets known requirements at this time.

### Direct Labor Force Requirements

Assuming the start of construction in 1984, a peak construction work force of approximately 3,200 (direct manpower requirements) would occur in the beginning of the second quarter of 1986 and last until the end of the year. Operation of the mines would require approximately 470 people, and the methanol plant approximately 450. In addition, it is estimated by Holmes and Narver that approximately 115 people would be required for the day-to-day operation and maintenance (O/M) of the camp, town site, and airport. Therefore, a total of approximately 1,242 regular O/M personnel would be required after start-up of the facility and completion of the town.

Indirect Employment and Total Population

The concept design for the project town site calls for a highly self-sufficient community with schools, recreational facilities, retail goods and services, and other basic urban amenities. Thus, a quantity of indirect, or secondary, employment would be necessary in the community to support the basic work force, as in any other small town in Alaska. This is in addition to the operation and maintenance work force associated with the airport, camp and town site. The amount of this indirect employment is estimated to be approximately 200. This represents an employment multiplier of about 1.2, which is typical for a town of this size in Southcentral Alaska (Kramer, et al., 1979).

Thus, total employment at the project site is estimated at 1,242. The total population of the town would therefore be about 2,600, as an average of approximately one nonworking dependent for each member of the labor force is expected (a labor force participation factor of 2.0).

The town site development concept plan discussed in this report has been scaled to a community size of approximately 2,600 residents with the capacity to increase to more than 4,200 persons (Holmes and Narver, 1981). Table 10.1 summarizes employment and population assumptions for the project.

OVERALL PROJECT DEVELOPMENT

The project is located about 75 miles northwest of Anchorage across Cook Inlet, in an area within the Kenai Peninsula Borough. The project extends upslope from Trading Bay a distance of about 25 miles to the Placer Amex Capps coal field.

Table 10.1

ANTICIPATED CONSTRUCTION AND OPERATION WORK FORCE
BELUGA METHANOL PROJECT

| Project Phase | Work Activity | Peak Number of Workers |
|---|---|---|
| Construction | | |
| (1Q 1983 to 1Q 1986) | Coal Mine | 550 |
| | Methanol Plant | 450 |
| | Camp and Permanent Townsite | 2,000 |
| | Camp and Airport O/M | 200 |
| | Total | 3,200 |
| Operations | | |
| (Beginning 1Q 1986) | Coal Mine | 470 |
| | Methanol Plant | 450 |
| | 50-Person Camp, Airport, and Townsite O/M | 115 |
| | Total | 1,035 |
| | Indirect Employment @ 0.2 | 207 |
| | Total | 1,242 |
| | Total Estimated Town Population at Approximately 1 Dependent per Employee | 2,600 |

Source: CIRI/Holmes and Narver, September 1981.

Figure 10.3 shows the general locations of key components of the project. These locations are not precise, however, there is sufficient land within the project area with moderate slope and reasonable foundation conditions to allow for a great deal of latitude in final site planning. Adjustments can be expected based upon further site studies, consultation with government agencies and evaluation of property ownerships.

The Capps mine and methanol plant currently are envisioned on land owned by CIRI; the proposed camp is located on borough land; and the proposed town site, airport and Chuitna West mine are located on state lands. The transportation corridor between the Capps Field and the plant traverses CIRI, state and borough lands within an existing 300-foot wide easement which runs in an unspecified alignment on state land over a distance of 27½ miles from the Capps Field to Trading Bay. The easement was granted by the state DNR.

Descriptions of the proposed construction camp, airport and town site in the following sections are based almost entirely upon the work by CIRI/Holmes and Narver (Conceptual Camp, Airport and Townsite Development Plan, Beluga Methanol Project, September 1981).

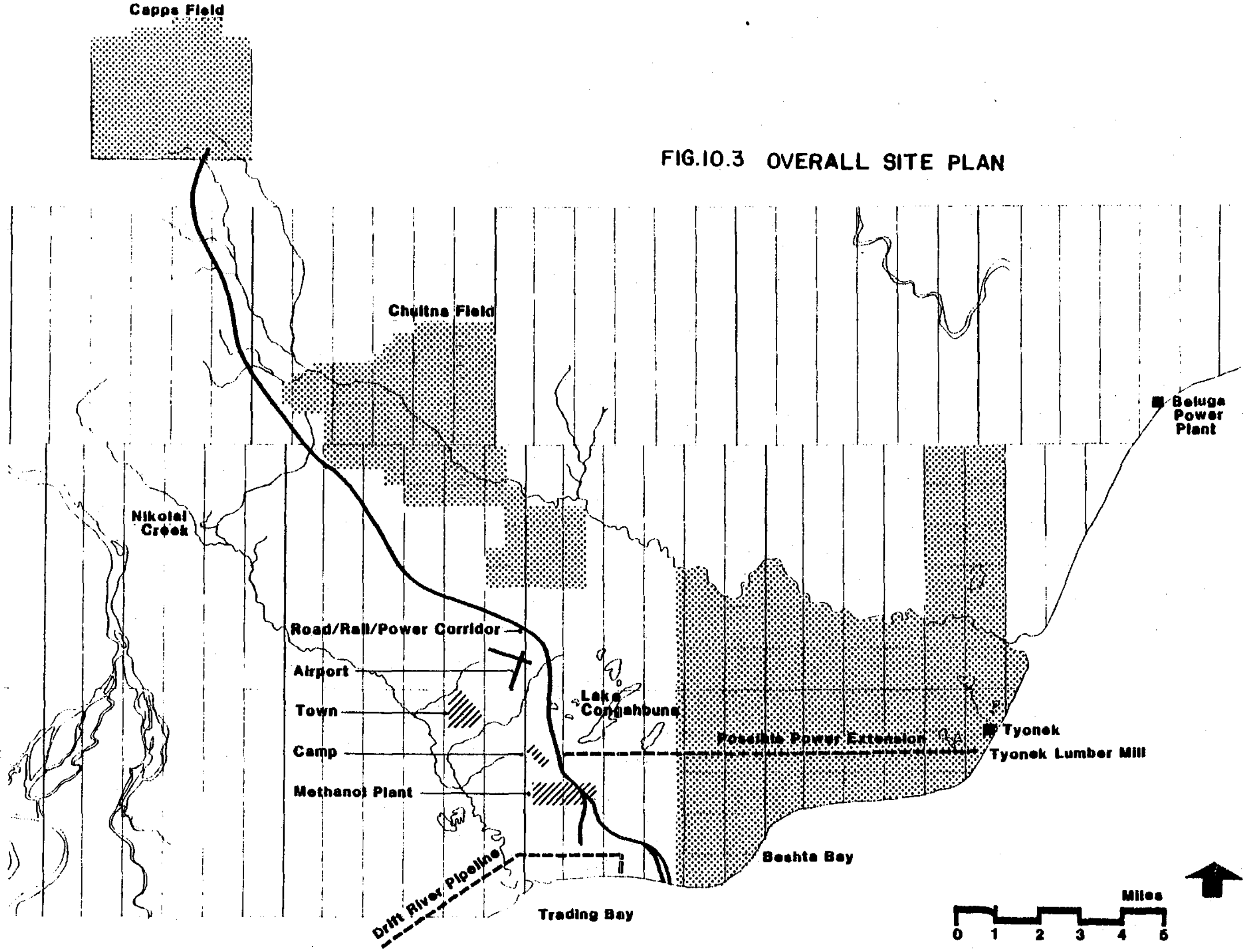
## Construction Camp

- Concept

  At peak construction, the project would require housing for about 3,200 people. Due to the remoteness of the project, all of these personnel would have to be housed in a newly constructed work camp. The camp would have to be built quickly in increments which could accommodate fluctuations in the work force.

  The most appropriate method of camp development for the support of the project is the use of prefabricated and preinstalled building modules which are readily available from contractors and

FIG. 10.3 OVERALL SITE PLAN



manufacturers in Alaska and other states. Because these modules require a minimum of field construction, the camp could be expanded or reduced in size at modest cost. The modules would be barged, or air-lifted by Lockheed Hercules aircraft. Trucks, helicopters or CATCO Rolligons could transport the units to their final site destination.

- Camp Facilities

The building modules would be arranged to serve a variety of camp uses. Approximately 62 dormitory-style barracks would be grouped in four quadrants -- each with its own dining, recreation, and laundry facilities. Administrative offices, warehouses, shops, a first-aid station, fuel storage, water and sewage treatment, access road, helipad and similar facilities would be built in the initial phase.

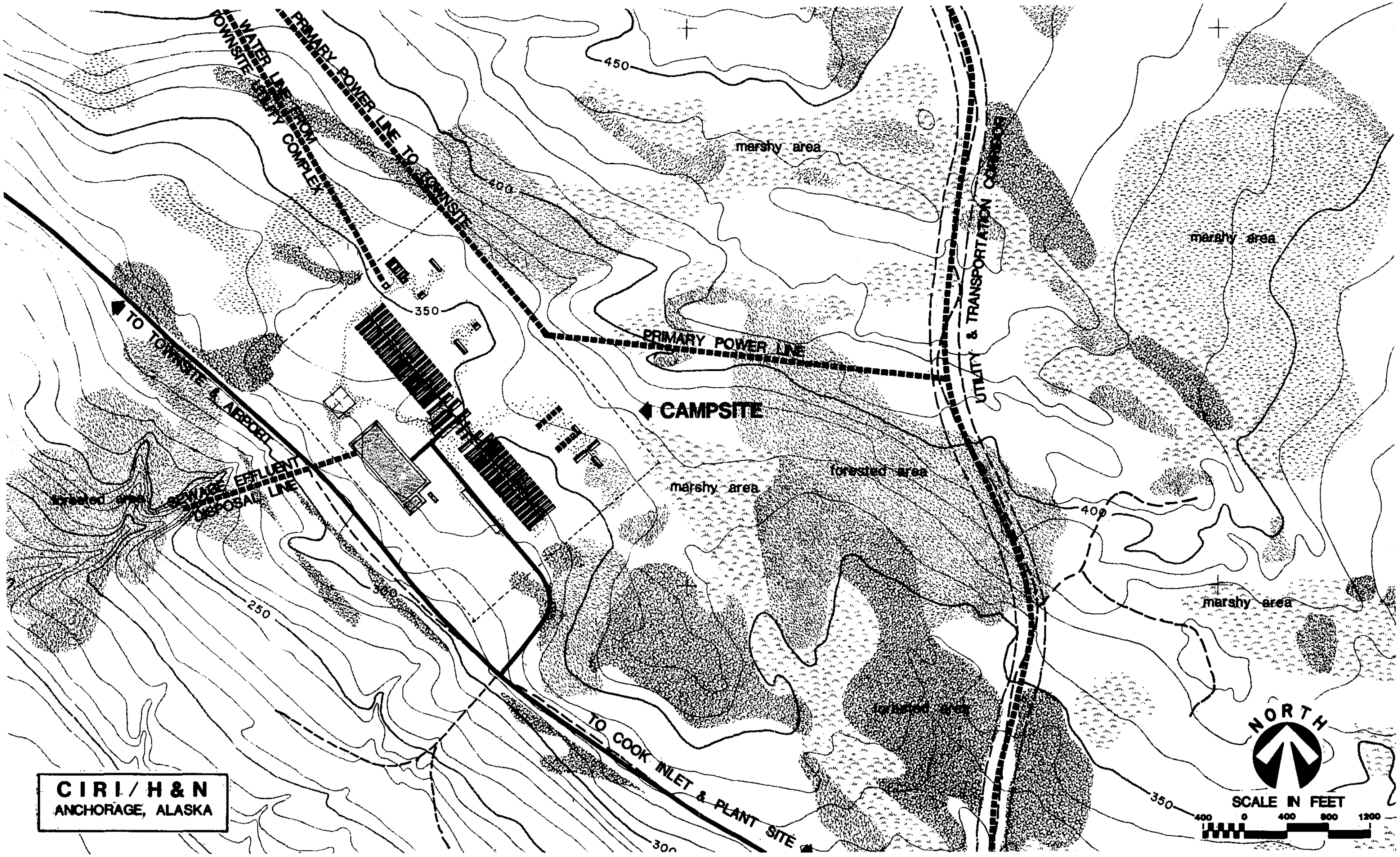
The camp's location in relation to other project facilities is shown in Figure 10.4. Its general location is close enough to the plant (within about a mile) to allow for a short bus ride, but not so close as to be affected by plant construction noise. Power and water are brought in above the camp, with road access, helipad, and sewage facilities located downhill.

Figure 10.5 shows the proposed configuration of camp facilities. Dormitories are arranged along a spine with the support dining, recreation, and laundry facilities at the mid-point. This configuration allows for efficiency of construction and operation, but could be modified based upon terrain features and requirements of camp O/M subcontractors.

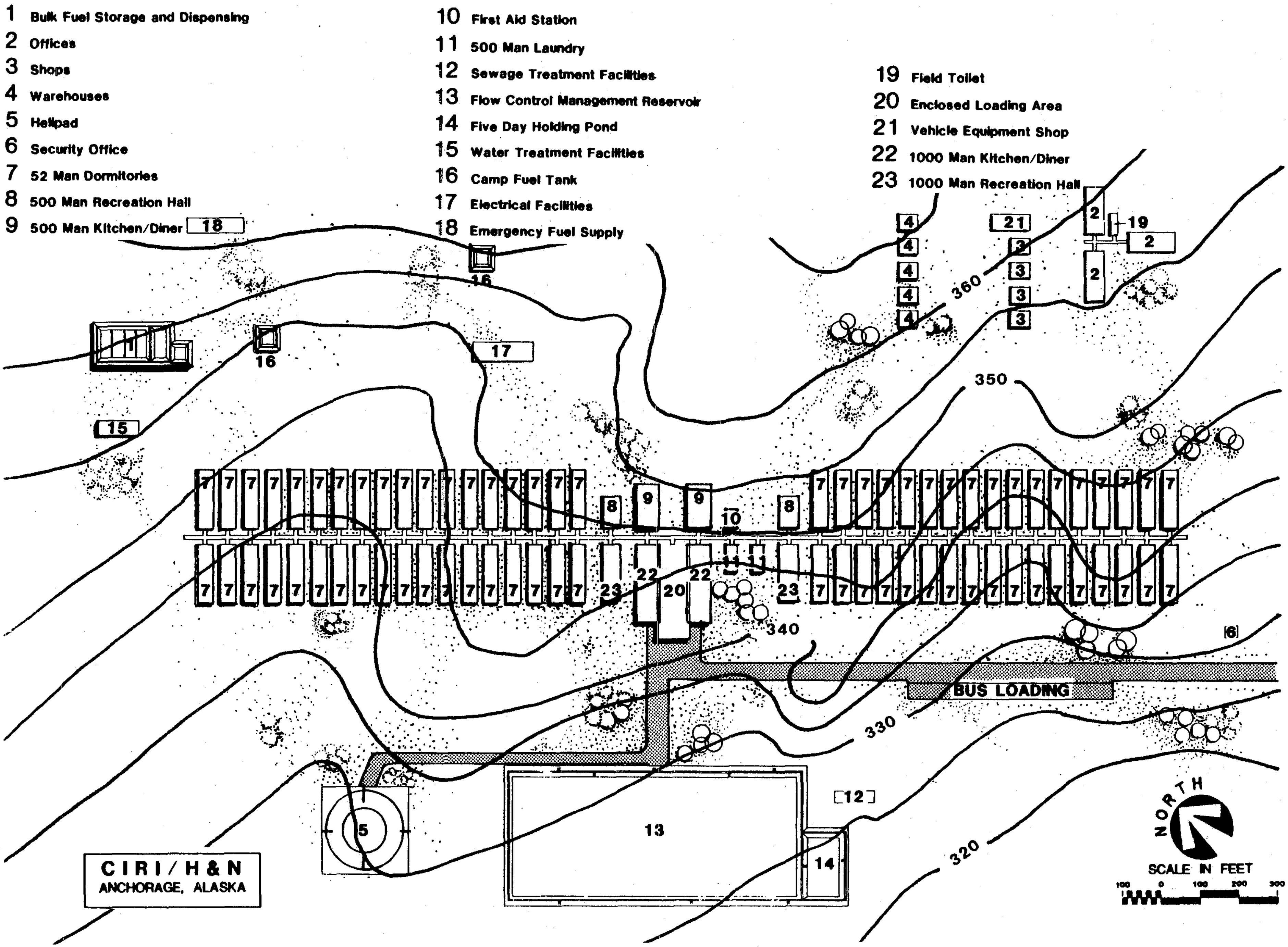
- Housing and Support Facilities

Housing and support functions would necessitate dormitory, kitchen/dining, recreation, first-aid, and central laundry facilities.

FIG. 10.4 CAMP SITE CONSIDERATIONS



# FIG. 10.5 CAMP PLAN



Each dormitory module would accommodate 52 persons in two-man rooms. The one-story structures would be about 35 feet wide and 144 feet long. In addition to the 26 rooms, each sleeper module would contain group washroom, shower and toilet facilities, clothes washers and dryers, and other amenities.

Four standard prefabricated and preinstalled kitchen/diner modules would be built. Assuming incremental development of four quadrants of dormitory modules, two 1,000-person kitchen/ dining halls, and two 500-person halls would be required.

The recreation hall is a vital component in any remote camp because of its influence on the morale of the construction and O/M work force. Assuming at least two work shifts, two 1,000-person recreation halls would be adequate to provide a full variety of recreational pursuits. A commissary and post office would be located in one of the halls.

A centrally located first-aid station would allow medical personnel to assess and stabilize medical emergencies before air evacuation to Anchorage; coordinate on-site injury assessment and treatment methods with Anchorage medical specialists; and provide selected out-patient services.

- <u>Utilities</u>

Camp utility systems would consist of water supply, treatment and distribution; sewage collection, treatment and effluent disposal; power supply and distribution; solid waste collection, reduction and disposal; and fuel storage. Potable water would be needed for domestic use and fire protection. The probable source would be groundwater obtained from wells.

Water would be stored in a ground-level or elevated tank. The storage requirement for potable water would be based upon the sum of fire demand and one-half daily domestic demand, or 344,000 gallons. Fire flow criteria established by the National Board of Fire Underwriters suggests that approximately 1,800 gallons per minute for two hours be provided, or a total storage of 216,000 gallons. Domestic demand is based upon a daily consumption of 80 gallons for approximately 3,200 persons, or about 256,000 gallons per day (gpd). Well pumps and booster pumps could be sized to provide approximately 445 gallons per minute (gpm) to serve a peak daily load equal to 2.5 times average flow requirements.

Sewage flows which would be generated by the camp are estimated at 60 gallons per person per day or a total of about 192,000 gpd. Treatment would consist of four 50,000-gallon package plants (e.g. extended aeration) preinstalled and prefabricated. These modules could be relocated to the town site as camp population declined. Tertiary treated effluent would flow via Arctic pipe down a drainage channel, then would be absorbed into substrata and eventually discharged into Nikolai Creek.

Power requirements probably would be met initially by on-site diesel generators and/or by the existing Chugach Electric Association power plant at Beluga, approximately 20 miles from the project site. Another possible source would be natural gas obtained from nearby Cook Inlet offshore wells.

Ultimately, a power plant would be included as part of the Beluga methanol project. The plant would serve overall needs of the methanol plant and other facilities, while the above-described power sources could provide emergency power.

Solid waste initially would be hauled to a landfill. For longer-range needs, a solid waste management facility should be constructed at the town site to serve later construction and operation phases of the project. Wastes would then be reduced, incinerated and deposited in the landfill.

Diesel oil and other oil-based products would be stored in a special, lined POL (petroleum, oil and lubricants) berm. The facility would be located away from the camp and town sites to reduce risks associated with possible fire or explosion.

## Airport

° Concept

A general transport airport is proposed to serve the construction and operation phases of the project. The airport would be sized to serve the Lockheed Hercules aircraft, in common usage in the state for heavy cargo as well as for carrying personnel and passengers and for medical evacuations.

The airport would be located northeast of the plant on land owned by the state. Given the large areas of poorly drained soils and swamp in the project area, a choice of good airport sites is limited. The recommended site best meets requirements for level terrain, adequate soils drainage and orientation to prevailing winds (Figure 10.6). Final design could require adjustments based upon closer evaluation of these requirements.

° Facilities

The airport is designed to provide adequate runway area, air control, lighting, storage and ancilliary facilities necessary to accommodate Lockheed Hercules aircraft during prevailing northerly and crosswind conditions. Figure 10.7 shows the preliminary design for the airport. It is believed that development of only a north-south runway is necessary for the construction phase of the project.

Runway length required for the Hercules is about one mile, while width should be about 300 feet. FAA criteria for a general trans-

FIG. 10.6 AIRPORT SITING CONSIDERATION

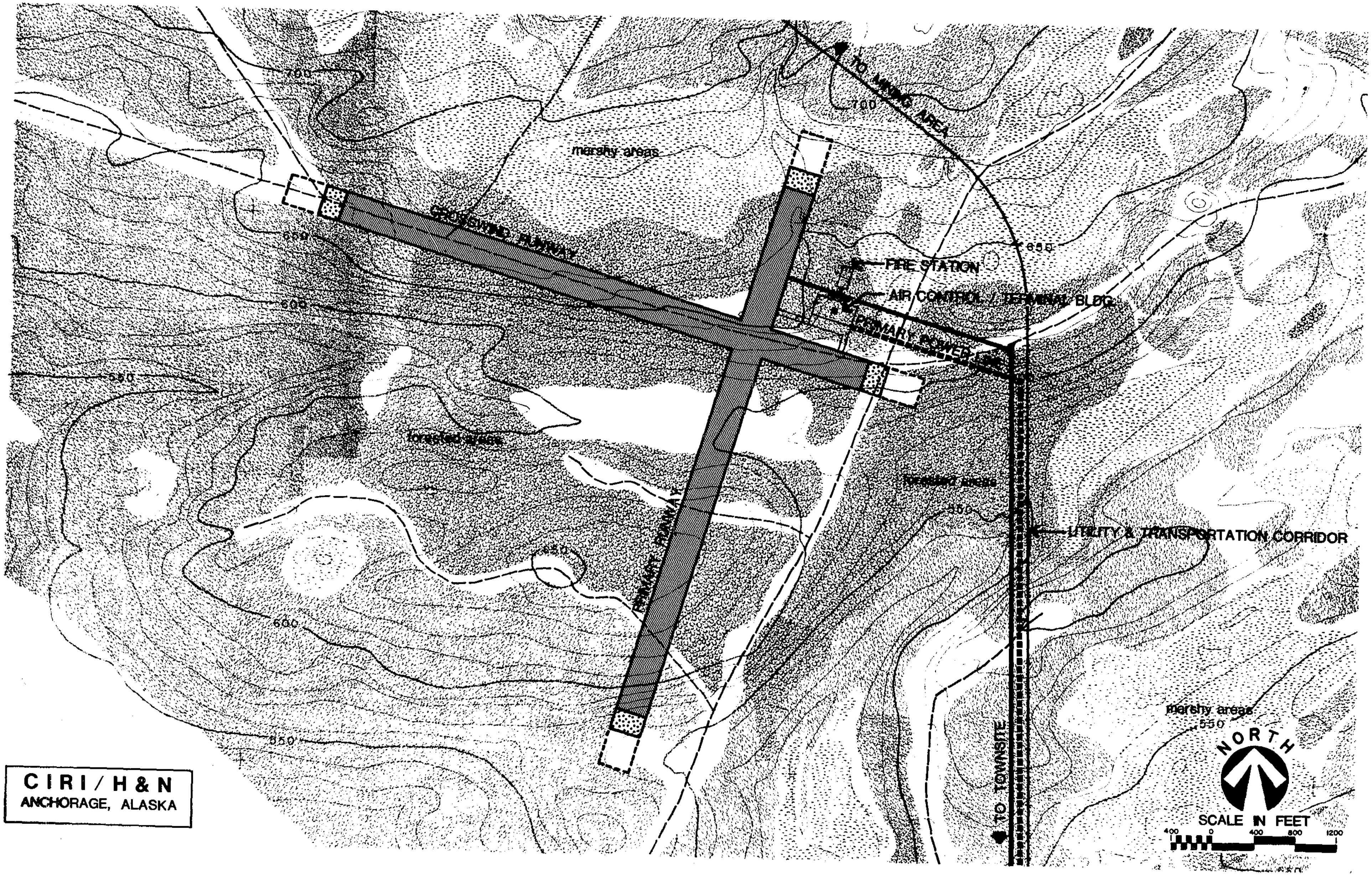



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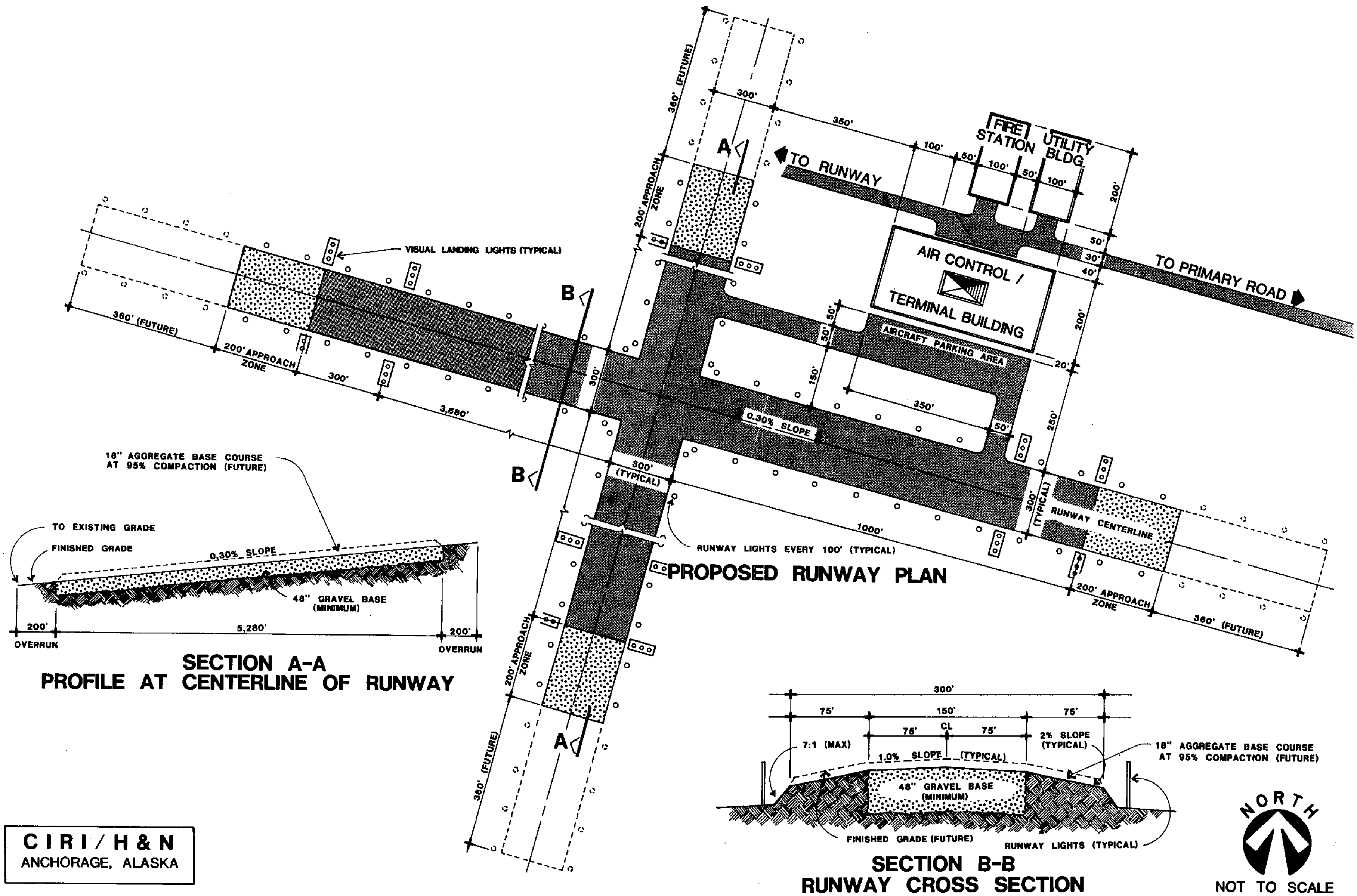
FIG.10.7 AIRPORT PLAN



port, nonprecision runway require a safety area at each end of 300 feet. An additional 200 feet is proposed at each end for adequate protection from potential obstructions. It is recommended that FAA clear zone slopes of 50:1 be established (instead of the normal 40:1 slope necessary for nonprecision runways) because of the likelihood that the runway would eventually serve Boeing 737 aircraft. If commercial jet service were instituted, the runway probably would have to be lengthened to 6,000 feet and widened to about 500 feet.

Other airport facilities would include a two-story air control/terminal building adjoining enclosed warehouse storage area. A fire station would be located adjacent to the air terminal, and would also provide fire suppression equipment for the nearby campsite. Fire suppression would utilize dry chemicals with backup from a fire truck pumper loaded with water. Water, sewage, power and solid waste requirements are expected to be small. Since domestic water requirements would be small, treated water would be trucked on a weekly basis from the camp or town to an insulated water storage tank near the terminal. Sewage effluent would be treated in a 500-gallon package treatment plant with effluent discharged into a small subsurface soil absorption system. Power would be provided by the same source which is selected to serve the construction camp. Initially, two 20 kv diesel generators would be used. Solid waste would be stored in a dumpster to be transported to the solid waste management facility at the proposed new town.

## Permanent New Town

° Concept

A relatively self-sufficient new community would be developed for the people who would be employed at the mine, methanol plant, and related facilities, and for their families. The town's estimated population would be about 2,600.

CIRI/Placer Amex would manage the development process, providing certain initial infrastructure to facilitate efficient development eventually having a full range of community services. Initial community development would provide the basic core of public infrastructure and housing. Private developers would provide additional housing, commercial and other facilities on a free-market basis within the broad guidelines of the overall town site plan. Schools would be built and operated by the Kenai Peninsula Borough.

The community might become an incorporated city, levying taxes and bonding for certain facilities (options discussed previously in this section under Kenai Peninsula Borough Services).

One option to the development of a permanent town site would be continued use of the construction camp beyond the construction phase. Rotating crews (without families) working seven days on/seven days off could be transported to Anchorage or Kenai. In any event, some of the camp's facilities could be adapted for use in the town site. Some camp housing could be designed for relocation and reconstruction as permanent housing. Water, sewer and power would be coordinated between the camp and town sites. Camp recreation halls might be relocated to the town site.

The preliminary land use plan for the proposed new town is shown in Figure 10.8. It was chosen from an analysis of alternative sites which considered such criteria as slope, drainage, land ownership, and proximity to the camp, plant and other facilities. The town site would be oriented along a high, well-drained bluff overlooking Nikolai Creek, about three miles from the plant.

- Housing, Education and Commercial Facilities

A variety of housing types including single-family homes and multi-family units would be provided by private builders. Some

## FIG.10.8 TOWN LAND USE PLAN

### Residential:

**SF** 16 to 24 single family units in six acre neighborhoods.
average density: 3.3 units/acre

**MF** 50 townhouse and apartment units in five acre neighborhoods.
average density: 10.0 units/acre

**FSF** Potential six acre expansion area for single family neighborhood development.

### Educational:

**EDUCATIONAL COMPLEX** High school and K-8 facility on sixty acres.

**FUTURE EDUCATIONAL EXPANSION** Potential twenty acre expansion area for additional K-8 facility

### Utilities:

**UTILITY COMPLEX** Water treatment, solid waste management, and power substation facilities on approx. 3.7 acres.

**STP** Sewage treatment plant on approximately 4.6 acres.

**FSTP** Potential sewage treatment plant relocation with single family neighborhood expansion on approximately 4.6 acres.

**MC** Motor vehicle maintenance and storage complex on 3.7 acres.

Improved road

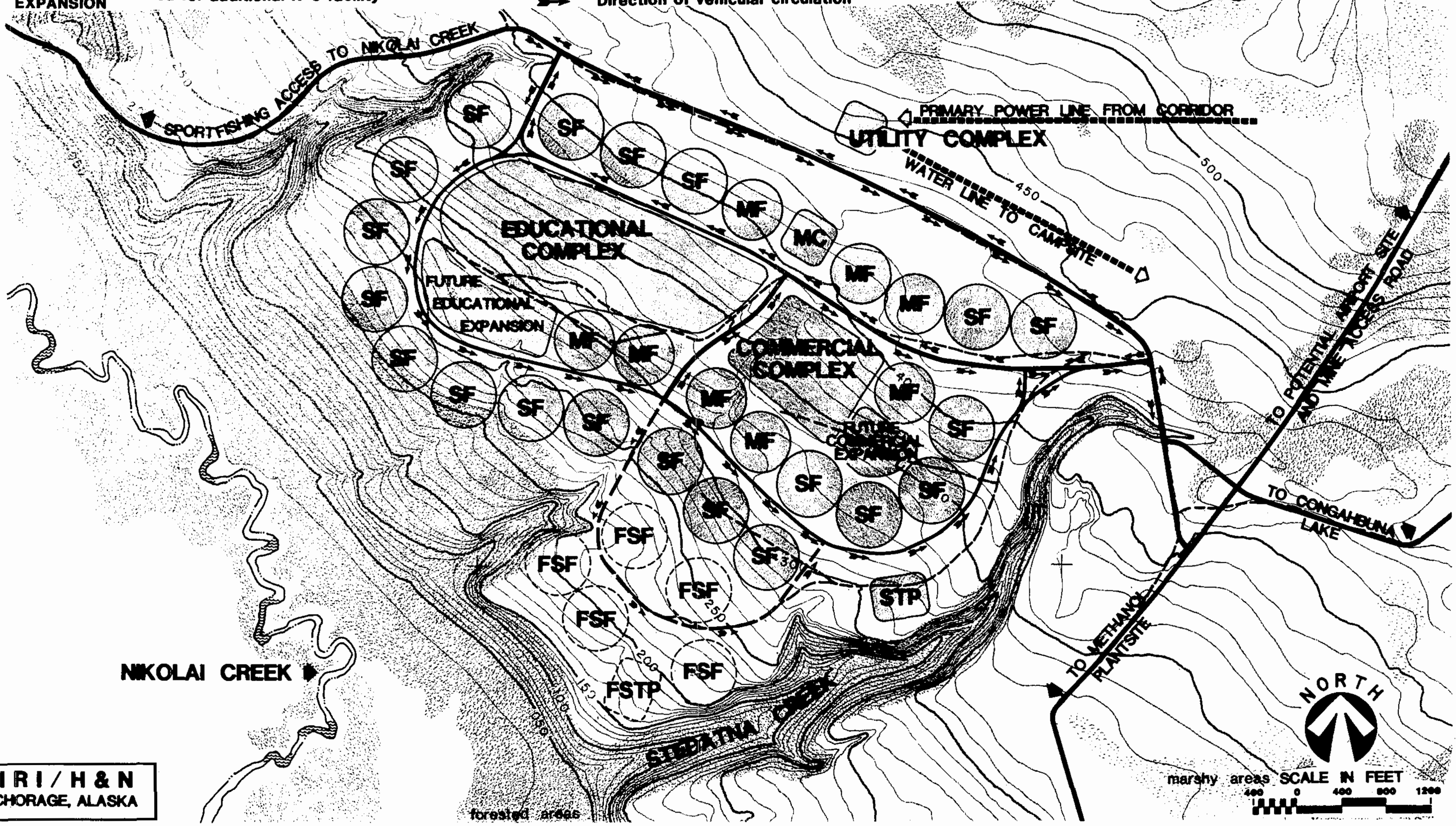
Potential improved road for single family expansion area.

Direction of vehicular circulation

### Commercial:

**COMMERCIAL COMPLEX** Combined shopping and entertainment, community services, offices, governmental administration, and residential apartment units on 30.0 acres.

**FUTURE COMMERCIAL EXPANSION** Potential ten acre commercial expansion area

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ANCHORAGE, ALASKA

mobile homes could be installed, but cost estimates have assumed all wood-frame housing. Using an average household size of about 2.5, approximately 1,020 units would be required. The tentative mix of units is about 400 single-family units, 125 townhouses, and 495 rental apartments (a reduction in the number of rental units is possible, depending upon employment agreements established by CIRI/Placer Amex). Development densities would be about 3.3 units per acre for single-family and 10 units per acre for townshouses/apartments, with higher densities for about 200 apartment units in the town center. Total residential land requirements and land costs have not been estimated.

Schools in the new community would function as both education and community recreation centers. Assuming a range of 25 to 35% school-age children, schools would have to be built for 650 to 910 students. Perhaps all of these students could be accommodated in one K-12 school. However, the Kenai Peninsula Borough has estimated the need for a K-8 school for 500 students and a high school for 800 students, so these conservative estimates have been used for cost estimating purposes. The borough estimated that a 20-acre site would be required for the K-8 school and a 40-acre site for the high school. It is anticipated the borough would build and operate the schools.

Commercial space would be needed for retail grocery and department stores, a medical clinic, bank, offices, restaurants, movie theater, and future government offices. A hotel and church site(s) may also be necessary. It is suggested that most of these services be conveniently grouped within a single energy-efficient structure -- perhaps along the lines of an enclosed shopping center mall.

- <u>Transportation</u>

Travel within the project area would be generally restricted to home-to-plant or mine trips, shopping trips, and less frequent trips within the community or to nearby fishing or recreation areas. Trips onto nearby Native lands would be greatly discouraged by Tyonek Native Corporation.

These trip-making characteristics provide the opportunity for the use of buses as the primary means of transportation in the area -- during both the construction and operations phases. Since roads are not developed outside of the area, and new roads would be developed primarily for truck use, the initial use of private automobiles should be discouraged. Buses could circulate throughout the project area on narrow roadways, while saving land and development costs usually required for wider roads and parking areas. Emergency vehicles, delivery trucks, and snow removal equipment would also use the roads.

Circulation throughout the town would be by 20- and 45-passenger buses, and a separate network of bicycle/cross-country ski trails. Approximately 20 45-passenger buses and six 20-passenger buses or 9-passenger vans would be used during the construction phase. All of these vehicles would be used during the operations phase for home-to-work trips, home-to-school trips, and trips to recreational areas such as Congahbuna Lake and Nikolai Creek. The smaller vehicles would be used within the town site on a 24-foot-wide one-way loop road, served by 12-foot-wide residential access streets. A 4-acre bus storage and maintenance facility is planned near the town center. At some point further into the development, private automobiles may be permitted.

- Utilities

The same types of utility services provided for the camp would be needed for the town. Possibilities exist to integrate some of the facilities (water supply, sewage treatment, solid waste disposal). Domestic and fire flow water requirements are estimated at 354,000 gpd (one-half daily domestic demand of 120 gallons per person plus 1,650 gpm for two hours of fire flow). Storage and treatment would be the same as described for the construction camp. Distribution would be by approximately 8-inch main and smaller diameter feeder lines.

Sewage flows generated by the town are estimated at 208,000 gpd (80 gallons per person). The four 50,000-gallon package treatment plants used at the construction site, plus a new 10,000-gallon package plant would be installed on an incremental basis. The plants would be sited downslope from the town with treated effluent discharged into Nikolai Creek.

Minimum power requirements for the town would be about 25 kv. It is assumed that initial power requirements could be met using the source which served the construction camp until the permanent power plant were built.

Solid waste equal to about 24,000 pounds per day of burnable material and 1,440 pounds per day of noncombustible material would be hauled to a solid waste management facility. After reduction, remaining solid waste would be disposed in the sanitary landfill.

## 11.0 ACOUSTIC ENVIRONMENT

### INTRODUCTION

Sound is radiant mechanical energy transmitted by longitudinal pressure waves in a material medium. Sound can be transmitted through gases, liquids or solids. The number of times a sound wave reaches its maximum and minimum pressures in a unit of time is referred to as its frequency, and frequency is expressed in Hertz (Hz), which refers to the number of cycles per second. Sounds with frequencies from about 16 to 20,000 Hz are in the range of human hearing.

Sound level or loudness usually is described using a dimensionless unit of pressure, the decibel (dB), and environmental noise generally is expressed using the A-weighted sound level in units of dB called dB(A). The A-weighting is an adjustment based on human hearing sensitivity at various frequencies. It is customary to call any undesirable sound "noise." Figure 11.1 illustrates various levels of noise in terms of A-weighted sound levels.

The result of combining two sound levels is not additive. Generally when two sounds are combined the resulting sound level is not more than 3 dB greater than the louder component. In terms of human hearing, a sound level difference of 1 to 2 dB is barely perceptible; 3 to 5 dB is clearly perceptible; and 7 to 10 dB is an effective doubling or halving of loudness.

Ambient background noise levels of 55 dB or less generally are acceptable. Residential areas near large cities generally have a background level of about 60 dB. Increases of up to 5 dB over ambient levels are generally considered to have a slight impact; increases of 5 to 10 dB would have a significant impact; and increases of 10 dB or more would have serious impacts.

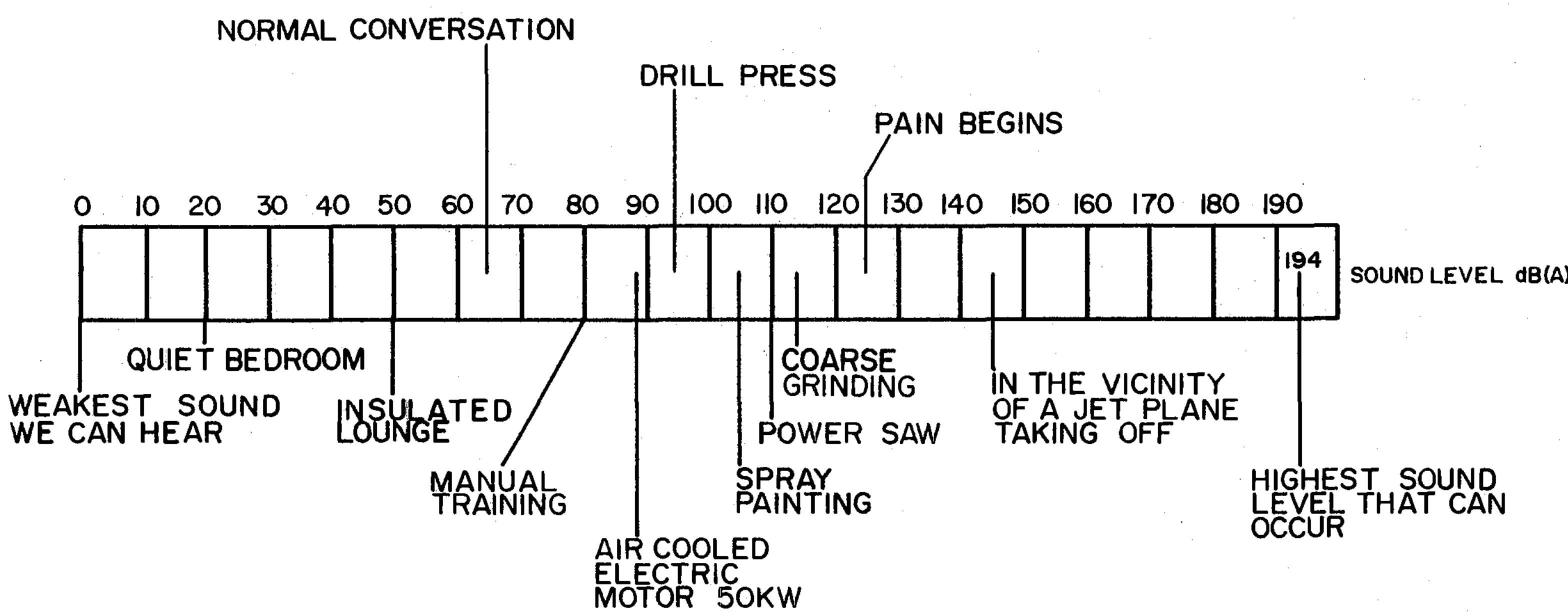


FIGURE 11.1 LEVELS OF NOISE IN TERMS OF A-WEIGHTED SOUND LEVELS, dB(A)

## GENERAL OVERVIEW

The Chuitna Center Ridge and Capps mine areas which would provide coal feedstock for this project are located in an uninhabited wilderness area between the elevations of 1,500 and 2,100 feet. There are essentially no man-induced noise sources in these areas other than occasional overflights by light aircraft. The ambient noise levels in these areas would probably vary between 20 and 35 dB(A).

The methanol plant site is located near the shore of Cook Inlet in a generally uninhabited area, although it is the location of ongoing timber harvest and oil industry activities. There are regular timber hauling activities with slow-moving heavy trucks producing noise in the 60 to 70 dB range at a distance of 400 feet. Although general vehicular traffic is sparce by rural standards, pickup and automobile traffic is generated by Granite Point fishing activities, the onshore oil receiving facility, and general recreational and hunting excursions. Overhead small aircraft traffic also is frequent. The present noise inducing activities near the plant site still produce an insignificant level of background noise. It is assumed the base ambient sound levels for the general methanol project site are between 30 and 40 dB(A).

## NOISE SENSITIVE LAND USES

There are no noise sensitive land uses within the project area other than the expected responses to higher levels of induced noise by the resident wildlife and bird populations.

# ENVIRONMENTAL EFFECTS

## 12.0 GEOLOGY AND SOILS

### CONSTRUCTION EFFECTS

Construction effects from this project on geology and soils would be the result of numerous activities ranging from the surveying of the land surface to the construction and operation of sedimentation ponds (Table 12.1). The primary concern during construction would be the control of erosion (primarily by surface water) to prevent the degradation of surface waters and the potential impact on the fishes utilizing these surface waters. Also of concern would be the general impact of such construction activities on generally unstable soils with particular concern for areas that could possibly fail due to high water contents and inherent slope instability. The former can be controlled by careful planning and operator training with close supervision; the latter can be controlled by detailed soil analysis and sound engineering design.

### LONG-TERM EFFECTS

Long-term effects from construction and operation of this project in terms of geology and soils would relate primarily to:

- Competency as Structural Foundation
- Erosion Potential
- Clays for Impermeable Sealers
- Aggregate Sources
- Seismic (Faulting)
- Geophysical Hazards
- Soil Suitability for Wastewater Disposal
- Slope Stability
- Permafrost

Table 12.1

PRELIMINARY LIST OF CONSTRUCTION ACTIVITIES ASSOCIATED WITH DEVELOPMENT IN THE BELUGA REGION

| | | | |
|---|---|---|---|
| 1. | Survey land surface | 21. | Build bridges |
| 2. | Operate drill rigs | 22. | Cut and fill |
| 3. | Remove surface features | 23. | Haul material |
| 4. | Store topsoil materials | 24. | Prepare surfaces and roadbeds |
| 5. | Dewater (by pumping) | 25. | Store material |
| 6. | Blast | 26. | Crush material |
| 7. | Remove overburden | 27. | Load material |
| 8. | Dispose of overburden | 28. | Operate railroads |
| 9. | Extract material | 29. | Operate access roads |
| 10. | Replace topsoil and revegetate | 30. | Operate haul roads |
| 11. | Divert surface waters | 31. | Store fuel and chemicals |
| 12. | Operate machinery and equipment | 32. | Operate maintenance yards and parking lots |
| 13. | Clear and grade | 33. | Operate electric transmission |
| 14. | Excavate | 34. | Operate water supply |
| 15. | Backfill and grade | 35. | Operate sewage treatment plant |
| 16. | Construct stream crossings | 36. | Operate septic tanks |
| 17. | Construct dikes and dams | 37. | Operate runoff controls |
| 18. | Install culverts | 38. | Operate waste rock dumps |
| 19. | Assemble structures | 39. | Operate sediment ponds |
| 20. | Pave surfaces | 40. | Construct docks |

Nearly all of these effects (or concerns) relate to the operation of the mines supporting the methanol plant. Stability of the material in the waste dumps would be of some concern due to the overall weak and water-sensitive nature of the material. The extensive distribution and depth of glacial tills will determine the overall slope of pit walls. Slide areas adjacent to the northeast side of the Capps pit area would most likely be susceptible to additional water. The finer-grain mud stones have very poor trafficability. The transportation corridor past the Chuitna west pit area may encounter siltstone and claystone slopes susceptible to instability without design precautions (e.g., flatting the slope). Drainage from open slopes would require interception to avoid progressive erosion. The transportation corridor crossing extensive areas of tundra may require excavation of the organic layer. The extent of granular borrow material available in the pit areas to support long-term operations has not yet been determined. Final plant location determinations may require the extensive removal of deep organic layers.

## MAJOR REGULATORY REQUIREMENTS

Regulations relative to impacts on geology and soils would be primarily through the permanent regulatory program of the Office of Surface Mining Reclamation and Enforcement. It is anticipated that the State of Alaska will enact regulations similar to those of OSMRE.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

While some degree of uncertainty remains as to the nature and permeability of the overburden in the pit areas and along the transportation corridor, there is nothing to suggest that the project as proposed would cause any unacceptable environmental impacts during either construction or the operation phases. Modification of the landscape within the mining areas would be unavoidable but should be environmentally acceptable assuming a proper mine design and careful monitoring to insure that proper construction and operation techniques are being applied.

# 13.0 HYDROLOGY

## CONSTRUCTION EFFECTS

### Groundwater

- **Construction Water Source**

  The only likely use of groundwater during the construction phase of the project would be as a potable water supply and possibly for concrete mix water. The test water well drilled in May 1981 near the proposed plant site indicated a presence of a deep groundwater source that could provide up to 100 gpm on a regular basis. The water is of reasonably good quality with possibly only chlorination required for treatment. It is assumed that the potable water supply would be used primarily to operate the construction camp. It is likely the groundwater supply would feed a storage reserve near the camp facility to meet peak water demands.

- **Effects on Water Table**

  It is probable that if groundwater were used it would be drawn from a deep source similar to that in the above-mentioned test well. Virtually nothing is known about groundwater movement in this area, but the abundance of surface sources suggests a system of aquifer feed-water that would preclude any detrimental effects on the water table based on the anticipated potable water requirements for this project.

- **Appropriation of Water Rights**

  Alaska Statutes Title 46 Water, Air, and Environmental Conservation reserves the waters of Alaska for the people of the state for common use. Waters may be appropriated with permit authority for beneficial uses which comply with standards for the protection of public health and safety, protection of previous permitted appropriations, and preservation of anadromous fish streams and public recreational opportunities. Any entity desiring to appropriate waters of the state must obtain a water appropriation permit from the director of the Division of Forest, Land and Water Management, Department of Natural Resources prior to developing the water source. This permit authorizes the holder to conduct the necessary work for appropriating water and to commence his appropriation; however, it does not secure rights to the water. When the permit holder has commenced use of the water, he must again notify the director, who will issue a "Certificate of Appropriation" upon demonstration that the means for taking the water have been developed and the permit holder has complied with all permit conditions. The certificate secures the holder's rights to the water. It is not anticipated that any difficulties would be encountered in CIRI/Placer Amex obtaining a "Certificate of Appropriation" for groundwater use.

Surface Water

° Siltation During Construction

Construction of the coal handling and plant facilities would occur over a period of several years. During this period and prior to initiation of processing activities, the only significant wastewaters generated on-site would be runoff waters. Because of construction work such as site grading, road building and other civil-associated activities, that precipitation runoff during this period would contain quantities of silt.

As an initial site activity, the facility's design proposes construction of two large earthen ponds to collect and detain runoff from the construction site. These would enable any silt contained in the runoff waters to settle prior to release of the runoff to natural channels. Runoff flows would be intercepted by the embankment forming the foundation of the southerly site access road, and would be directed through a channel under the roadway to the settling pond sites.

Because of physical conditions at the currently proposed processing site, two runoff control systems are anticipated. One would serve the coal handling area, approximately 100 acres, and the other would serve the methanol production area, approximately 220 acres. Each system's design is based on the Universal Soil Loss Equation. Each settling pond is sized to accommodate a 24-hour rainfall on the area served, with a frequency of return of once in 10 years, in addition to a sizable volume of settled silt. An alum feeding capability proportioned to the influent flow would enhance agglomeration and settling of turbidity-causing fines anticipated in the raw runoff. This system of runoff control should maintain sediment discharges at an acceptable level.

- Accidental Petroleum and Hazardous Substance Spills

As with any construction project, there likely would be small accidental spills of gasoline and diesel fuels, hydraulic fluids or other petroleum by-products. Minor accidental spills of materials such as solvents also would be expected, and these likely would qualify as hazardous substances. If such spills occurred in minor amounts on the plant site, they would be sufficiently removed from the nearest lakes, anadromous fish streams, and coastal waters to prevent impact. Such minor spills most likely would occur in the plant workpad area, a location which would also preclude direct contamination of adjacent wetlands.

The most detrimental place for a spill to occur would be near a stream crossing on the road system or near dock construction and material handling activities in the intertidal area. Such spills would be beyond the category of small accidental material handling spills discussed above. A spill there likely would involve a more serious accident, and would have a very low chance of occurrence. To protect against adverse impacts from such an accident, a cooperative and coordinated plan of response to oil and hazardous substances pollution emergencies would be forthcoming from an interagency group headed by the Alaska Department of Environmental Conservation, in accordance with state policies. This would represent an extreme sequence of events not unlike those possible during any large industrial construction project. Any accidental spills from routine construction activities are not anticipated to cause adverse environmental effects.

° As a Water Source for Construction

Surface water would be used during construction primarily for concrete batching, earthwork compaction and dust control. This water would be required in relatively low quantities and likely sources would be adjacent streams or ponds such as Congahbuna Creek, Congahbuna Lake or one of the other adjacent small ponds. Groundwater might also supply some of the concrete mix water. Due to the intermittent nature of the water requirement and the relatively small quantites that would be withdrawn, any effects on these water courses would be very temporary.

## LONG-TERM EFFECTS

### Groundwater

° Plant Water Source

The methanol plant and coal handling and processing facilities have a variety of water requirements, however, the largest requirement is make-up water for the plant cooling system. The highest water requirement cooling alternative reviewed in this project necessitated an excess of 300,000 gpm of once-through cooling water. This design scenario was favorable to capital cost but was discarded because of insufficient local water sources to meet this extraordinarily high demand. The present cooling concept is a recirculating system requiring about 15,000 gpm to replace the evaporation and other losses. The two exploratory water wells drilled as part of this study confirmed that deep groundwater sources would not be sufficient to meet the water requirements at the plant. Approximately 100 gpm on a regular basis may be available from a well in the plant site but this would be insufficient to meet much more than routine potable water needs. The only apparent alternative at this time is the installation of an extensive infiltration gallery system in the lower reaches of Nikolai Creek. This is discussed further later in this Section under Effects to Surface Waters. It is expected that there would be some well water used for domestic purposes whether at the plant or construction camp. Because there are no significant uses of groundwater in the Granite Point area at this time, there would not be any significant impact from the use of these wells for a potable water source. Based on the available information, a single well could provide between 100,000 and 150,000 gpd. It may also be possible to have two or three wells in close proximity near the plant without significant overlapping of the cones of depression of the drawdown curve of each well.

- Effects on Water Table and Marshes

It seems evident that any deep groundwater withdrawal for this project would come from the upland area of the Nikolai escarpment. This area is two to four miles from the Trading Bay State Game Refuge, so groundwater withdrawal should have no impact on the marshes in the refuge. Virtually no use is being made of the groundwater resources in this region. Consequently groundwater withdrawal of domestic quanities for this facility and its supporting construction activities should have only minor effects on the water table. Between uses or if withdrawal is later discontinued, the static water level should rapidly be restored to its present level.

- Appropriation of Water Rights

A permit to withdraw groundwater would have to be obtained from the state Department of Natural Resources. The details of this procedure are further explained earlier in this section under Appropriation of Water Rights. It is not anticipated that any difficulties would be encountered in CIRI/Placer Amex obtaining a Certificate of Appropriation for groundwater use.

## Surface Water

- Wastewater Discharges and Treatment

Wastewater discharges would result from water treatment facilities, processing and non-processing operations, blowdowns from boilers and cooling towers, repair shop associated with the servicing of locomotive engines, runoffs from coal storage and processing areas, and from infrequent cleaning of steam boilers. All of these wastewater streams are treatable using conventional technology and could be discharged to Cook Inlet in compliance with state Water Quality Standards.

Wastewater discharges from the proposed gasification/methanol plant complex would occur continuously and/or intermittently from several sources, which are summarized and discussed in the remainder of this section. It appears that each of these discharges is treatable using conventional technology and that discharge permits could be obtained. It is beyond the level of available data and scope of this study to analyze the environmental effects of each component of the discharge stream in detail.

The continuous discharges include:

- Water Treatment Blowdowns
- Char Filtrate
- Methanol Bottoms
- Pump Seal Waters
- Railroad Service Shop Wastewaters
- Sanitary Wastewaters
- Boiler Blowdown
- Cooling Tower Blowdown

The intermittent discharges include:

- Coal Storage Area Run-off
- Boiler Cleaning Wastewaters
- Process Area Runoff
- "Clean" Area Runoff

All treated effluents would be stored in a final treated effluent pond, and discharged through an effluent diffuser to Cook Inlet during ebb tide only. A portion of the treated effluent would be utilized for the conditioning of dry ash to minimize dust problems during load-out from ash silos. Stored treated effluent also would serve to meet the plant fire water demand.

The wastewaters generated in the proposed methanol plant according to the above listed categories, including estimated flows and characterization are described in this section. This information is the basis for the conceptual development of wastewater treatment facilities, and for estimating the characteristics of treated effluent proposed to be discharged to Cook Inlet.

Water Treatment Blowdowns (Continuous Discharge): Well water for general plant uses would be softened using the Cold Lime process to remove alkalinity and hardness, then would be neutralized and chlorinated before distribution. Due to the presence of high concentrations of silica in the well water, make-up water for boiler use would first be softened using the Warm Lime process for partial removal of silica, and then would be demineralized using a combination of cation and anion exchange beds.

Wastewater discharges from the water treatment facilities would result from the combined dewatering of sludges resulting from cold and warm lime softening, and from the regeneration of ion-exhange beds. Sludge dewatering would result in a discharge of 123 gpm of centrate, and ion exchange regeneration would result in a wastewater discharge of 185 gpm. These wastewater discharges contain only inorganic impurities. Since ion-exchange regenertion wastes are expected to be highly acidic, they would be neutralized. These wastewaters then would be combined with treated process wastewaters for discharge to Cook Inlet.

Char Filtrate (Continuous Discharge): Significant quantities of char are carried with the hot raw gas from the gasifiers. The major portion of the char is removed in cyclones prior to cooling of the raw gas. The gas is cooled by direct contact with water in scrubbers, which removes the remaining char, and also removes any "condensible" impurities. Wastewater resulting from gas scrubbing is clarified and cooled, and then is recycled to the scrubber. The underflow sludge from the clarifiers is dewatered in pressure filters. These pressure filters also dewater sludges from the clarifiers which handle wastewater discharges resulting from scrubbing of coal dryer gas. Char filtrate thus represents combined blowdowns from the dewatering of sludges resulting from gas cooling and from coal dryer gas scrubbing. The estimated flow of char filtrate is 878 gpm, and it would contain impurities condensed from the gas. The estimated concentration of contaminants in the char filtrate is shown in Table 13.1.

Table 13.1

SUMMARY OF ESTIMATED FLOWS AND CHARACTERISTICS
OF PROCESS - RELATED AND SANITARY WASTEWATER DISCHARGES

| Parameters | Char Filtrate | Methanol Bottoms | Pump Seal Water | Pretreated Effluent Railroad Shop | Contaminated Process Area Runoff | Pretreated Sanitary Wastewater Discharges | Total Wastewater |
|---|---|---|---|---|---|---|---|
| Flow, GPM | | | | | | | |
| AVG | 878 | 190 | 175 | 50 | - | 11 | 1304 |
| MAX | - | - | - | 80 | 340 | - | 1674 |
| $BOD_5$, mg/ℓ | 685 | 5 | - | 30 | 50 | 100 | 477 (373)[1] |
| TOC, mg/ℓ | 380 | 3 | - | 20 | 30 | 50 | 265 (208) |
| COD, mg/ℓ | 1360 | 10 | - | 60 | 100 | 200 | 947 (741) |
| Sus. Solids, mg/ℓ | 100 | 20 | - | 50 | 75 | 100 | 93 (73) |
| TDS, mg/ℓ | 1500 | - | - | 200 | 200 | 350 | 1073 (842) |
| Phenol, mg/ℓ | 5 | - | - | - | - | - | 3.4 (2.7) |
| Chloride, mg/ℓ | 760 | - | - | - | - | - | 512 (400) |
| Thiocyanate, mg/ℓ | 5 | - | - | - | - | - | 3.4 (2.7) |
| Cyanide, mg/ℓ | 46 | - | - | - | - | - | 31 (24) |
| Ammonia-N, mg/ℓ | 17 | - | - | - | - | - | 11.5 (9) |

[1] Concentrations indicated for maximum flow conditions.

Methanol Bottoms (Continuous Discharge): An estimated discharge of 190 gpm would result from the methanol distillation columns. This discharge is anticipated to contain approximately 5 ppm of methanol and 1 ppm of higher alcohols. The characteristics estimated for this discharge are shown in Table 13.1.

Pump Seal Water (Continuous Discharge): Water used to cool pump seals would be discharged to the process area sewers. An estimated discharge of 175 gpm would result from the use of water for pump seal cooling. Insignificant contaminants are anticipated in these discharges.

Railroad Service Shop Wastewaters (Continuous Discharge): A shop to service and repair locomotive engines would be provided. Wastewater discharges would occur from washing cars prior to repairs, as well as from runoff from the railroad tracks associated with the shop. It is proposed that wastewater discharges from the shop and runoff be pretreated to remove oil and settleable solid materials, and that the effluent be discharged to the process sewers. The average and maximum rates of flow of discharges from the railroad shop area are estimated at 30 and 50 gpm, respectively. The characteristics of pretreated effluent from the railroad shop are shown in Table 13.1.

Sanitary Wastewaters (Continuous Discharge): Sanitary facilities would be scattered throughout the plant area. To avoid problems of conveying relatively small volumes of sanitary wastes to a central location for treatment, it is envisioned that minor sanitary discharges from remote locations would be treated in individual septic tanks. Overflow from the septic tanks would be chlorinated using chlorine tablets, and discharged to the nearest process sewer. Centrally located package treatment plants providing secondary treatment and chlorination would be provided to serve major sanitary discharges.

Treated effluents from these package systems would also be discharged to the process sewer.

An estimated total quantity of 16,000 gpd (11 gpm) would be discharged from the various sanitary treatment facilities. The estimated characteristics of the pretreated sanitary wastewater discharges are:

| | |
|---|---|
| $BOD_5$ | 100 mg/ℓ |
| TOC | 50 mg/ℓ |
| COD | 200 mg/ℓ |
| Suspended Solids | 100 mg/ℓ |
| Total Dissolved Solids | 350 mg/ℓ |

The estimated flows and characteristics of process wastewaters, pretreated effluent from the railroad shop, pretreated sanitary wastewaters and controlled discharges of process area runoff are shown in Table 13.1. It is proposed to treat these wastewaters in on-site biological treatment facilities.

Boiler Blowdown (Continuous Discharge): There would be three classes of boilers in the coal gasification/methanol complex: high pressure steam boilers; Winkler waste heat recovery boiler; and Reformer waste heat recovery boiler. The estimated normal rate of flow of blowdown from the high pressure boilers is 135 gpm. The estimated normal rates of flow of blowdowns from the Winkler and Reformer waste heat recovery boilers are 37 and 15 gpm respectively. The principal contaminants are suspended and dissolved solids. The estimated suspended and dissolved solids concentrations are 30 and 350 mg/ℓ, respectively.

Cooling Tower Blowdown (Continuous Discharge): Waste heat is recovered from the condensing turbines and other processing areas using recirculated cooling water. This waste heat is removed from the cooling water in cooling towers. The estimated flow of water in the recirculating cooling system is approximately 330,000 gpm. The cooling tower is designed to operate at three cycles of concentration. The estimated averages are: evaporation 9,980 gpm; drift 333 gpm, and blowdown 4,660 gpm. The characteristics of cooling tower blowdown are estimated based on using well water as make-up to the cooling towers. The cooling tower blowdown characteristics are:

| | |
|---|---|
| Suspended Solids | 100 mg/ℓ |
| Dissolved Solids | 1,800 mg/ℓ |
| Iron | 2 mg/ℓ |

<u>Coal Storage Area Runoff (Intermittent Discharge)</u>: During normal operation of the production facilities the only significant wastewaters generated within the approximately 100-acre coal storage and handling area would be from periodic washdown of certain coal handling equipment operating areas, and from precipitation runoff. It is estimated that the washdown wastewaters could amount to approximately 54,000 gpd. Precipitation runoff would, of course, be variable, both in quantity and frequency of occurrence, and is further dependent on the coefficient of runoff, a function of the type of surface on which the precipitation falls. In this case, a 24-hour rainfall with a frequency of return of once in 10 years is expected to result in a total quantity of runoff of approximately 3.9 million gallons from the coal storage and handling area.

All clean-up and precipitation runoff waters occurring in the coal storage and handling area would be collected and stored in the coal handling area stormwater storage pond prior to ultimate disposition. The storage pond is designed to retain precipitation runoff from a 10-year, 24-hour storm, plus 10 days of accumulated clean-up water.

It is anticipated that clean-up and precipitation runoff wastewaters which come into direct contact with the low sulfur coal could become somewhat contaminated with low concentrations of leached acid and miscellaneous heavy metals, although they would be diluted substantially by runoff which has not been in contact with coal. The estimated characteristics of these wastewaters, based on the EPA Development Document for the Steam Electric Point Source Category, are presented in Table 13.2.

These wastewaters would be pumped to pretreatment facilities at a controlled rate (up to 320 gpm) and, combined with boiler cleaning wastewaters, would be treated for the removal of heavy metals and residual suspended solids. At this pumping rate, coal handling area stormwater runoff from a 10-year, 24-hour storm would be treated over a period of 10 days. The treated effluent would be combined with biologically treated process wastewaters prior to discharge to Cook Inlet through the effluent diffuser.

Boiler Cleaning Wastewaters (Intermittent Discharge): Periodic cleaning of boiler tubes and boiler tubes fireside is necessary to maintain efficient heat transfer capability of the boiler. Similarly, the air preheaters require periodic cleaning to remove soot and fly ash accumulations on the air preheater surfaces. The quantities of cleaning wastewaters would depend upon the cleaning frequency and the amount of water used for cleaning, and are estimated for this project from information presented in the EPA Development Document for the Steam Electric Point Source Category.

There are three high-pressure boilers, each capable of generating 900,000 pounds per hour of steam. Each boiler is cable of producing an "equivalent power" of 150 mw (based on 6,000

Table 13.2

SUMMARY OF COAL AREA WASTEWATER CHARACTERISTICS[1]

| Parameter | Concentration[2] |
|---|---|
| pH | 3.0 |
| Acidity, as $CaCo_3$ | 600.0 |
| Sulfate | 1,000.0 |
| Dissolved Solids | 1,500.0 |
| Suspended Solids | 300.0 |
| Iron | 180.0 |
| Manganese | 5.0 |
| Copper | 0.2 |
| Zinc | 1.2 |
| Aluminum | 40.0 |
| Nickel | 0.4 |

[1] Based on EPA Development Document for the Steam Electric Point Source Category

[2] All Units except pH are expressed in mg/ℓ.

pounds per hour steam per mw). Thus, the estimated volumes of boiler cleaning wastewater discharges are:

| | Cleaning Frequency | Water Use Gals/ MW/Cleaning | Total Cleaning Waste Gals/Year |
|---|---|---|---|
| Boiler Tube | 1/Year | 1,800 | 810,000 |
| Boiler Fireside | 2/Year | 800 | 720,000 |
| Air Preheater | 6/Year | 700 | 1,890,000 |
| | | TOTAL | 3,420,000 |

The estimated characteristics of boiler cleaning wastewaters are shown in Table 13.3. These wastewaters have high concentrations of various metals, and suspended and dissolved solids. The boiler cleaning wastewaters would be collected in a storage pond sized to handle the total discharge from one boiler cleaning. The cleaning wastewaters would be pumped to the pretreatement facilities at a controlled rate (up to 25 gpm) and, combined with coal handling area storm water runoff, would be treated for the removal of heavy metals and suspended solids. At this pumping rate, the boiler cleaning wastewater would be treated over a period of 15 days. The pretreated effluent would be combined with the biologically treated process wastewaters prior to discharge to Cook Inlet through the effluent diffuser.

Process Area Runoff (Intermittent Discharge): A substantial portion of the overall processing area (non-coal-handling) is occupied by process facilities and operations from which it is possible that minor drips, leaks or spills might occur. Thus, precipitation falling on these operating areas could inadvertently become slightly contaminated with miscellaneous organic constituents. Therefore, precipitation runoff from these operating areas would be collected and stored in a stormwater storage pond, and pumped at a reduced rate (0 to 340 gpm) to the process wastewater biological treatment facilities for treatment with the process wastewaters.

Table 13.3

SUMMARY OF BOILER CLEANING WASTEWATER CHARACTERISTICS[1]

| Parameters | Boiler Tube | Boiler Fireside | Air Preheater | Total Cleaning Wastes [2] |
|---|---|---|---|---|
| Total Solids, mg/ℓ | 11,000.0 | 13,400.00 | 12,075.0 | 11,695 |
| Dissolved Solids, mg/ℓ | 9,200.0 | 10,430.00 | 8.850.0 | 9,330 |
| Suspended Solids, mg/ℓ | 80.0 | 616.00 | 1,990.0 | 615 |
| Chromium, mg/ℓ | 4.4 | 2.50 | 6.0 | 4 |
| Copper, mg/ℓ | 166.0 | 1.25 | 3.4 | 90 |
| Iron, mg/ℓ | 1,077.0 | 150.00 | 974.0 | 820 |
| Nickel, mg/ℓ | 76.0 | 5.00 | 61.0 | 55 |
| Zinc, mg/ℓ | 36.0 | 7.50 | 7.0 | 22 |

[1] Based on information from the EPA Development Document for Steam Electric Power Generating Point Source Category

[2] Characteristics of combined cleaning wastewaters are based on estimated flow and characteristics of individual discharges

The stormwater storage pond is designed to retain potentially contaminated runoff associated with a 24-hour storm with a frequency of return of once in 10 years, a volume of approximately 5 million gallons. For purposes of establishing a conservative design basis, it is assumed that contaminated process area runoff has characteristics listed in Table 13.4.

Table 13.4

ESTIMATED CONTAMINATED PROCESS AREA RUNOFF CHARACTERISTICS

| Parameter | Concentration, mg/ℓ |
|---|---|
| BOD | 50 |
| TOC | 30 |
| COD | 100 |
| Suspended Solids | 75 |
| Total Dissolved Solids | 200 |

"Clean" Area Runoff (Intermittent Discharge): A significant portion of the total land area nominally classed as the process area (non-coal-handling area) would be essentially unused. Consequently, precipitation runoff from this unused area is expected to be essentially uncontaminated, and it should be possible to allow this runoff to occur without treatment. However, as a measure of insurance against the unforeseen, clean runoff waters would first be directed to a primary stormwater basin, which would serve as a primary separator, before being discharged to existing runoff drainage channels.

Treatment Requirements: Estimated requirements for treatment of anticipated industrial wastewater discharges are generally based on: 1) Effluent guidelines established by the EPA for several process-related major industrial manufacturing categories; and 2) the receiving water quality standards established by the Alaska Department of Environmental Conservation. Since synthetic fuel manufacturing is a relatively new industry, specific effluent guidelines have not yet been developed by EPA. As a result the approach to wastewater treatment would necessarily be technology based. Since the process wastewaters from the proposed coal gasification/methanol plant contain significant quantities of organic material, it is reasonable that these wastewaters should at least be treated to the secondary treatment level.

The remaining wastewaters anticipated from the proposed plant, such as blowdowns from cooling tower and boilers, coal storage area runoff and boiler cleaning wastes, are similar to those encountered in power generation plants. Therefore, treatment required for these wastewaters would be similar to that practiced by the power generating point source category.

Specific numerical limits for effluent discharges from the proposed wastewater treatment facilities would be included in the NPDES permit, which must be obtained from the EPA prior to the start-up and operation of the treatment facilities.

Additionally, effluent discharges would have to meet the state water quality standards, which regulate man-made alternations to waters of the state. Cook Inlet, at the point of proposed discharge, is classified as marine waters suitable for the growth and propagation of fish, shellfish, other aquatic life, and wildlife including seabirds, waterfowl and furbearers (18 AAC 70.020). Water quality parameters which are regulated for waters so classified are dissolved gas; pH; turbidity; temperature; dissolved inorganic substances; sediment; toxic and other deleterious organic and inorganic substances; color; petroleum hydrocarbons, oils and grease; radioactivity; total residual chlorine; and residues, floating solids, debris, sludge deposits, foam and scum (18 AAC 70.020). The criteria to be met are also covered in 18 AAC 70.020.

Since the treated effluents are to be diffused into the waters of Cook Inlet, the requirements of 18 AAC 70.032 also apply. Compliance involves establishment of a mixing zone for which a permit must be obtained from the Alaska Department of Environmental Conservation. The mixing zone should be determined at the same time the NPDES permit and the Section 401 certification under the Clean Water Act are being prepared.

Wastewater discharges from the proposed gasification/methanol plant can be classified into one of the following categories:

- Wastewaters principally containing organic materials
- Wastewaters principally containing inorganics & heavy metals
- Wastewaters containing inorganic materials only

The treatment approach consists of segregating wastewaters according to the contaminants known to be present, and treating them individually prior to combining all effluents for final discharge to Cook Inlet.

Wastewaters containing principally organic materials would be generated in the char filtration area, methanol distillation columns, pump seal cooling waters, railroad shop, contaminated runoff from processing areas, and sanitary wastewaters. Although pump seal cooling water discharges should not require treatment, they are included in this category because they would be discharged to the process sewer. To protect the process wastewater treatment facilities from oil and dirt that may be present in discharges from the railroad shop, these wastewaters would be pretreated before discharge to the process sewer.

The characteristics estimated for wastewater discharges from processing operations (Table 13.1) indicate the need for treatment to reduce the $BOD_5$. Biological treatment using the activated sludge process would be utilized to provide greater than 90% $BOD_5$ removal. Biological treatment also would be expected to remove essentially all of the phenol and thiocyanates present in the wastewaters. Based on experiences of biological treatment of coke-oven wastewaters as practiced in the iron and steel industry, significant removal of cyanide (60 to 80%) is expected in the proposed biological treatment facilities. However, a conservative cyanide removal estimate of only 55% is projected for this biological treatment facility.

Wastewaters containing principally inorganic impurities and heavy metals would be those resulting from coal storage area runoff and boiler cleaning operations. These wastewaters would be provided with physical/chemical treatment using lime addition to remove heavy metals and suspended solids. Physical/chemical treatment using lime addition is a proven method which is expected to provide a very high degree of heavy metals removal.

Wastewaters containing predominantly inorganic impurities would be those resulting from water treatment, boiler blowdown and cooling tower blowdown. These discharges would not require treatment other than blending with the treated effluents from biological and physical/chemical treatment facilities.

The above approaches are selected as the basis of treating the various wastewaters generated by the proposed coal gasification/methanol plant. These approaches would be expected to provide a sufficient degree of treatment to ensure that the combined total treated effluent would be suitable for discharge to Cook Inlet.

To further ensure that the total treated effluent adequately mixes with the waters of Cook Inlet, it is proposed to discharge treated wastewaters through a multiple port diffuser located several thousand feet from shore, and thus in an area with a water depth of at least several fathoms even at mean low tide.

Studies have been conducted incident to similar diffuser discharges of municipal effluents from the City of Anchorage into Cook Inlet. Based upon these studies, it is anticipated that multiple port diffuser discharge of effluents from the CIRI/ Placer Amex wastewater treatment facilities would receive an adequate dilution in the waters of Cook Inlet.

The effluent diffuser would be approximately 1,300 feet long, varying in diameter from 30 to 42 inches. The ports would be double nozzles on 25-foot spacings, with a nozzle diameter equal to or less than 4 inches. The diffuser would be served by approximately a 42-inch-diameter effluent sewer connecting it to the effluent storage pond.

- Projected Effluent Characteristics

The estimated characteristics of effluents proposed to be discharged to Cook Inlet are shown in Table 13.5. The characteristics of process wastewaters and inorganics containing wastewaters which would be treated by biological and physical/chemical treatment methods are based on the capabilities and performance expected to result from these treatment methods. Characteristics of other wastewaters (boiler blowdown, cooling tower blowdown, ion-exchange regenerant wastes, and water treatment plant sludge centrate) are estimated based on the system operating characteristics. The total effluent proposed to be discharged is a summation of these individual effluents.

Table 13.5

SUMMARY OF PROJECTED EFFLUENT CHARACTERISTICS

| Parameters[1] | Treated Bio Effluent | Boiler Blowdown | Treated Coal Pile Runoff and Boiler Cleaning Wastes | Ion-Exhange Regenerant Wastes | Treatment Plant Sludge Centrate | Cooling Tower Blowdown | Total Plant[3] Effluent |
|---|---|---|---|---|---|---|---|
| Flow, gpm - AVG | 1304 | 187 | 298 | 185 | 123 | 3660 | 5757 |
| MAX | 1674 | - | 321 | - | - | 4660 | 7150 |
| $BOD_5$ | 40 | - | - | - | - | - | 9 |
| TOC | 25 | - | - | - | - | - | 6 |
| COD | 200 | - | - | - | - | - | 45 (47)[2] |
| Suspended Solids | 25 | 30 | 75 | - | 500 | 100 | 84 |
| TDS | 1073 (845)[2] | 350 | 2000 (2550)[2] | 7000 | 1000 | 1800 | 1750 (1700) |
| Phenol | 0.001 | - | - | - | - | - | Neg |
| Chloride | 512 (400) | - | - | - | - | 8 | 125 (102) |
| Thiocyanate | 0.5 | - | - | - | - | - | 0.12 |
| Cyanide, mg/ℓ | 14 (11) | - | - | - | - | - | 3 |
| Ammonia Nitrogen | 5 | - | - | - | - | - | 1 |
| Total Heavy Metals [5] | - | - | 0.5 (0.7) | - | - | - | 0.03 |
| Iron | - | - | 9 | - | - | 2 | 1.75 (1.70) |
| Aluminum | - | - | 1 | - | - | - | 0.06 (0.05) |
| pH | 7-7.5 | 9+ | 9+ | 5-6 | 9+ | 7-7.5 | 7-8 |

[1] All contaminant concentrations are expressed as mg/ℓ except pH
[2] Concentration during maximum flow condition
[3] Proposed to be discharged to Cook Inlet
[4] Estimated to be present as complex cyanide
[5] Includes copper, nickel and zinc

- Effects to Surface Water

The preferred receiving water for the treated industrial wastewater discharge would be Cook Inlet. The currents are swift and the exchange rate is high in Cook Inlet, which would facilitate rapid dilution of the discharge. Compliance with water quality standards in Cook Inlet would primarily be a function of the level of treatment employed. In applying the State of Alaska water quality criteria to surface waters, the Department of Environmental Conservation will, in its discretion, prescribe in wastewater disposal permits a volume of dilution for the effluent within the receiving water. Water quality standards may be violated within this mixing zone; however, the standard must be met at every point outside its boundaries. Meeting the water quality criteria at the mixing zone boundary essentially would be a function of the level of treatment employed.

Construction of an outfall line a sufficient distance across the shallow intertidal area of Cook Inlet to waters deep enough to provide adequate dispersion would produce significant impacts, although on a very short-term basis. The general biological nature of the northern half of Cook Inlet is impoverished. It is a transient zone for substantial parts of the north Cook Inlet salmon run migrating particularly to the Chuitna, Beluga and Susitna river systems. The fish spend a very short time in this portion of Cook Inlet, and consequently, no detrimental effects on the salmon runs would be expected. The resident population in the intertidal zone of Cook Inlet near this project consists almost exclusively of the clam, macoma. This is not a productive harvestable shellfish area. Consequently, effects on the intertidal community would probably be inconsequential.

Any surface runoff from the construction of the methanol plant and adjacent facilities would be directed almost exclusively in a southeasterly direction by the topography. There is only one small, unnamed creek with its headwaters near the point of runoff discharge from plant construction activities. This is a very short stream and it discharges at the mouth of Nikolai Creek. Reasonable containment of runoff from plant construction should avoid heavy sediment discharges near this creek, however, should sedimentation occur, there are no significant fish populations to be affected.

Water for construction activities such as dust control and earthwork compaction may be drawn from Congahbuna Lake or Congahbuna Creek, immediately adjacent to the construction site. The use would be intermittent and the volume relatively low to preclude any noticeable impact on either source. Congahbuna Lake and Creek would be the preferred sources of non-potable water during the construction phase of the project.

The proposed town site located on the Nikolai escarpment bluff would most likely utilize Nikolai Creek as a receiving water for treated effluent from the sanitary sewer treatment facility. With secondary or tertiary treatment, a high quality effluent could be produced that would have a very minimal effect on Nikolai Creek. An alternative would be to pipe the discharge to the plant site and release it to Cook Inlet with the treated industrial wastewater effluent from the methanol plant treatment facility. There would be no significant impacts to Cook Inlet from this alternative.

The more significant area of surface water impact would be from the mining operation and activities in the transportation corridor. In the transportation corridor erosion and sedimentation, particularly during construction, would be the primary source of contamination to about nine different drainages crossing the corridor. Revegetation after construction and proper handling of runoff can minimize the additional sediment loads to an acceptable short-term level. In the mining operation, the runoff of surface waters in the discharge of heavily sediment laden water from the mine pit would be the single largest water quality control problem in the overall project. In the initial stages of mine operation there would be large volumes of highly organic overburden to be disposed of before there would be large volumes of underlying non-organic material which could be utilized to build containment dikes and retention ponds. The mine plan would provide a control for this runoff which, if left unrestrained, could produce highly sediment laden discharges. Such discharges, particularly in the Chuitna drainage system, would exceed the volume the system could assimilate. Due to the higher quality of water and diversity of fish species present, the Chuitna River system would be the most seriously affected by a highly sediment-laden discharge.

The mine plan would provide for the trapping of most surface drainage waters before they get to the mining operation and would direct them back into the natural drainage systems, relatively untouched and with no increase in sediment load. The surface waters that get into the mining operation and the groundwater contribution within the mining operation would be highly sediment laden waters which would be retained in a series of sediment ponds before being released back into the natural drainage systems. Considerably more information must be known about the potential sediment load of the discharges and the chemistry of the water before reasonable assessments can be made of the impacts from the release of these waters into the river systems. Water from the sediment ponds at the Capps Mine would all end up in Capps Creek and flow into the already sediment-laden Beluga drainage system. The Capps Mine plan specifically excludes any drainage discharge to the Nikolai Creek system. Discharge from the sediment ponds in the Chuitna Center Ridge Mine area most likely would end up in some portion of the Chuitna River drainage system. Other alternatives more remote at this time are a possible discharge to the Nikolai drainage system or the Chakachatna drainage system, both of which would require more distant transportation of the discharge water. The Chuitna Mine area probably would require a greater dewatering effort than the Capps Mine area and, consequently, there would be a larger discharge from the sediment control system. This is due to the Capps Mine being located at a higher altitude near the recharge area of the surrounding groundwater system, while the Chuitna Mine is at a lower elevation, receives more surface drainage, and is in a more productive area of the groundwater regime.

In summary, effects to the surface waters in Cook Inlet and adjacent to the plant should be negligible. There is a greater potential for perturbations to Nikolai Creek primarily due to its value as a fishery, however, if handled properly the impacts are anticipated to be minimal. The greatest potential for effects to the surface waters would be from the mining activities and construction in the transportation corridor. The following table provides a general overview of the project activities and surface water systems potentially affected by the proposed project.

Table 13.6

POSSIBLE INTERACTION OF PROJECT ACTIVITIES WITH SURFACE WATERS

| Environmental Perturbation | Cook Inlet | Chuitna System | Nikolai System | Beluga System |
|---|---|---|---|---|
| Alter Surface Runoff | P | M | P, T | M |
| Alter Peak Flows | | M | P | M |
| Alter Sedimentation | P | M | P,T | M |
| Alter Downstream Flows | | M | P | M |
| Alter Stream Channels | | M | M | M |
| Alter Water Chemistry | P | M | T | M |

P = Potential effects from Plant activities

T = Potential effects from Town Site

M = Potential effects from Mines & Transportation Corridor

## MAJOR REGULATORY REQUIREMENTS

A permit to appropriate water would be required from the Alaska Department of Natural Resources to withdraw and use groundwater resources. The authority for this requirement is Alaska Statute 46.15.030-185 "Appropriation and Use of Water" and 11 AAC 72 Water Use. Generally, it is not a complicated procedure to obtain this permit, but it could take a period of six to nine months. The permit should be applied for well in advance of the requirement.

If a direct surface source of water or an infiltration gallery near a stream is used, the same water rights permit would be required from the DNR except that if the application concerns use of a surface source of water, DNR asks the departments of Fish and Game and Environmental Conservation to review and comment on the proposed permit issuance. It is possible that under certain circumstances the Department of Fish and Game would require the applicant to also obtain an anadromous fish permit (Alaska Statute 16.05.870 "Protection of Fish and Game"), or that the DF&G would attach stipulations to the issuance of the DNR water rights permit.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

There is no indication that groundwater could not be used for the purposes and in the quantities described above in a totally acceptable manner. It should also be possible to acceptably use water from the surface systems in the vicinity of the plant, but it likely would be necessary to demonstrate to the reviewing agencies that the water used is excess to the minimum amount required to sustain the existing fishery. The use of water from Congahbuna Lake or any of its drainages for intermittent construction requirements should be less controversial than obtaining permit approval to construct an infiltration gallery system near Nikolai Creek. Although there is still a lack of low winter season flow data for Nikolai Creek, indications are that there is a sufficient reserve of water that could be intercepted before it reaches the creek and that the withdrawal could be permitted and done in an environmentally acceptable manner.

# 14.0 ECOSYSTEMS

The Office of Surface Mining Reclamation and Enforcement (OSMRE) regulations require all surface mining operations to minimize, to the extent possible, any adverse effects on fish, wildlife and related environmental values in the permit and adjacent areas (it is assumed that state regulations will require the same perspective). EPA has prepared "assessment guidelines" for New Source Coal Gasification Facilities (EPA-130/6-80-001). An outline of potential environmental impacts and relevant pollutants resulting from site preparation and construction practices has been previously prepared by others (Table 14.1) that provides the basis for individual project evaluation.

Similarly, a perturbation matrix can be developed relating activities during the construction and operation phases to environmental perturbations (biologic, geologic, edaphic, topographic, hydrologic, and meteorologic). A preliminary framework for the development of such a matrix is illustrated in Figure 14.1. Note that the development activities in this framework are essentially the same as those provided in Table 12.1 (Geology and Soils).

Many of the impacts associated with the exploration phase of the development of a coal mining project have already occurred in the general area due to activities of the oil, gas and logging industries. The area is crossed with many roads and seismic trails and dotted with barrow pits and abandoned drilling locations. Numerous air strip locations and old camp sites are also found throughout the region. Human activity, in the form of subsistence hunting and fishing, recreation and permanent residency occurs throughout the area.

## CONSTRUCTION AND LONG-TERM EFFECTS

This section summarizes by project activity both the potential construction and long term effects of this project on the terrestrial,

Table 14.1

## OUTLINE OF POTENTIAL ENVIRONMENTAL IMPACTS AND RELEVANT POLLUTANTS RESULTING FROM SITE PREPARATION AND CONSTRUCTION PRACTICES

| Construction practice | Potential environmental impacts | Primary pollutants |
|---|---|---|
| 1. Preconstruction | | |
| a. Site inventory | Short term and nominal | Dust, noise, sediment |
| (1) Vehicular traffic | Dust, sediment, tree injury | |
| (2) Test pits | Tree root injury, sediment | |
| b. Environmental monitoring | Negligible if properly done | Visual |
| c. Temporary controls | Short term and nominal | Sediment spoil, nutrients, solid waste |
| (1) Sedimentation ponds | Vegetation destroyed, water quality improved | |
| (2) Dikes and berms | Vegetation destroyed, water quality improved | |
| (3) Vegetation | Fertilizers in excess | |
| (4) Dust control | Negligible if properly done | |
| 2. Site Work | | |
| a. Clearing and demolition | Short term | Dust, sediment, noise solid wastes, wood wastes |
| (1) Clearing | Decreased area of protective tree, shrub, ground covers; stripping of topsoil; increased soil erosion, sedimentation, stormwater runoff; increased stream water temperatures; modification of stream banks and channels, water quality | |
| (2) Demolition | Increased dust, noise, solid wastes | |
| b. Temporary facilities | Long term | Gases, odors, fumes particulates, dust, deicing chemicals, noise, petroleum products, wastewater, solid wastes aerosols, pesticide |
| (1) Shops and storage sheds | Increased surface areas impervious to water infiltration, increased water runoff, petroleum products | |
| (2) Access roads and parking lots | Increased surface areas impervious to water infiltration, increased water runoff, generation of dust on unpaved areas | |

Table 14.1

Continued

## OUTLINE OF POTENTIAL ENVIRONMENTAL IMPACTS AND RELEVANT POLLUTANTS RESULTING FROM SITE PREPARATION AND CONSTRUCTION PRACTICES

| Construction practice | Potential environmental impacts | Primary pollutants |
|---|---|---|
| (3) Utility trenches and backfills | Increased visual impacts, soil erosion, sedimentation for short periods | |
| (4) Sanitary facilities | Increased visual impacts, solid wastes | |
| (5) Fences | Barriers to animal migration | |
| (6) Laydown areas | Visual impacts, increased runoff | |
| (7) Concrete batch plant | Increased visual impacts; disposal of wastewater, increased dust and noise | |
| (8) Temporary and permanent pest control (termites, weeds, insects) | Nondegradable or slowly degradable pesticides are accumulated by plants and animals, then passed up the food chain to man. Degradable pesticides having short biclogical half-lives are preferred for use | |
| c. Earthwork | Long term | Dust, noise, sediment debris, wood wastes solid wastes, pesticides, particulates bituminous products soil conditioner chemicals |
| (1) Excavation<br>(2) Grading<br>(3) Trenching<br>(4) Soil treatment | Stripping, soil stockpiling, and site grading; increased erosion, sedimentation, and runoff; soil compaction; increased in-soil levels of potentially hazardous materials; side effects on living plants and animals, and the incorporation of decomposition products into food chains, water quality | |
| d. Site drainage | Long term | Sediment |
| (1) Foundation drainage<br>(2) Dewatering<br>(3) Well points<br>(4) Stream channel relocation | Decreased volume of underground water for short and long time periods, increased stream flow volumes and velocities, downstream damages, water quality | |
| e. Landscaping | | Nutrients, pesticides |
| (1) Temporary seeding<br>(2) Permanent seeding and sodding | Decreased soil erosion and overland flow of stormwater, stabilization of exposed cut and fill slopes, increased water infiltration and underground storage of water, minimized visual impacts | |

Table 14.1

Continued

## OUTLINE OF POTENTIAL ENVIRONMENTAL IMPACTS AND RELEVANT POLLUTANTS RESULTING FROM SITE PREPARATION AND CONSTRUCTION PRACTICES

| Construction practice | Potential environmental impacts | Primary pollutants |
|---|---|---|
| 3. Permanent facilities | | |
| a. Coal gasification plant and heavy traffic areas | Long term | Sediment, dust, noise particulates |
| (1) Parking lots | Stormwater runoff, petroleum products | |
| (2) Switchyard | Visual impacts, sediment, runoff | |
| (3) Railroad spur line | Stormwater runoff and sedimentation | |
| b. Other buildings | Long term | Solid wastes |
| (1) Warehouses | Impervious surfaces, stormwater runoff, solid wastes, spillages | |
| (2) Sanitary waste treatment | Odors, discharges, bacteria, viruses | |
| c. Possible ancillary facilities | Long term | Sediment, trace elements, noise, caustic chemical wastes, spoil, flocculants, particule fumes, solid waste nutrients. |
| (1) Intake and discharge channel | Shoreline changes, bottom topography changes, fish migration, benthic fauna changes | |
| (2) Water supply and treatment | Waste discharges, water quality | |
| (3) Stormwater drainage | Sediment, water quality | |
| (4) Wastewater treatment | Sediment, water quality | |
| (5) Dams and impoundments | Dredging, shoreline erosion | |
| (6) Breakwaters, jetties, etc. | Circulation patterns in the waterway | |
| (7) Fuel handling equipment | Spillages, fire, and visual impacts | |
| (8) Seed storage areas and preparation facilities | Visual impacts, waste discharges | |
| (9) Oxygen plant and gas upgrading plant | Sediment runoff, landscape alteration, waste discharges | |
| (10) Cooling towers, power transmission lines, pipelines, substations | Visual impacts, sedimentation and erosion | |

Table 14.1

Continued

OUTLINE OF POTENTIAL ENVIRONMENTAL IMPACTS AND RELEVANT POLLUTANTS RESULTING FROM SITE PREPARATION AND CONSTRUCTION PRACTICES

| Construction practice | Potential environmental impacts | Primary pollutants |
| --- | --- | --- |
| (11) Conveying systems (cranes, hoists, chutes) | Visual impacts | |
| (12) Cooling lakes and ponds | Conversion of terrestrial and free flowing stream environment to a lake environment(land use trade-offs); hydrological changes, habitat changes, sedimentation, water quality | |
| (13) Solid waste handling equipment (incinerators, trash compactors) | Noise, visual impacts | Particulates, dust, solid wastes |
| d. Security fencing | Long term | Sediments, wood wastes |
| (1) Access road | Increased runoff | |
| (2) Fencing | Barriers to animal movements | |

Source: Hittman Associates, Inc. 1974. General environmental guidelines for evaluating and reporting the effects of nuclear power plant site preparation, plant and transmission facility construction. Modified from: Atomic Industrial Forum, Inc. Washington DC.

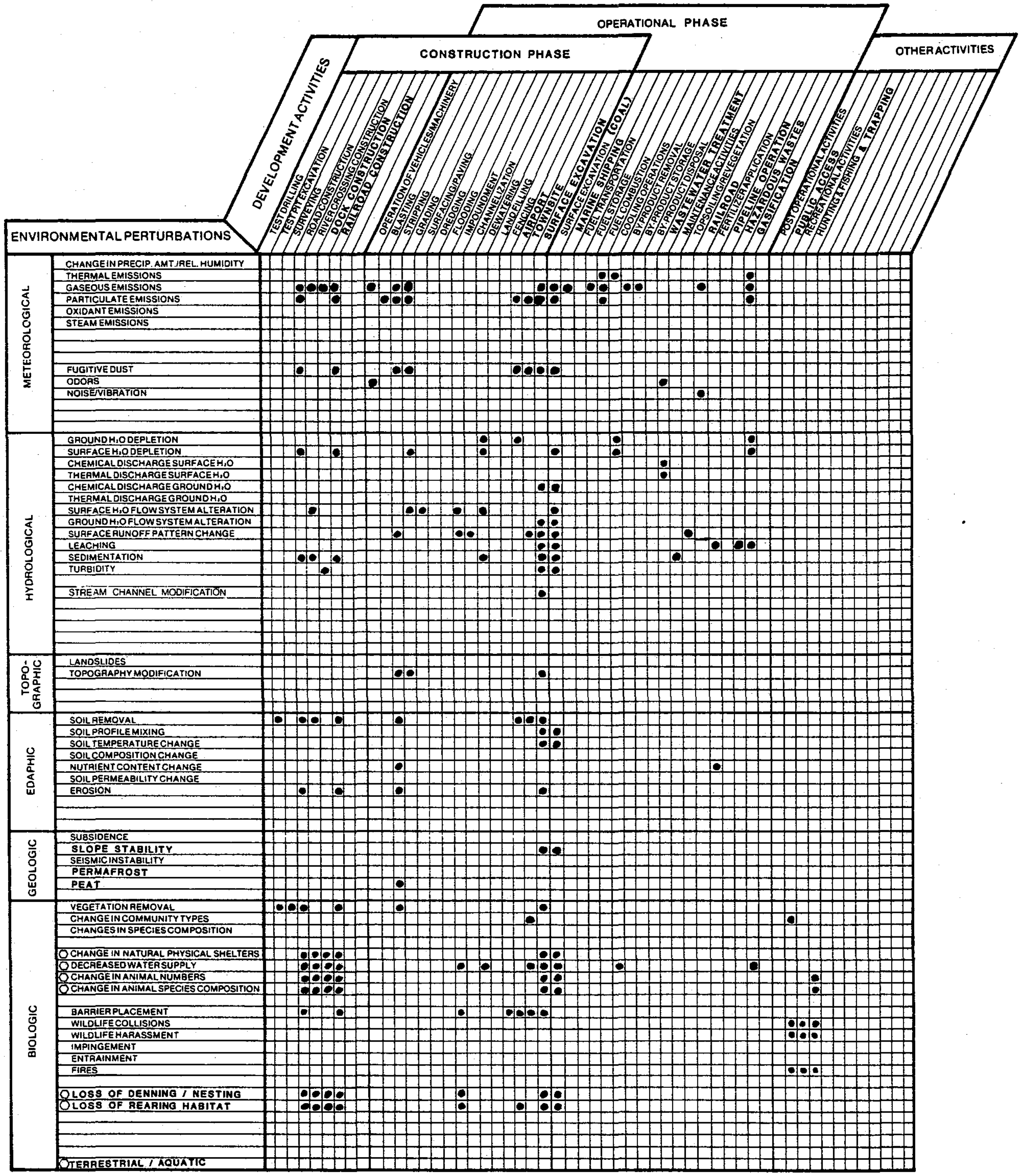


**FIGURE 14.1** A POSSIBLE PERTURBATION MATRIX FOR CONSIDERING ENVIRONMENTAL IMPACTS OF THE METHANOL PROJECT

aquatic and marine ecosystems.

Overburden Removal

- Loss of vegetation
- Soil disturbance
- Loss of physical shelter
- Changes in surface drainage

(All existing habitats above the coal would be lost permanently.)

Overburden Storage and Disposal

- Loss of habitat (by burial)
- Spoil piles could result in:
  - increased semimentation
  - wind-blow erosion of soil particles
  - Leaching of mineral
- Modification of topography
- Modification of surface drainage

Dewatering

- Drawdown of water table
- Disposal of pumped water (with high dissolved solids content, high acidity, and high metallic ion concentrations)

Among the long term effects to be considered from the project, most are related to the mining operation and transportation of the feed stock.

Aquifer Changes

- Elementation of shallow aquifers
- Alterations of percolation properties
- Interruption of groundwater flow
- Drawdown of deep aquifers

## Acid Mine Drainage

- Low sulfur characteristics of Beluga coal may minimize acidification (some general conditions to be expected from dewatering include low pH, high specific conductance, high concentration of metallic ions including iron, aluminum and manganese, and a high sulfate concentration).

## Sedimentation and Erosion

- Sedimentation would result from removal of overburden, transportation, stream diversions, stream crossings and mine restoration.
- Dewater discharges may contain fine coal particles, black shale and assorted minerals.
- Coal washing would result in the suspension of fine particles of coal.
- Solid residues would need to be landfilled.

## Surface Water Contamination

- Potential sources of water contamination are acid mine drainage, surface runoff, thermal effluent, various water and coal treatment chemicals, dust, leacheates from blasting residues, spoil piles, fuel spillage, ash, toxic strata and industrial wastes.
- Introduction of these contaminants would include charges in the dissolved oxygen content of the water, altered rates of photosymthesis, reduced light penetration, temperature change, pH changes, metallic ion changes and a deterioration of the color and odor of water.

## Groundwater Contamination

- Replacement of overburden in mine could have long-term effects on groundwater.
- Fuel spills.

## Site Restoration

- New vegetation types (monoculture)
- Increased soil permeability (acceleration of mass wasting processes)

Surface Water Changes

- Changes in groundwater levels and/or stream flows

Methanol Production

- Groundwater and surface water depletion
- Thermal pollution
- Potential acid rainfall
- Methanol spills
- Surface water from contamination from sludge disposal, gas purification, and wastewater disposal

Increased Harvest and Utilization of Fish and Wildlife Resources

- Increased harvest of limited populations (due to increased population and ease of access)

Of the above possible impacts, the greatest concern focuses on the impacts related to possible harm to the fishery resource by:

- Destruction or removal of habitat
- Increased sedimentation
- Disruption or depletion of flows
- Changes in water quality

The final analysis of impacts from this project on fish, wildlife and related environmental values will require the completion of the requisite baseline studies and the completion of mine plans and final design of the project.

## MAJOR REGULATORY REQUIREMENTS

Regulations for construction and operation of this facility relative to impacts on ecosystems would be enforced through the EPA, DEC, NMFS, FWS and DF&G. This regulation would most likely be in the form of stipulations concerning both construction and operation that became a part of either a COE permit for "Discharge of Dredged or Fill Material into U.S. Waters" or an EPA "Permit to Discharge into Water" (NPDES). In addition, stipulations related to the issuance of DF&G's "Anadromous Fish Protection Permit" would provide the state's primary method for protecting and preserving fish and game of anadromous waters.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

The vast majority of the potential impacts associated with the proposed project can be mitigated by proper design, construction and operational procedures. However, impacts on the headwaters of many of the smaller streams within the system would be unavoidable due to the very nature of mining operations. The loss of habitat created by the mines should not, of itself, constitute a substantial impact on the terrestrial ecosystems; and the reclamation plans provide for the restoration of such habitat as is lost in the initial mining stages. Loss of some wetland habitat on the Nikolai escarpment would be inevitable with the construction of the facility.

Many of the potential impacts indicated will be considered in greater depth as field investigations continue and more adequate baseline information becomes available. This additional information will provide the basis for the development of adequate mitigative measures.

## 15.0 AIR QUALITY

Atmospheric pollutant emissions are associated with virtually every aspect of the proposed project from the mining of coal to the synthesis and shipping of product methanol. Sulfur oxides, particulate matter, nitrogen oxides, carbon monoxide, and hydrocarbons represent the bulk of these emissions. The means by which pollutants are introduced to the atmosphere vary according to the operations creating the pollutants. Contaminated gas streams are directed to elevated stacks where possible; however, significant emissions are expected from diffuse, low-level sources such as vehicular traffic, wind-blown storage piles, and leaks in equipment fittings.

Once a particular pollutant reaches the atmosphere, the likelihood that it would adversely affect the environment depends on the ambient concentrations that result and the sensitivities of receptors that are present. Reasonable predictions of ambient air concentrations (± 25%) require detailed descriptions of existing conditions (pollutant monitoring), all important sources of air pollution, and the processes that will govern the transport and diffusion of pollutants (meteorological monitoring). An inventory of receptors in the area should consider sensitivities of animal and plant life, the possibility of altering soils and water systems, and other concerns such as inadvertent weather modification, changes in precipitation chemistry, deterioration of man-made materials, and visibility impairment. The existing data base is not sufficient to support a detailed analysis of the air quality impact of this project. There have been no previous efforts to collect meteorological or air quality data in the project area. The nearest National Weather Service stations are at Kenai and Anchorage, 35 and 75 miles away. Meteorological data also have been collected at the oil platforms in Cook Inlet, and at the Beluga power plant to the north and the Big River weather station to the south. The goals of this impact analysis therefore are limited to identification of the major sources of atmospheric pollutants, determination of the temporal and spacial scales over which significant impacts would occur, and recommendations on how to perform a more detailed analysis capable of satisfying the technical documentation requirements of a permit to operate a source of air pollution in the State of Alaska.

In the remainder of this section both construction and longer term effects are discussed with regard to the above objectives. An emissions inventory is presented for each case, and for situations when estimates of ambient air concentrations were possible the results of these calculations are discussed. Since the applicability of ambient air concentration estimates is limited to well defined sources of pollutants, the air quality impacts of construction and mining activities are described largely in qualitative terms.

## CONSTRUCTION EFFECTS

Pollutants of concern which would be associated with the construction phase of this project are particulate matter, nitrogen oxides, carbon monoxide, hydrocarbons, and sulfur oxides. Emission rates would vary seasonally depending on the amount of construction activity and the frequency of precipitation. Total annual emissions of pollutants would also vary during the anticipated 38-month construction period, reaching a peak in 1986.

The two largest classes of air pollutant sources during plant construction would be land disturbances and vehicular exhausts. Particulate matter would be generated by site clearing and preparation, the action of wind on exposed surfaces, gravel extraction and preparation, concrete batching operations, the burning of tree and brush cover, and diesel and gasoline powered equipment. Combustion of diesel fuel, gasoline, and vegetative cover also would produce carbon monoxide and hydrocarbons. Nitrogen oxides and sulfur oxides would be associated with diesel fuel and gasoline combustion, and to a lesser extent tree and brush burning. Significant ambient air impacts from the various pollutants emitted could affect an area of 40 square kilometers around this concentration of sources.

Pollution control measures would focus on the largest source of pollutants, vehicular traffic. Roadways, once built, would receive regular maintenance and would be sprayed with chemically treated water during dry spells. To the maximum extent possible, traffic would be confined to these roads. Vehicular exhaust emissions would be minimized through a regular inspection and maintenance program. To insure that the above practices would be implemented throughout the entire construction phase, they could be incorporated in construction contracts along with the other usual construction specifications.

## EMISSIONS AND LONG TERM EFFECTS

### Process Plant Area Emissions

° Coal Preparation

Coal arriving at the methanol plant would require a considerable amount of handling before use. Dust is generated during unloading; stacking and reclaiming of storage; and conveying, crushing, and screening operations. For the most part, this dust can be collected and passed through bag-type filters capable of 99.9% recovery. All operations except unloading, stacking and reclaiming can be controlled in this manner. A spray suppression system would control dust at the coal unloading station. Stacking and reclaiming of coal would be done with a bucket wheel stacker/ reclaimer. When this piece of equipment is operated properly, dust emissions can be reduced significantly compared to conventional methods of storage addition and recovery. Also, vehicular traffic around the storage pile, which can contribute up to 40% of the total fugitive particulate matter emissions associated with raw material storage facilities, is virtually eliminated by this method.

° Process Coal

Process coal must be dried before gasification, and this would be accomplished with coal-fired thermal dryers. Particulate matter, sulfur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons would be emitted during this operation. The contaminated exhaust gases would be scrubbed of particulate matter, then vented to the atmosphere. Ash and char would be conveyed pneumatically from the boilers and gasifiers to the coal preparation area before being loaded aboard trains bound for the mine. The nitrogen gas used as a transport medium would be vented to the atmosphere after a baghouse removed particulate matter. Carbon monoxide and a small amount of hydrogen sulfide would be present in this exhaust.

° Coal Gasification

The major, distinct sources of pollutants in this section would be related to the acid gas removal and sulfur recovery processes. Excess carbon dioxide would be removed selectively from the synthesis gas in the acid gas removal process and then released to the atmosphere. This carbon dioxide exhaust would be contaminated with hydrogen sulfide, carbonyl sulfide and carbon monoxide. Synthesis gas also would be stripped of hydrogen sulfide, resulting in a contaminated gas stream that requires further processing. A Stretford sulfur recovery system would remove 99.5% of the hydrogen sulfide from this stream. Cleaned gas which contains a small amount of hydrogen sulfide, carbonyl sulfide and carbon monoxide then would be vented to the atmosphere.

In the area where methanol is produced from synthesis gas, a reformer furnace would be used which burns purge gases from downstream methanol synthesis operations. Combustion products containing nitrogen oxides would be exhausted to the atmosphere. The gasifier coal-feed system would require nitrogen purging to remove gases that escape from the gasifiers during charging. These purge streams would be directed to a continuously operating elevated flare. Vapor recovery systems on synthesis gas scrubber wastewater treatment and compression equipment also would be directed to this flare. Particulate scrubbing would be performed before the coal-feed system and wastewater treating vents were flared.

- Fugitive Emissions

  Associated with synthesis gas processing would be fugitive emissions from leaks in pipeline valves and flanges, relief and sampling valves, pump and compressor seals, and fuel and product storage tanks. Product storage losses and compressor seal losses would be controlled by vapor recovery systems. This is also true for losses associated with shiploading of methanol. The remaining sources of fugitive emissions must be controlled through regular monitoring and maintenance. These fugitive emissions would include hydrocarbons, carbon monoxide and hydrogen sulfide.

  A single water cooling system using mechanical draft cooling towers would serve various heat exchanging equipment throughout the plant. Water losses to the atmosphere would only be contaminated by leaks that develop in any of these heat exchangers. Possible contaminants include gaseous compounds such as carbon monoxide and hydrogen sulfide, hydrocarbons (mostly methanol), and dissolved solids that are not removed in make-up water treatment.

Power Plant

The majority of steam and all power requirements would be supplied by coal and gasifier char fired boilers. Combustion products would be vented directly to the atmosphere after approximately 99.9% particulate removal by a bag-type dust collector. This exhaust stream would contain residual particulate matter, nitrogen oxides, sulfur oxides, carbon monoxide and hydrocarbons. Particulate matter emissions would have a composition similar to the ash produced. With a few notable exceptions, trace elements would appear in the same concentrations both in bottom ash and fly ash. Very efficient particulate removal is, therefore, an effective way of minimizing trace element emissions. Certain emissions of mercury and selenium may be volatile in the boiler exhaust gas and could not be captured by a bag filter. Elements such as lead and cadmium tend to be concentrated in the fly ash, thus decreasing the effectiveness with which a baghouse can reduce their emission. Other trace elements of concern that have been detected in Alaska coals are beryllium and fluorine.

° Start-up and Shutdown

Pollutant emissions during start-up would differ from normal operating emissions for two important reasons: Initial heat requirements would be supplied by natural gas combustion, and off-specification synthesis gas would require disposal. One low-pressure flare system would be necessary to burn off-specification synthesis gas produced in the gasification start-up sequence. This gas would be scrubbed of particulate matter before flaring. It would not pass through sulfur removal equipment, so sulfur oxides would be emitted, as well as nitrogen oxides and particulate matter. Natural gas burned for initial equipment heating would create nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter and hydrocarbons. In the coal preparation area a small increase in fugitive particulate matter emissions would be expected due to the increased activity around storage piles as they are brought up to the required size.

Process equipment must be shut down for inspection, maintenance and cleaning, causing changes in emissions similar to those experienced during start-up. Particulate matter, sulfur oxides and nitrogen oxides would be emitted from the low pressure flare system until gasification stops. The initial purge of shutdown equipment also requires flaring.

- Emergencies

  Diverted synthesis gas would be directed to either the high or low pressure flare system in the event of process upsets that cause or require equipment shutdowns in any of the three methanol production trains. Nitrogen oxides, sulfur oxides, particulate matter, carbon monoxide and hydrocarbons would result from flaring the diverted gas streams.

Mining Area Emissions

The largest emissions of air pollution which would be associated with the surface mining activities arise from major equipment operation and haul road traffic. Minor sources include the coal handling facilities, and blasting, drilling, and ash unloading operations. The diesel-electric railroad which would transport coal from the mine to the plant and ash from the plant to the mine would be a significant source of pollutants. Most of the total emissions from all of the above sources would be comprised of particulate matter; however, diesel fuel combustion also produces nitrogen oxides, carbon monoxide, sulfur oxides and hydrocarbons.

Air pollution control measures for mining and coal transportation address both major and minor sources. Water trucks would be used to wet haul roads in dry weather. Emissions from diesel fuel combustion can be minimized by an aggressive repair and maintenance program. Dust collection would be possible for coal handling operations (screening, crushing, conveying). Coal storage piles, normally one of the largest sources of particulate matter, would be enclosed, and recovery of coal would be from the bottom of the heap. Temporary stabilization of spoil piles before recycling and of ash soil cover before revegetation would minimize wind-generated dust.

Air Emission Effects

Emission rates for the various pollutants were related to ambient air concentrations by means of computer-based atmospheric dispersion models. These dispersion models are generally classified as the Gaussian type and are considered to be state-of-the-art techniques for estimating the impact of non-reactive pollutants. Some basic assumptions inherent in these algorithms are:

1. The emission rate is constant and continuous over the time period of interest.

2. All meteorological variables are constant over the time period of interest.

3. The wind speed is constant throughout the height of the plume.

4. Concentration profiles in the crosswind and verticle directions are described by Gaussian distributions.

5. Adsorption, deposition, and possible chemical changes within the plume are not considered.

6. The effects of terrain on wind currents are not considered.

The procedures used to make dispersion estimates were: All plant emissions were quantified and points of release were described; meteorological conditions leading to high ambient air concentrations were identified for each source type; and finally, calculations were made of the maximum ambient air concentrations which could result. The values obtained were compared to applicable air quality standards.

Models Used

Two EPA recommended dispersion models were used in this screening analysis. The PTMAX model, a single source model capable of estimating maximum ambient air impacts and the distance downwind that they will occur, was used for evaluating the impact of point sources in neutral/unstable atmospheric conditions for averaging periods 24 hours or less. The VALLEY model was used for estimating 24-hour average concentrations due to all sources for which stable atmospheric conditions and impaction of plumes on elevated terrain was a concern. VALLEY was also used for calculating annual average concentrations for $SO_2$, $NO_2$, and particulate matter.

Since estimates of pollutant concentrations are required for various averaging times ranging from 1 hour to a day, and the PTMAX model only calculates concentrations appropriate for a 1 hour average, factors relating concentrations averaged over different time periods were used. In this way multiple hourly average concentrations could be estimated from 1 hour average concentrations. These factors were applied independent of stability classification and in the following manner:

$$X\text{ (3-hour)} = 0.8X\text{(1-hour)}$$
$$X\text{ (8-hour)} = 0.6X\text{(1-hour)}$$
$$X\text{(24-hour)} = 0.3X\text{(1-hour)}$$

Table 15.1 summarizes New Source Performance Standards (NSPS) emission requirements and expected emission rates based on a methanol production rate of 54,000 barrels per day.

The Clean Air Act created regulatory requirements to prevent significant deterioration (PSD) of air quality both in attainment areas, or areas of the country currently cleaner than the National Ambient Air Quality Standards (NAAQS). The Beluga-Tyonek areas currently have ambient air quality cleaner than defined in the NAAQS for criteria pollutants, and has been designated a Class II attainment area.

Table 15.1

NEW SOURCE PERFORMANCE STANDARDS AND ANTICIPATED EMISSION RATES

| | NSPS EMISSION LIMITATIONS | | | | EXPECTED EMISSIONS (μg/dscm unless specified) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Source | $SO_2$ | $NO_2$ | Particulate | Opacity | $SO_2$ | $NO_2$ | Particulate | CO | Reduced S |
| Boilers | 1.2 lbs/MMBtu | 0.70 lbs/MMBtu | 0.10 lbs/MMBtu | 20% | 0.53 lbs/MMBtu | 0.70 lbs/MMBtu | 0.10 lbs/MMBtu | 0.08 lbs/MMBtu | |
| Coal Dryers | | | 70 μg/dscm | 20% | 44 | 82.1 | 24.2 | 27 | |
| Coal Preparation | | | 40 μg/dscm | 10% | | | | | |
| Ash Loading | | | | | | | 0.2 gm/sec | | |
| Coal Storage | | | | | | | 4.4 gm/sec | | |
| Flare | | | | | 18.3 | 23 | | | |
| Sulfer Recovery | | | | | | | | 50 | 28 |
| Ash & Char Transport | | | | | | | 1.6 | 547.3 | 5.5 |
| Reformer | | | | | | 78.7 | | | |

PSD review is required when a criteria pollutant in an attainment area for that pollutant is emitted in excess of 100 to 250 tons per year after the use of pollution control equipment. Acceptable and expected emissions levels for applicable criteria and non-criteria pollutants are given in Table 15.2.

Table 15.3 summarizes the yearly emissions of particulate matter, sulfur oxides, nitrogen oxides, carbon monoxide, reduced sulfur compounds, and hydrocarbons that would be associated with the coal gasification plant and the mine. The emissions rates are based on a methanol production rate of 54,000 barrels per day.

The procedures for estimating maximum concentration increases due to the new source were designed to describe worst case situations with a factor of safety. When it was determined that allowable increases or concentration ceilings would be threatened, it was concluded that the disperson of emissions creating these conditions should be analyzed in more detail.

The models used are subject to limitations not only due to assumptions inherent in their use but also because the input data are not necessarily truly representative of conditions at the proposed site. The primary concerns about the applicability of this analysis and their impact on a preconstruction monitoring program are discussed below.

1. PTMAX and VALLEY models use vertical and horizontal dispersion parameters ($\sigma z$ and $\sigma y$ in the calculations) that were developed for releases over open, flat terrain and short (a few kilometers) distances of travel. Dispersion in complex terrain is better described by site-specific parameters that can be developed from measurements of wind speed fluctuations. Since the diffusion of pollutants is sensitive to these measurements of turbulence, a monitoring program that would provide enough data to calculate

Table 15.2

ACCEPTED AND ANTICIPATED EMISSION LEVELS

| Pollutant | Air Quality Standards[a] ($\mu g/M^3$) | PSD Class II Increment[b] ($\mu g/M^3$) | Maximum Impact of all Sources ($\mu g/M^3$) | Distance of Maximum (KM) | Significant Ambient Air Impacts[c] ($\mu g/M^3$) | Significant Monitoring Concentrations[d] ($\mu g/M^3$) | Area of Significant Impact ($Km^2$) | Comments |
|---|---|---|---|---|---|---|---|---|
| Sulfur Oxides | | | | | | | | 1. No monitoring exemption. |
| 3 hr. | 1300 | 512 | | | 25 | | | 2. Area of significant impact |
| 24 hr. | 365 | 91 | 100 | 10 | 5 | 13 | | entirely north/northwest of |
| Annual | | | | | | | | plant site. |
| Nitrogen Oxides | | | | | | | | |
| 24 hr. | | | | | | 14 | | (See Sulfur Oxides) |
| Annual | 100 | | 6 | 10 | 1 | | 100+ | |
| Particulate Matter | | | | | | | | 1. No monitoring exemption. 2. Area of significant impact to |
| 24 hr. | 150 | 37 | 40 | 7 | 5 | 10 | | the immediate northwest of |
| Annual | 60 | 19 | | | 1 | | 4 | plant site (3 km). |
| Carbon Monoxide | | | | | | | | 1. Possible monitoring exemption. However, all sources have not |
| 1 hr. | 40000 | | | | 2000 | | | been considered. |
| 8 hr. | 40000 | | 200 | 3.5 | 500 | 575 | | |
| Reduced Sulfur | | | | | | | | (See Carbon Monoxide) |
| 30 min. | 50 | 10 (1 hr) | 3.5-7.0 | | .04 ($H_2S$) | | | |

a. 18 aal 50.10.
b. 40 CFR 51.24.
c. "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)," USEPA, November, 1980.

Table 15.3

EMISSION INVENTORY

| Source | LONG TERM EMISSIONS (TN/YR) | | | | | |
|---|---|---|---|---|---|---|
| | Particulate Matter | Sulfur Oxides (AS $SO_2$) | Nitrogen Oxides (AS $SO_2$) | Carbon Monoxide | Reduced Sulfur Compounds* (AS $SO_2$) | Hydrocarbons |
| 1. Boilers | 1720 | 8935 | 12000 | 1314 | -- | 263 |
| 2. Dryers | 613 | 1112 | 2090 | 280 | -- | 44 |
| 3. Continuous Flaring | N.E. | 140 | 180 | N.E. | -- | N.E. |
| 4. Acid Gas Removal $CO_2$ Vent | -- | -- | -- | 2800 | 48 | -- |
| 5. Sulfur Recovery | -- | -- | -- | 302 | 102 | -- |
| 6. Coal Preparation Area Dust Collection | 47 | -- | -- | -- | -- | |
| 7. Coal Storage | 175 | -- | -- | -- | -- | -- |
| 8. Railroad | 30 | 70 | 390 | 190 | -- | 33 |
| 9. Reformers | 13[a] | 25[a] | 814 | 31[a] | -- | 6[a] |
| 10. Ash & Char Transport | 9 | -- | -- | 1000 | 6 | -- |
| 11. Storage Tanks | -- | -- | -- | X | -- | X |
| 12. Process Plant Fugitive | N.E. | -- | -- | N.E. | N.E. | N.E. |

Table 15.3
Continued

EMISSION INVENTORY

| Source | LONG TERM EMISSIONS (TN/YR) Particulate Matter | Sulfur Oxides (AS $SO_2$) | Nitrogen Oxides (AS $SO_2$) | Carbon Monoxide | Reduced Sulfur Compounds* (AS $SO_2$) | Hydrocarbons |
|---|---|---|---|---|---|---|
| 13. Mining | | | | | | |
| a. Fugitive | N.E. | -- | -- | -- | -- | -- |
| b. Heavy Equipment | X | X | X | X | -- | X |
| Startup Emissions (lb/hr) | | | | | | |
| 1. Gasifiers (10 hrs.) | | | | | -- | |
| 2. Boilers (2 hrs.) | | | | | -- | |
| 3. Flaring (2 hrs.) | | | | | -- | |
| Emergency Emissions (lb/hr) | | | | | | |
| 1. Low Pressure Flaring (10 min.) | | | | | | |
| 2. High Pressure Flaring (10 min.) | | | | | | |

X = Later

the dispersion parameters appropriate for the proposed plant site is necessary.

2. Background concentrations used in this analysis were necessarily conservative. In some cases they represent a significant portion of the ambient air concentration ceiling. A monitoring program to measure the actual concentrations of $SO_2$, $NO_2$, and TSP would greatly improve estimates of maximum impacts. In addition, monitoring data for $NO_2$ taken by others south of the plant site and across Cook Inlet, where most of the industrial development is located, would help to determine whether pristine conditions are present in that area also.

3. Meteorological data used for input to the annual average analysis was collected at a National Weather Service Station near Kenai. These data must be assumed to vary somewhat from actual conditions in the project area, but are considered sufficiently representative for use in this preliminary feasibility analysis.

## MAJOR REGULATORY REQUIREMENTS

The federal Clean Air Act Prevention of Significant Deterioration (PSD) program and the State of Alaska Air Quality Control Permit to Operate program are the two significant regulatory frameworks that would impose major permit requirements on this project. The PSD program requires preconstruction approval of plants that have significant emissions potentials. A plant is subject to PSD regulations if potential emissions of any regulated pollutant exceed 100 tons per year for plants within 28 specified industrial categories or if potential emissions exceed 250 tons per year for any other plant. Coal gasification or methanol plants are not listed among the 28 source types. However, the proposed plant would generate the pollutant emissions estimated to exceed 250 tons per year, so PSD preconstruction review would be required. The review is an extensive procedure involving baseline meteorological and air quality monitoring, rigorous data analysis and an intensive permit review by the Environmental Protection Agency (EPA). The Region 10 office of the EPA would review this project and issue the PSD permit. PSD permits typically stipulate compliance monitoring and reporting. A lead time of 24 to 30 months should be allowed to complete the permitting process.

The State of Alaska Air Quality Control permit program is administered under the authority of 18 AAC 50 by the Alaska Department of Environmental Conservation. This program involves a permit to operate, compared to the preconstruction review concept on which the PSD program is based. Permit applications should be filed with the DEC 30 days or more prior to the commencement of operations, and must be accompanied with a specified set of information and operating documents. The DEC may require the permit applicant to install and maintain monitoring equipment, and to provide source test reports, emission data and periodic reports. The Air Quality Control Permit to Operate is issued for a period not to exceed 5 years, at which time a permit application must be filed anew.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

A review of existing data concerning meteorological and ambient air quality background conditions and the screening review of the anticipated emissions from the plant indicate that the proposed facility could be built well within the limits of present air quality laws using current technology. There would be measurable deterioration of the ambient air quality surrounding the immediate project area, but it would be well within the allowable increments set forth in the federal environmental regulations. This feasibility study indicates that both the state and federal permits could be obtained, although in the case of the PSD permit it could be an expensive and time consuming process.

# 16.0 OCEANOGRAPHY

## CONSTRUCTION EFFECTS

Oceanographic conditions within the Beluga/Trading Bay/Drift River area probably would be only slightly and temporarily affected by construction of the proposed facilities including the construction dock. The primary impact would be relatively small increases in the amounts of sediment and turbidity in the marine environment.

The ocean floor would be disturbed temporarily by the driving of piles for the construction dock facilities. Fill material utilized in the construction of the dock would be clean, well graded sands and gravels to minimize the impact on water quality. The estimated suspended sediment which would be created by all the construction activities is very small relative to the normal amount of sediment naturally present in upper Cook Inlet waters.

## LONG-TERM EFFECTS

The effects of accidental spills of methanol into the marine environment are considered later in Section 21.0 METHANOL IN THE ENVIRONMENT. This discussion considers the source and transport of those potential spills. The most likely opportunity for an accidental spill would be at the Drift River terminal, either during maneuvering or load transfer operations. Spills also could occur in transit, most commonly due to equipment failure, human error, ballast discharges, structural failures or vessel casualities. Hazards to navigation in Cook Inlet and ice conditions are considered in Section 7.0 OCEANOGRAPHY.

The two main factors which affect transport of spills are currents and wind. Generally the speed of pollutant transport due to current and wind is 3% of the wind speed plus the current speed. Detailed current measurements along the west side of upper Cook Inlet are lacking, therefore, specific pollutant transport determinations cannot be made. Generally, currents move north along the west side of the inlet, mixing with freshwater sources which flow in from the major tributaries, and then move easterly near Fire Island, and south along the Kenai Peninsula. Bathymetry, tidal ranges, and currents are being studied in this general area as part of another project study related to the development of the Beluga coal fields.

## MAJOR REGULATORY REQUIREMENTS

During construction, fill material would be dredged out of and/or placed into upper Cook Inlet -- a navigable waterway. In addition, the construction operation would place a structure in a navigable waterway. These operations would require two permits, to be obtained from the U.S. Department of Defense, Department of the Army, Corps of Engineers.

The discharge of dredge or fill material into U.S. waters, including tidelands and wetlands, must be authorized by the Corps of Engineers. This permit is mandated primarily by Section 404 of the Clean Water Act, as Amended. The other major federal permit concerns the placement of any structure in or over the navigable waters of the United States; or the excavation of material in such; or the accomplishment of any other work affecting the course, location, condition or capacity of such waters. This permit requirement originates from Section 10 of the River and Harbor Act of 1899.

In addition to the above federal programs, state regulations affecting the proposed project are concerned primarily with discharges to the marine environment and adherence to pertinent coastal zone management regulations.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

The anticipated short-term construction effects on the marine environment are considered to be nominal due primarily to the size of Cook Inlet and the heavy natural sediment load. With adequate safeguards, the long-term impacts should also be negligible.

## 17.0 ARCHAEOLOGIC AND HISTORIC SITES

### CONSTRUCTION EFFECTS

A literature survey of historical and archaeological sites indicates that there are eight sites besides the many within the present Village of Tyonek that are near the study area. Only the site at the Village of Ladd lies outside of the former Moquawkie Reservation boundaries in the lower Chuitna River vicinity. The possibility that undiscovered sites might be found or impacted during construction activities is always present.

An on-the-ground survey would be necessary to determine the probable location and significance of any sites in the area. Probable sites would include aboriginal hunting trails; remains of structures and artifacts situated along those trails; seasonal camp sites, particularly in fishing areas; storage cache pits; and military trails.

Greatest potential impact to unidentified archaeologic and historic sites would arise during opening of and production from a surface coal mine. Any site not identified before production begins probably would not be recognized during production. Indirect impacts to the sites could arise from exposure to the influx of additional people to the previously remote area.

### LONG-TERM EFFECTS

Long-term effects of the proposed development regarding preservation of archaeologic and historic sites could result from the increased use of the area, particularly if visitors included amateur artifact collectors.

## MAJOR REGULATORY REQUIREMENTS

Prior to commencement of construction, a letter detailing the proposed construction and a map outlining the impacted area must be sent to the chief of the State Office of History and Archaeology. A review of the application will be made by the state, and a determination will be made concerning whether an on-the-ground survey of the area is necessary. The guidelines for such a survey can be found at 36 CFR 800, Protection of Historic and Cultural Properties.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

There are no known archaeologic or historic sites in the immediate project area. Although research indicates a potential for various cultural remains in the general vicinity, careful construction practices and a preconstruction archaeological survey would prevent adverse effects on potential archaeologic or historic sites.

## 18.0 SOLID WASTE

### CONSTRUCTION EFFECTS

#### Clearing Debris

Vegetation consisting of brush and moderate tree cover would be cleared from approximately a 1,000-acre plant site area. In addition, vegetation would be cleared from a transportation corridor to the the mine areas. Material would be stacked and burned. Air quality would be temporarily impacted adversely in the surrounding area but rapid dispersion in a clean air shed should quickly alleviate the effects.

#### Construction Refuse

Solid waste refuse produced during construction would consist primarily of construction rubble including boxes, cans, wrapping paper, hardware, broken and leftover materials, etc. Construction workers would generate additional refuse (Table 18.1), at a rate of about 7 lbs. per worker per day. This refuse would be compacted and disposed of in an environmentally acceptable landfill.

Table 18.1
CONSTRUCTION REFUSE

| Manpower (Date) | Compacted Refuse | | Bulky Refuse | |
|---|---|---|---|---|
| | Lbs./Day | Cu.Ft./Day | Lbs./Day | Cu.Ft./Day |
| 500 Construction (1984-85) | 3,500 | 88 | 3,500 | 605 |
| 3,500 Construction (1986) | 24,500 | 612 | 24,500 | 4,235 |

Basis: 7 lbs/day generated per man. (Anderson 1972)
Bulky Refuse: 162 lb./cu.yd. (Jackson 1979)
Compacted Refuse: 40 lb./cu.ft. (Kroneburger 1977)

## LONG-TERM EFFECTS

### Ash and Sludge

Ash and char would account for the largest amount of solid waste. There also would be some sludge, which would be predominantly ash that has been scrubbed from the raw gas, then concentrated.

Ash and sludge streams would be generated from coal storage and preparation, gasification, raw gas cleaning, and cooling processes. Precipitation would be the major problem in the coal storage and preparation area. Runoff water would contain suspended particulate matter. This water would be collected in a retention pond lined to prevent groundwater seepage, and would have a residence time of significant duration to allow solids to settle and to promote biological action.

Retained solids would result from stockpiled coal, which is not a solid waste as defined by 40 CFR 261 (A) and, therefore, not subject to Resource Conservation and Recovery Act (RCRA) regulations.

The largest amounts of ash and char would be produced by the gasification of coal in the Winkler gasifiers and the subsequent gas cooling and char recovery. Ash and char also would be generated in the coal receiving, storage and preparation areas. Char from the waste heat recovery system would be removed by dry cyclones and used as fuel in the offsite boilers and therefore is not a waste stream, but a fuel material. Ash would be produced from the power plant boilers. The combined solid waste that must be disposed of is described in Table 18.2.

Ash would be produced by the power plant boilers. The combined solid waste that must be disposed of is described in Table 18.2. The ash and char solid waste is not a hazardous waste as described in 40 CFR 261.3. The preferred method of handling would be to

Table 18.2

COMBINED SOLID WASTE

Tons per Day (TPD)/Cubic Yards per Day (Cy/d)

| Coal/Char TPD | Ash TPD | Water TPD | Total TPD | Total Cy/d | Dry Cy/d | Wet Cy/d |
|---|---|---|---|---|---|---|
| 181.0 | 689.1 | 2,917.6 | 2,917.6 | 3,974 | 1,544 | 2,430 |
| 132.5 | 4,595.9 | 945.2 | 5,673.6 | 9,831 | 8,709 | 1,122 |
| 313.5 | 5,285.0 | 2,992.7 | 8,591.2 | 13,805 | 10,253 | 3,552 |

return it to the mine pit as part of the surface mining reclamation program. .Two trains each utilizing 11 special side-dump ash cars would operate three trips per day to dispose of a total 66 carloads of ash. Two trains utilizing 12 special side-dump sludge cars would make three trips daily to dispose of a total 72 carloads of sludge per day. The combined ash and car would contribute a total dry volume of 10,253 cubic yards per day of solid waste toward filling the mine pit. Although this volume would be easily accommodated in the mine pit, a substantial committment of real estate would be required to dispose of the same quantity in a sanitary landfill.

Any solids remaining in the raw gas would be removed in the raw gas cleaning and cooling sections by Quench Venturi type scrubbing. The spent water would be withdrawn to settlers where the particle-laden water would be concentrated to 15% solids content, then sent to a rotary filter system it would be concentrated to 70% solids. The filtrate would be sent to wastewater treatment. Further evaluation of the cake is necessary to determine an environmentally suitable method of disposal.

Methanol Process Solid Wastes

Solid process wastes consist of spent catalysts from various process sections including CO shift and COS hydrolysis, acid gas removal, sulfur recovery system, guard vessels, and methanol synthesis. It must be emphasized that catalysts are only disposed of periodically. Expected normal catalyst lives are given in Table 18.3.

Table 18.3

EXPECTED LIVES OF CATALYSTS

| Catalysts | Normal Life |
|---|---|
| CO Shift | 3 years |
| COS Hydrolysis | 3 years |
| Sulfur Guard (Zn0) | 1.5 years |
| Chlorine Guard (Proprietary) | 1.5 years |
| Methanol Synthesis (Cu Based, Proprietary) | 5 years |

Further evaluation of each spent catalyst will be needed to determine methods of disposal which are environmentally acceptable. Spent catalysts in solvents generally would be regenerated, but those which must eventually be thrown away are sufficiently benign that they can safely be disposed in a landfill. Several spent catalysts may have a marketable value for recovery of metals. These include ZnS from spent Zn0 and spent copper-based catalyst from methanol synthesis.

Further evaluation of purge solution from the acid gas recovery unit is also needed. However, sodium sulfate, sodium thiosulfate and sodium carbonate are not on the hazardous materials list (40 CFR 261[D]).

Approximately 22 tons per day of by-product sulfur would be produced from the Stretford sulfur recovery unit. This would be a chemically inert material most likely in the form of molten sulfur. It is nonhazardous. The preferred method of handling the material would be to return it to the mine pit as part of the surface mining reclamation program.

Hazardous Substances

The solid waste materials anticipated to be produced from the gasification/methanol plant operation were reviewed, and at this time there are no materials known which are considered to be hazardous per the Subpart D list of materials in the Hazardous Waste Management System (40 CFR 261[D]). After the plant commences operation, a testing program would be required to confirm that hazardous materials are not being produced. If it is discovered that any of the materials are hazardous, they would be subject to the "cradle-to-grave" control as defined in RCRA.

Fugitive Coal Dust

Although coal dust is a solid waste by-product from plant operation, the discussion of its impacts is presented in Section 15.0 AIR QUALITY since it is an airborne contaminant.

Refuse

Operation of the plant and mine would generate refuse in amounts estimated as:

| | |
|---|---|
| Manpower Basis | 1,000 |
| Compacted Refuse | 175 cu.ft./day (7,000 lbs/day) |
| Bulky Refuse | 1,210 cu.ft./day (7,000 lbs/day) |

This material either would be incinerated or disposed of in an environmentally acceptable landfill. An incinerator would be subject to environmental controls under Alaska Solid Waste Management Regulations (18 AAC 60) which control particulate emissions to the atmosphere. A landfill would be subject to regulations under the same program to control possible leachate contamination of surface and groundwater systems.

## Sanitary Waste Solids

Sanitary wastes would be processed in a treatment plant at the secondary level such that the effluent can be discharged either to Cook Inlet or Nikolai Creek in a manner that does not cause violation of Alaska Water Quality Standards. The sludges would be disposed of in a landfill.

# MAJOR REGULATORY REQUIREMENTS

## RCRA of 1976 (Federal)

The Resource Conservation and Recovery Act of 1976 (RCRA) requires the Environmental Protection Agency to establish a national Hazardous Waste Management Program to regulate all aspects of hazardous waste from the time it is generated to the time it is properly disposed of. This gives the EPA important regulatory authorities with respect to hazardous waste.

On May 2, 1980 the EPA instituted a "cradle-to-grave" management system which was promulgated in the May 19, 1980 Federal Register. These regulations are expected to have a major effect on the methods used for hazardous waste disposal.

The new regulations require previous land-based disposal and combustion management techniques to exhibit more efficient disposal technologies. Land-based disposal facilities are required to demonstrate more effective containment of waste. This containment should prevent the leaching of contaminants into groundwater sources. Ambient groundwater monitoring of surface impoundments, landfills and land-treatment facilities containing hazardous wastes will be implemented to evaluate containment efficiency. Ambient groundwater monitoring must be initiated by November 19, 1981 unless it can be shown that the hazardous waste has a low potential for migration.

Combustion technologies will also be required to show improved performance standards for emission control, destruction efficiency and residual management.

A solid waste is classified hazardous if it exhibits any one of the four characteristics of ignitability, corrosivity, reactivity and toxicity (40 CFR 261 [C]) or is included on the list developed by EPA (40 CFR 261 [D]). Persons who generate, transport, treat, store or dispose of such hazardous wastes must comply with all applicable requirements of 40 CFR 122, 124 and 262 through 265 of Chapter 1 and the notification requirements of Section 3010 of RCRA. 40 CFR 261 (A) establishes special requirements for small-quantity generators (less than 1,000 kg/mo). It also contains the EPA definitions of solid and hazardous wastes plus a list of materials which are either wholly or partially excluded from the requirements in 40 CFR Parts 262 through 265, 122 and 124.

### 18 AAC 60 (State of Alaska)

Under the Alaska Administrative Code (ACC), a Solid Waste Management program is administered by the Alaska Department of Environmental Conservation. The program institutes a permitting procedure to control landfill operations and incinerators with greater capacity than 200 pounds per hour. The disposal methods selected for this project would require permitting under 18 AAC 60.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

All known solid wastes from this project should be safely disposable either in a landfill or by incineration. There are some methods of disposal for certain sludges that are yet to be defined. If any of these materials turn out to be hazardous or otherwise unsafe to dispose of either in a sanitary landfill or in the mine reclamation operations, other environmentally acceptable alternatives such as incineration or removal to a hazardous waste depository would be employed.

# 19.0 SHORT- AND LONG-TERM SOCIOECONOMIC EFFECTS

## COOK INLET IMPACTS

### Population and Employment

In the long term, it is expected that the project would create some 1,300 direct and indirect jobs at the project site, and a local population of approximately 2,600. Much of this employment likely would originate from Anchorage and the Kenai Peninsula. It is unlikely that additional employment and population would result directly from this project on the west side of Cook Inlet (discussed further in the following section). However, it is expected that the project would generate additional employment in Anchorage and the Kenai-Soldotna area. These off-site employment effects would result from the purchases of goods and services by the plant and its work force, and from the expenditure of property tax revenue by the Kenai Peninsula Borough.

As the commercial transportation and communications center of Alaska, Anchorage is affected to some extent by resource development throughout the state. The secondary economic impact on Anchorage would be significant with this project because it is located only 75 air miles from the city. It is likely that the plant operator would locate its administrative headquarters in Anchorage, thus creating direct project employment in the municipality. However, it is indirect employment and income created by the plant which would be most important to Anchorage. Substantial quantities of operation and maintenance supplies would be purchased in Anchorage or through Anchorage dealers, as would construction, engineering, transportation, and other services. Material and labor for specialty fabrication and construction associated with ongoing capital improvements would also be purchased in Anchorage and, to a lesser extent, in the Kenai area.

In addition to goods and services purchased by the plant operator and its contractors, Anchorage would also provide goods and services to the residents of the new west Cook Inlet community. Anchorage wholesalers would supply local retailers with the bulk of groceries and durable goods that they would market in the new town.

Public sector expenditures from property tax revenues derived from the project may also be expected to create employment, in this case for the Kenai-Soldotna area. Predictions of future property tax revenues to the Kenai Peninsula Borough from the project have not been attempted, but they likely would be substantial. Much of the property tax revenue generated by the project likely would be used to provide local services to the new town residents. However, the plant would represent a significant taxing asset to the entire borough (it would substantially increase the per capita valuation of the borough), and revenue derived from it would be used to expand borough services and facilities on the peninsula, as well as in the west Cook Inlet project area. Thus, the project would result in an expansion of borough employment and borough-related employment (construction and maintenance work, etc.) in Soldotna and elsewhere in the borough. Also, the scope of routine administrative tasks of the borough (planning and zoning, for example) would expand as a result of the existence of the plant and new town, necessitating some increase in borough staff.

## Growth-Inducing Effects

Apart from the secondary employment effects in the Anchorage and Kenai areas discussed above, this project would not be expected to stimulate "downstream" industrial development or other sizable commercial or resource development ventures locally or elsewhere in the state.

Methanol produced by this project would be used primarily as a supplemental fuel source. Its primary market would be the west coast of the United States. Its high cost relative to other energy sources in Alaska does not make it attractive as a source of energy for new industry or feedstock for local petrochemical manufacture.

Construction and operation of the mine, plant, and town sites should not affect the economic feasibility of other resource ventures in the west side of Cook Inlet, such as gas and oil exploration, logging and timber processing, hardrock mining, fish processing, or manufacturing ventures. These types of projects stand or fall on the basis of economic factors and forces that are largely external to the region. Facilities used in the operation of this coal-methanol project do not have direct application to development projects that are not coal related.

The feasibility of other coal development projects could be enhanced if certain infrastructure could be shared between projects: The airport; segments of the transportation corridor between the mine areas and the plant; the new town; telecommunications towers; dock, and/or other facilities. Savings realized through cost sharing and economies of scale from joint use of infrastructure could result in significant reductions in capital costs.

Joint use of infrastructure would require a great deal of planning by the ventures involved, including consideration of the location of facilities, their design, and financing.

Land Use, Transportation and Ownership Changes

In terms of land use, changes would tend to accelerate a process begun with the timber sale to Kodiak Lumber Mills in 1975. That is, most of the area proposed for development of the plant, camp, new town and airport is now crisscrossed by logging roads, and most of the spruce trees have been cut. Timber cutting and sporadic oil, gas and coal exploration activities in recent years have already introduced some permanent changes to an area formerly used only for subsistence hunting and fishing.

Despite these recent areawide activities, the project would affect land ownership and management practices of the state, borough, CIRI, and possibly the Tyonek Native Corporation.

° State Lands

The new town and airport would be located on state land. The methanol plant likely would be on CIRI land. The state already has granted a 300-foot-wide easement for the mine-to-dock transportation corridor. The state Department of Natural Resources likely would lease land for the town, whose developers would in turn sublease properties for housing, commercial and other development. The DNR would oversee siting of the town, camp, airport and plant, giving particular attention to issues of sanitation, potential for stream degradation, availability of water, and other land management and classification criteria (AS 38.04.900, AS 38.05.020, AS 38.05.300). Ultimately, the Kenai Peninsula Borough would be responsible for town zoning, subdivisions, and miscellaneous permits.

The normal mechanism for DNR disposal of land for project facilities requires that land first be classified for specific purposes. Most of the state land in the project area is classified for Resource Management, the broadest of 17 management categories (coastal sections are mostly designated Industrial Lands). DNR's Planning Section could (under present statutes) develop an area land use plan to determine more specific classifications better suited to the proposed uses. For example, the methanol plant could be designated as Industrial Land (as were the Kodiak Lumber Mill dock at North Foreland and the Chugach Electric power plant north of Tyonek). The town site could be designated as

Commercial Land or Residential Land, or conceivably the entire project could be classified as Industrial Land. Each of the state departments which would take part in preparation of the plan (such as Fish and Game, Community and Regional Affairs, Transporation and Public Facilities, Environmental Conservation, Commerce and Economic Development, and the DNR Division of Parks) presumably would wish to establish land classifications specific to their concerns. Native corporations, the borough and industry also would participate in preparing the plan.

Additional likely areas of concern to the state would be Material Land classification for appropriate gravel extraction sites, and possible Wildlife Habitat Land for certain streams. Dual or multiple-use classifications are possible, if uses are compatible (11 AAC 55.040).

Once the land use plan for state lands had been approved, the DNR Division of Forest, Land and Water Management could execute land disposal (lease, sale, grant or exchange) agreements for sites or proposed project facilities. If lease arrangements were executed, special provisions (such as restrictions on airport use to approved aircraft, and/or eventual public use and maintenance of the airport) could be included. DNR could also grant miscellaneous road and power easements.

The preparation of an areawide plan utilizing public hearings can be a very time-consuming task (2-3 years). The Governor's Coal Policy Group and the Beluga Interagency Task Force could help expedite the process by assisting in identifying critical issues and appropriate land use planning responses.

However the plan is prepared, it should consider not only the CIRI/Placer Amex project, but also the Bass-Hunt-Wilson coal mine and port, and other possible power generation projects in the vicinity. Extension of a new road or rail line from the Matanuska Valley and construction of new power lines to serve these projects have been discussed in the past. The Alaska Power Authority will soon be studying the feasibility of hydroelectric power generation at Lake Chakachamna, about 25 miles west of the project site. These projects all have implications for growth in the Matanuska-Susitna and Kenai Peninsula boroughs. How these projects fit into regional patterns of growth and energy facilities siting has not been investigated.

Thus, a land use plan should not only consider state lands, but other ownerships as well, to guide the development of west Cook Inlet. Such a plan might seek to minimize the duplication of transportation and utility corridors, or to consolidate development of the proposed CIRI/Placer Amex and Bass-Hunt-Wilson town sites. It might also consider the kind and location of port facilities which are being studied for the entire state by the Department of Transportation and Public Facilities (report due September 1981).

- <u>Borough Lands</u>

The proposed camp site and a portion of the transportation corridor cross Kenai Peninsula Borough land west of Congahbuna Lake. CIRI/Placer Amex would have to negotiate with the borough for right-of-way and lease of about 175 acres for the camp. Although the camp would be dismantled, some road and utility lines could remain in place. A small 50-man camp could remain for visitors after the plant is in operation.

- <u>Cook Inlet Region, Inc. Lands (CIRI)</u>

CIRI is an active participant in the venture and would seek to expedite project development on its lands. Most of the methanol plant likely would be located on land whose surface estate is owned by CIRI. CIRI's ownership allows for gravel removal.

There do not appear to be significant pre-existing leases which would preclude plant development at this site.

° Tyonek Native Corporation Lands

No facilities are planned on land owned by the Tyonek Native Corporation, and Tyonek Native Corporation has stated its opposition to any easements across its land.

Borough Services Impacts

Development of a town near the plant could require the provision of some services from the Kenai Peninsula Borough. These services would include education, planning, and regulation of land use. The level of planning, zoning and subdivision services provided by the borough would depend on whether the community functions as a "company town" or becomes an incorporated city. Education would be the responsibility of the borough in either a company town or an incorporated city.

Actual impacts upon the borough would be expected to be small. The cost of education is borne almost entirely by the state; and even if the new town became an incorporated city, the borough would be expected to delegate most of its planning and land use regulation powers to the city. Also, although the borough can establish local service districts in unincorporated areas to provide such services as sewer, water, roads, and solid waste, this is considered unlikely. Rather, industry would choose to develop these facilities under its own needs and timetable.

The borough should be affected only if significant growth takes place outside the town, on the Kenai Peninsula itself. Under these circumstances, expansion of streets, utilities and subdivisions could make demands upon the borough which might require some form of short-term impact funding assistance.

° Options for Town Management and Governance

The choice between a company town or an incorporated city involves questions of development control and cost-sharing for the provision of services. A decision by industry to build and maintain all of the town's facilities and services would allow for greater control than would be possible if it became an incorporated city. Involvement of borough government in a company town would be largely restricted to the development and operation of schools.

On the other hand, if the city were to incorporate, it would be eligible for state revenue sharing funds; however, costs of municipal administration would also be created. A second-class city may be formed upon petition to the Local Boundary Commission. Requirements include: Designation of city limits within which municipal services are to be provided; demonstration that the community includes sufficient human and financial resources to support services; demonstration of a need for city government. The degree of difficulty for the Kenai borough to provide some services to the remote site would play a part in this decision.

When the community reached a permanent population of 400, it could incorporate as a first-class city which could levy and collect special charges, property and sales taxes or assessments to amortize bonded indebtedness for sewage collection and water distribution systems, streets and other facilities. The municipality would be eligible for other state and federal aid not available to a private community.

Bills now in the state legislature (SB 180, HB 170) propose changes to the Municipal Code. Under the proposals, a city incorporated after July 1, 1981 is entitled to an "organizational grant" of $50,000 for the first year of transition to city government. A city eligible for the first-year grant would be eligible for a second year grant of $25,000.

The bills also abolish "Development Cities" legislation enacted some years ago to facilitate energy-related new town development (AS 29.18.230-450). Part of the argument to drop the legislation stems from a state policy which discourages funding for special private interest projects, such as a company new town, where broad public benefits are negligible. On the other hand, incorporation would make a community eligible for a variety of state-funded programs. The legislation is expected to be enacted in the 1982 legislative session.

- <u>Borough Planning of the Town Site</u>

  Under state law, boroughs have responsibilities for planning, platting and land use regulation on an areawide basis. However, the borough assembly may delegate any of its powers and responsibilities to a general law city in the borough, if the city first consents by ordinance to this delegation. The emerging policy of the Kenai Peninsula Borough is to pass on zoning and platting powers to towns, while retaining an overall planning function. Thus, if the town became an incorporated city, it could have many of the planning powers it would have as a company town, albeit in a somewhat different form. The borough has no formal policy on town site development associated with the proposed methanol plant.

- <u>Impacts if Growth Occurs in the Kenai Peninsula</u>

  Because the town would be isolated, impacts upon the borough might be negligible. However, the situation could change if only a small town were ultimately developed, with a sizable number of people living on the Kenai Peninsula. There could be a need for greater fire and police protection, more planning and administrative responsibilities and other new services associated with an expanded population in Kenai.

Experience from other areas of the country, notably Montana and North Dakota, indicates that the areawide economic benefits of energy projects lag for several years after project start-up. During early years of project mobilization and construction, local jurisdictions may be called upon to increase their planning staffs, expand schools, widen roads and install new utilities. This may occur during a period when little, if any, revenues flow to these jurisdictions. In the worst case, jurisdictions may be incapable of adequately responding to the project until it is too late and disruption is severe. Resentment for the project by local residents may be only partly lessened by the large property tax revenues received at a later time.

If rapid growth occurred on the Kenai Peninsula, some form of short-term impact assistance funding might be considered for the Kenai Peninsula Borough.

The key to any funding assistance agreement would be the identification and quantification of short-term project impacts in contrast to those associated with areawide growth.

## TYONEK VILLAGE IMPACTS

Potential effects of the project on the Village of Tyonek are the most significant socioeconomic impact issue raised by this project. The nature and extent of actual impacts on Tyonek would depend upon the success of planning and mitigation measures undertaken by the project sponsors, the state and borough governments, the Cook Inlet Native Association, the Tyonek Native Corporation, and the villagers themselves. Certain village impacts seem inevitable, such as increased contact with non-Native people and institutions, and conflicts with non-Native sportfishing and hunting. The project would create substantial opportunities for economic benefit to the community; but the extent to which these would be realized depends on the responses of the village residents, and the village and regional Native corporations.

Village Impacts

Planning by the Tyoneks should be able to adequately protect the village and its institutions from direct impact by the project. That is, there is no reason why the project should have direct physical intrusions into the community from automobile traffic, sightseers, nonlocal school children, shoppers, and so on. The traditional village council and the Tyonek Native Corporation can legally control access to the village by nonresidents. The Tyonek School is too small and too far from the project town site to be a practical alternative to construction of a new school at the community.

Once the mine, plant, and new community were developed and operating, the village and its new neighbors probably would adjust to a mutually acceptable pattern of coexistence that would not require formal restrictions on movement. However, the village could prohibit access across its land if problems were to occur.

Culture and Life-style Changes

In contrast to the physical penetration of daily village life by the project, defenses against intrusions on the village culture and life-style are less readily available to the Tyoneks. It is here that impacts seem inevitable, although the severity and long-term significance cannot be foreseen.

A nearby new town with movies, recreational activities, restaurants and so forth would be an irresistable attraction to village residents, especially younger people. Tyonek youth are familiar with the modern white world (Anchorage is an inexpensive plane flight away, and the village receives direct line-of-sight television signals from Anchorage); but now this life-style would be at their doorsteps.

Interaction between villagers and the new town would doubtless hasten the process of acculturation which has been under way in Tyonek for a century, and the cultural cohesion of the community would be weakened further.

The presence of the new project community and interaction with Tyonek residents could result in problems of a social-psychological nature. The Battelle study (1979) speculates at length about the potential for this type of problem:

> Although Tyonek residents have had considerable contact with the dominant American lifestyle, this contact would be greatly expanded by coal development. Under those circumstances, a variety of interpersonal and intergroup conflicts would likely surface . . . Coal development would also mean that, for the first time in their long history, Tyonek residents would be in the minority in their own region. Minority status usually is a breeding ground for racism and discrimination. Status and cultural differences therefore can be factors in intensifying unfriendly and perhaps hostile relationships.
>
> With the potential for social conflict comes a potential for social deviancy such as vandalism, larceny, alcoholism, and drug abuse. All of these forms of deviancy contribute to one another and in many cases can be emphasized by prevailing differences of opinions, intergroup relations, and feelings of inferiority, especially on the part of the group relegated to a minority status. Intergroup conflict can also affect employment, job productivity, learning in the classroom, and can disrupt a community's total way of life.

Proximity of the new town to Tyonek would also seem likely to create conflicts between village subsistence hunters and fishermen and non-Native sportsmen. Many of the new town's residents would be outdoorsmen (indeed, the population of this remote Alaska setting could tend to be self-selected for this interest). The Tyoneks have traditionally hunted and fished over a wide geographical area -- wider, certainly, than the limits of the land they now control through selections made under the Alaska Native Claims Settlement Act. Even if the project work force did not have automobiles, hunters and fishermen would have mobility by snowmachine, motor bikes, small all-terrain vehicles, airplanes, and boats. Preferential treatment of the Tyoneks under the state's subsistence law seems unlikely, since management distinctions are based on place of residence rather than race or length of residency. Therefore, the stage is set for conflict and competition between the villagers and newcomers over increasingly scarce fish and game resources on the west side of Cook Inlet.

Erosion of the Tyoneks' subsistence resource base poses a potentially serious threat to the traditional village life-style and cultural values. Seasonal subsistence pursuits are an important source of food, focus of village life, and spiritual link with the past. Further decline of the fish and wildlife population that supports this activity could contribute to the emergency of social-psychological problems discussed above.

Economic Impacts

The project would create employment and business opportunities for individual Tyonek residents and the village as a whole. The villagers themselves must act to realize the potential benefits of this economic opportunity, although the project sponsor could enhance the opportunities through such methods as job training, flexible hours and work schedules, and preferential contracting and purchasing policies.

During the construction phase, there would be high demand for laborers, equipment operators, mechanics and other craft workmen. Also, there would be demand for food service and housekeeping labor in the construction camp. These jobs would be filled by the respective unions, which probably would be obligated to minimum Equal Employment Opportunity (EEO) goals by the project labor agreement. There would also be demand for office and clerical help at the site, which is typically non-union.

After the mines, plant, town, and airport were developed and operating, the range of employment opportunities would expand and the complications of union dispatch would be lessened or eliminated. Numerous skilled and unskilled jobs in the mine, plant, and maintenance shops would be available. The town would create approximately 220 jobs in stores, restaurants, banks, a hotel, post office, airport, and other private and public enterprises, many of which would require little or no training and would appeal equally to women and men. In short, there would be ample opportunity for motivated villagers to obtain employment with some aspect of the project.

In addition to direct employment opportunities, the project would offer the possibility of Native-owned businesses supplying goods or services required for maintenance and operation. For example, a business formed by the Tyonek Native Corporation might negotiate a maintenance contract for roads, or a snow-removal contract for the airport runway. Also, it might seek to obtain a business franchise at the town, or become a vendor of supplies and material purchased regularly by the plant and its contractors. In this case, the village corporation would be an employer, and it might wish to provide work schedules, hours, and job-sharing to accommodate seasonal local subsistence activities. Thus, a village-owned enterprise could contribute to community income through jobs and business profits.

# 20.0 ACOUSTIC ENVIRONMENT

## CONSTRUCTION EFFECTS

### Construction Activities

During construction of the proposed methanol plant, the primary noise source would be earthmoving equipment, pile drivers and compressors. Typical noise levels for this equipment measured at a distance of 50 feet are:

| | |
|---|---|
| Earthmoving Equipment | 80 dBa |
| Pile Drivers | 95 dBa |
| Compressors | 75 dBa |

This would impose a significant noise increment on a pristine 30 to 40 dBa area, but the increase would be temporary and would have little or no adverse effect on present inhabitants. The nearest permanent inhabitants are at the Union Oil collection facility near Granite Point, and there is one permanent residence on the Granite Point beach area. There are also several seasonal residents on the beach during fishing season. The construction activities should be sufficiently far away (one to two miles) to be muffled by the terrain and vegetation and to be virtually un-noticed by the nearest inhabitants. The largest earthmoving equipment in the mine areas would be 15 to 25 miles away and would have no impact on the few individuals currently in the area. The noise from all construction activities would be expected, at least temporarily, to displace wildlife. The project construction activity and noise would not affect any known critical habitat areas.

### Vehicular Traffic

General transportation requirements for project construction activities would substantially increase the volume of vehicular traffic in the general Granite Point area. The traffic would be slow-moving and would occur in fairly heavily vegetated areas, factors which would minimize traffic-generated noise to a relatively un-noticeable level to the local inhabitants. The sound level of various truck traffic would range from approximately 72 to 89 dBa at 50 feet and decrease to a range of 54 to 71 dBa at about 400 feet.

## LONG-TERM EFFECTS

When the plant is operational, the principal continuous sources of noise would be the coal crushers, blowers, burners, agitators, compressors, pumps, turbines, condensors, coolers, air fins and diesel engines. To estimate the effects of this catagory of noise sources an analysis was done of 91 major noise-producing sources. Each had acoustic emissions in excess of 90 dBa at 50 feet. The analysis also assumes the noises emitted are from the source on a flat plain and does not consider the dampening effects of terrain, vegetation or special noise abating modifications that could be made to the equipment. At the fence line of the plant, an average distance of 1,000 feet from the noise sources, the sound levels were predicted to be 58 to 67 dBa. At a distance of one mile, the sound pressure level is estimated to drop to 51 dBa. At a distance of two miles, which is in the proximity of the nearest inhabitants, the sound pressure level is estimated to be 45 dBa. With the sound dampening effects of terrain and vegetation, and additional acoustic treatment required by the Occupational Safety and Health Act (OSHA) on high concentrations of noise sources, it is expected that the 45 dBa level could be further reduced to somewhere near the high end of the present ambient level of about 40 dBa. For this analysis to be conservative, dBa values in a high range were intentionally used.

Other equipment associated with the methanol plant is not influential when considering environmental impacts of noise at a large distance from the plant. These noises are relevant when considering compliance with OSHA worker exposure levels of 90 dBa, 8-hour time-weighted average (29 CFR 1910.95). When the equipment cannot meet these requirements, other noise control measures such as silencers, noise control installations, acoustical hoods, and closures, etc. would be employed. Heavy pieces of mechanical equipment with vibrating characteristics would be mounted on vibration isolators and piped with elastomer couplings to minimize noise. Steam piping and other gas lines are designed for reduced velocities to prevent excess noise. Ejectors, reducers and related equipment which might otherwise produce excessive noise are insulated.

Figure 20.1 illustrates levels of noise anticipated with the plant operation.

## MAJOR REGULATORY REQUIREMENTS

There are no State of Alaska areawide noise control regulations outside of the Department of Labor Occupational Safety and Health Standards. The Kenai Peninsula Borough, which has jurisdiction over this area, also does not have a noise control ordinance program. The principal noise control requirements would be through the federal OSHA Occupational Safety and Health Standards (29 CFR 1910) which basically cover individual source noise emissions particularly as they relate to employee safety within the confines of the workplace.

## ENVIRONMENTAL ACCEPTABILITY OF PROPOSED ACTION

The short-term construction noise effects are considered to be nominal in terms of a significant impact on the human population or wildlife of the area. With reasonable engineering, the long-term noise effects from plant operation should be limited to an area within a two mile radius (12 square miles) which is primarily within the

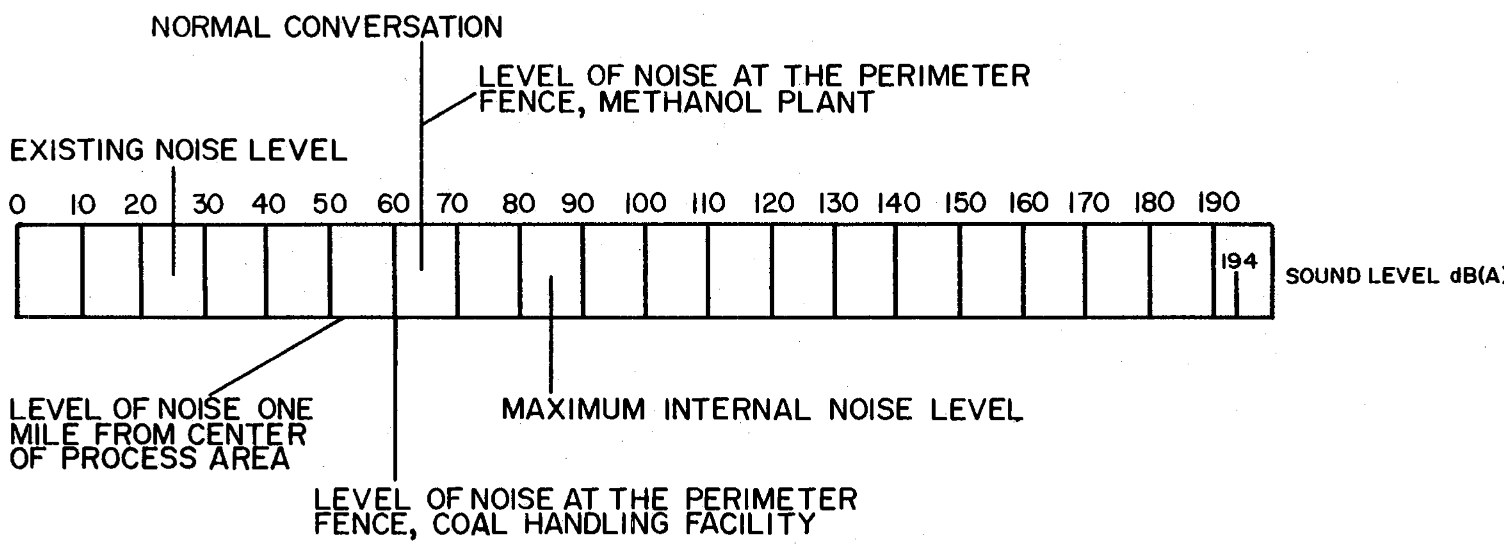


FIGURE 20.1 LEVELS OF NOISE, dB(A) – BELUGA METHANOL PLANT

range of the nearest population. Noise impacts on wildlife would not be severe and should in all cases be acceptable both from an environmental safeguard and a permitting standpoint. In the long-term, the population near Granite Point is expected to expand and eventually exist somewhat closer to the plant site than it currently does. Accompanying this growth would be a higher ambient noise level of 40 to 50 dBa on which would be imposed noise emission levels estimated to measure 51 to 67 dBa between the plant fence line and a point one mile away. In neither the short nor the long term is it expected that noise levels in a populated area would exceed an urban/residential level of 60 dBa or exceed an annoyance level of about 65 dBa.

## 21.0 METHANOL IN THE ENVIRONMENT (SUMMARY)*

### METHANOL IN THE ENVIRONMENT (GENERAL)

### Environmental Hazards, Aquatic and Marine

Investigations of the biological consequences of methanol spills or leaks into aquatic ecosystems indicate that many organisms are tolerant to low concentrations. However, significant disruptions of ecosystem dynamics may occur under certain conditions. The biological effects of an aquatic methanol accident are correlated with many factors including scale and duration of spill, tidal involvement, currents, temperature, available oxygen, potential organic and inorganic synergists, particular flora and fauna involved, and the interactions of ecosystem components.

### Marine and Estuarine

The following discussion presents a synopsis of the relative effects that might be anticipated in the event there were a methanol spill in Cook Inlet.

Substrate-forming invertebrates are key organisms in intertidal marine and estuarine environments. Both coastal and estuarine communities are largely dependent upon shelled or tube-dwelling organisms for substrate stability, temperature regulation, canopy, and larval settlement characteristics. Substrate formers with sealable shells or tubes vary in susceptibility to experimental concentrations of 100 ppm to 5% methanol. However, many invertebrates cannot survive acute, short-term exposure to concentrations ranging from 0.1 to 5% in filtered seawater. Immediate physiological consequences of acute exposure to methanol include reversible and/or irreversible ciliary narcosis, neuronal disruptions leading to disorientation,

* Prepared by Peter D'Eliisceu

"biological clock" suppression and alteration, inappropriate color changes, untimely autotomy and cardiac arrhythmia. Carbon-14 ($C^{14}$) labeled methanol was found to concentrate in excretory organs, neurons and gonadal tissues after only a few minutes exposure to low-level alcohol-seawater mixes. Chronic exposure to methanol (0.01 to 1% for 7 to 14 days) proved to be disruptive to gametogenesis, embryogenesis, larval development and larval settlement in many molluscs, crustaceans, polychaetes, and other invertebrates.

In addition, the molting processes of several crustaceans (including many commercial and game species) are accelerated by methanol exposure. In spill situations this acceleration could cause premature instar and adult molting, allowing increased population loss through disease, predation, or other environmental factors. In some molluscs, resistance to both tissue invasion and destruction by trematode parasites is greatly reduced. This could also lead to increased incidence of infection in the bird and fish definitive hosts of these parasites. Plankton, mollusc and polychaete larvae are generally susceptible to methanol concentrations as low as 100 ppm. However, these larvae and many invertebrates with ciliated respiratory structures are much less affected in highly aerated conditions. A concentration of about 1% methanol in seawater is tolerated by many common components of intertidal, mudflat, and estuarine ecosystems if heavy metals are eliminated from methylation. However, lower levels of methanol are toxic if metal contamination is considered. Molting disruptions and cardiac arrhythmias of selected crustaceans have been monitored, with commercially important crabs and lobsters receiving major focus. Examples have included toxic disruptions of the eastern lobster _Homarus_, and several _Cancer_ crab species from the west coast. As in previous crustacean investigations, ethanol proved more toxic than methanol, causing death or irreversible neuromuscular disruptions at 1 to 3% volume. Methanol tolerance limits are generally higher for those animals studied, ranging from 3 to 10% depending on species, size and nutritional state of the organism.

Other test animals evaluated for fuel-water physiological tolerances and responses include the marine gastropods Tegula funebralis, Barleeia sp., and several limpet species of Notoacmaea. The intertidal crab Pachygrapsus crassipes has also been monitored. In exposures to 1 to 30% by volume fuel in water, operculate snails Tegula and Barleeia were not differentially susceptible to alcohol or gasoline. However, gasoline-water mixtures were 25 to 45% more lethal than either alcohol for the non-operculate limpet Notoacmaea.

Crab test animals proved 50 to 60% more disrupted by gasoline mixtures in comparison to both alcohols. In $LD_{50}$ determinations, line-scaled on 100 to 0 non-unit comparison, the rank is indolene 100--ethanol 50--methanol 30. In procedures monitoring myogenic heart rates and neurobiology of Pachygrapsus, significant disruptions of rhythm, pulse intensity, secondary beats, and chamber coordination occur with indolene at 1% volume, 3% ethanol, and 5% methanol per 1 hour exposures. In most cases, arrhythmias are reversible for methanol, but recovery is generally incomplete for indolene exposures, with permanent neuromuscular damage occurring in many cases thus far monitored.

Since low levels of methanol occur naturally in many stable habitats and as alcohol is generally quite miscible, volatile, and degradable, gross environmental impact from moderate spills appears unlikely.

An evaluation of the toxicity of crude oil versus methanol in the marine environment shows major differences in effect. While many of the components of crude oil are held at the surface at ambient temperatures, some extremely toxic components are soluble in water and directly affect subsurface organisms. Since methanol is less toxic initially and has a much shorter residence time than oil (hours vs. years), it is considered a much less disruptive pollutant. Normal biodegradation of methanol is more rapid than crude oil or gasoline in aquatic and terrestrial habitats. In addition, recolonization by important organisms is much more rapid in alcohol-disrupted habitats.

Assessments of experimental spill sites for methanol and ethanol have shown nearly equivalent recovery. Coastal sites may show Shannon-Weaver diversity indices of 6.2 to 6.4 seven months post-spill. Sites have nearly fully recovered, nearing the 8.15 diversity index of the prespill baseline study.

Work with commercially important crabs and other marine anthropods has focused on the neuromuscular disruptions from fuel exposure, and clearance time and physiology. Electronic monitoring of isolated heart nuclei from these animals in vivo demonstrated rapid arrhythmia in ethanol and methanol exposures of 3% volume in seawater. Autoradiographs of haemolymph samples taken at five minute intervals after $C^{14}$ methanol exposure have demonstrated rapid partial clearance from the body. However, muscle and antennal gland samples have indicated continued toxicity after 55 minutes of clearance time for some specimens. Various physiological and behavioral disruptions associated with methanol spill situations would probably be short-term in field conditions. However, complete tissue clearance of alcohols is a matter of 2 to 5 hours, depending upon size, nutritional state, and microhabitat of the organism tested. Therefore, animals collected from a spill encounter should not be eaten unless purged (alive), or leached for more than minimum clearance time.

Comparison of Marine Environmental Impact Costs: Methanol/Oil

A comparison of the costs and consequences of crude oil spills versus alcohol spills indicates a further benefit in the transportation sector of alcohol fuel utilization. In assessing the direct and indirect costs of major oil spills, it is apparent that both acute immediate losses and residual losses are more severe than those losses associated with methanol.

An evaluation of the cleanup costs, repair for physical damage to boats, nets, filters, etc., and various socioeconomic losses due to some monitored oil spills shows a general pattern. In a major spill involving coastlines, such as those of the 1967 Torrey Canyon spill (off Cornwall, England), the 1969 Santa Barbara Channel spill and the 1978 Amaco Cadiz spill on the French Burgundy coast, costs may include initial expenditures for containment of the spill such as transportation and placement of physical barriers. Further attempts with suction-pump recollection, chemical surfacant dispersal, detergent application or absorption to straw, floating bellets or other material are generally applied. Later removal or degradation of larger residue is considered a "final" step. However, the residence time of some soluble components of the oil and small particulate residue pollutant is very long. An estimate of seven to 12 years retention of these residues in soft organic substrates and marshlands of France is not considered conservative. The monetary loss of fragile commercial species of crustacea, molluscs, and fish can be greater than the initial losses. In the case of the Amaco Cadiz spill, nearly all the commerical oyster industry of this region was lost and required waiting five to six years for reseeding of spat to replenish the industry. Loss of marshlands in the Santa Barbara and Amaco Cadiz spills and consequent decreases in some commercial crustacean and fish populations have been estimated at $2 million and $10 million, respectively. The physical and biological properties of alcohol fuels (methanol in particular) negate several of the possibilities for fiscal losses which would be expected in a spill situation involving oil. Short biological residence time, dilution and very rapid microbial degradation of methanol compared to crude oil components all contribute to this reduced loss.

Cleanup of a moderate to large methanol spill would involve removal of dead organisms, if necessary, monitoring of alcohol levels for several tidal periods, possible aeration of water as a restoration technique and perhaps innoculation of water with methotrophic bacteria, such as <u>Pseudomonas flourescens</u>. The most likely efforts to be employed for minor spills of methanol would be maintaining security of the area for one or two tidal periods. Normal degradation would complete the cleanup process with the least disruptions.

While monetary costs of floral and faunal losses due to oil pollution in the sea are not well documented, the physiological effects and population disruptions to birds, mammals, sessil invertebrates, zooplankton, phytoplankton, algal canopy, and other organisms are the objects of intensive current research.

Table 21.1 shows a comparison of the costs of example spills of crude oil, diesel fuel, and methanol. There is a large reduction in cleanup cost for methanol in contrast to diesel oil and crude oil. The petroleum figures taken from are from literature, and the methanol costs are estimated assuming worst-case conditions, based on research and small scale experiments conducted on the Santa Cruz, California coast. The major cost reduction factors associated with methanol spill clean-up are:

a. Decreased Manpower Requirements. Fewer man-hours for immediate cleanup operations are required for methanol. These figures include lower involvements of death of vertebrate animals, chemical treatments, monitoring, and health security operations.

b. Residual Toxic Effects are Shorter. Methanol toxic effects would last hours rather than years as would effects of heavy fuel oil.

c. Costs of Cleanup Materials. Possible innoculation of waters with alcohol-consuming bacteria and aeration of water or intertidal zones are significantly less expensive than sweeping, suction, dispersant-coagulant, or other technologies necessary for oil clean-up operations.

d. Transportation. Transportation costs of vehicles and vessels necessary for alcohol clean-ups are much less than those for oil spill situations.

e. Legal. Fines for environmental losses would likely be significantly less for methanol spills. However, for this comparison they are considered equivalent.

Table 21.1

COST COMPARISON OF SELECTED CRUDE OIL, DIESEL FUEL, AND METHANOL SPILLS

| Fuel | Spill Situation | Year | Estimated Total Cost | Volume | Cost Volume |
|---|---|---|---|---|---|
| Diesel | Tampico Mara | 1957 | 1,000,000 | 20,000 Met.Ton | $50/MT |
| Crude | Torrey Canyon | 1967 | 17,020,000 | 100,000 Met.Ton | $172/MT |
| Crude | Santa Barbara | 1967 | 50,500,000 | 3.4 Mill. Gals | 14.9¢/gal |
| Crude | Amoco Cadiz, Fr. | 1978 | 100,000,000 | 6.0 Mill. Gals | 16.7¢/gal |
| Methanol* | Santa Cruz, CA | 1977/78 | 120,000 | 1.0 Mill. Gals | .12¢/gal |

* Methanol estimate established in 100 gallon spill enclosed system experiments.

## Fresh Water

The following discussion presents a synopsis of the relative effects that might be anticipated in the event there were a methanol spill affecting one of the region's rivers or streams, such as could occur along the transportation corridor.

Methanol impacts on both lotic and lentic aquatic systems are correlated with several physical and biological factors. While tolerances vary among organisms (Table 21.2) the potential disruptions of populations or communities depend on amount and duration of spill, water volume and flow rate, temperature, oxygen tension, seasonality or temporality of effected species, and the life stage of organisms with larvae, resistant spores, or motile instars. While few freshwater organisms can tolerate long-term exposure to even 500 ppm methanol, many organisms can survive acute or short-term exposures of 1% volume. Some adult crus tacea may even tolerate 10% for several hours. In general, aquatic insect larvae are subject to narcosis at concentrations as low as 0.5%. In particular, lotic fish prey species of Odonata, Plecoptera, Ephemeroptera, and Diptera are killed at 1% concentrations at ambient temperatures. However, recolonization of experimental spill sites involving these larvae is very rapid. Apparently, the rapid dispersal and dilution of the alcohol in moving water systems allows reoccupation of disrupted habitats through immigration from upstream populations. Insect larvae exposed to, but not killed by alcohol generally recover from the narcotic effects in several hours. However, behavioral disruptions during this recovery period, including disorientation, phototactic and thigmotactic reversals, and color changes make them more vulnerable to predators and physical disruptions.

Observations of some freshwater organisms indicate a wide range of tolerance for methanol. As examples, narcosis occurs in some aquatic insect larvae in concentrations as low as 0.5%, while several crayfish species can live in 10% methanol solutions up to five hours.

Table 21.2

FRESHWATER ORGANISMS -- METHANOL TOXICOLOGY

| Organism | LD50 (15°C) (%, 3 hrs.) | (at 500 ppm, 3 hrs.) Disorientation | Narcosis | Color Change |
|---|---|---|---|---|
| *Salmo trutta* | 0.50 | + | + | |
| *Salmo clarkii* | 0.50 | + | + | |
| *Salmo gairdnerii* | 0.75 | + | + | |
| *Gambusia affinis* | 0.75 | + | + | |
| *Pomoxis* sp. | 0.75 | + | + | |
| *Lepomis* sp. | 0.75 | + | + | |
| *Micropterus salmoides* | 0.75 | + | + | |
| *Cyprinus* sp. | 1.00 | + | + | |
| *Pacifasticus* 3 spp. | 3.0-5.0 | + | + | |
| *Procambarus* sp. | 3.00 | | + | + |
| *Apus* sp. | 1.00 | + | + | |
| *Asellus* sp. | 0.75 | + | + | |
| Neuroptera (larva) | 0.50 | + | + | |
| Plecoptera (larva) | 0.50 | + | + | |
| Ephemeroptera (larva) | 0.50 | + | + | |
| Odonata (larva) | 0.50 | + | + | |
| Trichoptera (larva) | 0.50 | + | + | |
| Diptera (larva) | 0.50 | + | + | |
| Coleoptera (larva) | 0.50 | + | + | |
| Colepotera (adults) | 1.50 | | | |
| *Spongilla* 2 spp.* | 1.00 | | + | |
| *Sphaerium* 3 spp. | 3.00 | | | |
| *Anodonta* sp. | 3.00 | | | |
| *Physa* 3 spp. | 1.50 | | | |
| *Pisidium casertanum* | 2.00 | | | |
| *Oscillatoria* sp. | 1.00 | | | |
| *Nostoc* sp. | 1.00 | | | |

* Choanocyte activity

Note: Many of these organisms are not present in the Beluga region.

Natural exposure to concentrated alcohols in freshwater habitats is probably negligible, making this latter tolerance remarkable. Several genera of both freshwater and marine bacteria are tolerant of 1% methanol. Under some experimental field and lab conditions, bacteria will metabolize $C^{14}$ labeled methanol as a carbon source. Current assessment of methanol toxicity to small aquatic organisms suggests that the effects of one-time spills or leaks would probably be minimal, except in proximal areas where concentrations reach or exceed 1%.

Control spills in several habitats and laboratory aquaria indicate rapid deterioration of both individuals and community interactions at alcohol concentrations above 5% volume in lentic waters and 5% volume in lotic waters. Although oxygen concentrations appear to influence survivorship, the natural exposure to both alcohols in still, lentic waters seems to be a significant factor in organismic tolerance levels for organisms from this habitat. While recovery observations are still being carried out, preliminary evidence suggests more rapid stabilization in running, lentic waters. This is probably due to the more allogenic, colonizer-based community structure in this habitat, wherein major components move in from upstream waters. These studies will continue to document seasonal variations in community structure and species diversity.

Specific neuronal dysfunctions have been monitored for the crayfish <u>Pacifasticus</u> exposed to 5, 20, 30 and 50% of methanol for 30 and 60 minute periods. Cardiac nuclei desynchony, tachycardia, bradycardia, and other symptoms were noted. Other experiments of 30% and 50% methanol proved irreversibly toxic in 90% of the exposure situations.

Tolerances for several larval Trichoptera species have been established for both methanol-water and ethanol-water solutions. These important freshwater insect larvae occupy several niches and could prove useful as indicator organisms in the case of alcohol spills.

Depending on species, previous exposure, water temperature, oxygen tension, and chemical factors, Trichoptera tolerate 1 to 10% methanol or ethanol by volume. Important genera evaluated have included _Tinodes_ and _Athripsodis_, and other key groups.

Chronic toxicity studies with the eggs of the mayfly _Ephemerella (Ephemerella) infrequens_ have indicated that at concentrations of 1.0 and 1.6% methanol, there was no additional mortality but that development and hatching were somewhat delayed. At 2.5% methanol overall survival was low (only 10.6% at 60 days) and no eggs hatched. At even higher concentrations (3.0% plus) no eggs developed. _Ephemerella_ eggs appear to be less sensitive to methanol than those of several fish species including grayling and Arctic char.

Acute toxicity studies of the nymphs of five species of benthic macroinvertebrates -- the mayflies _Rithrogena doddsi_, _Ephemerella (Ephemerella) infrequens_, and _Siphlonurus columbianus_, the stonefly _Isogenus (Isogenoides) elongatus_, and the caddiesfly _Hydropsyche slossonae_. The resultant data indicate that:

a. If comparisons are restricted to intermediate nymphal stages, _Isogenus_ is least sensitive to methanol, with _Diphlonurus_ and _Ephemerella_ intermediate, and _Rithrogena_ most sensitive;

b. There was no consistent significant difference between the toxicity of analytical and technical grade methanol;

c. For _Siphlonurus_, there appears to be no difference in the sensitivity of mature nymphs and the black wingpad stage, whereas for _Ephemerella_, the latter stage is significantly more sensitive than the mature nymph;

d. In comparison with Arctic char, two species, _Hydropsyche_ and _Rithrogena_ appear to be at least as sensitive, while three species, *Ephemerella*, *Siphlonurus*, and *Isogenus* appear to be less sensitive than the fish.

Effects of methanol on permanent and seasonal freshwater fish are considered later in this section. Selected methanol toxicology is summarized in Table 21.2.

Terrestrial Effects -- Direct Exposure

The following discussion presents a synopsis of the relative effects that might be anticipated if there were a methanol spill on land.

Macrobiota and microbiota components in soil exposure experiments have wide ranges of tolerance in methanol. Soft-bodied organisms such as oligochaete and enchytraeid worms, nematodes, and soil protozoa are quickly eliminated in surface saturation experiments. Arthropod populations dependent on surface canopy vegetation are also drastically reduced, as grasses, mosses, and other plants are killed by surface saturation of methanol. However, arthropods at lower soil depths, or that are very mobile in the soil, are not affected (Table 21.3). Monitored plots of soil surface saturation spills in oak forest habitats indicate rapid recolonization of surface horizons. Animal populations below 20 cm in these plots were affected little by saturation spills.

In addition, fungal and bacterial populations show great tolerance and recolonization of surface horizons exposed to methanol. Preliminary data show about 60% of initial fungal activity recovers in horizons 10 to 30 cm deep one week after surface saturation. Ninety percent recovery is noted in similar plots and depths three weeks after saturation. Bacterial activity at 10 to 30 cm horizons is 85% of initial after three weeks. The rapid recovery or recolonization of these important agents of nutrient cycling is probably due to the very resistant spores and resistant stages produced by many species. Surface nitrates in experimental plots were nearly stable,

Table 21.3

ORGANISMIC RECOLONIZATION OF SURFACE SATURATED SOILS
METHANOL TOXICOLOGY

| Organism | Population Loss (5% Intervals) | Post Exposure 1 week (% below initial) | Post Exposure 3 weeks (% below initial) |
|---|---|---|---|
| Lepidoptera (larva) 5 spp. | 100 | 100 | 100 |
| Diptera (larva) 2 spp. | 90 | 90 | 90 |
| Collembola 4 spp. | 100 | 50 | 5 |
| Nematoda 4 spp. | 85 | 30 | 15 |
| Enchytraeid 2 spp. | 85 | 25 | 20 |
| Oligochaeta | 90 | 30 | 10 |
| Coleoptera (adult) | 90 | 20 | 0 |
| Coleptera (larvae) | 90 | 90 | 90 |
| mites 4 spp. | 95 | 40 | 15 |
| millipedes 3 spp. | 70 | 40 | 10 |
| centipedes 2 spp. | 10 | 100 | 100 |
| Orthoptera 3 spp. | 100 | 100 | 100 |
| bacteria | 90 | 40 | 15 |
| fungi | 70 | 60 | 10 |

also indicating the rapid recovery of the microfauna. Laboratory assessment of lateral and vertical movement of methanol in soil shows both rapid initial penetration and degradation of $C^{14}$ labeled spills. In oak forest soils, penetration and movement is limited to the immediate spill area. Methothrophic soil bacteria become labeled in a few hours at the perimeter of such tracer sites.

## Emissions

Preliminary evaluation of the toxicity of methanol spills or evaporative emissions shows minimal organismic effects. Flow chamber experiments indicate little disruption of plant and animal physiology at anticipated levels of methanol. Reversible narcosis occurs in many flying insect species at 500 ppm methanol for 1 hour exposures. Important pollinators may be adversely affected by methanol emissions under chronic or massive exposure, but further work is needed to determine the extent of direct and indirect disruptions.

Additional consideraton has been given to other pollinator and flying predator species of insects, including various Hymenoptera, Diptera, and Lepidoptera. More active fliers appear to be less tolerant of alcohol emissions, but low-level exposures elicited reversible narcosis and other effects in most cases. Exposure chamber evaluations demonstrated reversible disorientation and decreased feeding-gathering behavior in honeybee, wild bee, wasp, skipper, butterfly, and moth species tested at expected levels of pollution. Two species of carpenter bee, and three species of hover flies lost flying territory orientation under similar conditions. However, all of species' territories were reestablished in clean-air conditions in 0.5 to 2.5 hours after initial exposure completion. Predatory wasp prey capture abilities were decreased from 31% to 3% success ratio in chamber presentations of prey species. Larvae of the honeybee, Apis, and several species of moth soil larvae were killed by open air exposures (1,000 ppm methanol).

Other studies have involved the neuronal, hormonal, and muscular effects of methanol, ethanol, and indolene on selected arthropods. Various Hymenoptera, Diptera, and Orthoptera have been evaluated. The results indicated a relationship of tolerance to metabolic rate. The more rapid breathing and flying Hymenoptera and Diptera were more susceptible to gaseous fuels than the more terrestrial Orthoptera. In conditions approximating 500 ppm at 18° to 22°C, indolene most quickly caused narcosis and disorientation, followed by ethanol and methanol, respectively. Electronic monitoring of heart function showed arrhythmia, deletions, and secondary beats under all three fuel exposures. Possible permanent flight muscle dysfunction in honeybees at the above conditions was recorded in these experiments and is currently under investigation.

Other projects have involved arachnid exposures to methanol near or above levels expected in field spill situations. The results of these tests indicate a gradient of tolerance among these important predatory, nutrient cycling, and pollinator organisms. Arachnids as a group proved extremely hardy, showing reversible narcosis only after prolonged exposure to 300 ppm methanol. Narcosis and reversible neuronal disruptions occurred at 100 ppm ethanol/methanol in air for several orders of flying insects. Ongoing investigations involve hormone and pheromone disruptions at expected field spill levels of methanol. As most insect pheromones are short carbon chains of low molecular weight, the effects of low levels of alcohol are expected to be minimal.

## METHANOL IN THE ENVIRONMENT (SPECIFIC)

### Introduction

An overview of the biological consequences of methanol spills and leaks demonstrates a wide range of effects in different situations. The specific consequences of methanol on animal populations in the

Beluga to Drift River areas are associated with both biological and physical factors. In particular, life stage, nutritional state, seasonal reproduction, microhabitat, migration, sediment load, oxygen concentration, temperature, and exposure levels are most important in assessing impacts of spills or leaks from the plant site, pipeline, or tanker terminal. The consequences of methanol spill/ leak incidents may be summarized in organismic groupings.

## Fish

Experimental tests for acute and chronic exposure to methanol indicate a wide range of tolerance, which varies within taxanomic groups, adult, age/size, and life stage. In addition, availability of oxygen during exposure, post exposure conditions, and other factors contribute to degree of disruption in fish by supra-ambient concentrations of methanol.

Several trout and salmon species may tolerate 1% methanol for 3 to 5 days. While behavioral alterations occur at this concentration, permanent damage is uncommon. It is probable that the eggs, sperm, embryos, and post-embryonic alevins of salmonid fishes can withstand brief exposures to methanol at 1%. A 1% concentration kills grayling eggs if continued over their incubation period. Trout fry are apparently unharmed by 24-hour exposures to 0.8%. Adult rainbow and brook trout tolerate 3% methanol for 24 hours, when aeration of water is supplied.

Blood analyses for methanol in exposed trout and salmon indicate non-selective removal of the alcohol via urine and gill surface diffusion. Adult brook trout exposed to 1% methanol show complete clearance in blood tests 12 hours after exposure.

A 10% concentration of methanol is lethal to most fish, depending upon oxygen demands and availability in each case. Eggs and embryonic stages of most fish are killed at 10% methanol, even during exposures of less than 1 minute.

Several unknowns exist for salmon and other fish of the Beluga-Drift River area in interactions with methanol accidents. Preliminary results show delayed embryogenesis and hatching at sublethal doses. The effect of ambient methanol on fertilization is unknown. Both sperm and ova could be extremely sensitive to low concentrations of methanol. It is also likely that sublethal doses of methanol could disrupt sensory recognition in spawning, migration, and courtship in some fish. In the sediment-laden waters of the upper inlet, these disruptions could prove significant. The exposure of spawning, migrating, or developing fish to methanol concentrations approaching 1% is potentially very disruptive. In addition, food chain alterations for resident or anadromous feeding fish may be significant in reproductive and adult success.

Human consumption of methanol-killed fish is not advisable. While this alcohol is rapidly removed from live tissues, it can remain in dead organisms in significant amounts.

Crustaceans

Crabs and shrimp in the Beluga-Drift River area are much more vulnerable to methanol exposure at developmental stages than at the adult stage. Studies have demonstrated reversible physiological disruptions in various crustaceans exposed to high ambient methanol concentrations. However, preliminary data suggest delayed metamorphis, color alteration, and reduced size in various crustacean instars associated with 100 to 1,000 ppm methanol. These data suggest potential damage to the tanner crab fisheries following any major incident, as this species has a floating, surface-dwelling larvae found throughout the lower inlet. Other species of commercially important crabs and shrimp have free-swimming larvae capable of avoiding temporary surface concentrations of methanol. However, tanner crab adults are generally found far south of the Drift River Terminal. Significant and commercially important crustacea in lower Cook Inlet include:

| | |
|---|---|
| King Crab | Paralithodes camschatica |
| Tanner Crab | Chinoecetes bairdi |
| Dungeness Crab | Cancer magister |
| Pink Shrimp | Pandalus borealis |
| Humpy Shrimp | Pandalus goniuris |
| Coonstripe Shrimp | Pandalus bypsinotus |
| Spot Shrimp | Pandalus platyceros |
| Sidestripe Shrimp | Pandalopsis dispar |

Most adult crabs and shrimp in the area of interest are somewhat migratory. King crab populations, for example, occupy deep waters in various localities throughout most of the year, and early in the spring the adults move to shallow waters (15 to 30 fathoms) to breed. Fertilized eggs are carried for a year. The following spring (usually mid-April) free-swimming larvae occupy middle and lower levels of shallower waters. Consequently, this species is not found in extremely shallow areas, or at the surface where vulnerability to methanol would be increased. In addition, like nearly all commercially important crustacea of this inlet, the king crab population are far removed from the Beluga-Drift River area.

In general, the significant crab and shrimp populations of Cook Inlet are in minimal jeopardy from methanol for several reasons: Adult mobility, adult tolerance levels, most have subsurface larvae, and geographic distance from likely spill locations (plant and terminal sites).

Molluscs

Molluscan species in the area of interest are more vulnerable as larvae than as adults. While ciliary narcosis is common in clams and other molluscs exposed to methanol, the effects of concentrations up to 3% are usually reversible. Only adults in very high alcohol concentrations for extended periods would be lost in spill situations. Significant and commercially important mollusca in lower Cook Inlet include:

| | |
|---|---|
| Razor clam | Siliqua patula |
| Northern (or Weathervane) scallop | Patinopecten caurinus |
| Heart clam | 1. Cinocardium ciliatum<br>2. Cinocardium californiense |
| Soft-Shelled clam | 1. Mya sp.<br>2. Yoldia myalis |
| Bent-Nosed clam | Macoma balthica |

While razor clams and other clams are abundant in the central and lower portions of the inlet, the sport and commercially significant beds occur away from the proposed methanol plant site. However, Harriet Point near Drift River is on the surface current line from the Drift River Terminal. This area could suffer minor adult losses in a major spill situation. Methanol concentrations would have to exceed 3% over a 24-hour tidal period for damage to occur.

However, as the veligers of some clams (including the razor clam) are tapetic or infaunal in pools or soft mud, they may be more vulnerable to low ambient methanol concentrations. Californian strand and estuarine clam veligers are killed by 100 to 1,000 ppm methanol, depending on species, temperature, and available oxygen. It is considered very unlikely that spills from the Beluga-Drift River area could reach recognized clam beds in significant amounts.

Birds and Mammals

Disruptions to bird and mammal populations in Cook Inlet from any methanol spills are considered unlikely. Since methanol is not biologically magnified within food chains, it is not ordinarily passed from prey to predator. Studies have demonstrated high non-primate tolerance for methanol, in both acute and chronic exposure studies. Habitat disruption from methanol spills into marshlands or mudflats would be less permanent than from crude oil or diesel fuel spills. Recovery of habitats following methanol spills is very rapid. Marsh nesting birds and mammals could suffer temporary loss of canopy in a saturation spill. Mobile cetaceans and pinnipeds would suffer minimal disruptions from either acute or chronic spills. Consumption of contaminated fish or crustaceans by birds or mammals following a spill similarly presents little hazard to non-human vertebrates.

## Summary

The rapid dispersal, dilution, evaporation, and biological degradation of methanol in both aquatic and terrestrial habitats minimize its impact on living systems. Methanol in low levels is a normal component in many habitats, particularly mudflats, and many organisms are behaviorally, biochemically, and morphologically equipped to tolerate its presence. Soil penetration and aquifer involvement are minimal concerns with methanol production. The extreme currents and tides of the Beluga-Drift River area and the subsequent dilution of any spilled methanol from this facility, suggest that most impacts would not be severe or of long duration. Human impacts to fish and crustacean fisheries would be very localized in any spill situation from methanol plant to tanker terminal. Long-term disruptions to fisheries, or bird and mammal populations are considered unlikely in all but the most localized, worst-case possibilities.

SAFETY & RISK

SAFETY AND RISK

## 22.0 SAFETY AND RISK ANALYSIS

### INTRODUCTION

The purpose of this section is to assess an occupational health and safety program for the proposed methanol plant, because there are potentially hazardous situations inherent to the coal gasification process. Regulatory standards are cited where compliance is mandatory to achieve a given level of protection. In addition, potential hazards are enumerated to facilitate further evaluation of the programs necessary to achieve the desired level of protection. The most serious hazards are created by the possibility of fugitive emissions of carbon monoxide, hydrogen sulfide and methane.

A thorough safety/risk analysis involves complete identification and evaluation of hazardous elements to protect personnel, facilities and the environment against accidents. This level of analysis would consider the entire project from mining to shipping. A more detailed assessment as well as similar evaluations relative to the operation of the mine, transportation system, pipeline, and marine loading facility will be made in Phase II.

### ASSESSMENT PROCEDURES

#### Program Characteristics

An early and complete safety analysis can eliminate potential safety and health problems that may otherwise, unknowingly, be produced during planning and construction phases of the project. This analysis can also provide the foundation upon which a thorough safety program can be developed for the construction and operation phases of the project. This safety program can minimize the impact of physical and chemical hazards on human health. An effective safety program requires management commitment both to the development of the program and to its implementation.

A thorough safety analysis should begin prior to the commencement of construction to provide optimum cost effectiveness. Implementation procedures and guideline characteristics for such a preconstruction safety analysis and review should include:

1. Management's accident control philosophy should be described by a clear, workable policy.

2. Responsibility must be clearly defined to cover all aspects of the program.

3. An organization must be formed to carry out the program.

4. Realistic objectives must be set.

5. Reporting procedures must be implemented so that accident facts can be recorded and causative factors analyzed.

6. An analysis of the relationship of facilities, personnel, equipment and materials to accident causes must be performed.

7. Personnel must be properly trained in their jobs, and management must promote realistic caution at all times.

8. Programs must be evaluated regularly to strengthen weaknesses.

9. Recognition must be provided for outstanding effort and achievement.

10. Top management must exert leadership in order to maintain program effectiveness.

## Regulatory Assessment

An important area of regulatory concern is focused on the possible carcinogenic, mutagenic and teratogenic effects of polycyclic aromatic hydrocarbons (PAH) on human health. Polycyclic aromatic hydrocarbons are present in highest concentrations where incomplete combustion occurs. However, the Winkler gasifier is a partial oxidation system whereby the PAH compounds are converted into carbon oxides and hydrogen due to the relatively high temperature of gasification. Therefore, the major concern of the Winkler gasifier is not PAH compounds but, rather, the exposure to carbon monoxide and hydrogen sulfide, substances normally inherent to gasification processes.

The Occupational Safety and Health Administration (OSHA) Regulations, Title 29, Code of Federal Regulations, Part 1910 (cited 29 CFR 1910) at Subpart 2 (cited 29 CFR 1910 Subpart 2) lists a number of toxic and hazardous substance exposure limits. Of these toxic substances listed by OSHA, the following trace compounds in the raw gas are predicted to fall within the following ranges:

| | |
|---|---|
| $NH_3$ | 3 to 10 ppm (vol.) |
| HCN | 10 to 20 ppm (vol.) |
| $C_2H_2$ | 50 to 150 ppm (vol.) |
| $C_6H_6$ | 10 to 30 ppm (vol.) |
| $H_2S$ | 700 ppm (vol.) |
| COS | 100 ppm (vol.) |

It should be noted that the above concentrations of $H_2S$ and $C_6H_6$ are above acceptable ceiling limits pursuant to OSHA standards (i.e. 20 ppm - $H_2S$; 1 ppm $C_6H_6$). Further applicable regulations are cited throughout this section where mandatory standards apply.

SAFETY OVERVIEW

## Health Effects

The major hindrance to accurate risk assessment in a coal gasification plant arises because occupational exposures are to complex mixtures of chemicals rather than a single chemical. Chemicals similar in constitution and toxicologic mechanisms may simply have an additive toxic effect; or others may have a more serious synergistic effect, which is of particular concern with carcinogens. Some non-carcinogenic chemicals may enhance the potency of carcinogens when present. However, if components act independently, each can be considered as though the others were not present.

Effects of toxicant exposure on human health deviate dramatically. Assessment of these effects, again, are complicated by the complex chemical mixtures present. Exposure effects may vary from temporary irritation (e.g. ammonia exposure) to death within minutes (e.g. hydrogen sulfide exposure). Exposure to polycyclic aromatic hydrocarbons may cause problems that are not apparent for decades. Protection of the work environment from these hazards requires an effective sampling program to determine potential toxicant exposure. Effective engineering and work practice controls can be developed through this sampling program.

Coal gasification is essentially a closed process with few continual opportunities for air or surface contamination. Process operating conditions will determine the source of potential exposure. For example, vessel entry would be the predominant exposure source during down time (maintenance), while fugitive emissions from process equipment could be the primary exposure source when on-stream (operating). It is therefore logical to define possible hazards with respect to operating stages. The gasification process can be broken down into four modes of operation: Process Down Time, Start-up, On-stream Operation and Shutdown.

° Process Down Time

Process down time exposures would result primarily from maintenance and repair operations which require an employee to enter a vessel. Vessels may contain residual gases and surface contaminants such that entry may pose health hazards to employees. A safe work permit system should be established as a checklist for the employee to proceed safely.

The following hazards apply both to vessels and confined areas. Similar hazards exist when opening a process line and thus require similar attention. Among the health and safety hazards that must be checked prior to vessel entry are:

Atmosphere: Areas containing less than 19% oxygen concentrations are considered inert for human respiratory functions. Oxygen concentrations far below 19% should be expected in all areas of the gasification process and may further exist in the baghouse areas.

Enclosed area within the process may contain vapors from volatile liquids. These vapors are capable of forming explosive mixtures upon contact with air. Coal dust present in the coal preparation areas is equally capable of explosion at high concentrations.

Gases and Liquids: A number of liquid, gaseous and vaporous constituents in the process are toxic. These toxic constituents should be expected in all gas stream vessels and lines.

To insure these hazards are minimized before opening the vessel, all material must be evacuated and properly disposed of in a safe manner. Flushing the vessel with steam or an adequate solvent will remove toxic gases and residues. Purging with an inert gas following flushing should remove the last traces of toxic gases and vapors. Physical isolation of the vessel is required to separate it from all sources of hazardous material. Isolation of a vessel involves plugging a line or removing a section of process pipe. Only if other methods are not possible should the use of a valve be permitted as an isolation method; then both supervisor and worker should "lock-out" a closed valve.

Before human entry, the existing (inert) vessel atmosphere should be thoroughly exhausted by means of exhaust fans and flexible ducts inserted into vessel crevices. Testing of the vessel should verify:

1. Greater than 19% oxygen concentration;

2. Atmospheres less than 1/10 the Lower Explosive Limit (as given in the Handbook of Industrial Loss Prevention);

3. Absence of toxic gases and vapors, determined by either direct instrument reading or indicator tubes.

If testing indicates insufficient oxygen or toxic vapors are present, respiratory equipment must be provided in accordance with 29 CFR 1910.134. However, respiratory equipment is a last resort method only to be used after it has been demonstrated that engineering work practice offers insufficient protection.

No more employees shall enter a vessel than there are means to retrieve safely in an emergency. A standby employee must be present at all times outside the vessel whenever an employee is inside a vessel. The standby employee should maintain continuous contact with the person inside and should be prepared to initiate rescue procedures should it become necessary.

Opening a process line may expose a worker to the same toxic hazards as entering a vessel. Prior to opening, the process line should be blocked both upstream and downstream. An exhaust hood should be used to remove any toxic gases and vapors to the flare. Once an exhaust hood is in place, the bleed valve can be opened gradually.

- <u>Start-up</u>

Start-up procedures should include leak tests. Cold and hot testing with an inert gas are necessary for adequate detection of any potential process leaks. Detection of these leaks before operation begins will reduce the probability both of health hazards and emergency shutdowns. Adequate training programs prior to start-up are a necessity.

- On-stream Operation

Worker exposure would occur from process equipment leaks. Equipment such as pumps, compressors, valves and flanges are subject to relatively high temperatures and pressures. Corrosive and acidic liquids may be encountered especially in pumping coal runoff water from the retention ponds. Proper selection of equipment, seals and gasket materials to withstand such abuse is needed to minimize the potential for leaks. Triple mechanical seals may be necessary to effectively reduce the possibility of toxic material leaks in some areas of the process scheme.

Leaks occurring at operating pressure should be readily recognized as adverse effects on operating parameters or spontaneous combustion upon gaseous entry into the atmosphere. Neither condition is acceptable for any length of time; therefore little exposure from a continuous source is expected as operating procedures would provide for shutdown and repair.

Numerous techniques can be employed to further reduce the risks from process related leaks, among them various types of exhaust ventilation. Requirements for ventilation are given in 29 CFR 1910.94; furthermore, construction, installation, inspection and maintenance of exhaust systems must conform to standards given in American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2 - 1960, and ANSI Z33.1 - 1961. "Elephant hoses" can and should be utilized in enclosed areas. These long flexible exhaust hoses should be conveniently located so they can be placed over a leak as it occurs. When not in use each hose should be dampered. Areas where more frequent leaking occurs should utilize local exhaust ventilation.

Liquid leak exposures can be minimized by the use of portable shields and drip pans. Lines containing toxic materials should be designed with parallel duplicate lines and valves so that leaks can be bypassed to allow for continued operation. In critical process areas, the installation of parallel pumps and compressors could circumvent an unplanned shutdown due to leaks.

° <u>Shutdowns</u>

Shutdown essentially would present the same hazards as those encountered with the process down time operation. The only difference is that line material would be vented to the flare. To insure safety, the lines should be purged with inert gas until instrumentation indicates no process gas remains. All other safety procedures as given in the Process Down Time section should be adhered to as part of normal safety practice.

## PROCESS HAZARDS

While process operating conditions will establish the type and limits of exposure, a thorough safety/risk analysis must also evaluate operational hazards unique to each process section. Extensive pre-construction investigation of each process section is required to develop an adequate safety program. This review will be accomplished in Phase II.

### Coal Storage

Potential hazards inherent in coal storage are dusting, fire and leaching.

Dust is an intermittent health hazard caused by the loading, unloading and clean-up of coal in the storage area. Only storage facility personnel should be affected, as the area is located a significant distance from the process itself. Good housekeeping techniques can substantially reduce hazards and should be rigidly enforced.

Lignite and sub-bituminous coals can ignite when dry and exposed to ambient air conditions. These surface fires produce hazardous gases and particulates similar to coke oven emissions. These emissions are a source of polycyclic aromatic hydrocarbons and should be handled accordingly. As with dusting, good housekeeping procedures can reduce hazards.

## Coal Preparation

Exposure to dust and excessive noise are the primary safety concerns in the coal preparation area.

Dusting is possible from any equipment, especially equipment that requires frequent disassembly for maintenance. Dust produced from crushing coal presents a number of inhalation hazards, most notably precipitating pneumoconiosis. Dust explosion also increases the possibility of a fire hazard.

Additioanl fire and inhalation hazards exist in the coal drying area should the temperature in the drying zone exceed safe limits. The possibility of fire from spontaneous combustion also exists during conveying of this dried coal.

All grinding operations are inherently noisy. Although operation is located away from the process plant, operating personnel may still be affected psychologically. Mandatory occupational noise exposure limits are set in 29 CFR 1910.95.

## Coal Feeding

Valves in the coal feeding process are subject to extraordinary abuse, particularly lockhopper valves. Faulty valves may cause reactor off-gas to escape to the atmosphere, as these valves are located at the low pressure portion of the system. A double block valve arrangement will be utilized minimizing potential leaks. Preliminary designs of the valves will occur in Phase II as well as the interlock control system.

## Gasification

Potential health and safety hazards in the gasification areas will be due primarily to: leaks, plugged lines and insulation problems.

Leaks may involve the temporary release of extremely toxic substances into the gasification areas, most notably carbon monoxide and, to a lesser extent, hydrogen sulfide. Even though leaks would be detected quickly in this area, potential loss of life is a grave reality should only minimal exposure occur.

Plugged lines may be a frequent problem in gasification and all previous safety precautions given in the process down safety assessment apply. Due to the formation of extremely toxic gases and vapors, additional emphasis should be placed on all safety precautions before vessel entry. Solids present in the gasifier should be essentially inert as they will be highly coked or ashed.

## Ash Removal and Disposal

Valves in the ash removal and disposal lockhoppers are subject to the same abuses as those in the coal feeding process. High failure incidence may occur in these valves. Valve leaks can allow process gas to escape to the atmosphere causing potential inhalation hazards. Ash and chars are essentially inert but may absorb dissolved trace elements from recycle water. These elements may later leach out upon rain exposure and produce a potentially toxic leachate.

## Venturi Scrubber

The Venturi Scrubber recycle pump is subject to excessive wear due to the pumping of solids. This excessive wear necessitates frequent visual inspections to prevent possible leaking of toxic substances.

Appropriate sampling techniques are necessary to reduce the possibility of burns from hot sample water. Sludge must also be handled carefully to prevent both worker exposure and accidental spills.

## Shift Conversion

In normal operation, few hazards are foreseen with the shift conversion process. Normal maintenance operations should also present few hazards if the high concentrations of carbon monoxide in the reaction vessels are adequately purged.

## Acid Gas Removal

If leaking gas and vapors occur from the acid gas removal system, there may be the possibility of toxic exposure. Fugitive emissions may release toxic substances (e.g. $H_2S$) from any section of the process up to and including the sulfur recovery system.

## Methanol Synthesis

Adherence to proper operating procedures should produce few hazards. Leaks may occur due to: plugged bed or lines, leaking valves or leaking pumps. Leaks will release carbon monoxide, methane and hydrogen in the work place. It is expected that carbon monoxide will be emitted in greater amounts than methane or hydrogen. However, frequency and severity of such leaks should be far less than in the upstream portion of the plant. Leaks may also occur in the reformer section of the process, possibly releasing carbon monoxide, hydrocarbon gases or hydrogen.

### Methanol Distillation

If leaking occurs in the distillation columns, there is a possibility of worker exposure to the high concentration of methanol. Due to the extremely toxic nature of methanol, exposure to it should be avoided under all circumstances.

### Utilities

The coal-to-methanol process would require numerous support utilities for operation. Utilities are generally located within a single building and are inherently noisy.

## MONITORING THE PROCESS ENVIRONMENT

### Industrial Hygiene

An effective industrial hygiene program is composed of the following occupational health programs functioning together.

### Monitoring

A monitoring program is implemented as a warning signal. The signal utilizes an indicator substance present in the process scheme such that any leak of the indicator would allow determination of a toxic constituent. The toxic constituent can be assumed to leak in the same ratio as the indicator substance. Although this assumption may not always be valid, the signal is not proposed as an absolute test of compliance, but rather an indicator of possible noncompliance.

This type of monitoring program avoids insensitivity to trace constituents at a reasonable cost.

Carbon monoxide would appear to be the best indicator for the gasification process. Carbon monoxide is present in high concentrations, and is also easily monitored in real time or by remote samplers. Alarm systems are available that can detect carbon monoxide levels as low a 0.2 $mg/M^3$.

## Medical

Employees should be provided with preplacement and periodic medical examinations. The preplacement examination should include full physical and laboratory tests to ascertain general fitness, identify high-risk individuals, and set a basis for further routine examinations.

Medical records should be compiled for each employee and these records must contain employee exposure data. Medical records should be maintained for 40 years in accordance with OSHA regulations (29 CFR 1910.20).

## Education and Training

Periodic meetings of all employees should be conducted to describe all potential health hazards in detail. Details of the medical program should also be made available to each employee. Personal hygiene should be emphasized to further promote worker protection.

Toxic effects can also be reduced by minimizing skin contact with soiled clothing. Plant shower facilities should be provided, as should laundering facilities for protective clothing. Requirements for these installations and other plant sanitation equipment are given at 29 CFR 1910.141.

## Compliance

Control methods should be implemented and evaluated regularly. Control methods include engineering, work practice and administrative controls. Protective devices should also be evaluated to determine compliance with safety and health standards (i.e., Occupational Noise Exposure [29 CFR 1910.95]; Personal Protective Equipment [29 CFR 1910, Subpart I]; etc).

## Regulated Areas

Process areas may be regulated that exceed carbon monoxide concentrations of 35 ppm on a regular basis. Job functions may also be regulated to reduce the number of exposures to a particular hazard.

Posting of warning signs to reinforce adherence to specific safety requirements in each area enhances the effectiveness of the overall health and safety program. Specifications for such safety signs are given at 29 CFR 1910 145. Safety color coding should also be used to mark physical hazards as given at 29 CFR 1910.144.

## Emergency Procedures

Emergency procedures should be developed where hazardous substances are handled. These procedures should be compiled in writing. Sufficient protection training should also be given to the applicable personnel. Means of egress and emergency procedures should be provided as given at 29 CFR 1910, Subpart E and 29 CFR 1910, Subpart Z.

# FIRE SAFETY

A potential fire hazard exists whenever a vessel, duct, flange, pump, compressor or valve is opened. Coal particles adsorb a number of gases readily so that the possibility of a fire occurring remains even after gas purging of the system.

Gaseous effluents from the gasifier are the primary sources of fire hazards. Hot gas can escape from ruptured pipes, leaks or improper sampling procedures. Fugitive gas can ignite spontaneously upon entry to the atmosphere or drift several hundred feet before exploding. The number of potential leak hazards can be eliminated by installation of double valve sampling ports.

All automatic process control systems should have redundant instrumentation to prevent vessels from overheating.

Requirements for fire protection and equipment are given by OSHA at 29 CFR 1910, Subpart L.

## Conclusion

This report was developed as the foundation for a thorough safety analysis. The report presents an attempt to realize potential safety hazards and assess their detrimental effects on human welfare. Although further safety evaluation is necessary, every conscientious effort shall be made to minimize physical and chemical hazards afflicting human health.

The ultimate objective of this evaluation shall be final application of an acceptable safety program at the CIRI/Placer Amex Production Facility; this ultimate objective will be accomplished in Phase II.

# SITE EVALUATION

SITE EVALUATION SUMMARY

# 23.0 SITE SELECTION

## INTRODUCTION

Construction of a methanol plant is being considered in a major coal resource area on west Cook Inlet referred to as the Beluga area. For purposes of this study this is an area of approximately 450 square miles bounded on the north by the Beluga River, on the south by Nikolai Creek, on the west by the Capps Glacier and on the east by the shore of Cook Inlet. In order to narrow the alternatives for siting the methanol plant within this broad area a screening analysis was used. Due to unavailability, Tyonek Native Corporation lands (former Moquawkie Indian Reservation) and the Bass Hunt Wilson coal lease areas were eliminated from consideration, thereby reducing the 450 square miles area to 370 square miles. By eliminating the areas of natural water courses and the wetlands consisting of small lakes and other significant standing water, the candidate area is further reduced to about 150 square miles. To proceed further with plant site selection the following three-step process was used to narrow the alternatives to the best available site:

Level I - Screening Analysis
Level II - Preliminary Site Selection
Level III - Final Site Selection

The Level I and Level II reviews were done as part of this feasibility study. Level III, "Final Site Selection", will be conducted during Phase II of development of this project if it is determined feasible to proceed. The following discussion summarizes the review process that determined a proposed plant site to use as a base case for this feasibility study.

Level I - Screening Analysis

The apparent alternatives for siting a methanol plant are to place it near the feedstock source (the mine); place it near the transportation infrastructure (a dock on Cook Inlet); or place it in a location remote from the feedstock source (most likely a market area). With this in mind, four specific areas were reviewed:

a. Granite Point and vicinity on Cook Inlet
b. The Capps coal mine area
c. The Chuitna coal mine area
d. Remote location

° Granite Point on Cook Inlet

The area reviewed is approximately 10 square miles in size on the west Cook Inlet shoreline generally between Granite Point and the mouth of Nikolai Creek. A distinct advantage of this location would be realized in the transportation of the finished product due to close proximity to the existing 20-inch diameter Cook Inlet pipeline, which currently transports crude oil to a tanker terminal operation at Drift River, approximately 40 miles to the south. The oil fields served by this line are nearly depleted, and the pipeline would be available by the time the plant were in operation. Also, a plant near the shore would ease the movement of large prefabricated plant modules, allowing more flexibility in planning and construction. Other positive factors include a more favorable climate and shorter period of snow cover than at the higher elevations of the mine areas. A disadvantage is that the plant would be 15 to 25 miles from the coal feedstock necessitating a mine-to-plant transportation system.

° Capps Coal Field Area

The Capps Field is one of two proposed mining areas that would provide coal to the methanol plant. The Capps mine area is approximately 25 miles from Cook Inlet, at about 2,000 feet elevation near the Capps Glacier. An advantage of this location is that it would not only be near the feedstock source but also near the first coal that would be produced from either mine area. It would also be sufficiently removed from the shores of Cook Inlet to be visually unnoticeable. A principal disadvantage would be the need for a pipeline system from the mine to Cook Inlet to transport the methanol. Another disadvantage to the upland location would be difficulty in obtaining sufficient water for plant operation. It is unlikely that significant quantities of groundwater could be obtained in the vicinity, and the surface sources are inappropriate due to their seasonal nature as sources, and due to water quality and/or use as a fish habitat.

A further disadvantage to the Capps location is that the coal produced from the Chuitna Field would have to be hauled upgrade from approximately 1,400 feet elevation to 2,000 feet, the elevation to the plant at the Capps mine. To operate a plant in this location would require investment in both coal and methanol transportation systems.

° <u>Chuitna Coal Field Area</u>

The Chuitna mine area is approximately 15 miles from the shore of Cook Inlet at an elevation of about 1,400 feet. This field is generally on a direct line route from Cook Inlet to the Capps Field. Advantages of the Chuitna mine area would include the relatively unnoticeable location and its nearness to the feedstock. The pipeline transportation system to carry methanol to Cook Inlet would be approximately 10 miles shorter than from a Capps site and the coal supplied from the Capps mine could be transported downgrade, instead of uphill from Chuitna to a Capps plant site.

- Remote Location

  To complete the site selection alternatives, the possibility of an area away from Beluga or even outside of Alaska was also recognized. A remote site was dismissed as unfeasible particularly due to the need for double handling of coal, and additional marine transportation costs associated with getting coal to the processing location. In light of present market conditions and current and anticipated energy policies during the life of this project it appears essential to economic feasibility to have the plant close enough to the coal source so that the coal may be provided with minimal handling utilizing no more than one major mode of transportation. The relatively clean and undeveloped Alaska location also offer advantages in environmental permitting, since there are not already significant contributions of air pollution or wastewaters in the area consuming allowable "increments" of emissions to the environment, as would be the case in most west coast locations.

- Comparison of Alternatives

  At this point the Capps Mine and the remote location were eliminated from further consideration for reasons generally described above. The two more likely alternatives, Granite Point and the Chuitna Field, were then further compared using evaluation criteria relevant to both locations. Each site was assigned a numerical value (3 = good, 2 = average, 1 = poor) reflecting its compatability with the requirements or restrictions associated with each of the evaluation criteria. Table 23.1 shows the results of this comparison and numerical ranking.

  Although all qualitative rating criteria were considered equally in the above table, greater weight should be given to transportation, environment, and capital costs. The ratings on each of these three criteria, as well as the overall outcome favored the

Table 23.1

QUALITATIVE COMPARISON OF SITES

| Evaluation Criteria | Site Alternatives: Chuitna Mine | Site Alternatives: Shore of Cook Inlet |
|---|---|---|
| Coal Transportation | 3 | 1 |
| General Environmental | 2 | 2 |
| Capital Costs | 1 | 3 |
| Permit Concerns | 2 | 2 |
| Wetlands | 3 | 2 |
| Product Transportation | 1 | 3 |
| Geotechnical | 1 | 2 |
| Climate | 1 | 2 |
| Water Availability | 1 | 3 |
| Power (external) | 1 | 2 |
| Dock Access | 1 | 3 |
| Land Availability | 2 | 2 |
| Site Preparation | 2 | 2 |
| Support Services | 1 | 2 |
| Wastewater Discharge | 1 | 3 |
| Labor Factors | 1 | 2 |
| Visibility | 2 | 1 |
| Site Drainage | 2 | 2 |
| TOTAL | 28 | 39 |

Cook Inlet site, so a second comparison using weighting factors for certain criteria was not necessary. The conclusion of the screening analysis is that a site near the shore of Cook Inlet would best serve the objectives of this project.

A disadvantage of the tidewater site noted in the analysis was the need for a transportation system to move the coal to the process facility. This concern becomes less significant in light of the reasonable assumption that regardless of plant location, there eventually will be a mine-to-shore transportation system for movement and marketing of bulk coal totally unrelated to this project. This reaffirms the selection of the Cook Inlet site.

## Level II - Preliminary Site Selection

The next level of site selection involved choosing a specific area with a minimum of 1,000 contiguous acres near the shore of Cook Inlet between Granite Point and the mouth of Nikolai Creek that appears suitable for location of the methanol plant. The site designated in this review would form the base case for this feasibility study.

The area under review is approximately 10 square miles, constrained by extensive wetlands and standing water to the north, the Trading Bay State Game Refuge to the south, the shore of Cook Inlet to the west, and, on the east, the desire to remain reasonably close to Cook Inlet. Within these parameters there are two general site alternatives for the plant: Tidewater in the low-lying area below the bluffs, or in the upland area between the bluff line and Congahbuna Lake.

° Near Tidewater

There is a somewhat confined area very near high tideline in elevation between Granite Point and the mouth of Nikolai Creek that could be considered a candidate plant site. The land is sufficiently restricted in area, however, that it may not allow for sufficient flexibility in the final plant lay-out if site-specific geotechnical analysis or other considerations imposed further constraints. The physical characteristics of the site might require splitting the facility into upland and tidewater-elevation locations in any case. The foremost advantage of this tidewater location would be that it would enable the plant to be constructed utilizing very large prefabricated plant units which could be barged into place through dredged channels and then fixed into position; the channels could be reclaimed by backfilling. This method of building the plant could have a positive affect on capital costs which could not be realized utilizing an inland site. A tidewater location also would facilitate the discharge of treated wastewater effluent into Cook Inlet, the most likely receiving body of water for an industrial discharge. However, this tidewater location is a wetlands area and would require a Corps of Engineers permit. Obtaining a permit could be very controversial due to proximity to the Trading Bay State Game Refuge. The permit application would have a reasonable potential to be denied in favor of more environmentally acceptable upland locations. A plant located at tidewater also would be susceptible to damage from storm-generated high tides.

- Upland Location

An upland location 4 square miles in area was identified for this site alternative (Sections 17, 18, 19 and 20, T11N, R13W, Seward Meridian). Three-quarters of this land is controlled by the project participant, CIRI. Selection of this location would avoid the natural hazards associated with being near the shoreline at sea level, but also would remove the option of being able to barge large prefabricated plant units into place. However, it still would be possible to receive and install large prefabricated interplant modules using a coordinated barge and surface transportation network. Portions of this candidate site area are considered wetlands by definition; however, it is believed that these wetland areas fall under the jurisdiction of the Corps of Engineers nationwide permit authority, a classification which avoids complications that may be associated with obtaining permits for a tidewater location. Environmental and geotechnical constraints all appear reasonable for this location, and indications are that necessary permits could be granted.

The conclusion of the preliminary site selection review is that the methanol plant should be located on the upland somewhere between Congahbuna Lake and the Cook Inlet bluff line. A specific plant site within the general 4 square mile area was designated for use as the base case in this feasibility study.

## Level III - Final Site Selection

The last stage of site selection involves adjusting the preliminary site location to make it most compatible with the actual conditions and constraints identified by this feasibility study. This final site selection step would be accomplished under Phase II of project development, if it is determined feasible to proceed with the project. At this point it appears that the primary factor that will influence some adjustment of the site location will be specific soils conditions. Broad areas within the preliminary site area have been found to have greater depths of organic overburden than originally anticipated. Indications are that some relocation of the upland plant site in a northwesterly direction would avoid some deep overburden and reduce capital costs through reduced site preparation. Further engineering soils exploration would precede the final site selection decision.

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